

# ZBasic System Library Reference Manual

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# System Library Reference

## Routines by Category

The ZBasic System Library provides a rich collection comprising hundreds of subroutines and functions that you can use to add functionality to your application. The routines may be divided into several conceptual categories as shown below.

### Type Conversion Functions

CBit()	convert a value to type Bit
CBool()	convert a value to type Boolean
CByte()	convert a value to type Byte
CByteArray()	convert an integral value to a reference to a Byte array
CInt()	convert a value to type Integer
CLng()	convert a value to type Long
CNibble()	convert a value to type Nibble
CSng()	convert a value to type Single
CStr()	convert a value to type String
CStrHex()	convert a value to a String containing hexadecimal characters
CType()	convert a value to an enumeration member
CUInt()	convert a value to type UnsignedInteger
CULng()	convert a value to type Long
FixB()	convert a Single value to type Byte
FixI()	convert a Single value to type Integer
FixL()	convert a Single value to type Long
FixUI()	convert a Single value to type UnsignedInteger
FixUL()	convert a Single value to type UnsignedLong
To<enum>()	convert a value to an enumeration member

### Mathematical Functions

Abs()	absolute value
Acos()	arc cosine
Asin()	arc sine
Atn()	arc tangent
Atn2()	arc tangent (quadrant-correct)
Ceiling()	largest integer not greater than a Single value
Cos()	cosine
DegToRad()	convert degrees to radians
Exp()	$e^x$
Exp10()	$10^x$
Fix()	integer portion of a Single value
Floor()	smallest integer not less than a Single value
Fraction()	fractional portion of a Single value
Log()	natural logarithm
Log10()	common logarithm
Max()	determine the largest of two values
Min()	determine the smallest of two values
Pow()	raise a value to a power
RadToDeg()	convert radians to degrees
Signum()	determine if a value is negative, zero or positive
Sin()	sine
SngClass()	return the class information for a Single value
Sqr()	square root
Tan()	tangent

## Memory-related Routines

BitCopy()	copy a sequence of bits from one part of RAM to another
BlockMove()	copy data from one part of RAM to another
GetBit()	extract a bit from a value in RAM
GetEEPROM()	copy data from Program Memory to RAM
GetPersistent()	copy data from Persistent Memory to RAM
GetProgMem()	copy data from Program Memory to RAM
MemAddress()	determine the RAM address of a variable
MemAddressU()	determine the RAM address of a variable
MemCmp()	compare two blocks of data in RAM
MemCopy()	copy data from one part of RAM to another
MemSet()	initialize a block of memory with a byte value
PersistentPeek()	read a byte from Persistent Memory
PersistentPoke()	write a byte to Persistent Memory
PutBit()	set or clear a bit in a value in RAM
PutEEPROM()	copy data from RAM to Program Memory
PutPersistent()	copy data from RAM to Persistent Memory
PutProgMem()	copy data from RAM to Program Memory
RamPeek()	read a byte from RAM
RamPeekDword()	read a 32-bit value from RAM
RamPeekWord()	read a 16-bit value from RAM
RamPoke()	write a byte to RAM
RamPokeDword()	write a 32-bit value to RAM
RamPokeWord()	write a 16-bit value to RAM
System.Alloc()	allocate a block of memory
System.Free()	deallocate a block of memory
System.HeapHeadRoom()	determine the amount of unused space in the heap
System.HeapSize()	determine the amount of space reserved for the heap
VarPtr()	determine the RAM address of a variable

## String-related Routines

Asc()	extract a character value from a string
Chr()	convert a character value to a string
Fmt()	convert a <code>Single</code> value to a string
LCase()	convert upper case letters to lower case in a string
Left()	return the leftmost characters from a string
Len()	determine the number of characters in a string
Mid()	extract or set a substring in a string
Right()	return the rightmost characters from a string
StrAddress()	determine the address where string characters are stored
StrCompare()	compare two strings, optionally ignoring alphabetic case
StrFind()	search for the first occurrence of a string within a string
StrReplace()	replace character sequences in a string
StrType()	determine the characteristics of a string
Trim()	remove leading and trailing spaces from a string
UCase()	convert lower case letters to upper case in a string
ValueI()	convert string characters to the equivalent <code>Integer</code> value
ValueL()	convert string characters to the equivalent <code>Long</code> value
ValueS()	convert string characters to the equivalent <code>Single</code> value

## Input/Output Routines

ADCToCom1()	stream analog conversion data to Com1
BusRead()	read data from a bus-oriented device
BusWrite()	write data to a bus-oriented device
CloseI2C()	deinitialize an I2C communication channel
ClosePWM()	deinitialize a 16-bit PWM channel
ClosePWM8()	deinitialize an 8-bit PWM channel
CloseSPI()	deinitialize an SPI communication channel
CloseX10()	deinitialize an X-10 communication channel
Com1toDAC()	receive stream of analog conversion data
CountTransitions()	count transitions on an input pin
DACPin()	produce an analog voltage on an output pin
DefineBus()	specify the parameters for accessing a bus-oriented device
DefineSPI()	specify the parameters for software-based SPI communication
DefineX10()	specify the communication parameters for an X-10 channel
FreqOut()	produce a dual-frequency sine wave on an output pin
Get1Wire()	receive a bit using the 1-Wire protocol
Get1WireByte()	receive a byte using the 1-Wire protocol
Get1WireData()	receive one or more bytes using the 1-Wire protocol
GetADC()	perform an analog to digital conversion on an input
GetPin()	read the state of an input pin
I2CCmd()	send/receive data over an I2C channel
I2CGetByte()	receive a byte on an I2C channel
I2CPutByte()	send a byte on an I2C channel
I2CStart()	create a Start condition on an I2C channel
I2CStop()	create a Stop condition on an I2C channel
InputCapture()	record the high/low times of a pulse train on an input pin
InputCaptureEx()	record the high/low times of a pulse train on an input pin
OpenI2C()	prepare for I2C communication with an external device
OpenI2CSlave()	activate I2C slave mode
OpenSPI()	prepare for SPI communication with an external device
OpenSPISlave()	activate SPI slave mode
OpenPWM()	prepare for 16-bit PWM generation
OpenPWM8()	prepare for 8-bit PWM generation
OpenX10()	prepare an X-10 communication channel for use
OutputCapture()	produce a pulse train
OutputCaptureEx()	produce a pulse train on any output pin
PlaySound()	reproduce sampled audio on an output pin
PortBit()	compose a designator for a specific bit in an I/O port
PortMask()	compute the bitmask for the port with which a pin is associated
PulseIn()	measure a pulse width on an input pin
PulseOut()	generate a pulse on an output pin
Put1Wire()	send a bit using the 1-Wire protocol
Put1WireByte()	send a byte using the 1-Wire protocol
Put1WireData()	send one or more bytes using the 1-Wire protocol
PutDAC()	produce an analog voltage on an output pin
PutPin()	configure an I/O pin
PWM()	initiate 16-bit PWM generation or change the duty cycle
PWM8()	initiate 8-bit PWM generation or change the duty cycle
RCTime()	measure an RC charge/discharge time
Reset1Wire()	send a reset signal using the 1-Wire protocol
ShiftIn()	perform synchronous serial input
ShiftInEx()	perform synchronous serial input with more configurability
ShiftOut()	perform synchronous serial output

ShiftOutEx()	perform synchronous serial output with more configurability
SPICmd()	perform SPI communication with an external device
StatusX10()	determine the status of an X-10 communication channel
X10Cmd()	send commands using the X-10 protocol

## Serial Communication Routines

Debug.Print	send strings to Com1 via the system output queue
CloseCom()	terminate the use of a serial channel
ComChannels()	prepare for using multiple serial channels
Console.Read()	retrieve a character from Com1 via the system input queue
Console.ReadLine()	retrieve a line from Com1 via the system input queue
Console.Write()	send a string to Com1 via the system output queue
Console.WriteLine()	send a string to Com1 via the system output queue
ControlCom()	specify flow control pins for a serial channel
DefineCom()	set the characteristics of a serial channel
DefineCom3()	set the characteristics of serial channel 3
OpenCom()	prepare a serial channel for use
StatusCom()	determine the status of a serial channel

## Queue Management Routines

ClearQueue()	delete data from a queue
GetQueue()	retrieve data from a queue
GetQueueBufferSize()	determine the size of the data area of a queue
GetQueueCount()	determine the number of bytes of data in a queue
GetQueueSpace()	determine the amount of space available in a queue
GetQueueStr()	populate a string with characters from a queue
OpenQueue()	prepare a queue for use
PeekQueue()	copy data from a queue without removing it
PutQueue()	put data in a queue
PutQueueByte()	put a byte into a queue
PutQueueStr()	put the characters of a string in a queue
SearchQueue()	search a queue for a data byte or sequence
StatusQueue()	determine if a queue has data available

## Date/Time Routines

GetDate()	get the month, day, year corresponding to a date value
GetDayNumber()	compute the day number corresponding to a day of a year
GetDayOfWeek()	get the day of the week corresponding to a date value
GetDayOfYear()	get the ordinal day of the year corresponding to a date value
GetElapsedMicroTime()	compute an elapsed time relative to previous timing data
GetMicroTime()	populate a buffer with high resolution timing data
GetTime()	get the current hour, minute and second
GetTimestamp()	get the current date and time information
PutDate()	set the current month, day, year
PutTime()	set the current hour, minute and second
PutTimestamp()	set the current date and time information
Timer()	get the current clock tick value

## Data Manipulation Routines

FlipBits()	reverse the order of bits in a byte
HiByte()	extract the high byte of a value
HiWord()	extract the high word of a value
LoByte()	extract the low byte of a value
LoWord()	extract the low word of a value
MakeDword()	construct a 32-bit value from two 16-bit values
MakeWord()	construct a 16-bit value from two 8-bit values
MakeString()	construct a string from a sequence of bytes
MidWord()	extract the middle two bytes of a 4-byte value
SetBits()	set the state of specified bits in a byte
Shl()	shift a value to the left
Shr()	shift a value to the right
ToggleBits()	change the state of specified bits in a byte

## Task-related Routines

CallTask	prepare a task to begin execution
DisableInt()	disable interrupts
Delay()	pause a task
DelayUntilClockTick()	pause a task
EnableInt()	conditionally re-enable interrupts
ExitTask()	cause a task to terminate
LockTask()	suspend normal task switching
Pause()	pause a task without relinquishing control
ResumeTask()	cause a waiting task to resume execution
RunTask()	cause a specific task to run
Semaphore()	coordinate the use of a resource
SetInterval()	set the interval timer period
Sleep()	pause a task
StackCheck()	enable or disable stack checking
StatusTask()	determine the status of a task
System.TaskHeadRoom()	determine the unused space in a task's stack
TaskIsLocked()	determine if a task is locked
TaskIsValid()	determine if a task stack is in the task list
UnlockTask()	resume normal task switching
UpdateRTC()	update RTC registers to account for missed ticks
WaitForInterrupt()	pause a task until an external event occurs
WaitForInterval()	pause a task until an interval timer expires
Yield()	allow another task to run

## Miscellaneous Routines

CloseWatchDog()	deactivate the watchdog timer
CPUSleep()	cause the CPU to go into sleep mode
CRC16()	compute a 16-bit CRC value
CRC32()	compute a 32-bit CRC value
FirstTime()	determine if this is the first the program has been run since downloading
GetMicroTime()	populate a buffer with higher precision timing information
GetElapsedMicroTime()	determine the elapsed time relative to previous time information
IIf()	select the value of one of two expressions
LBound()	determine the lower bound of an array
LongJump()	perform a non-local goto (e.g. for exception handling)
NoOp()	execute a "nop" instruction
OpenWatchDog()	activate the watchdog timer
ParityCheck()	check the parity of a data byte

<code>Randomize()</code>	initialize the random number generator
<code>ResetProcessor()</code>	reset the CPU
<code>Rnd()</code>	retrieve the next random number
<code>SerialNumber()</code>	retrieve the system software serial number
<code>SetJump()</code>	prepare for a non-local Goto (e.g. exception handling)
<code>SizeOf()</code>	determine the size of a data item
<code>SizeOfU()</code>	determine the size of a data item
<code>System.DeviceID()</code>	retrieve the identification characters for the device
<code>UBound()</code>	determine the upper bound of an array
<code>WatchDog()</code>	reset the watchdog timer
<code>ZXCmdMode()</code>	activate the “command mode” (for downloading)

## Resource Usage

The AVR devices on which the ZX microcontrollers are based offer a variety of resources for use in your program, e.g. timers, interrupts, USART (hardware serial port), analog-to-digital converters, etc. Some of these resources are allocated to specific functions of the ZX microcontroller and/or are used by certain ZBasic System Library routines. The resources available on a particular ZX device vary depending on the particular CPU upon which the device is based. The table below indicates the underlying CPU for the various ZX devices. The remainder of this section provides an overview of resource allocation for ZX devices.

**Underlying CPU Type for ZX Devices**

<b>ZX Model</b>	<b>CPU Type</b>
ZX-24, ZX-40, ZX-44, ZX-24e	mega32
ZX-24a, ZX-40a, ZX-44a, ZX-24ae	mega644
ZX-24p, ZX-40p, ZX-44p, ZX-24n, ZX-40n, ZX-44n, ZX-24ne, ZX-24pe, ZX-24nu, ZX-24pu	mega644P
ZX-24r, ZX-40r, ZX-44r, ZX-24s, ZX-40s, ZX-44s, ZX-24ru, ZX-24su	mega1284P
ZX-328n, ZX-328l, ZX-32n, ZX-32l, ZX-328nu	mega328P
ZX-1280, ZX-1280n	mega1280
ZX-1281, ZX-1281n, ZX-1281e, ZX-1281ne	mega1281
ZX-128e, ZX-128ne	mega128
ZX-128a1	xmega128A1
ZX-24x, ZX-32a4, ZX-24xu	xmega32A4

## USART

An on-board hardware serial port, or USART, is used for the Com1 serial channel. By default, the USART is configured to operate at 19,200 baud and is utilized by the System Library Routines Console.Read, Console.ReadLine, Console.Write, Console.WriteLine and Debug.Print. You may reconfigure the USART to a different speed by using the System Library routine OpenCom, specifying channel 1. The USART is also used for the ADCtoCom1 and Com1toDAC routines. In both of these cases, the Com1 speed is automatically configured.

Some ZX devices have more than one hardware USART. In these cases, one of the USARTs is assigned to the Com1 serial channel, another USART is assigned to the Com2 serial channel, etc. as shown in the table below. The effect of these assignments is generally only important with respect to which I/O pins are available for other purposes if the additional hardware USARTs are not being used. It also will be important if your program manipulates the USART registers directly.

**Hardware USART Channel Assignment and I/O Pin Usage**

<b>ZX Model</b>	<b>USART</b>	<b>Serial Channel</b>	<b>Tx Pin</b>	<b>Rx Pin</b>
ZX-24, ZX-24a	USART0	Com1 <sup>1</sup>	1, D.1	2, D.0
ZX-24p, ZX-24n, ZX-24r, ZX-24s	USART0	Com1 <sup>1</sup>	1, D.1	2, D.0
	USART1	Com2	11, D.3	6, D.2
ZX-40, ZX-40a	USART0	Com1	15, D.1	14, D.0
ZX-40p, ZX-40n, ZX-40r, ZX-40s	USART0	Com1	15, D.1	14, D.0
	USART1	Com2	17, D.3	16, D.2
ZX-44, ZX-44a	USART0	Com1	10, D.1	9, D.0
ZX-44p, ZX-44n, ZX-44r, ZX-44s	USART0	Com1	10, D.1	9, D.0
	USART1	Com2	12, D.3	11, D.2
ZX-328n, ZX-328l	USART0	Com1	3, D.1	2, D.0
ZX-32n, ZX-32l	USART0	Com1	31, D.1	30, D.0
ZX-1281	USART1	Com1	28, D.3	27, D.2
	USART0	Com2	3, E.1	2, E.0
ZX-1280	USART0	Com1	3, E.1	2, E.0
	USART1	Com2	46, D.3	45, D.2
	USART2	Com7	13, H.1	12, H.0

	USART3	Com8	64, J.1	63, J.0
ZX-24x	USARTD0	Com1 <sup>1</sup>	1, D.3	2, D.2
	USARTD1	Com2	D.7	D.6
	USARTC0	Com7	9, C.3	10, C.2
	USARTC1	Com8	5, C.7	6, C.6
	USARTE0	Com9	19, E.3	18, E.2
ZX-32a4	USARTD0	Com1	23, D.3	22, D.2
	USARTD1	Com2	27, D.7	26, D.6
	USARTC0	Com7	13, C.3	12, C.2
	USARTC1	Com8	17, C.7	16, C.6
	USARTE0	Com9	33, E.3	32, E.2
ZX-128a1	USARTD0	Com1	28, D.3	27, D.2
	USARTD1	Com2	32, D.7	31, D.6
	USARTC0	Com7	18, C.3	17, C.2
	USARTC1	Com8	22, C.7	21, C.6
	USARTE0	Com9	38, E.3	37, E.2
	USARTE1	Com10	42, E.7	41, E.6
	USARTF0	Com11	48, F.3	47, F.2
	USARTF1	Com12	52, F.7	51, F.6
ZX-24e, ZX-24ae	USART0	Com1 <sup>1</sup>	1, D.1	2, D.0
ZX-24ne, ZX-24pe	USART0	Com1 <sup>1</sup>	1, D.1	2, D.0
	USART1	Com2	17, D.3	18, D.2
ZX-24nu, ZX-24pu, ZX-24ru, ZX-24su	USART0	Com1	1, D.1	2, D.0
	USART1	Com2	17, D.3	18, D.2
ZX-24xu	USARTD0	Com1	1, D.3	2, D.2
	USARTD1	Com2	13, D.7	14, D.6
	USARTC0	Com7	9, C.3	10, C.2
	USARTC1	Com8	5, C.7	6, C.6
	USARTE0	Com9	21, E.3	22, E.2
ZX-328nu	USART0	Com1	19, D.1	20, D.0
ZX-128e, ZX-128ne, ZX-1281e, ZX-1281ne	USART0	Com1 <sup>1</sup>	19, E.1	20, E.0
	USART1	Com2	9, D.3	10, D.2

<sup>1</sup>For these devices, the Com1 signals are logically inverted.

## SPI Interface

On some ZX devices, your program is stored in an external EEPROM that is read and written using the SPI interface. A dedicated I/O pin is required for selecting the EEPROM device during SPI operations and this I/O pin cannot be used for other purposes. However, the SPI bus itself can be used to communicate with other SPI devices. Although most SPI devices are tolerant of the ZX device using the SPI bus to fetch instructions from your program, a few are not. Generally speaking, if you can send and receive all of the data that an SPI device requires using a single call to `SPICmd()`, then that SPI device is usable with the ZX models that utilize an external EEPROM. The table below indicates which devices use an external EEPROM for user programs and, if so, the I/O pin used for the chip select.

**SPI EEPROM Usage and CS Pin By Controller Index**

ZX Model	Uses SPI EEPROM	Idx 0 CS Pin	Idx 1 CS Pin	Idx 2 CS Pin	Idx 3 CS Pin
ZX-24, ZX-24a, ZX-24p	Yes	B.4			
ZX-40, ZX-40a, ZX-40p	Yes	5, B.4			
ZX-44, ZX-44a, ZX-44p	Yes	44, B.4			
ZX-24x	No	D.4	8, C.4		
ZX-24n, ZX-24r, ZX-24s	No	B.4			
ZX-40n, ZX-40r, ZX-40s	No	5, B.4			
ZX-44n, ZX-44r, ZX-44s	No	44, B.4			
ZX-328n, ZX-328l	No	16, B.2			
ZX-32n, ZX-32l	No	14, B.2			

ZX-1281, ZX-1281n	No	10, B.0			
ZX-1280, ZX-1280n	No	19, B.0			
ZX-32a4	No	24, D.4	23, C.4		
ZX-128a1	No	29, D.4	19, C.4	39, E.4	49, F.4
ZX-24e, ZX-24ae, ZX-24pe, ZX-24pu	Yes	24, B.4			
ZX-24ne, ZX-24nu, ZX-24ru, ZX-24su	No	24, B.4			
ZX-128e, ZX-128ne, ZX-1281e, ZX-1281ne	No	28, B.0			
ZX-24xu	No	16, D.4	8, C.4		
ZX-328nu	No	13, B.2			

It is important to note that even for the devices that do not use the external SPI EEPROM, the SPI CS pin cannot be used as a general purpose input if the SPI bus is used in your application. This restriction is an artifact of the design of the CPU's SPI controller. The SPI CS pin can, however, be used as a general purpose output.

## Analog-to-Digital Converters

Most ZX devices support up to 8 analog inputs. These inputs may be fed to the internal analog-to-digital converter (ADC) or they may be used to perform analog level comparisons. The I/O port containing the analog inputs varies by ZX device as indicated in the table below. The System Library routines `GetADC()` and `ADCtoCom1()` use the ADC. The analog comparator is used by `WaitForInterrupt()` when configured to await an analog comparator event.

**Analog Input Ports by CPU Type**

Underlying CPU Type	Analog Port 1	Analog Port 2
mega32, mega644, mega644P, mega1284P	Port A	-
mega328P	Port C	-
mega128, mega1281	Port F	-
mega1280	Port F	Port K
xmega128A1, xmega32A4	Port A	Port B

## Interrupts

Some of the System Library routines disable interrupts in order to achieve the precise timing that is required. Having interrupts disabled for long periods of time can interfere with the operation of other parts of the system that use interrupts like task management, serial I/O and the real time clock. In most cases, the System Library routines have been implemented to keep track of real time clock interrupts that should have occurred during the time interrupts are disabled and then the RTC is updated at the end of the operation. This strategy avoids the problem of the RTC losing time.

Unfortunately, there is no way to similarly protect the serial I/O process. You can reduce the impact of having interrupts disabled with respect to serial output by ensuring that all serial output queues are empty before calling a System Library routine that disables interrupts. This is not as critical for a hardware-based serial channel (e.g. Com1) as it is for the software-based serial channels Com3 to Com6. There is no way, however, to work around the problem of serial input data arriving while interrupts are disabled. The hardware-based serial channels will store one received character and hold it while interrupts are disabled but if a second character arrives while interrupts are disabled it will be lost. Channels 3-6 rely on interrupts for every bit received so the situation is much more problematic. In this case, having interrupts disabled for longer than approximately one-third of the bit time will likely cause garbled input if a character's transmit time overlaps the period when interrupts are disabled. For characters being transmitted by channels 3-6, having interrupts disabled for more than about 10% of the bit time may cause the receiver to lose synchronization.

For reference purposes, the table below indicates which I/O routines disable interrupts for the duration of their execution. See the individual descriptions for more detailed information.

## System Library Routines that Disable Interrupts

CountTransitions	I2CputByte	RCTime
DACPin	PlaySound	ResetWire
FreqOut	PulseIn	ShiftIn
GetWire	PulseOut	ShiftInEx
GetWireByte	PutWire	ShiftOut
GetWireData	PutWireByte	ShiftOutEx
I2CCmd	PutWireData	
I2CgetByte	PutDAC	

The I2C routines do not disable interrupts when the hardware I2C controller is used (e.g. channel 0).

## Interrupt Service Routines

For the native code devices (e.g. ZX-24n), a few interrupt service routines (ISRs) are always included in your program (e.g. for Com1 and the RTC) while others are included only if certain System Library routines are used in your program. In some cases, the additional ISRs that are included when a specific System Library routine is used depends on how the routine is invoked and what the compiler can deduce regarding which ISRs might be needed. For example, if OpenCom() is invoked one or more times but the compiler can determine that the Com1 is always the channel being used, no additional ISRs are included since the Com1 ISRs are always included. On the other hand, if the compiler cannot determine which channel is being opened in one or more cases, it includes the ISRs for all Com channels, both hardware-based and software-based channels.

In the description of each System Library routine, information is given about the set of ISRs might be included in your program if you use that routine. This information is only important, of course, if you are also providing one or more ISRs in your code because conflicts may arise. (See the section entitled “Defining Interrupt Service Routines” in the ZBasic Language Reference Manual for more information on how this is done.) The table below gives an overview of which System Library routines may cause ISRs to be included automatically in your program. The shaded entries represent ISRs that are always included.

**System Library Routines that May Load ISRs**

Routine	mega644P	mega328P	mega128
ADCToCom1()	Timer1_CompA	Timer1_CompA	Timer1_CompA
Com1toDAC()	Timer1_CompA	Timer1_CompA	Timer1_CompA
InputCapture()	Timer1_Capt Timer1_Ovf	Timer1_Capt Timer1_Ovf	Timer1_Capt Timer1_Ovf Timer3_Capt Timer3_Ovf
OpenCom()	USART0_RX	USART0_RX	USART0_RX
	USART0_TX	USART0_TX	USART0_TX
	USART0_UDRE	USART0_UDRE	USART0_UDRE
	USART1_RX		USART1_RX
	USART1_TX		USART1_TX
	USART1_UDRE		USART1_UDRE
OpenX10()	Timer2_CompA	Timer2_CompA	Timer2_CompA
	INT0	INT0	n/a
	Timer0_CompB	Timer0_CompB	
OutputCapture()	Timer1_CompB	Timer1_CompB	Timer1_CompB
			Timer1_CompC
			Timer3_CompB

WaitForInterrupt()	INT0	INT0	INT0
	INT1	INT1	INT1
	INT2		INT2
			INT3
			INT4
			INT5
			INT6
			INT7
	PCINT0	PCINT0	
	PCINT1	PCINT1	
	PCINT2	PCINT2	
	PCINT3		
	Analog_Comp	Analog_Comp	Analog_Comp

### System Library Routines that May Load ISRs

Routine	mega1284P	mega1281	mega1280
ADCToCom1()	Timer3_CompA	Timer4_CompA	Timer4_CompA
Com1toDAC()	Timer3_CompA	Timer4_CompA	Timer4_CompA
InputCapture()	Timer1_Capt	Timer1_Capt	Timer1_Capt
	Timer1_Ovf	Timer1_Ovf	Timer1_Ovf
	Timer3_Capt	Timer3_Capt	Timer3_Capt
	Timer3_Ovf	Timer3_Ovf	Timer3_Ovf
			Timer4_Capt
			Timer4_Ovf
			Timer5_Capt
OpenCom()	USART0_RX	USART0_RX	USART0_RX
	USART0_TX	USART0_TX	USART0_TX
	USART0_UDRE	USART0_UDRE	USART0_UDRE
	USART1_RX	USART1_RX	USART1_RX
	USART1_TX	USART1_TX	USART1_TX
	USART1_UDRE	USART1_UDRE	USART1_UDRE
			USART2_RX
			USART2_TX
			USART2_UDRE
			USART3_RX
			USART3_TX
			USART3_UDRE
	Timer2_CompA	Timer0_CompA	Timer0_CompA
OpenX10()	INT0	INT0	INT0
	Timer0_CompB	Timer2_CompB	Timer2_CompB
OutputCapture()	Timer1_CompB	Timer1_CompB	Timer1_CompB
	Timer1_CompC	Timer1_CompC	Timer1_CompC
	Timer3_CompB	Timer3_CompB	Timer3_CompB
			Timer4_CompB
			Timer5_CompB
WaitForInterrupt()	INT0	INT0	INT0
	INT1	INT1	INT1
	INT2	INT2	INT2
	INT3	INT3	INT3
		INT4	INT4
		INT5	INT5
		INT6	INT6
		INT7	INT7
		PCINT0	PCINT0
		PCINT1	PCINT1
		PCINT2	PCINT2
	Analog_Comp	Analog_Comp	Analog_Comp

### System Library Routines that May Load ISRs

Routine	xmega32A4	xmega128A1
InputCapture( )	TCC0_CCA	TCC0_CCA
	TCC0_OVF	TCC0_OVF
	TCD0_CCA	TCD0_CCA
	TCD0_OVF	TCD0_OVF
	TCD1_CCA	TCD1_CCA
	TCD1_OVF	TCD1_OVF
	TCE0_CCA	TCE0_CCA
	TCE0_OVF	TCE0_OVF
		TCE1_CCA
		TCE1_OVF
		TCF0_CCA
		TCF0_OVF
		TCF1_CCA
		TCF1_OVF
OpenCom( )	USARTC0_RXC	USARTC0_RXC
	USARTC0_TXC	USARTC0_TXC
	USARTC0_DRE	USARTC0_DRE
	USARTC1_RXC	USARTC1_RXC
	USARTC1_TXC	USARTC1_TXC
	USARTC1_DRE	USARTC1_DRE
	USARTD0_RXC	USARTD0_RXC
	USARTD0_TXC	USARTD0_TXC
	USARTD0_DRE	USARTD0_DRE
	USARTD1_RXC	USARTD1_RXC
	USARTD1_TXC	USARTD1_TXC
	USARTD1_DRE	USARTD1_DRE
	USARTE0_RXC	USARTE0_RXC
	USARTE0_TXC	USARTE0_TXC
	USARTE0_DRE	USARTE0_DRE
		USARTE1_RXC
		USARTE1_TXC
		USARTE1_DRE
		USARTF0_RXC
		USARTF0_TXC
		USARTF0_DRE
		USARTF1_RXC
		USARTF1_TXC
		USARTF1_DRE
	TCD1_CCA	TCD1_CCA
OpenX10( )	ACA_AC0	ACA_AC0
	TCC1_CCB	TCC1_CCB
OutputCapture( )	TCC0_CCB	TCC0_CCB
	TCD0_CCB	TCD0_CCB
	TCD1_CCB	TCD1_CCB
	TCE0_CCB	TCE0_CCB
		TCE1_CCB
		TCF0_CCB
		TCF1_CCB
WaitForInterrupt( )	PORTA_INT0	PORTA_INT0
	PORTA_INT1	PORTA_INT1
	PORTB_INT0	PORTB_INT0
	PORTB_INT1	PORTB_INT1
	PORTC_INT0	PORTC_INT0
	PORTC_INT1	PORTC_INT1
	PORTD_INT0	PORTD_INT0
	PORTD_INT1	PORTD_INT1
	PORTE_INT0	PORTE_INT0

PORTE_INT1	PORTE_INT1 PORTF_INT0 PORTF_INT1 PORTH_INT0 PORTH_INT1 PORTJ_INT0 PORTJ_INT1 PORTK_INT0 PORTK_INT1 PORTQ_INT0 PORTQ_INT1
ACA_AC0	ACA_AC0
ACA_AC1	ACA_AC1
ACA_ACW	ACA_ACW
ACB_AC0	ACB_AC0
ACB_AC1	ACB_AC1
ACB_ACW	ACB_ACW

## Timers

ZX devices have three or more timers, depending on the underlying CPU type, that are used for various purposes. One of the timers is used to implement the real time clock (RTC), another is used for the software-based serial ports and a third timer is used to provide the precise timing required for certain I/O routines. The specific timer that is used for a particular function varies depending on the underlying CPU type as shown in the table below.

Timer Usage by CPU Type						
Underlying CPU	RTC	I/O	Serial	16-bit PWM	InputCapture	OutputCapture
mega32, mega328P, mega644, mega644P	Timer0	Timer1	Timer2	Timer1	Timer1	Timer1
mega1284P	Timer0	Timer3	Timer2	Timer1 Timer3	Timer1 Timer3	Timer1 Timer3
mega128	Timer0	Timer1	Timer2	Timer1 Timer3	Timer1 Timer3	Timer1 Timer3
mega1281	Timer2	Timer4	Timer0	Timer1 Timer3	Timer1 Timer3	Timer1 Timer3
mega1280	Timer2	Timer4	Timer0	Timer1 Timer3 Timer4 Timer5	Timer1 Timer3 Timer4 Timer5	Timer1 Timer3 Timer4 Timer5
xmega32A4	TimerC1	TimerE0	TimerD1	TimerC0 TimerD0 TimerD1 TimerE0	TimerC0 TimerD0 TimerD1 TimerE0	TimerC0 TimerD0 TimerD1 TimerE0
xmega128A1	TimerC1	TimerF1	TimerD1	TimerC0 TimerD0 TimerD1 TimerE0 TimerE1 TimerF0 TimerF1	TimerC0 TimerD0 TimerD1 TimerE0 TimerE1 TimerF0 TimerF1	TimerC0 TimerD0 TimerD1 TimerE0 TimerE1 TimerF0 TimerF1

The RTC Timer is programmed to generate an interrupt that is used to update the RTC and to trigger task switching. Because its role is so central, the RTC Timer cannot be used for any other purpose. The I/O Timer is used by several I/O related routines as explained in more detail below. The Serial Timer is used to generate interrupts to implement the timing required for serial channels Com3 to Com6. If none of the channels 3-6 is open, the Serial Port Timer can be used for other purposes in your program. Timers are

also used for some specialized I/O functions as indicated in the table above.

On ATmega-based devices, the Serial timer is also used for 8-bit PWM generation. Consequently, use of 8-bit PWM and use of Com3 to Com6 are mutually exclusive.

For each timer, there exists a built-in variable that indicates when the timer is in use. For example, `Register.Timer0Busy` and `Register.TimerC1Busy` are Boolean values that indicate when Timer0 (ATmega) and TimerC1 (ATxmega), respectively, are in use. Prior to using a timer, the system checks the value of this variable to see if it is already being used. If it is not in use, the system sets the flag to `True` and then proceeds to use the timer. When it is finished using the timer, the system sets the busy flag to `False`. Your program may do the same by passing the Register variable as a parameter to the `Semaphore()` function.

## I/O Timer Pre-scaler Values

Some of the System Library routines that use a timer allow you to modify the frequency used to clock the timer while others use a fixed frequency determined by the requirements of the routine. The routines that do allow frequency modification are divided into two groups, one controlled by the value of `Register.TimerSpeed1` and the other controlled by the value of `Register.TimerSpeed2`. The table below shows the System Library routines that use a timer and, where applicable, the timer speed variable that controls the timer frequency.

<b>System Library Routines Using TimerSpeed Values</b>	
<b>Routine</b>	<b>TimerSpeed Value</b>
<code>ADCToCom1()</code>	
<code>Com1toDAC()</code>	
<code>CountTransitions()</code>	<code>TimerSpeed1</code> <sup>1</sup>
<code>FreqOut()</code>	
<code>Get1Wire()</code>	
<code>Get1WireByte()</code>	
<code>Get1WireData()</code>	
<code>I2CCmd()</code> <sup>2</sup>	<code>TimerSpeed1</code>
<code>I2CGetByte()</code> <sup>2</sup>	<code>TimerSpeed1</code>
<code>I2CPutByte()</code> <sup>2</sup>	<code>TimerSpeed1</code>
<code>InputCapture()</code>	<code>TimerSpeed1</code>
<code>InputCaptureEx()</code>	<code>TimerSpeed1</code>
<code>OutputCapture()</code>	<code>TimerSpeed1</code>
<code>OutputCaptureEx()</code>	<code>TimerSpeed1</code>
<code>OpenPWM()</code>	
<code>RCTime()</code>	<code>TimerSpeed2</code> <sup>1</sup>
<code>PlaySound()</code>	
<code>PulseIn()</code>	<code>TimerSpeed2</code> <sup>1</sup>
<code>PulseOut()</code>	<code>TimerSpeed2</code> <sup>1</sup>
<code>Put1Wire()</code>	
<code>Put1WireByte()</code>	
<code>Put1WireData()</code>	
<code>PWM()</code>	
<code>Reset1Wire()</code>	
<code>ShiftIn()</code>	<code>TimerSpeed1</code>
<code>ShiftInEx()</code>	<code>TimerSpeed1</code>
<code>ShiftOut()</code>	<code>TimerSpeed1</code>
<code>ShiftOutEx()</code>	<code>TimerSpeed1</code>
<code>X10Cmd()</code>	

Notes:

- 1) The timer frequency is scaled. See below.

- 2) The timer is used only for channels 1-4.

The table below shows the correspondence between the allowable values for the TimerSpeed registers and the resulting clock frequency applied to the I/O Timer in terms of the CPU frequency. The divisor specified is applied to the CPU clock frequency to yield the I/O Timer clock frequency. For compatibility with BasicX (but only for ZX processors running at 14.7456MHz), some of the routines effectively divide the timer frequency by 2 so that the time units associated with parameters or return values is preserved. If you change the timer speed setting, the scale factor is still applied.

TimerSpeed Selector Values		
TimerSpeed Value	ATmega	ATxmega
0	Off	Off
1	F_CPU / 1	F_CPU / 1
2	F_CPU / 8	F_CPU / 2
3	F_CPU / 64	F_CPU / 4
4	F_CPU / 256	F_CPU / 8
5	F_CPU / 1024	F_CPU / 64
6	External T1	F_CPU / 256
7	External T2	F_CPU / 1024
8-15	n/a	Event 0-7

The default values of `Register.TimerSpeed1` and `Register.TimerSpeed2` are shown in the table below.

Default TimerSpeed Values		
CPU Family	TimerSpeed1	TimerSpeed2
ATmega	1	2
ATxmega	2	4

Note that setting the value of either of the timer speed registers other than by direct assignment using an assignment statement will produce undefined results. Also note that on the ZX-24 series devices, the T1 input signal is common with Port C, bit 7. If you wish to use an external clock source you'll have to configure pin 5 to be an input so as not to interfere with that signal. Of course, transitions on Port C bit 7 can be used to clock the timer when the T1 input signal is selected.

There are several important facts to keep in mind if you modify either of the timer speed values. Firstly, the timer speed values are initialized by the system when it begins running and they are never modified by the system thereafter. If you change a timer speed value, that value will be used by all of the related System Library routines until you change it again. Secondly, the applicable TimerSpeed value is used during the configuration and setup of each I/O function. If you change the TimerSpeed value after a particular I/O function is configured, the change will not affect I/O functions configured before that change.

Note, also, that values returned by some of the System Library routines are scaled based on the default timer speed values. If you change the timer speed setting, you'll have to apply an additional scale factor in order to get the correct results. For example, if you set `Register.TimerSpeed2` to 3 on an ATmega-based device running at 14.7MHz and then call the subroutine `PulseIn()`, a pulse having a width of 100µs will return the value of approximately 12.5µs since the clock speed that you specified is 1/8 that of the default. In order to get the correct pulse width, in seconds, you will have to multiply the value returned by 8. Those return values that are not scaled to seconds represent a number of periods of the timer frequency. So, for example, if you change `Register.TimerSpeed1` to 2 on an ATmega-based device running at 14.7MHz, the values returned by `InputCapture()` represent units of 542nS instead of the default 67.8nS.

The other Register value related to the I/O Timer is the "timer busy" flag, e.g. `Register.Timer1Busy`. Whenever a System Library routine that requires the I/O Timer prepares to execute, it first checks the value of this Boolean flag to see if the timer is already in use. If the flag is `True`, the routine will not execute; usually returning without doing anything (but see the descriptions of the various routines for

specific details). If the flag is `False`, the routine sets it to `True` and then goes about using the timer. When it has finished its function, it sets the flag back to `False`.

Your code can use the timer busy flag as the parameter to the `Semaphore()` function in order to get exclusive access to the timer. Of course, you must set timer busy flag to `False` when your code is finished with the timer to indicate that the timer is no longer in use. Likewise, you may want to acquire a semaphore on a timer busy flag for the I/O Timer before calling a System Library routine that uses I/O Timer. If you succeed in setting the semaphore you'll know that the timer is not already in use. An example of code for this purpose (for ZX devices that use `Timer1` for the I/O Timer) is shown below.

```
' wait until the timer is available
Do While (Not Semaphore(Register.Timer1Busy))
    Call Sleep(0.5)
Loop

' use the timer
Call LockTask()
Register.Timer1Busy = False
Call ShiftOut(12, 13, 8, &H55)
Call UnlockTask()
```

Note, particularly, the line immediately before the call to `ShiftOut()`. After the semaphore is acquired `Register.Timer1Busy` will be `True`. Unless it is set to `False`, the call to `ShiftOut()` will fail because that subroutine will think that the timer is in use.

**Caution:** setting the busy flag for a timer to `True` and never setting it back to `False` will prevent System Library routines that require that timer from functioning.

## Processor Speed Issues

Although the standard clock speed for ATmega-based ZX devices is generally 14.7456MHz, special versions are available that run slower and faster. ZX devices based on the ATxmega run at 29.4912MHz. The table below summarizes the differences that arise due to the difference in operating speeds.

Processor Speed Variations				
Issue	7.3728MHz	14.7456MHz	18.432MHz	29.4912MHz
RTC Tick Frequency	512 Hz	512 Hz	500 Hz	512 Hz
RTC Fast Tick Frequency	512 Hz	1024 Hz	1 KHz	1024 Hz
RTC Timer Frequency	115.2 KHz	230.4 KHz	72 KHz	230.4 KHz
Multi-tasking Time Slice	1.95 mS	1.95 mS	2.0 mS	1.95 mS
Default TimerSpeed1 Units	135.6 nS	67.8 nS	54.4 nS	67.8 nS
Default TimerSpeed2 Units	1.085 µS	1.085 µS*	434 nS	271 nS
CountTransitions() Sample Rate	204.8 KHz	409.6 KHz	512 KHz	737.3 KHz

Note, particularly, that the value for `TimerSpeed2` at 14.7456MHz is scaled to match the value corresponding to operating at 7.3728MHz. This is done for compatibility with BasicX devices that operate at the latter speed. Consult the preceding sections for information on which routines use the `TimerSpeed1` and `TimerSpeed2` values.

It is highly recommended to use the built-in values `Register.CPUFrequency`, `Register.RTCTickFrequency`, and `Register.RTCTimerFrequency` instead of using hard-coded values. Doing so also simplifies code that must run on multiple devices that operate at different speeds. See the descriptions in the ZBasic Language Reference Manual for more details.

## Detailed Descriptions

In the descriptions that follow, the parameter types that are accepted by each routine are described. Some parameters accept a specific fundamental data type while others may accept a few similar types. Others accept virtually any parameter type. In order to more succinctly describe the types of parameters accepted, some descriptive type categories are used. For example, the category *integral* is used to connote those types that have the integral characteristic, such as Byte, Integer, UnsignedInteger, Long and UnsignedLong. The table below indicates which types belong to which categories.

**Type Category Membership**

Type/Category	any type	integral	int8/16	int16	int32	any 32-bit	signed	numeric
Boolean	x							
Bit	x	x	x					x
Nibble	x	x	x					x
Byte	x	x	x					x
Integer	x	x	x	x			x	x
UnsignedInteger	x	x	x	x				x
Enum	x							
Long	x	x			x	x	x	x
UnsignedLong	x	x			x	x		x
Single	x					x	x	x
String	x							

The remainder of this document presents complete descriptions of each of the System Library routines, arranged in alphabetical order. Unless specifically noted otherwise, the descriptions apply to all ZX models. In some cases, a routine exhibits different behavior in BasicX compatibility mode or operates in a manner that is slightly different from that implemented in the BasicX environment. In these cases, the heading **Compatibility** will appear in the description detailing the differences. The advanced System Library routines that are not present in the BasicX environment are also similarly noted. If you are not using BasicX compatibility mode or are not upgrading BasicX code these notations may be safely ignored.



# Abs

**Type**            Function returning the same type as the parameter

**Invocation**    Abs(arg)

Parameter	Method	Type	Description
arg	ByVal	numeric	The value from which the absolute value will be computed.

## Discussion

The absolute value function returns the magnitude of the passed value. It is primarily useful for signed numeric types such as `Single`, `Integer` and `Long`. Unsigned parameter values will be returned unchanged.

The type of the return value will be the same as the type of the parameter provided.

## Example

```
Dim i as Integer, j as Integer

i = -45
j = Abs(i) ' result is 45
```

# Acos

**Type**            Function returning Single

**Invocation**    Acos(arg)

Parameter	Method	Type	Description
arg	ByVal	Single	The value from which the arc cosine will be computed.

## Discussion

The arc cosine function is the inverse of the cosine function. The return value will be the angle, expressed in radians, whose cosine corresponds to the passed value. The type of the return value will be `Single` and the value will range from 0.0 to  $\pi$ . If the argument is greater than 1.0 or less than  $-1.0$ , the result will be undefined.

## Example

```
Dim val as Single, theta as Single

val = 0.5
theta = Acos(val) 'the result will be approximately 1.0472.
```

**See Also**        Cos, DegToRad, RadToDeg

# ADCtoCom1

**Type** Subroutine

**Invocation** ADCtoCom1(pin, rate)

Parameter	Method	Type	Description
pin	ByVal	Byte	The pin number from which analog readings will be taken. Valid pins are those corresponding to PortA, pins 13 to 20.
rate	ByVal	int16	The rate at which conversions will be performed. The value is the number of conversions per second and may range from 28 to 11000 samples per second.

## Discussion

Calling this subroutine causes a continuous series of analog-to-digital conversions to be performed on the signal appearing at the specified pin. Each 8-bit digital result is automatically sent out the Com1 serial port. Before starting the conversions, the baud rate of Com1 is set to 115,200. The specified pin is automatically set to the proper state for A/D conversion so no additional setup is required prior to use. The conversion stream will continue until `ADCtoCom1()` is called again with the `pin` parameter set to zero (the `rate` parameter being meaningless in this case).

The analog input range is approximately 0.25 to 0.75 times  $V_{cc}$  (1.25 volts to 3.75 volts when running on 5 volts) and the resulting digital range is 0 to 255. Analog input levels below the low end of the range and above the high end of the range will produce the low and high digital values, respectively.

Note that the subroutine `Com1ToDAC()` is designed to receive the data stream generated by this Subroutine. For best accuracy, state changes on other pins of the port containing the analog input should be avoided during the conversion process.

## Resource Usage

This subroutine uses the processor's A/D converter, Com1 and the I/O Timer. No other use of these resources should be attempted while the conversion is active. For native code devices, the following ISRs are required.

### ISRs Required

Underlying CPU	ISR Name
mega328P, mega644P, mega128	Timer1_CompA
mega1284P	Timer3_CompA
mega1281	Timer4_CompA
mega1280	Timer4_CompA

## Compatibility

This subroutine is not available on ATxmega-based ZX devices.

**See Also** Com1toDAC

# Asc

**Type**                Function returning Byte

**Invocation**        Asc(str)  
                      Asc(str, index)

Parameter	Method	Type	Description
str	ByVal	String	The string from which a character will be returned.
index	ByVal	int8/16	The 1-based position in the string from which the character will be returned.

## Discussion

This function returns the ASCII character code of the character at the position of the string that is specified. If the second parameter is missing, position 1 is assumed. Note that if the index is less than 1 or larger than the number of characters in the string the return value will be zero.

## Example

```
Dim s as String
Dim b as Byte

s = "Howdy"
b = Asc(s)
```

After execution, the variable `b` will have the value of 72 (48 hex), the character code for H.

## Compatibility

BasicX does not support the presence of the second parameter.

**See Also**            Chr

# Asin

---

**Type**            Function returning Single

**Invocation**    Asin(arg)

Parameter	Method	Type	Description
arg	ByVal	Single	The value from which the arc sine will be computed.

## Discussion

The arc sine function is the inverse of the sine function. The return value will be the angle, expressed in radians, whose sine corresponds to the passed value. The type of the return value will be `Single` and the value will range from  $-\pi/2$  to  $\pi/2$ . If the argument is greater than 1.0 or less than  $-1.0$ , the result will be undefined.

## Example

```
Dim val as Single, theta as Single

val = 0.5
theta = Asin(val)                    ' result is approximately 0.5236
```

**See Also**        Sin, DegToRad, RadToDeg

# Atn

**Type**            Function returning Single

**Invocation**    Atn(arg)

Parameter	Method	Type	Description
arg	ByVal	Single	The value from which the arc tangent will be computed.

## Discussion

The arc tangent function is the inverse of the tangent function. The return value will be the angle, expressed in radians, whose tangent corresponds to the passed value. The return value will be of type `Single` and the value will range from  $-\pi/2$  to  $\pi/2$ .

## Example

```
Dim val as Single, theta as Single

val = 0.5
theta = Atn(val) ' result is approximately 0.4636
```

**See Also**            Atn2, DegToRad, RadToDeg

# Atn2

**Type**            Function returning Single

**Invocation**    Atn2(y, x)

Parameter	Method	Type	Description
y	ByVal	Single	y coordinate.
x	ByVal	Single	x coordinate.

## Discussion

This function computes the principal value of the arc tangent of  $y/x$ , using the signs of both arguments to determine the quadrant of the return value. The return value will be the angle, expressed in radians, from the positive x-axis to the line connecting the origin and the given point. The type of the return value will be `Single` and the value will range from - to . If x is zero, the result is undefined unless y is also zero in which case 0.0 will be returned.

## Example

```
Dim x as Single, y as Single, theta as Single

x = 1.0
y = -1.0
theta = Atn2(y, x)            ' result is -0.7854
```

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also**        Atn, DegToRad, RadToDeg

# BitCopy

**Type** Subroutine

**Invocation** BitCopy(destAddr, destBitOfst, srcAddr, srcBitOfst, bitCount)

Parameter	Method	Type	Description
dstAddr	ByVal	integral	The address to which to begin copying.
dstBitOfst	ByVal	integral	The bit offset to which to begin copying.
srcAddr	ByVal	integral	The address from which to begin copying.
srcBitOfst	ByVal	integral	The bit offset from which to begin copying.
bitCount	ByVal	integral	The number of bits to copy.

## Discussion

This subroutine can be used to copy an arbitrary number of bits from one location in RAM to another. The copy operation may begin and/or end in the middle of a byte if desired. An overlapping copy (when the destination is in the midst of the data being copied) is handled correctly so that the data to be copied is not overwritten.

For the purposes of this subroutine, RAM considered a sequence of bits with the least significant bits of each byte preceding the more significant bits. This is the same model of RAM that is utilized by `GetBit()` and `PutBit()`. The least significant bit of a byte is at offset zero and the most significant bit is at offset 7.

Note that the bit offsets specified for the second and fourth parameters may have values greater than 7. If a bit offset greater than 7 is given, the corresponding address component is adjusted internally to give the same effect. For example, if an address of 200 and a bit offset of 19 are specified, these are converted internally to 202 and 3, respectively.

All six parameters are converted internally to `UnsignedInteger`.

## Caution

This subroutine should be used with care because it is possible to overwrite important data on the stack or other areas of memory which may cause your program to malfunction.

## Compatibility

This subroutine is not available on ZX models that are based on the ATmega32 processor (e.g. the ZX-24). Moreover, it is not available in BasicX compatibility mode.

**See Also** MemCopy, MemSet

# BlockMove

---

**Type** Subroutine

**Invocation** BlockMove(count, source, destination)

Parameter	Method	Type	Description
count	ByVal	integral	The number of bytes to copy.
source	ByVal	integral	The address from which to begin copying.
destination	ByVal	integral	The address to which to begin copying.

## Discussion

This subroutine is provided for compatibility with BasicX. The more aptly named `MemCopy( )` should be used by new applications. An overlapping copy (when the destination is in the midst of the data being copied) is handled correctly so that the data to be copied is not overwritten.

## Compatibility

With VM firmware versions prior to v1.1.0 an overlapping copy is not handled correctly nor is it handled correctly in BasicX. A BasicX application that relies on the incorrect handling will, therefore, not work as expected when run on ZX processors.

**See Also** BitCopy, MemCopy

# BusRead

**Type** Subroutine

**Invocation** BusRead(addr, data, count)  
BusRead(addr, data, count, delta)

Parameter	Method	Type	Description
addr	ByVal	integral	The bus address at which to begin reading.
data	ByRef	anyType	A buffer to receive the data read.
count	ByVal	integral	The number of bytes to read.
delta	ByVal	integral	The amount by which the address should be changed after each byte is read.

## Discussion

For ZX models that support external RAM (e.g. ZX-1281), if the external RAM interface is enabled and a bus has not been defined using DefineBus(), then the external RAM interface is used for the read operation. In this case, the full 16 bits of the specified address are used and the delta parameter is interpreted as a signed 8-bit value that is sign-extended before adding it to the address with each iteration.

For ZX models that do not support external RAM or if the external RAM interface is not enabled, this routine performs a series of read operations on the bus previously defined with the DefineBus() call. This is called the “bit bang” mode. For each read cycle, the low 8-bits of the address is output on the previously specified port and then the ALE pin is strobed (high, then back low). Next, the port is made an input and the RD pin is set low, data is read via the PIN register corresponding to the port, and the RD pin is set back high again. The data value read is stored in the buffer, the specified delta is added to the 8-bit bus address and the cycle is repeated until the specified number of bytes has been read.

It is important to remember that in the bit bang mode only 8 bits of the address are used. Depending on the values of the addr, count and delta parameters, the effective address may wrap around to zero. For example, with delta=1 specifying a count parameter larger than (256 - LoByte(addr)) will result in the effective address wrapping around to zero.

In either mode, if the optional delta parameter is not specified, the value of 1 is assumed. Specifying the delta as zero will result in multiple reads from the same address. A delta of -1 or &Hff will result in the address being decremented after each read.

## Example

```
Dim data(1 to 20) as Byte
Call DefineBus(Port.A, C.0, C.1, C.2)
Call BusRead(0, data, SizeOf(data))
```

## Compatibility

This subroutine is not available on ZX models that are based on the ATmega32 processor (e.g. the ZX-24) nor is it available on ATmega-based ZX devices. Moreover, it is not available in BasicX compatibility mode.

**See Also** BusWrite, DefineBus

# BusWrite

**Type** Subroutine

**Invocation** BusWrite(addr, data, count)  
BusWrite(addr, data, count, delta)

Parameter	Method	Type	Description
addr	ByVal	integral	The bus address at which to begin writing.
data	ByRef	anyType	The data to be written.
count	ByVal	integral	The number of bytes to write.
delta	ByVal	integral	The amount by which the address should be changed after each byte is written.

## Discussion

For ZX models that support external RAM (e.g. ZX-1281), if the external RAM interface is enabled and bus has not been defined using DefineBus(), then the external RAM interface is used for the write operation. In this case, the full 16 bits of the specified address are used and the delta parameter is interpreted as a signed 8-bit value that is sign-extended before adding it to the address with each iteration.

For ZX models that do not support external RAM or if the external RAM interface is not enabled, this routine performs a series of write operations on the bus previously defined with the DefineBus() call. This is called the “bit bang” mode. For each write cycle, the low 8-bits of the address is output on the previously specified port and then the ALE pin is strobed (high, then back low). Then, the next data value to be written is output on the port and the WR pin is strobed (low then back high). Finally, the specified delta is added to the bus address and the cycle is repeated until the specified number of bytes has been written.

It is important to remember that in the bit bang mode only 8 bits of the address are used. Depending on the values of the addr, count and delta parameters, the effective address may wrap around to zero. For example, with delta=1 specifying a count parameter larger than (256 - LoByte(addr)) will result in the effective address wrapping around to zero.

In either mode, if the optional delta parameter is not specified, the value of 1 is assumed. Specifying the delta as zero will result in multiple writes to the same address. A delta of -1 or &Hff will result in the address being decremented after each write.

## Example

```
Dim data(1 to 20) as Byte
Call DefineBus(Port.A, C.0, C.1, C.2)
Call BusWrite(0, data, SizeOf(data))
```

## Compatibility

This subroutine is not available on ZX models that are based on the ATmega32 processor (e.g. the ZX-24) nor is it available on ATmega-based ZX devices. Moreover, it is not available in BasicX compatibility mode.

**See Also** BusRead, DefineBus

# CallTask

**Type** Special Purpose

**Invocation** CallTask taskName, taskStack  
CallTask taskName, taskStack, taskStackSize  
CallTask taskName( parameterList ), taskStack  
CallTask taskName( parameterList ), taskStack, taskStackSize

Parameter	Method	Type	Description
taskName	ByVal	identifier	The name of the task to invoke.
parameterList	varies	varies	Zero or more parameters to be passed to the task, separated by commas.
taskStack	ByRef	array of Byte	The stack for the task (see discussion)
taskStackSize	ByVal	integral	The size of the stack.

## Discussion

This construct is used to prepare a task for running; the task doesn't actually execute until its turn comes up in the normal task rotation. In the first and second cases, the `taskName` given must be the name of a user-defined subroutine that takes no parameters. In the third and fourth cases, the `taskName` given must be a user-defined subroutine that takes a number of parameters whose type and number match that of the supplied parameter list. The subroutine may be public or private but if it is private it must exist in the same module as the `CallTask` invocation that refers to it.

The `taskStack` may be a `Byte` array, typically defined at the module level, that contains a sufficient amount of space for the task's stack needs. The array can be public or private but if it is private it must exist in the same module as the `CallTask` invocation that refers to it. Alternately, the stack for a task may be specified by giving its address as an integral expression. In this case, it is usually also advisable to specify the size of the stack since the compiler cannot deduce the size. A task must have exclusive use of the memory dedicated to its task stack. A particular task stack may be used by more than one task but one task must terminate before the next task can re-use the task stack.

If a task is passed parameters when it is invoked, it is advisable that those parameters be passed `ByVal` because the lifetime of the task may exceed the lifetime of the routine from which the task was invoked. If parameters are passed `ByRef` (explicitly or implicitly), the compiler will issue a warning. Also, certain types of expressions (notably, those involving user-defined functions that return `String` types) may not be used as parameter values for task invocation because they require the creation of temporary variable space on the stack during evaluation. The compiler will issue an error message when it detects such situations. This problem can be rectified by manually creating a variable (preferably at the module level) to hold the parameter value.

For native mode devices (e.g. ZX-24n), the task stack size must either be explicitly specified or it must be determinable by the compiler from the size of the task stack array. The compiler will issue an error message if it cannot determine the size of the task stack.

Please read the section on multi-tasking in the ZBasic Reference Manual for more details, including information about how to determine the proper task stack size.

## Example 1

```
Dim taskStack(1 to 50) as Byte

Sub Main()
    CallTask MyTask, taskStack
    Do
        Debug.Print "Hello from Main"
        Call Delay(1.0)
    
```

```

        Loop
End Sub

Sub MyTask()
    Do
        Debug.Print "Hello from MyTask"
        Call Delay(2.0)
    Loop
End Sub

```

## Example 2

```

Dim taskStack(1 to 50) as Byte

Sub Main()
    CallTask MyTask(2.0), taskStack
    Do
        Debug.Print "Hello from Main"
        Call Delay(1.0)
    Loop
End Sub

Sub MyTask(ByVal taskDelay as Single)
    Do
        Debug.Print "Hello from MyTask"
        Call Delay(taskDelay)
    Loop
End Sub

```

## Example 3

```

Dim taskStack(1 to 50) as Byte

Sub Main()
    Dim stkAddr as UnsignedInteger
    Dim stkSize as Integer

    stkAddr = taskStack.DataAddress
    stkSize = SizeOf(taskStack)
    CallTask MyTask(2.0), stkAddr, stkSize
    Do
        Debug.Print "Hello from Main"
        Call Delay(1.0)
    Loop
End Sub

Sub MyTask(ByVal taskDelay as Single)
    Do
        Debug.Print "Hello from MyTask"
        Call Delay(taskDelay)
    Loop
End Sub

```

## Compatibility

In BasicX compatibility mode, the task name must be enclosed in quotes (i.e. so that it appears to be a string). Also, task parameters, specifying the task stack by address, and specifying the task stack size are not supported in BasicX compatibility mode.

# CBit

**Type**            Function returning Bit

**Invocation**    CBit(arg)

Parameter	Method	Type	Description
arg	ByVal	integral, String or Boolean	The value to convert to a Bit value.

## Discussion

This function converts a numeric, String or Boolean value to a Bit value as described in the table below.

Input Type	Result
integral, Boolean	The value is the least significant bit of the supplied value.
String	The result is the least significant bit of the numeric value of the characters in the string, ignoring leading space and tab characters. The value string may begin with a plus or minus sign and an optional radix indicator (&H for hexadecimal, &O for octal, &B or &X for binary, all case insensitive). The conversion is terminated upon reaching the end of the string or encountering the first character that is not valid for the indicated radix.

## Example

```
Dim pinVal as Bit  
  
pinVal = CBit(GetPin(12))
```

## Compatibility

This function is not available in BasicX compatibility mode.

# CBool

**Type**            Function returning Boolean

**Invocation**    CBool(arg)

Parameter	Method	Type	Description
arg	ByVal	Byte	The value to convert to a Boolean value.

## Discussion

This function converts a Byte value to a Boolean value. If the byte has the value 0 the result will be False, otherwise it will be True.

## Example

```
Dim pinHi as Boolean

pinHi = CBool(GetPin(12))
```

# CByte

**Type** Function returning Byte

**Invocation** CByte(arg)

Parameter	Method	Type	Description
arg	ByVal	numeric, String, Boolean or Enum	The value to convert to Byte.

## Discussion

This function converts any numeric or enumeration value to a Byte value. See the table below for details of the conversion.

Input Type	Result
Boolean	Returns the byte value of the Boolean data item: 0 or 255.
Byte	No effect, the value is as supplied.
Integer	Returns the low byte of the value provided. However, if the supplied value is negative or greater than 255, the returned value will be 255.
UnsignedInteger	Returns the low byte of the value provided. However, if the supplied value is greater than 255, the returned value will be 255.
Enum	Returns the low byte of the value provided. However, if the supplied value is greater than 255, the returned value will be 255.
Long	Returns the low byte of the value provided. However, if the supplied value is negative or greater than 255, the returned value will be 255.
UnsignedLong	Returns the low byte of the value provided. However, if the supplied value is greater than 255, the returned value will be 255.
Single	The supplied value is converted to a Long value (signed 32-bit integer), rounded to the nearest integer. If the fractional part is exactly 0.5, the resulting integer will be even. This is known as "statistical rounding". If the resulting integer value is negative or larger than 255, the result will be 255. Otherwise, the result will be the integral value.
String	The result is the numeric value of the characters in the string, ignoring leading space and tab characters. The value string may begin with a plus or minus sign and an optional radix indicator (&H for hexadecimal, &O for octal, &B or &X for binary, all case insensitive). The conversion is terminated upon reaching the end of the string or encountering the first character that is not valid for the indicated radix.

## Compatibility

In BasicX, calling CByte() with an UnsignedInteger argument returns the low byte of the value. This behavior is inconsistent with the other type conversions. This implementation attempts to make them consistent.

# CByteArray

---

**Type**                Function returning a reference to a Byte array

**Invocation**        CByteArray(addr)

Parameter	Method	Type	Description
addr	ByVal	int16	The address to be converted to a reference to a Byte array.

## Discussion

This special function is useful when you have an integral value that you know to be the address of a Byte array and you want to pass it to a subroutine or function that requires a Byte array parameter. The example below shows it being used to determine the number of bytes of data available in the system input queue.

## Example

```
Dim cnt as Integer
cnt = GetQueueCount(CByteArray(Register.RxQueue))
```

**See Also**            StatusTask

# Ceiling

---

**Type**            Function returning Single

**Invocation**    Ceiling(arg)

Parameter	Method	Type	Description
arg	ByVal	Single	The value of which to compute the ceiling.

## Discussion

This function returns a Single value that is the smallest integer that is greater than or equal to the supplied value, effectively rounding up to the nearest integer.

## Example

```
Dim ceil as Single

ceil = Ceiling(1.5)      ' result is 2.0
ceil = Ceiling(-1.5)    ' result is -1.0
```

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also**        Floor, Fraction

# Chr

---

**Type**            Function returning String

**Invocation**    Chr(arg)

Parameter	Method	Type	Description
arg	ByVal	integral	The character code to place in the string.

## Discussion

This function returns a string containing a single character having the value of the supplied parameter. If the parameter is a multi-byte type such as Integer or Long the least significant byte of the value is used and the remaining bytes are ignored.

Tables of ASCII character values may be found in many places on the Internet. A search for “ASCII table” or “ASCII chart” will produce many results.

## Example

```
Dim s as String  
s = Chr(33)
```

After execution, *s* will be " !" because 33 is the decimal code for the exclamation mark.

**See Also**        Asc

# CInt

**Type**            Function returning Integer

**Invocation**    CInt(arg)

Parameter	Method	Type	Description
arg	ByVal	numeric, Boolean, String or Enum	The value to convert to Integer.

## Discussion

This function converts any numeric or enumeration value to an Integer value. See the table below for details of the conversion.

Input Type	Result
Byte, Boolean	High byte zero, low byte as supplied.
Integer	No effect, the value is as supplied.
UnsignedInteger	Value bits are the same as supplied, although interpreted as a signed value.
Enum	The resulting value is the Enum member value.
Long	The resulting value will be the low word of the supplied value.
UnsignedLong	The resulting value will be the low word of the supplied value.
Single	The supplied value is converted to signed 32-bit integer, rounded to the nearest integer. If the fractional part is exactly 0.5, the resulting integer will be even. This is known as "statistical rounding". If the resulting integer is larger than will fit in 16-bits, the result is undefined.
String	The result is the numeric value of the characters in the string, ignoring leading space and tab characters. The value string may begin with a plus or minus sign and an optional radix indicator (&H for hexadecimal, &O for octal, &B or &X for binary, all case insensitive). The conversion is terminated upon reaching the end of the string or encountering the first character that is not valid for the indicated radix.

## Example

```
Dim i as Integer

i = CInt(2.5)      ' result is 2
i = CInt(1.5)      ' result is 2
```

# ClearQueue

**Type** Subroutine

**Invocation** ClearQueue(queue)

Parameter	Method	Type	Description
queue	ByRef	array of Byte	The queue to be cleared.

## Discussion

This routine modifies the tracking information contained in the queue data structure to indicate that the queue is empty. If the queue is already empty, this has no effect. If there are characters in the queue, they will be discarded.

Note that before any queue operations are performed, the queue data structure must be initialized. See the discussion of `OpenQueue( )` for more details.

## Example

```
Dim inQueue(1 to 40) as Byte

Call OpenQueue(inQueue, SizeOf(inQueue))
Call PutQueueStr(inQueue, "Hello")
Call ClearQueue(inQueue)
```

After the call to `ClearQueue()` the queue will no longer contain the characters that were added.

## Compatibility

BasicX allows any type for the first parameter. The ZBasic implementation requires that it be an array of `Byte`.

# CLng

**Type**                Function returning Long

**Invocation**        CLng(arg)

Parameter	Method	Type	Description
arg	ByVal	numeric, Boolean, String or Enum	The value to convert to Long.

## Discussion

This function converts any numeric or enumeration value to a Long value. See the table below for details of the conversion.

Input Type	Result
Byte, Boolean	High 3 bytes zero, low byte as supplied.
Integer	High word will be all ones if the supplied value is negative, zero otherwise. Low word as supplied.
UnsignedInteger	High word zero, low word as supplied.
Enum	The resulting value is the Enum member value.
Long	No effect, the value is as supplied.
UnsignedLong	Value bits are the same as supplied, although interpreted as a signed value.
Single	The supplied value is converted to a signed 32-bit integer, rounded to the nearest integer. If the fractional part is exactly 0.5, the resulting integer will be even. This is known as “statistical rounding”. If the magnitude of the supplied value is too large to be represented in 32 bits, the result is undefined.
String	The result is the numeric value of the characters in the string, ignoring leading space and tab characters. The value string may begin with a plus or minus sign and an optional radix indicator (&H for hexadecimal, &O for octal, &B or &X for binary, all case insensitive). The conversion is terminated upon reaching the end of the string or encountering the first character that is not valid for the indicated radix.

## Example

```
Dim l as Long
```

```
l = CLng(2.5)            ' result is 2  
l = CLng(1.5)           ' result is 2
```

# CloseCom

**Type** Subroutine

**Invocation** CloseCom(channel, inQueue, outQueue)

Parameter	Method	Type	Description
channel	ByVal	Byte	The serial channel to close.
inQueue	ByRef	array of Byte	The input queue associated with the channel.
outQueue	ByRef	array of Byte	The output queue associated with the channel.

## Discussion

This routine shuts down the specified serial channel. All communication is terminated even if there are still characters in the output queue that have not yet been sent. This call does not clear the queues. If that is a requirement, calls to `ClearQueue()` will need to be made. Alternately, you may want to use the value returned by `StatusCom()` to wait for all queued characters to be transmitted before invoking `CloseCom()`.

Invoking this subroutine for Com1 (`channel = 1`) does not actually close the Com1 channel. Rather, doing so causes Com1 to revert to the default speed (19.2K baud) and to using the default I/O queues.

If the specified serial channel is not open or if an invalid channel number is given the call has no effect. If the channel being closed is the only one of the software-based channels (Com3-Com6) that is open, the Serial Timer will be turned off and the corresponding timer busy flag will be set to False indicating that the Serial Timer is available for other uses.

**See Also** ClearQueue, DefineCom, OpenCom, StatusCom

# CloseDAC

---

**Type** Subroutine

**Invocation** CloseDAC(channel)  
CloseDAC(channel, status)

Parameter	Method	Type	Description
channel	ByVal	Byte	The DAC channel to close.
status	ByRef	Boolean	A variable to receive the status code.

## Discussion

This subroutine terminates the DAC operation on the specified channel. The `status` parameter, if supplied, receives a value to indicate success or failure of the call. If the second channel of the DAC channel pair is also open, it will continue to operate unaffected.

## Example

```
Call CloseDAC(1) ' terminate DAC on channel 1
```

## Compatibility

This subroutine is not available in BasicX compatibility mode nor is it available on ATmega-based ZX devices.

**See Also** DAC, OpenDAC

# Closel2C

**Type** Subroutine

**Invocation** Closel2C(channel)

Parameter	Method	Type	Description
channel	ByVal	Byte	The I2C channel number (0-4).

## Discussion

This subroutine closes an I2C channel. For the hardware I2C channel, it disables the on-board I2C controller allowing the hardware I2C pins to be used for other purposes. For software I2C channels it has no effect.

## Compatibility

This subroutine is not available in BasicX compatibility mode.

**See Also** OpenI2C

# ClosePWM

---

**Type** Subroutine

**Invocation** ClosePWM(channel)  
ClosePWM(channel, status)

Parameter	Method	Type	Description
channel	ByVal	Byte	The PWM channel to close.
status	ByRef	Boolean	A variable to receive the status code.

## Discussion

This subroutine terminates the PWM signal generation on the specified channel and all other PWM channels associated with the same 16-bit timer. The resulting state of the output pins for the affected channels is indeterminate. If your application requires a specific output state, it is recommended that you call `PutPin()` to set the desired state prior to calling `ClosePWM()`.

A side effect of a successful `ClosePWM()` call is that the timer busy flag for the associated timer (e.g. `Register.Timer1Busy`) will be set to `False` indicating that the timer may be used for other purposes.

## Example

```
Call ClosePWM(1) ' terminate PWM on channel 1 and 2
```

## Compatibility

This subroutine is not available in BasicX compatibility mode.

**See Also** OpenPWM, PWM

# ClosePWM8

**Type** Subroutine

**Invocation** ClosePWM8(channel)  
ClosePWM8(channel, status)

Parameter	Method	Type	Description
channel	ByVal	Byte	The 8-bit PWM channel to close.
status	ByRef	Boolean	A variable to receive the status code.

## Discussion

This subroutine terminates the PWM signal generation on the specified 8-bit channel and all other PWM channels associated with the same 8-bit timer. The resulting state of the output pins for the affected channels is indeterminate. If your application requires a specific output state, it is recommended that you call `PutPin()` to set the desired state prior to calling `ClosePWM8()`.

The `status` parameter, if supplied, receives a value to indicate success or failure of the call.

A side effect of a successful `ClosePWM8()` call is that the timer busy flag for the associated timer (e.g. `Register.Timer2Busy`) will be set to `False` indicating that the timer may be used for other purposes.

## Example

```
Call ClosePWM8(1) ' terminate PWM on channel 1 (and channel 2)
```

## Compatibility

This subroutine is not available in BasicX compatibility mode nor is it available on ATxmega-based ZX devices.

**See Also** OpenPWM8, PWM8

# CloseSPI

---

**Type** Subroutine

**Invocation** CloseSPI(channel)

Parameter	Method	Type	Description
channel	ByVal	Byte	The SPI channel number (1-4).

## Discussion

This subroutine closes an SPI channel. The primary purpose for this subroutine is to cancel SPI Slave mode. It has no effect for channels that are not open or channels that are open in Master mode.

## Compatibility

This subroutine is not available in BasicX compatibility mode.

**See Also** OpenSPI, SPICmd

# CloseWatchDog

---

**Type**            Subroutine

**Invocation**    CloseWatchDog()

## Discussion

This subroutine disables the watchdog timer.

## Compatibility

This subroutine is not available in BasicX compatibility mode.

**See Also**        OpenWatchDog, WatchDog

# CloseX10

**Type** Subroutine

**Invocation** CloseX10(channel, inQueue, outQueue)

Parameter	Method	Type	Description
channel	ByVal	Byte	The X-10 channel to close.
inQueue	ByRef	array of Byte	The input queue associated with the channel.
outQueue	ByRef	array of Byte	The output queue associated with the channel.

## Discussion

This routine shuts down the specified X-10 communication channel. All communication is terminated even if there are still data in the output queue that have not yet been sent. This call does not clear the queues. If that is a requirement, calls to `ClearQueue()` will need to be made.

If the specified X-10 channel is not open or if an invalid channel number is given the call has no effect. The `inQueue` and `outQueue` parameters are currently not used but are present for congruency with `CloseCom()`. Zero values may be used for either or both parameters.

## Resource Usage

The X-10 communication requires the use of a zero-crossing signal input to the ZX. See the description of `OpenX10()` for more information.

## Compatibility

This subroutine is not available on ZX models that are based on the ATmega32 processor (e.g. the ZX-24). Moreover, it is not available in BasicX compatibility mode.

**See Also** DefineX10, OpenX10, StatusX10

# CNibble

**Type**            Function returning Nibble

**Invocation**    CNibble(arg)

Parameter	Method	Type	Description
arg	ByVal	integral, String or Boolean	The value to convert to a Nibble value.

## Discussion

This function converts a numeric, String or Boolean value to a Nibble value as described in the table below.

Input Type	Result
integral, Boolean	The value is the four least significant bits of the supplied value.
String	The result is the four least significant bits of the numeric value of the characters in the string, ignoring leading space and tab characters. The value string may begin with a plus or minus sign and an optional radix indicator (&H for hexadecimal, &O for octal, &B or &X for binary, all case insensitive). The conversion is terminated upon reaching the end of the string or encountering the first character that is not valid for the indicated radix.

## Example

```
Dim nVal as Nibble  
  
nVal = CNibble(Register.PortC)
```

## Compatibility

This function is not available in BasicX compatibility mode.

# Com1toDAC

**Type** Subroutine

**Invocation** Com1toDAC(pin)

Parameter	Method	Type	Description
pin	ByVal	Byte	The pin number on which the analog voltage will be re-created.

## Discussion

Calling this subroutine prepares Com1 to receive a continuous stream of 8-bit values from an external source. The baud rate is automatically set 115,200. When each value is received, the value is output as an analog voltage on the specified pin. The resulting analog voltage will range from near 0 volts corresponding to the received value of 0 to near the processor voltage (usually +5 volts) corresponding to the received value of 255. The method used to create the analog voltage is similar to that used for PutDAC() and the signal will require some filtering. See the description of PutDAC() for more details. The output pin is updated at a fixed rate of 11,000 times per second.

This routine returns immediately after setting up the conversion process. The conversion process will be terminated if Com1toDAC() is called again with a parameter of zero. Also, if data is not received for approximately 200 cycles, the conversion process will be automatically terminated.

Note that the subroutine ADCtoCom1() is designed to produce the data stream to be received by this subroutine.

## Resource Usage

This subroutine uses Com1 and the I/O Timer. No other use of these resources should be attempted while the reception is active. For native code devices, the following ISRs are automatically loaded.

ISRs Required	
Underlying CPU	ISR Name
mega328P, mega644P, mega128	Timer1_CompA
mega1284P	Timer3_CompA
mega1281	Timer4_CompA
mega1280	Timer4_CompA

## Compatibility

This subroutine is not available on ATxmega-based ZX devices.

**See Also** ADCtoCom1

# ComChannels

**Type** Subroutine

**Invocation** ComChannels(count, maxSpeed)

Parameter	Method	Type	Description
count	ByVal	Byte	The total desired number of software-derived serial channels.
maxSpeed	ByVal	int8/16	The desired maximum baud rate to be supported.

## Discussion

In addition to the serial channel implemented in hardware on the processor (Com1), the system can support up to four additional serial communication channels that are implemented in the system software. The software-based serial channels are numbered Com3 through Com6. However, by default, only one additional channel, Com3, is supported. If you want to use serial channels 4 through 6 you must call this subroutine first to specify the maximum number (up to 4) that you want to have available. This subroutine must be called only when there are no open software-based serial channels (COM3 through COM6). If it is called when one or more channels are already open, it will have no effect.

After ComChannels() has been invoked, the serial channels that will be available depends on the value specified by the `count` parameter. If the value 2 is specified, for example, channels Com3 and Com4 will be available. If the maximum value of 4 is specified, then serial channels 3, 4, 5 and 6 will be available. Once the number of software-based serial channels has been established you may then use DefineCom(), OpenCom(), and CloseCom() to manage the available channels by specifying the appropriate channel number in those calls.

In addition to specifying the total number of software-based serial channels that you want, you must also specify the maximum baud rate that you wish to utilize. The supported rates are 300, 600, 1200, 2400, 4800, 9600 and 19,200 baud but see below for additional discussion about the maximum baud.

Because the COM3 to COM6 serial channels are implemented in software, when one or more of the channels is open there will be a certain amount of processing overhead that will reduce the speed at which program instructions will be executed. Moreover, the processing overhead is higher when supporting higher baud rates as compared to lower baud rates and the overhead is higher when supporting a larger number of channels. It is prudent, therefore, to choose the lowest baud rate and lowest number of channels that is practical for your circumstances.

Also note that when supporting two or more channels, there is a small possibility that incoming characters might not be properly recognized at the highest rate. The probability of not being able to properly synchronize on the incoming character's start bit increases with each additional channel that is supported. For this reason, it is recommended that the maximum baud rate be limited to 9600 when configured for 2 or more channels.

For devices operating at 7.37MHz, the number of software-implemented serial channels should be limited to two and the maximum speed should be limited to 9600 baud.

## Resource Usage

The software-implemented serial channels utilize the Serial Timer for the bit rate timing. No other use of the Serial Timer should be attempted when serial channels 3-6 are open. The "Busy" flag for the timer used to implement the software serial channels will be set to True when one or more of the software-implemented serial channels is open.

### Example

```
Dim iq4(1 to 20) as Byte
Dim oq4(1 to 20) as Byte

Call ComChannels(4, 4800)
Call DefineCom(6, 12, 13, &H80)
Call OpenCom(6, 4800, iq4, oq4)
```

### Compatibility

This routine is not available in BasicX compatibility mode.

**See Also**      DefineCom, CloseCom, OpenCom, StatusCom

# Console.Read

---

**Type**                Function returning Byte

**Invocation**        Console.Read()

## Discussion

This function can be invoked to retrieve a character from the input queue associated with Com1 (by default, but see Option Console in the ZBasic Language Reference Manual). If the value of Register.Console.Echo is True, the character will automatically be sent back out via the output queue associated with the designated serial channel. When this function is called it will not return until a character is available. However, other tasks will continue to execute. You may wish to query the designated queue to find out if there are characters available before calling this function. See the example below.

## Example

```
Dim b as Byte
b = Console.Read() ' this will wait until a character is available

If (GetQueueCount(CByteArray(Register.RxQueue)) > 0) Then
    b = Console.Read() ' read the next available character
End If
```

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also**            Console.ReadLine, Console.Write, Console.WriteLine

# Console.ReadLine

---

**Type**                Function returning String

**Invocation**        Console.ReadLine()

## Discussion

This function can be invoked to retrieve a sequence of characters from the input queue associated with Com1 (by default, but see Option Console in the ZBasic Language Reference Manual) terminated by an end-of-line character. If the value of `Register.Console.Echo` is `True`, each character received will automatically be sent back out via the output queue associated with the designated serial channel. When this function is called it will not return until an end-of-line character is received. However, other tasks will continue to execute. The end-of-line character is line feed (&H0a) by default but you may change it using `Register.Console.EOL`.

While the characters of the line are being read, if a backspace character is received (&H08) the most recently received character will be deleted from the internal buffer. Additional backspace characters will each remove another character from the buffer until it is empty. If a carriage return is received (&H0d) it will be ignored unless `Register.Console.EOL` is a carriage return.

The end-of-line character is not included in the returned string and the maximum length of the string is 255 characters. Additional characters received after the 255<sup>th</sup> character will be discarded while awaiting the end-of-line character.

## Example

```
Dim s as String
s = Console.ReadLine()
```

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also**            Console.Read, Console.Write, Console.WriteLine

# Console.Write

**Type** Special Purpose

**Invocation** Console.Write(arg)

Parameter	Method	Type	Description
arg	ByVal	String	A string to send to Com1.

## Discussion

Console.Write is neither a subroutine nor a function. It has more in common with ZBasic statements but it is described here for ease of reference. This special purpose method is useful for outputting debugging information and other data to Com1 (by default, but see Option Console in the ZBasic Language Reference Manual). Note that no carriage return/new line is output after the string.

When this method is invoked, execution of the current task will not continue and no other task will be allowed to run until the string's characters have been transferred to the system output queue. The Debug.Print page contains some example code that illustrates a way to mitigate the latency that results from this implementation detail.

In contrast to other System Library routines that copy data to a queue, the string length is not limited to the system output queue length.

## Example

```
Console.Write("Hello, world! ")
```

```
Console.Write("The value is " & CStr(val))
```

This example uses the concatenation operator to produce a single string that is passed to the method.

**See Also** Debug.Print, Console.Read, Console.ReadLine, Console.WriteLine

# Console.WriteLine

**Type** Special Purpose

**Invocation** Console.WriteLine(arg)

Parameter	Method	Type	Description
arg	ByVal	String	A string to send to Com1.

## Discussion

Console.WriteLine is neither a subroutine nor a function. It has more in common with ZBasic statements but it is described here for ease of reference. This special purpose method is useful for outputting debugging information and other data to Com1 (by default, but see Option Console in the ZBasic Language Reference Manual). Note that a carriage return/new line is always output following the string.

When this method is invoked, execution of the current task will not continue and no other task will be allowed to run until the string's characters have been transferred to the system output queue. This caveat applies separately to the string specified by the parameter and to the end-of-line sequence that is also output. The Debug.Print page contains some example code that illustrates a way to mitigate the latency that results from this implementation detail.

In contrast to other System Library routines that copy data to a queue, the string length is not limited to the system output queue length.

## Examples

```
Console.WriteLine("Hello, world! ")
```

```
Console.WriteLine("The value is " & CStr(val))
```

The second example uses the concatenation operator to produce a single string that is passed to the method.

**See Also** Debug.Print, Console.Read, Console.ReadLine, Console.Write

# ControlCom

**Type** Subroutine

**Invocation** ControlCom(chan, rxFlowPin, txFlowPin)  
ControlCom(chan, rxFlowPin, txFlowPin, flags)

Parameter	Method	Type	Description
chan	ByVal	Byte	The serial channel of interest.
rxFlowPin	ByVal	Byte	The pin to use for receive flow control.
txFlowPin	ByVal	Byte	The pin to use for transmit flow control.
flags	ByVal	Byte	Flag bits controlling the sense of the flow control lines.

## Discussion

This subroutine sets a flow control pin for the receive side and/or transmit side of a serial channel. Either or both of the second and third parameters may be zero indicating that that type of flow control is not desired. If the fourth parameter is not specified, it defaults to the value zero indicating that the flow control pins should be active high. If the fourth parameter is specified, the bits of its value have the meaning given in the table below.

Flag Parameter Values	
Value	Meaning
&H01	The receive flow control pin should be active low.
&H02	The transmit flow control pin should be active low.

The remaining bits are currently undefined but may be used in the future. For compatibility with new functionality that may be added in the future, the unused bits should always be zero.

If a receive flow control pin is specified, the pin will be made an output and placed in the active state. This indicates to the sender that the ZX is ready to accept serial data. When the channel's receive queue is nearly full (two bytes of space left), the receive flow control pin will be set to the inactive state indicating to the sender that data transmission should be temporarily suspended. When additional space becomes available in the receive queue (at least three bytes), the receive flow control pin will be set back to the active state.

If a transmit flow control pin is specified, the pin will be made an input. Before sending data, the ZX will check the state of the transmit flow control pin and, if it is at the inactive level, no data will be sent. Note that the input is checked periodically and transmission will resume if the transmit flow control pin is in the active state when sampled.

The current state of the flow control signals is part of the value returned by StatusCom().

It is important to note that a receive queue that is too small is likely to result in a deadlock since there will never be enough free space to activate the flow control signal. Also, when a channel is closed the flow control settings for the channel are cleared. For that reason, it is recommended that the call to ControlCom() be made, if desired, some time after a channel is opened and before it is closed.

## Compatibility

This subroutine is not available on ZX devices based on the mega32 (e.g. ZX-24). Moreover it is not available in BasicX compatibility mode.

**See Also** CloseCom, ComChannels, DefineCom, OpenCom, StatusCom

# Cos

---

**Type**            Function returning Single

**Invocation**    Cos(arg)

Parameter	Method	Type	Description
arg	ByVal	Single	The angle, in radians, of which the cosine will be computed.

## Discussion

The return value will be the cosine of the supplied value, ranging from −1.0 to 1.0.

## Example

```
Const pi as Single = 3.14159
Dim val as Single

val = Cos(pi)            ' result is -1.0
```

**See Also**        Acos, DegToRad, RadToDeg

# CountTransitions

**Type** Function returning Long

**Invocation** CountTransitions(pin, interval)

Parameter	Method	Type	Description
pin	ByVal	Byte	The pin on which logic transitions will be counted.
interval	ByVal	Single or Long	The time interval specified in seconds or I/O Timer ticks, respectively, during which transitions will be counted. See the discussion below for information on range and resolution.

## Discussion

When called, this routine will begin counting logic transitions on the specified pin and will continue until the specified interval has elapsed. During the counting process processor interrupts are disabled. This strategy allows high precision in measuring the interval but has the drawback that other processes that utilize interrupts will not function correctly. Among such affected processes are all serial communication and multi-tasking. For this reason, the counting interval should be kept as short as possible. RTC ticks that occur during the counting process are accumulated and the RTC is updated when the counting is finished.

The specified pin, which you must configure to be an input before calling, is sampled at a fixed rate of approximately 1/36 (ATxmega) or 1/40 (ATxmega) of the CPU frequency. The sample rate, default resolution and maximum measurement interval are shown in the table below for various CPU frequencies. You may modify the range and resolution of the measurement interval by modifying the built-in variable `Register.TimerSpeed1`. See the special section on Timers for more details.

**Important CountTransitions Values**

Processor Family	Frequency	Sample Rate	Default Resolution	Maximum Interval	Max. RTC Adj. Interval
ATmega	7.3738 MHz	204.8 KHz	4.883 $\mu$ S	10,485 sec.	128 sec.
ATmega	14.7456 MHz	409.6 KHz	2.441 $\mu$ S	5,242 sec.	64 sec.
ATmega	18.432 MHz	512.0 KHz	1.953 $\mu$ S	4,194 sec.	65 sec.
ATxmega	29.4912 MHz	737.3 KHz	1.356 $\mu$ S	2,912 sec.	64 sec.

## Resource Usage

This function uses the I/O Timer and disables interrupts during the counting process. However, RTC ticks are accumulated during the process and the RTC is updated upon completion. The maximum number of missed RTC ticks that can be tracked is 65,535. A measurement interval longer than that number of fast RTC ticks will result in incorrect RTC accumulator values. The maximum measurement interval for correct adjustment the RTC is shown in the table above.

## Compatibility

In BasicX missed RTC ticks are not accounted for.

# CPUSleep

**Type** Subroutine

**Invocation** CPUSleep()

## Discussion

This routine puts the processor into a special sleep mode in which activity and power consumption are reduced. The nature of the sleep mode is controlled by certain bits in one of the CPU registers (see table below). For more information about the sleep mode, consult the Atmel documentation for the ATmega or ATxmega processor on which your ZX device is based.

**Register Containing the Sleep Mode Bits**

<b>ZX Model</b>	<b>Register</b>
ZX-24, ZX-40, ZX-44, ZX-24e	Register.MCUCR
ZX-24a, ZX-40a, ZX-44a, ZX-24ae	Register.SMCR
ZX-24p, ZX-40p, ZX-44p, ZX-24pe, ZX-24pu	Register.SMCR
ZX-24n, ZX-40n, ZX-44n, ZX-24ne, ZX-24nu	Register.SMCR
ZX-24r, ZX-40r, ZX-44r, ZX-24s, ZX-40s, ZX-44s, ZX-24ru, ZX-24su	Register.SMCR
ZX-328n, ZX-328l, ZX-32n, ZX-32l, ZX-328nu	Register.SMCR
ZX-1281, ZX-1281n, ZX-1280, ZX-1280n, ZX-1281e, ZX-1281ne	Register.SMCR
ZX-128e, ZX-128ne	Register.MCUCR
ZX-24x, ZX-32a4, ZX-128a1, ZX-24xu	Register.SLEEP_CTRL

# CRC16

**Type** Function returning UnsignedInteger

**Invocation** CRC16(data, count, crcPoly, crclnit, crcFlags)

Parameter	Method	Type	Description
data	ByRef	anyType	The data bytes to add to the CRC value.
count	ByVal	integral	The number of bytes to process.
crcPoly	ByVal	UnsignedInteger	The CRC polynomial to use.
crclnit	ByVal	UnsignedInteger	The initial value of the CRC.
crcFlags	ByVal	integral	Flag bits that control the CRC computation.

## Discussion

This function computes the CRC value over a number of data bytes using a specified polynomial and initial value. The values to use for the polynomial and the initial value depend on the style of CRC that you need to generate. See the discussion below for further details. The `flags` parameter contains bits that control aspects of the CRC computation as described in the table below.

Flag Values for the CRC Computation			
Constant	Hex	Binary	Description
zxCRCRefIn	&H01	xxxx xxx1	Each input data bytes will be “reflected”.
zxCRCRefOut	&H02	xxxx xx1x	The final CRC value will be “reflected”.

The remaining bits are reserved for future use and should always be zero.

In this context, the term “reflection” refers to reversing the order of the bits in a data item so that the most significant becomes the least significant and vice versa. For a multi-byte data item, the bits in each byte are reversed and the order of the bytes is reversed as well.

Although this function will typically be used to compute the CRC value for an entire block of data at once, it may also be used in a byte-by-byte or data burst mode. To do so, you would pass the computed CRC value from the previous iteration as the initial value. Note, however, that you shouldn’t use the `zxRefOut` flag bit in this case. Rather, if you need reflected output you would perform the bit reversal on the final CRC value when you reach the end of the data stream. You can reverse the bit order of a 16-bit value by using the following code fragment.

```
crc = MakeWord(FlipBits(HiByte(crc)), FlipBits(LoByte(crc)))
```

CRC algorithms can be described by a parametric model known as the RockSoft model (see [http://www.repairfaq.org/filipg/LINK/F\\_crc\\_v34.html#CRCV\\_005](http://www.repairfaq.org/filipg/LINK/F_crc_v34.html#CRCV_005)). This CRC implementation supports the POLY, INIT, REFIN and REFOUT parameters of the model with WIDTH=16 and XOROUT=0. If necessary, you can easily implement a non-zero XOROUT parameter by using the following code fragment.

```
crc = crc Xor XorOutValue
```

The Rocksoft model parameters for commonly used CRC computations are given in the table below.

**Rocksoft Model Parameters for Common CRC Algorithms**

<b>Parameter/Type</b>	<b>CRC-16</b>	<b>CRC-CCITT</b>	<b>ModBus</b>	<b>CRC-32</b>
WIDTH	16	16	16	32
POLY	&H8005	&H1021	&H8005	&H04c11db7
INIT	&H0000	&Hffff	&Hffff	&Hffffffff
REFIN	True	False	True	True
REFOUT	True	False	True	True
XOROUT	&H0000	&H0000	&H0000	&Hffffffff
CHECK	&Hbb3d	&H29b1	&H4b37	&Hcbf43926

The parameters are included in the table above for the CRC-32 algorithm but, of course, they must be used with the `CRC32()` function. The CHECK value is the CRC result for the string of characters "123456789".

Additional information on CRC calculations may be found in many places on the Internet. One useful site that implements a CRC calculator is <http://www.zorc.breitbandkatze.de/crc.html>. If you don't know the parameters required for a particular CRC, you may be able to deduce the correct parameters by using the calculator if you have a sample message and its CRC value. One of the variables available in the CRC calculator on the web page mentioned is "direct" vs. "nondirect". This implementation uses the "direct" method.

### Example

```
Dim data(1 to 20) as Byte
Dim crc as UnsignedInteger
' compute the CRC using the CRC-16 algorithm
crc = CRC16(data, 10, &H8005, &H0000, zxCRCRefIn Or zxCRCRefOut)
```

### Compatibility

This function is not available in BasicX compatibility mode. Also, on ZX models that are based on the ATmega32 processor (e.g. the ZX-24) this function is implemented in "user code" (as opposed to being part of the VM) and is consequently slower than on other ZX models.

**See Also**      CRC32

# CRC32

**Type** Function returning UnsignedLong

**Invocation** CRC32(data, count, crcPoly, crclnit, crcFlags)

Parameter	Method	Type	Description
data	ByRef	anyType	The data bytes to add to the CRC value.
count	ByVal	integral	The number of bytes to process.
crcPoly	ByVal	UnsignedLong	The CRC polynomial to use.
crclnit	ByVal	UnsignedLong	The initial value of the CRC.
crcFlags	ByVal	integral	Flag bits that control the CRC computation.

## Discussion

This function computes the CRC value over a number of data bytes using a specified polynomial and initial value. The values to use for the polynomial and the initial value depend on the style of CRC that you need to generate. The `flags` parameter contains bits that control aspects of the CRC computation as described in the table below.

Flag Values for the CRC Computation			
Constant	Hex	Binary	Description
zxCRCRefIn	&H01	xxxx xxx1	The input data bytes will be “reflected”.
zxCRCRefOut	&H02	xxxx xx1x	The final CRC will be “reflected”.

The remaining bits are reserved for future use and should always be zero.

Although this function will typically be used to compute the CRC value for an entire block of data at once, it may also be used in a byte-by-byte or data burst mode. To do so, you would pass the computed CRC value from the previous iteration as the initial value. Note, however, that you shouldn't use the `zxRefOut` flag bit in this case. Rather, if you need reflected output you would perform the bit reversal on the final CRC value when you reach the end of the data stream.

See the discussion of the `CRC16()` function for additional information.

## Example

```
Dim data(1 to 20) as Byte
Dim crc as UnsignedLong
crc = Not CRC32(data, 10, &H04c11db7, &Hfffffff, zxCRCRefIn Or zxCRCRefOut)
```

## Compatibility

This function is not available in BasicX compatibility mode. Also, on ZX models that are based on the ATmega32 processor (e.g. the ZX-24) this function is implemented in “user code” (as opposed to being part of the VM) and is consequently slower than on other ZX models.

**See Also** CRC16

# CSng

**Type**            Function returning Single

**Invocation**    CSng(arg)

Parameter	Method	Type	Description
arg	ByVal	numeric or Enum	The value to convert to Single.

## Discussion

This function converts any numeric or enumeration value to a `Single` value. For integral and `Enum` types, the result will be the floating point approximation of the integral value. If a `Single` type parameter is supplied, the result is identical to the parameter value. If a `String` type parameter is supplied, the result will be the numeric value of the character string. The form of the character representation supported is identical to that supported by `ValueS()`.

## Example

```
Dim b as Byte
Dim f as Single

b = 21
f = CSng(b)
```

## Compatibility

In BasicX, passing an `UnsignedLong` value larger than 2,147,483,647 erroneously generates a negative `Single` result. This implementation handles `UnsignedLong` values correctly.

# CStr

**Type**            Function returning String

**Invocation**    CStr(arg)

Parameter	Method	Type	Description
arg	ByVal	any type	The value to convert to String.

## Discussion

This function converts any Boolean, numeric or enumeration value to a String value. See the table below for details of the conversion.

Input Type	Result
Boolean	The string "True" or "False".
Byte, Bit, Nibble	A string containing decimal digits representing the value.
Integer	A string containing decimal digits representing the value. If the value is negative, the string will begin with a minus sign.
UnsignedInteger	A string containing decimal digits representing the value.
Enum	A string containing decimal digits representing the Enum member value.
Long	A string containing decimal digits representing the value. If the value is negative, the string will begin with a minus sign.
UnsignedLong	A string containing decimal digits representing the value.
Single	A string representing the value. Depending on the value, the form may be standard decimal form with a decimal point separating the whole and fractional parts or it may be in "scientific notation" form. In some cases, there will be no decimal point at all, e.g. with values having no fractional part.

When converting `Single` values, some special cases are detected resulting in the strings shown in the table below. See the function `SngClass()` for more information about the special cases.

Special Value	Result
NaN	" * . * " .
±Infinity	" & . & "
Denormalized value	" # . # "

## Compatibility

In BasicX the special `Single` values are not handled properly.

**See Also**            CStrHex, Fmt

# CStrHex

**Type**                Function returning String

**Invocation**        CStrHex(arg)

Parameter	Method	Type	Description
arg	ByVal	numeric	The value to convert to a hexadecimal String.

## Discussion

This function converts any Boolean, numeric or enumeration value to a String value. The content of the string will be hexadecimal characters that represent the value of the bytes comprising the passed value. The number of characters in the string varies depending on the type of the value passed. See the table below.

Input Type	Number of Characters
Boolean, Bit, Nibble, Byte	2
Integer, UnsignedInteger, Enum	4
Long, UnsignedLong, Single	8

## Compatibility

This function is not available in BasicX compatibility mode.

# CType

**Type**                Function returning an enumeration member

**Invocation**        CType(value, enumType)

Parameter	Method	Type	Description
value	ByVal	numeric or Enum	The value to convert to an Enum member.
enumType	ByVal	Enum	The name of the Enum type.

## Discussion

This function converts any numeric or enumeration member value to an enumeration member. No checking is done to confirm that the given value actually corresponds to one of the enumeration members.

See the section on enumerations in the ZBasic Reference Manual for more information.

## Example

```
Enum Color
    Red
    Green
    Blue
End Enum

Dim c as Color

c = CType(1, Color)      ' c will have the value Green
```

# CUInt

**Type**                      Function returning UnsignedInteger

**Invocation**            CUInt(arg)

Parameter	Method	Type	Description
arg	ByVal	numeric, Boolean, String or Enum	The value to convert to UnsignedInteger.

## Discussion

This function converts any numeric or enumeration value to an UnsignedInteger value. See the table below for details of the conversion.

Input Type	Result
Byte, Boolean	High byte zero, low byte as supplied.
Integer	Value bits are the same as supplied, although interpreted as an unsigned value.
UnsignedInteger	No effect, the value is as supplied.
Enum	Resulting value is the Enum member value.
Long	Resulting value is the low word of the supplied value.
UnsignedLong	Resulting value is the low word of the supplied value.
Single	The supplied value is converted to a signed 32-bit integer, rounded to the nearest integer. If the fractional part is exactly 0.5, the resulting integer will be even. This is known as “statistical rounding”. If the resulting signed integer is negative or larger than 65535, the result is undefined. Otherwise, the result is the value of the integer.
String	The result is the numeric value of the characters in the string, ignoring leading space and tab characters. The value string may begin with a plus or minus sign and an optional radix indicator (&H for hexadecimal, &O for octal, &B or &X for binary, all case insensitive). The conversion is terminated upon reaching the end of the string or encountering the first character that is not valid for the indicated radix.

## Example

```
Dim u as UnsignedInteger

u = CUInt(2.5)        ' result is 2
u = CUInt(1.5)        ' result is 2
```

## Compatibility

The ability to convert from `Single` is not supported in BasicX compatibility mode.

# CULng

**Type**                      Function returning UnsignedLong

**Invocation**            CULng(arg)

Parameter	Method	Type	Description
arg	ByVal	numeric, Boolean, String or Enum	The value to convert to UnsignedLong.

## Discussion

This function converts any numeric or enumeration value to an UnsignedLong value. See the table below for details of the conversion.

Input Type	Result
Byte, Boolean	High 3 bytes zero, low byte as supplied.
Integer	High word will be zero, low word as supplied.
UnsignedInteger	High word will be zero, low word as supplied.
Enum	High word zero, low word contains Enum member value.
Long	Value bits are the same as supplied, although interpreted as an unsigned value.
UnsignedLong	No effect, the value is as supplied.
Single	Supplied value converted to signed 32-bit integer, rounded to the nearest integer. If the fractional part is exactly 0.5, the resulting integer will be even. This is known as “statistical rounding”. If the supplied value is negative or if it is too large to be represented in 32 bits, the result is undefined.
String	The result is the numeric value of the characters in the string, ignoring leading space and tab characters. The value string may begin with a plus or minus sign and an optional radix indicator (&H for hexadecimal, &O for octal, &B or &X for binary, all case insensitive). The conversion is terminated upon reaching the end of the string or encountering the first character that is not valid for the indicated radix.

## Example

```
Dim ul as UnsignedLong
```

```
ul = CULng(2.5)     ' result is 2  
ul = CULng(1.5)     ' result is 2
```

# DAC

---

**Type** Subroutine

**Invocation** DAC(channel, dacValue)  
DAC(channel, dacValue, stat)

Parameter	Method	Type	Description
channel	ByVal	Byte	The DAC channel to use.
dacValue	ByVal	integral	The desired DAC value (see discussion below).
stat	ByRef	Boolean	The variable to receive the status code.

## Discussion

This routine creates an analog signal on the pin corresponding to the specified channel (see OpenDAC() for more information). Only the least significant 12 bits of the specified value are used and the resulting analog level will be approximately equal to `dacValue` divided by 4095 times the DAC reference voltage specified with OpenDAC().

## Compatibility

This subroutine is not available in BasicX compatibility mode nor is it available on ATmega-based ZX devices.

**See Also** CloseDAC, OpenDAC

# DACPin

**Type** Subroutine

**Invocation** DACPin(pin, dacValue, dacAccumulator)

Parameter	Method	Type	Description
pin	ByVal	Byte	The pin to which the DAC signal will be output.
dacValue	ByVal	Byte	The value representing the desired analog output. See the discussion below.
dacAccumulator	ByRef	Byte	A value used in the DAC process. See discussion below.

## Discussion

This routine creates a digital approximation of an analog signal on the specified pin using a pseudo-PWM technique. ZBasic supports this routine for backward compatibility. New applications should use `PutDAC()` as it is more flexible. See the description of `PutDAC()` for more information.

For ZX devices based on the ATxmega, a hardware DAC is available. In most applications requiring a DAC, using the hardware DAC will produce much better results.

## Resource Usage

This routine disables interrupts for approximately 200µS during the generation process.

**See Also** DAC, OpenDAC, PutDAC

# Debug.Print

**Type** Special Purpose

**Invocation** Debug.Print stringList

Parameter	Method	Type	Description
stringList	ByVal	String	One or more strings or values to send out Com1.

## Discussion

Debug.Print is neither a subroutine nor a function. It has more in common with ZBasic statements but it is described here for ease of reference. This special purpose method is useful for outputting debugging information and other data to Com1 (by default, but see Option Console in the ZBasic Language Reference Manual). The arguments provided to the command consist of zero or more strings or values each separated by a semicolon. If non-string values are supplied, they are converted to strings automatically using the CStr() function. Unless the list ends with a semicolon, a carriage return/new line will also be output after all of the strings have been output.

When this statement is invoked, execution of the current task will not continue and no other task will be allowed to run until the string's characters have been transferred to the system output queue. This caveat applies independently to each string in the semicolon-separated list as well as to the end-of-line string, if applicable. The latency-inducing effect described above can be mitigated by preparing a new output queue that is sufficiently large such that there is always enough free space in the queue when this method is invoked. See the example below.

In contrast to other System Library routines that copy data to a queue, the string length is not limited to the system output queue length.

## Examples

```
Debug.Print "Hello, world! "
```

This prints the given string followed by a carriage return/new line.

```
Debug.Print "The value is ";CStr(val);
```

This prints the string followed immediately by the string equivalent of the value. Note that since the command ends with a semicolon, no carriage return/new line will be generated.

```
Dim iq(1 to 20) as Byte
Dim oq(1 to 100) as Byte
Call OpenQueue(iq, SizeOf(iq))
Call OpenQueue(oq, SizeOf(oq))
Call OpenCom(1, 19200, iq, oq)
```

This example code shows how to increase the size of the output queue in order to reduce latency. The default input could be retained by replacing the last line above with the following line and deleting the other lines that refer to the variable iq.

```
Call OpenCom(1, 19200, CByteArray(Register.RxQueue), oq)
```

**See Also** Console.Write, Console.WriteLine

# DefineBus

**Type** Subroutine

**Invocation** DefineBus(port, alePin, rdPin, wrPin)

Parameter	Method	Type	Description
port	ByVal	integral	The port to use for address and data. PortA=0, PortB=1, etc.
alePin	ByVal	integral	The pin to use for the address latch strobe.
rdPin	ByVal	integral	The pin to use for the read data strobe.
wrPin	ByVal	integral	The pin to use for the write data strobe.

## Discussion

This subroutine is used to define the parameters to use for subsequent BusRead() and BusWrite() operations. The port specified by the `port` parameter is used both for outputting the address from which to read/write and for reading/writing the data. The port is specified by giving a port index – PortA = 0, PortB = 1, etc. You may use the built-in constants `Port.A`, `Port.B`, etc. to specify the port index. If all the parameters are valid, the pin specified by the `alePin` parameter is set to output low while the pins specified by the `rdPin` and `wrPin` parameters are set to output high. If any of the provided parameters is invalid, the bus will not be properly configured and subsequent calls to `BusRead()` or `BusWrite()` will return immediately with no effect.

The pin numbers specified for the `alePin`, `rdPin` and `wrPin` parameters must all be different and none of them should be in the port specified by the `port` parameter. If these conditions are violated, the result is undefined.

## Example

```
Call DefineBus(Port.A, C.0, C.1, C.2)
```

## Compatibility

This subroutine is not available on ZX models that are based on the ATmega32 processor (e.g. the ZX-24) nor is it available on ATxmega-based ZX devices. Moreover, it is not available in BasicX compatibility mode.

**See Also** BusRead, BusWrite

# DefineCom

**Type** Subroutine

**Invocation** DefineCom(channel, rxPin, txPin, flags)  
DefineCom(channel, rxPin, txPin, flags, stopBits)

Parameter	Method	Type	Description
channel	ByVal	Byte	The serial channel being defined.
rxPin	ByVal	Byte	The pin which will serve as the receive line.
txPin	ByVal	Byte	The pin which will serve as the transmit line.
flags	ByVal	Byte	Configuration flags. See the discussion below.
stopBits	ByVal	Byte	The desired number of stop bits.

## Discussion

This routine configures a serial channel, preparing it to be opened using `OpenCom()`. If the specified channel is already open, this routine does nothing. Likewise, there is no effect if the specified channel is invalid (see the `ComChannels()` routine) or if either of the `rxPin` and `txPin` parameters are invalid or both are zero. Note that either `rxPin` or `txPin` may be zero, allowing you to define a transmit-only or receive-only serial channel.

If the specified channel is a hardware UART (e.g. `Com1`), the `rxPin` and `txPin` parameters must both be zero. Otherwise, if they are valid, the pins specified by `rxPin` and `txPin` are automatically configured as input and output, respectively. However, if the `rxPin` and `txPin` parameter values are equal and non-zero, the pin is initially configured as an input to support half-duplex, bussed operation. In this mode, the pin will be made an output when transmitting a zero bit if configured for non-inverted operation or when transmitting a one bit if configured for inverted operation. A pull-up resistor (non-inverted mode) or pull-down resistor (inverted mode) is required for bussed operation since the pin will only be actively driven in one of the two output states.

The `flags` parameter contains several bit fields used to specify some of the details of the operation of the serial channel.

**Serial Channel Configuration Flag Values**

Function	Hex Value	Bit Mask
Inverted Logic <sup>1</sup>	&H80	1x xx xx xx
Non-inverted Logic	&H00	0x xx xx xx
Ignore Parity Bit	&H40	x1 xx xx xx
Even Parity	&H30	xx 11 xx xx
Odd Parity	&H20	xx 10 xx xx
No Parity	&H00	xx 00 xx xx
7-bit Data	&H07	xx xx 01 11
8-bit Data	&H08	xx xx 10 00
7-bit Data, bussed mode <sup>1</sup>	&H0b	xx xx 10 11
8-bit Data, bussed mode <sup>1</sup>	&H0c	xx xx 11 00

<sup>1</sup> Applicable only to software-based channels (3-6).

The remaining bit values are currently undefined but may be employed in the future.

When Non-inverted Logic is selected, the idle state of the transmit line will be logic 1. When a character transmission is begun, a “start bit” of logic zero will be sent for one bit time (the inverse of the baud rate). Next the data bits are sent, each for one bit time, beginning with the least significant bit and continuing through the eighth data bit or parity bit as the case may be. Finally, one or more “stop bits” of logic one are sent, each for one bit time. With Inverted Logic, each of these elements is complemented – the idle state of the transmit line is logic 0.

Whether you should choose the Inverted or Non-inverted mode depends on the device that you intend to communicate with and how many, if any, level converters exist between the two devices. Typically, if the other device is capable of sending and receiving TTL-level serial data, you'll likely choose Non-inverted Logic.

If the "Ignore Parity" flag is asserted, in 7-bit mode the most significant bit of each character received will be zero and in 8-bit mode only one byte will be stored in the queue for each character received. If the "Ignore Parity" bit is not asserted, in 7-bit mode the MSB will contain the received parity bit and in 8-bit mode a second byte containing the parity bit will be stored in the queue for each character received. The `ParityCheck()` function is useful for checking the parity of a received character.

The software UART channels support a bussed mode where the transmit pin is actively driven only during logic zero periods (low for non-inverted mode, high for inverted mode). This mode, selected by using the special values shown in the table above for 7-bit and 8-bit data widths (the normal values augmented by 4), is useful for having multiple devices driving the same transmit line. This mode is commonly referred to as *open drain* (non-inverted mode) or *open source* (inverted mode) operation and requires a pullup resistor (non-inverted mode) or a pulldown resistor (inverted mode) on the common transmit line in order to establish the proper logic level when the line is not being actively driven by any device.

For a software UART channel, if the optional `stopBits` parameter is not specified, one stop bit is transmitted for each character sent. Otherwise, the specified number of stop bits is transmitted. The allowable range for `stopBits` is 1 to 240. If a value outside this range is specified, the default of 1 stop bit will be used. The ability to specify two or more stop bits is useful for slowing down the transmission of data in cases where the receiver needs additional time to process received data.

Note that a pullup resistor (Non-inverted mode) or a pulldown resistor (Inverted mode) is recommended on the transmit line to force the transmit line to the idle state prior to the time your program initializes the COM port. If you don't do this, the receiving device may see false transmissions prior to the first character actually transmitted. Depending on what other circuitry is connected to the receive line, you may need to do the same to prevent the ZX from receiving false transmissions.

This subroutine may be used to specify the data width, parity mode and stop bits for a hardware UART channel (e.g. `Com1`) provided that it is called when the channel is closed. When used this way, the `txPin` and `rxPin` parameters are ignored and values of 2 or more for the `stopBits` parameter will select 2 stop bits. Also, the flag for inverted data mode is likewise ignored.

## Example

```
Call ComChannels(2, 9600)
Call DefineCom(4, 0, 12, &H08)
```

This call prepares channel 4 for transmit-only using pin 12, eight data bits, no parity and non-inverted logic.

## Compatibility

This function is not available in BasicX compatibility mode; you must use `DefineCom3()`. Additionally, BasicX does not support 8-bit plus parity modes nor does it support the "Strip Parity" mode. Furthermore, in BasicX characters received in 7-bit/no parity mode are aligned toward the MSB while in this implementation they are properly aligned toward the LSB.

For mega32-based ZX devices (e.g. the ZX-24), the ability to define the characteristics of `Com1` is not supported nor is half-duplex bussed mode. Specifying the same pin for rx and tx on these devices will produce undefined results.

**See Also**      `ComChannels`, `ControlCom`, `OpenCom`, `StatusCom`

# DefineCom3

---

**Type** Subroutine

**Invocation** DefineCom3(rxPin, txPin, flags)

Parameter	Method	Type	Description
rxPin	ByVal	Byte	The pin which will serve as the receive line.
txPin	ByVal	Byte	The pin which will serve as the transmit line.
flags	ByVal	Byte	Configuration flags. See the discussion below.

## Discussion

This routine is provided solely for BasicX compatibility. It is equivalent to using `Call DefineCom(3, rxPin, txPin, flags)`. See the `DefineCom()` routine for more information.

# DefineSPI

---

**Type** Subroutine

**Invocation** DefineSPI(`clkPin`, `mosiPin`, `misoPin`)

Parameter	Method	Type	Description
<code>clkPin</code>	ByVal	Byte	The pin to serve as the SPI clock signal (output).
<code>mosiPin</code>	ByVal	Byte	The pin to serve as the SPI MOSI signal (output).
<code>misoPin</code>	ByVal	Byte	The pin to serve as the SPI MISO signal (input).

## Discussion

This subroutine is used to specify the clock and data pins to use for the software driven SPI implementation (sometimes known as a “bit banded” implementation). If the `flags` parameter to the OpenSPI subroutine requests software SPI, OpenSPI will initialize the specified pins (`clkPin` and `mosiPin` as output, `misoPin` as input) and set `clkPin` to the idle state specified by the `flags` parameter to OpenSPI. If software SPI is not requested, OpenSPI will initialize the hardware SPI controller according to the `flags` parameter to OpenSPI.

It is important to be aware that the pin values set by DefineSPI are used by both the OpenSPI and SPICmd routines. This fact requires some extra attention if your application uses multiple SPI channels and two or more of them use the software-driven implementation. In such cases, you must ensure that the SPI pins have been correctly set by a prior call to DefineSPI before each call to OpenSPI and SPICmd. If your application uses just one channel with software SPI, a single call to DefineSPI will suffice and if it does not use software SPI at all then DefineSPI needn't be called either.

## Compatibility

This subroutine is not supported in BasicX mode nor it is supported on any VM mode ZX device.

**See Also** OpenSPI, SPICmd

# DefineX10

**Type** Subroutine

**Invocation** DefineX10(channel, rxPin, txPin, flags)  
DefineX10(channel, rxPin, txPin, flags, agcResetPin, agcWindowPin)

Parameter	Method	Type	Description
channel	ByVal	Byte	The X-10 channel being defined. The valid range is 1-2.
rxPin	ByVal	Byte	The pin which will serve as the receive line.
txPin	ByVal	Byte	The pin which will serve as the transmit line.
flags	ByVal	Byte	Configuration flags. See the discussion below.
agcResetPin	ByVal	Byte	The pin on which to generate the AGC reset signal.
agcWindowPin	ByVal	Byte	The pin on which to generate the AGC window signal.

## Discussion

This routine configures an X-10 communication channel, preparing it to be opened using `OpenX10()`. If the specified channel is already open, this routine does nothing. Likewise if the specified channel is invalid or if both the `rxPin` and `txPin` parameters are zero or invalid. Note that either `rxPin` or `txPin` may be zero, allowing you to define a transmit-only or a receive-only X-10 channel. If valid, the pins specified by `rxPin` and `txPin` are automatically configured as input and output, respectively.

The `flags` parameter contains several bit fields used to specify some of the details of the operation of the X-10 channel.

**Configuration Flags Bit Values**

Function	Hex Value	Bit Mask
LSB-first Transmit Bit Order	&H08	xx xx 1x xx
MSB-first Transmit Bit Order	&H00	xx xx 0x xx
Inverted Transmit Logic	&H04	xx xx x1 xx
Non-inverted Transmit Logic	&H00	xx xx x0 xx
LSB-first Receive Bit Order	&H02	xx xx xx 1x
MSB-first Receive Bit Order	&H00	xx xx xx 0x
Inverted Receive Logic	&H01	xx xx xx x1
Non-inverted Receive Logic	&H00	xx xx xx x0

The remaining bits are currently undefined but may be employed in the future.

When non-inverted modes are selected, the idle state of the transmit line or receive line will be logic 0. Whether you should choose the inverted or non-inverted mode depends on the interface circuitry that you use to connect to your X-10 transmitter/receiver.

When LSB-first modes are selected, the first bit to be sent/received will be the least significant bit of each byte. This is useful when a Bit array is used to assemble/decompose the data that is sent/received since the lower-indexed bits in a byte are of lower significance.

The second form with the additional parameters is provided for use with the CM15A and similar modules. The fifth parameter specifies a pin number on which to generate an active low signal to reset the CM15A AGC circuitry. The sixth parameter specifies a pin number on which to generate an active high signal marking the CM15A AGC window, approximately 1mS following each zero crossing.

## Example

```
Call DefineX10(1, 0, 12, &H00)
```

This call prepares channel 1 for transmit-only using pin 12, non-inverted logic, MSB-first operation.

### **Compatibility**

This subroutine is not available on ZX models that are based on the ATmega32 processor (e.g. the ZX-24). The second form is only available on native mode devices. Neither form is available in BasicX compatibility mode.

**See Also**      CloseX10, OpenX10, StatusX10

# DegToRad

---

**Type**                Function returning Single

**Invocation**        DegToRad(angle)

Parameter	Method	Type	Description
angle	ByVal	Single	The angle, in degrees, to convert to radian measure.

## Discussion

The trigonometric functions in the System Library all use radian angle measure. Depending on the programming task, it is sometimes more convenient to think of angles in terms of degrees. This function and its inverse RadToDeg() facilitate the conversion between the two systems.

Depending on optimization settings, if the parameter supplied to this function is known to be constant at compile time, the compiler converts the value at compile time. Otherwise, code is generated to perform the conversion (multiplication by a conversion factor) at run time.

## Example

```
Dim f as Single
Dim theta as Single        ' the angle in degrees

f = Sin(DegToRad(theta))
```

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also**            RadToDeg

# Delay

**Type** Subroutine

**Invocation** Delay(time)

Parameter	Method	Type	Description
time	ByVal	Single	The amount of time to delay, in seconds.

## Discussion

This routine suspends the current task for a period of time at least as long as specified. The actual delay depends on what other tasks actually do that may run in the interim. It is possible that the task will be suspended indefinitely depending on what another task might do.

Note that if the current task is locked, this call will unlock it.

There is a subtle difference between `Delay()` and `Sleep()` when the arguments are non-zero. For `Delay()` the specified time is the minimum amount of delay that the task will experience assuming that no other task is ready to run. The actual delay could be up to 1.95ms longer than the specified delay. For `Sleep()`, the specified time is the maximum amount of delay that the task will experience assuming that no other task is ready to run. The actual delay could be up to 1.95ms less than the specified delay.

## Example

```
Do
    Call PutPin(25, 0)
    Call Delay(0.5)
    Call PutPin(25, 1)
    Call Delay(0.5)
Loop
```

This loop causes the red LED to turn on and off alternately for a half second each.

## Compatibility

The BasicX documentation specifically indicates that `Delay()` will unlock a locked task. However, tests indicate that this only happens if the parameter to `Delay()` is non-zero. This implementation unlocks a task on any `Delay()` call.

**See Also** DelayUntilClockTick, Pause, Sleep, Register.RTCStopWatch

# DelayUntilClockTick

---

**Type** Subroutine

**Invocation** DelayUntilClockTick()

## Discussion

This routine suspends the current task until at least the next tick of the RTC. The actual delay depends on what other tasks actually do that may run in the interim. It is possible that the task will be suspended indefinitely.

If no other tasks are ready to run, the actual delay could be between 0 and 1.95ms.

This routine is exactly equivalent to `Sleep(1)`.

**See Also** Delay, Pause, Sleep

# DisableInt

---

**Type**                      Function returning Byte

**Invocation**            DisableInt()

## Discussion

This routine disables interrupts, preventing any interrupt source from interrupting the current task. Most commonly, this function is used to temporarily disable interrupts thereby allowing a sequence of instructions to execute without interruption. Of course, interrupts should be disabled for the shortest possible time in order to avoid missing important interrupts (e.g. real time clock interrupts). If interrupts are disabled for longer than one period of the RTC fast tick (typically 976 uS) you run the risk of missing an RTC tick which will result in the RTC losing time.

The most common use for DisableInt() is to implement “atomic access” to variables. This should be done for any variable that occupies multiple bytes of memory (e.g. Integer, Long, etc.) or for a read-modify-write operation on any variable when there is a possibility that another task or interrupt handler might attempt to access the same variable.

The value returned by DisableInt() should be passed to EnableInt(). Doing so will allow proper nesting of DisableInt() and EnableInt() calls.

## Note

The Atomic block construct (described in the ZBasic Language Reference Manual) is the preferred method for implementing atomic access.

## Example

```
Dim iflag as Byte

iflag = DisableInt()
' place code here that must not be interrupted
Call EnableInt(iflag)
```

**See Also**                EnableInt, UpdateRTC, Yield

# EnableInt

**Type** Subroutine

**Invocation** EnableInt(flag)

Parameter	Method	Type	Description
flag	ByVal	Byte	The value controlling re-enabling of interrupts.

## Discussion

This routine conditionally re-enables interrupts depending on the value of the `flag` parameter. If the most significant bit of the `flag` parameter is a 1, interrupts will be re-enabled. Otherwise, the state of the interrupt enabling will not change. Passing the value returned from `DisableInt()` implements proper nesting of `DisableInt()` and `EnableInt()` calls so they are most often used in pairs as shown in the example below.

## Note

The Atomic block construct (described in the ZBasic Language Reference Manual) is the preferred method for implementing atomic access.

## Example

```
Dim iflag as Byte

iflag = DisableInt()
' place code here that must not be interrupted
Call EnableInt(iflag)
```

**See Also** DisableInt, UpdateRTC, Yield

# ExitTask

**Type** Subroutine

**Invocation** ExitTask(taskStack)  
ExitTask()

Parameter	Method	Type	Description
taskStack	ByRef	array of Byte	The stack for a task of interest.

## Discussion

This routine attempts to terminate an active task. If no task stack is explicitly given, the task stack for the `Main()` routine is assumed.

If this routine is invoked using an array other than one that is or was being used for a task stack the result is undefined.

See the section on Task Management in the ZBasic Reference Manual for additional information regarding task management.

When a task exits, whether normally or via `ExitTask()`, that task's status is first set to 254 indicating that it is in the process of exiting but that it is still in the task list. The exiting task will remain in the task list until the task manager runs again. The task manager runs whenever a task switch is called for but you can force it to run by invoking `Sleep()` or `Yield()`. Once the task manager removes an exiting task from the task list, its status will change to 255 indicating that it is fully terminated.

## Compatibility

This routine is not available in BasicX compatibility mode.

**See Also** ResumeTask, RunTask, StatusTask

# Exp

---

**Type**            Function returning Single

**Invocation**    Exp(arg)

Parameter	Method	Type	Description
arg	ByVal	Single	The power of e to be computed.

## Discussion

This function returns the `Single` value corresponding to the value `e` raised to the specified power. The transcendental value `e`, upon which the natural logarithm is based, is approximately 2.718. This function is the inverse of the `Log( )` function.

**See Also**        Exp10, Log, Log10, Pow

# Exp10

---

**Type**            Function returning Single

**Invocation**    Exp10(arg)

Parameter	Method	Type	Description
arg	ByVal	Single	The power of 10 to be computed.

## Discussion

This function returns the `Single` value corresponding to the value 10 raised to the specified power. This function is the inverse of the `Log10()` function.

**See Also**        Exp, Log, Log10, Pow

# FirstTime

---

**Type**                Function returning Boolean

**Invocation**        FirstTime()

## Discussion

When called the first time after downloading a program, this function will return True. Thereafter, it will always return False even if the processor is powered down or reset. Subsequently downloading again will again cause the function to return True on the first call, etc.

# Fix

---

**Type**            Function returning Single

**Invocation**    Fix(arg)

Parameter	Method	Type	Description
arg	ByVal	Single	The value to be “fixed”.

## Discussion

This function returns the `Single` representation of the integer that is nearest the supplied value, rounding toward zero.

## Example

```
Dim f as Single
```

```
f = Fix(1.5)            ' result is 1.0  
f = Fix(-1.5)          ' result is -1.0
```

**See Also**        Ceiling, Floor, Fraction

# FixB

**Type**            Function returning Byte

**Invocation**    FixB(arg)

Parameter	Method	Type	Description
arg	ByVal	Single	The value to be changed to integral form.

## Discussion

The supplied `Single` value is first converted to a signed 32-bit integer, rounding toward zero, and then the low 8 bits of that value is returned. The result isn't particularly useful if the provided `Single` value is negative or larger than 255.

## Example

```
Dim b as Byte

b = FixB(100.5)                    ' result is 100
```

# FixI

**Type**            Function returning Integer

**Invocation**    FixI(arg)

Parameter	Method	Type	Description
arg	ByVal	Single	The value to be changed to integral form.

## Discussion

The supplied `Single` value is first converted to a signed 32-bit integer, rounding toward zero, and then the low 16 bits of that value is returned. The result isn't particularly useful if the provided `Single` value is outside the range  $-32768$  to  $32767$ , inclusive.

## Example

```
Dim i as Integer

i = FixI(-100.5)           ' result is -100
```

## Compatibility

For compatibility with BasicX, if the provided `Single` value is larger than  $32767$  this function returns  $32767$ . Similarly, if the value is less than  $-32767$  (not  $-32768$  as one would expect) this function returns  $-32767$ .

# FixL

**Type**            Function returning Long

**Invocation**    FixL(arg)

Parameter	Method	Type	Description
arg	ByVal	Single	The value to be changed to integral form.

## Discussion

The supplied `Single` value is converted to a signed 32-bit integer, rounding toward zero, and that value is returned. The result isn't particularly useful if the provided `Single` value is outside the range – 2,147,485,648 to 2,147,485,647, inclusive.

## Example

```
Dim l as Long
```

```
l = FixL(-100.5)                    ' result is -100
```

# FixUI

**Type**            Function returning UnsignedInteger

**Invocation**    FixUI(arg)

Parameter	Method	Type	Description
arg	ByVal	Single	The value to be changed to integral form.

## Discussion

The supplied `Single` value is first converted to a signed 32-bit integer, rounding toward zero, and then the low 16 bits of that value is returned. The result isn't particularly useful if the provided `Single` value is outside the range 0 to 65535, inclusive.

## Example

```
Dim ui as UnsignedInteger

ui = FixUI(100.5)            ' result is 100
```

# FixUL

**Type**            Function returning UnsignedLong

**Invocation**    FixUL(arg)

Parameter	Method	Type	Description
arg	ByVal	Single	The value to be changed to integral form.

## Discussion

The supplied `Single` value is converted to a signed 32-bit integer, rounding toward zero, and that value is returned. The result isn't particularly useful if the provided `Single` value is outside the range 0 to 4,294,967,295, inclusive.

## Example

```
Dim ul as UnsignedLong

ul = FixUL(100.5)            ' result is 100
```

# FlipBits

---

**Type**            Function returning Byte

**Invocation**    FlipBits(arg)

Parameter	Method	Type	Description
arg	ByVal	Byte	The value to be bit-wise reversed.

## Discussion

This function reverses the order of the bits in the supplied value and returns the result. This is useful, for example, if you want to send data using `ShiftOut()` but you want the least significant bit to be sent first.

## Example

```
Dim b as Byte

b = &B1011_0110
b = FlipBits(b)      ' result is &B0110_1101
```

# Floor

---

**Type**            Function returning Single

**Invocation**    Floor(arg)

Parameter	Method	Type	Description
arg	ByVal	Single	The value of which to compute the floor.

## Discussion

This function returns a `Single` value that is equal to the largest integer that is less than or equal to the supplied value, effectively rounding down to the nearest integer.

## Example

```
Dim flr as Single

flr = Floor(1.5)    ' result is 1.0
flr = Floor(-1.5)  ' result is -2.0
```

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also**        Ceiling, Fix

# Fmt

**Type**            Function returning String

**Invocation**    Fmt(val, fracDigits)

Parameter	Method	Type	Description
val	ByVal	Single	The value to convert to a string.
fracDigits	ByVal	Byte	The number of digits to produce following the decimal point.

## Discussion

This function returns a `String` that represents the value of the `val` parameter. The string will have a number of digits following the decimal point as specified by the `fracDigits` parameter. The maximum number of digits to the right of the decimal point is 6. If the `fracDigits` parameter specifies a larger number, it will be ignored and 6 will be used.

For very large and very small values, the returned string may be in scientific notation form. Also, some special cases are detected resulting in the strings shown in the table below. See the System Library function `SngClass()` for more information about the special values.

Special Value	Result <sup>1</sup>
NaN	" * . ** "
±Infinity	" & . && "
Denormalized value	" # . ## "

<sup>1</sup>The number of special characters following the decimal point will be the same as the number of fraction digits that would have been generated had the value been normal.

## Compatibility

In BasicX, the maximum number of fraction digits is 3 and the valid range of the value parameter is –999.0 to +999.0. If either of those ranges is exceeded, BasicX produces a string containing a single asterisk. Moreover, no provision is made for detecting special values such as NaN.

# Fraction

---

**Type**            Function returning Single

**Invocation**    Fraction(val)

Parameter	Method	Type	Description
val	ByVal	Single	The value from which the fractional part will be returned.

## Discussion

This function returns the fractional portion of the supplied value. The sign of the returned value will be the same as that of the value provided.

## Example

```
Dim frac as Single

frac = Fraction(1.5)      ' result is 0.5
frac = Fraction(-1.5)    ' result is -0.5
```

## Compatibility

This function is not available in BasicX compatibility mode.

# FreqOut

**Type** Subroutine

**Invocation** FreqOut(pin, freqA, freqB, duration)

Parameter	Method	Type	Description
pin	ByVal	Byte	The pin on which the signal will be created.
freqA	ByVal	Integer	The primary frequency, in Hertz.
freqB	ByVal	Integer	The secondary frequency, in Hertz.
duration	ByVal	Single or Integer	The duration of the signal, in seconds or units. See the discussion below for more details.

## Discussion

This routine generates a signal on the specified pin that is a digital approximation of two superimposed sine waves having the specified frequencies. The method used to produce the signal is a pseudo-PWM technique similar to that used for `DACPin()`. The output signal is actually purely digital, consisting of a series of precisely timed pulses that have an average value approximating that of two superimposed sine waves. This signal must be filtered to get an analog approximation. Depending on what you want to do with the signal, it may need to be amplified as well.

The duration of the signal may be specified in seconds by providing a `Single` value. Alternately, the time may be specified in units of approximately 1 millisecond by giving duration as an `Integer` or `UnsignedInteger` value. In either case, the valid range is approximately 1ms to 32 seconds.

Before beginning the frequency generation, the specified pin will be made an output. When the routine returns, the pin will still be an output.

If the pin is invalid, or both frequencies are zero, or the duration is zero, this routine does nothing. The maximum frequency that can be produced is approximately 14.4KHz. Requesting higher frequencies will produce undefined results.

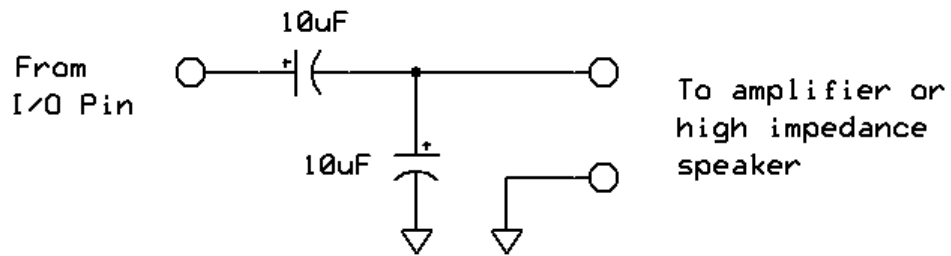
## Resource Usage

This routine uses the I/O Timer and disables interrupts until the signal generation is completed. RTC ticks are accumulated during the process so long signal durations should not cause a loss in RTC accuracy.

## Example

```
Call FreqOut(pin, 440, 880, 5.0) ' play middle C/high C for 5 seconds
```

Because of the high frequency nature of the pulse train used to synthesize the waveform some filtering is required. The example circuit below may be used to couple the output to a high impedance speaker (> 40  $\Omega$ ) or an amplifier. Note, however, that the signal is too large to be fed to the microphone input of an amplifier. Instead, the Auxiliary or Line input should be used.



### Compatibility

In BasicX, the RTC will lose time if the duration is longer than 1 millisecond. Also, the duration is documented as being limited to about 2.5 seconds

# Get1Wire

---

**Type**            Function returning Byte

**Invocation**    Get1Wire(pin)

Parameter	Method	Type	Description
pin	ByVal	Byte	The pin to be used for 1-Wire I/O.

## Discussion

This function retrieves a single bit using the 1-Wire protocol. To perform a 1-Wire operation, this function along with related 1-Wire routines must be used in the proper sequence. See the specifications of your 1-Wire device for more information.

The value returned will be either 0 or 1.

## Resource Usage

This routine uses the I/O Timer and disables interrupts for approximately 100µS.

## Example

```
Dim b as Byte  
  
b = Get1Wire(12)
```

**See Also**            Get1WireByte, Get1WireData, Put1Wire,  
Put1WireByte, Put1WireData, Reset1Wire

# Get1WireByte

**Type**            Function returning Byte

**Invocation**    Get1WireByte(pin)

Parameter	Method	Type	Description
pin	ByVal	Byte	The pin to be used for 1-Wire I/O.

## Discussion

This function reads a byte value (LSB first) using the 1-Wire protocol. It may be used instead of a series of calls to `Get1Wire()` in order to read a byte at a time. To perform a 1-Wire operation, this function along with related 1-Wire routines must be used in the proper sequence. See the specifications of your 1-Wire device for more information.

## Resource Usage

This routine uses the I/O Timer and disables interrupts for about 100µS for each bit received.

## Example

```
Dim b as Byte  
  
b = Get1WireByte(12)
```

## Compatibility

This routine is not available in BasicX compatibility mode.

**See Also**            Get1Wire, Get1WireData, Put1Wire,  
Put1WireByte, Put1WireData, Reset1Wire

# Get1WireData

**Type** Subroutine

**Invocation** Get1WireData(pin, data, count)

Parameter	Method	Type	Description
pin	ByVal	Byte	The pin to be used for 1-Wire I/O.
data	ByRef	any type	The variable to receive the bytes read.
count	ByVal	Byte	The number of bytes to read.

## Discussion

This function retrieves 1 or more bytes (each LSB first) using the 1-Wire protocol and writes them to the given variable. To perform a 1-Wire operation, this function along with related 1-Wire routines must be used in the proper sequence. See the specifications of your 1-Wire device for more information.

## Caution

If the variable provided has fewer bytes than the given count, subsequent memory locations will be altered, usually with undesirable consequences.

## Resource Usage

This routine uses the I/O Timer and disables interrupts for about 100µS for each bit received.

## Example

```
Dim ba(1 to 10) as Byte  
  
Call Get1WireData(12, ba, SizeOf(ba))
```

**See Also** Get1Wire, Get1WireByte, Put1Wire, Put1WireByte, Put1WireData, Reset1Wire

# GetADC (subroutine form)

Type	Subroutine
Invocation	GetADC(pin, val) GetADC(pin, val, fullScale) GetADC(pin, val, fullScale, offset)

Parameter	Method	Type	Description
pin	ByVal	Byte	The pin from which to read an analog voltage.
Val	ByRef	Single	The variable in which to return the result.
fullScale	ByVal	Single	The full-scale voltage value.
offset	ByVal	Integral	The offset to apply before scaling.

## Discussion

This function performs an analog-to-digital conversion on the signal present on the specified pin that must be one of the analog port pins (see the table below). The return value will be a 10-bit (for ATxmega-based devices) or 12-bit (for ATxmega-based devices) digital approximation of the input voltage with a range from zero to the reference voltage (see below). For the first form, the returned value is scaled to the range 0.0 to 1.0 and for the remaining forms it is scaled to the range 0.0 to value of the *fullScale* parameter. For the third form, the value of the offset parameter (which could be negative) is added to the 10-bit ADC value before scaling. This is useful, for example, for removing the effect of a non-zero offset voltage of the ADC.

You must make the pin an input before calling this routine.

For ATmega-based devices, the conversion is performed using the AVcc reference voltage (connected internally to Vcc on the ZX-24, ZX-24a, ZX-24p, ZX-24n, ZX-24r, ZX-24s, ZX-24e, ZX-24ae, ZX-24ne, ZX-24pe, ZX-24nu, ZX-24pu, ZX-24ru, ZX-24su, ZX-328nu, ZX-128e, ZX-128ne, ZX-1281e and ZX-1281ne). For ATxmega-based devices, the conversion is performed using a reference voltage of Vcc/1.6.

## Resource Usage

Only analog port pins may be used to perform an analog-to-digital conversion. The analog port pins vary depending on the ZX model and some ZX models have more analog input pins available. Also, on some devices (e.g. ZX-32n, ZX-32l and ZX-328nu) some of the pins are dedicated analog inputs; having no digital functions.

Analog Ports and Pins

ZX Models	Port	Pins	Port	Pins
ZX-24, ZX-24a, ZX-24p, ZX-24n, ZX-24r, ZX-24s	PortA	13-20	-	-
ZX-40, ZX-40a, ZX-40p, ZX-40n, ZX-40r, ZX-40s	PortA	33-40	-	-
ZX-44, ZX-44a, ZX-44p, ZX-44n, ZX-44r, ZX-44s	PortA	30-37	-	-
ZX-328n, ZX-328l	PortC	23-28	-	-
ZX-32n, ZX-32l	PortC	23-28, 19, 22	-	-
ZX-1281, ZX-1281n	PortF	54-61	-	-
ZX-1280, ZX-1280n	PortF	90-97	PortK	82-89
ZX-24x	PortA	13-20	PortB	7-9
ZX-32a4	PortA	40-44, 1-3	PortB	4-7
ZX-128a1	PortA	95-100, 1, 2	PortB	5-12
ZX-24e, ZX-24ae, ZX-24ne, ZX-24pe, ZX-24nu, ZX-24pu, ZX-24ru, ZX-24su	PortA	29-36	-	-
ZX-24xu	PortA	29-36	PortB	25-28
ZX-128e, ZX-128ne, ZX-1281e, ZX-1281ne	PortF	29-36	-	-
ZX-328nu	PortC	17-24	-	-

Most ZX processors contain a single analog-to-digital converter thus allowing only one conversion to be performed at a time. The conversion process takes approximately 220uS during which time the calling task will be awaiting conversion completion.

### **Compatibility**

Although the BasicX manual indicates that that it is not necessary to configure the pin to be an input before calling, tests indicate that it is, in fact, necessary to do so. Consequently, the behavior of this implementation matches the actual behavior of the BasicX platform. The second and third forms are not available in BasicX mode.

# GetADC (function form)

**Type** Function returning Integer

**Invocation** GetADC(pin)

Parameter	Method	Type	Description
pin	ByVal	Byte	The pin from which to read an analog voltage.

## Discussion

This function performs an analog-to-digital conversion of the voltage present on the specified pin which must be one of the analog port pins (see the table below). The return value will be a 10-bit digital approximation of the input voltage with a range from zero to the reference voltage (see below). The return value represents the measured voltage according to the formula  $V_{ref} * adcVal / FS$  where  $V_{ref}$  is the reference voltage,  $adcVal$  is the value returned by GetADC(), and FS is 1024 for mega-based devices and 4096 for xmega-based devices.

You must make the specified pin an input before calling this routine.

For ATmega-based devices, the conversion is performed using the AVcc reference voltage (connected internally to Vcc on the ZX-24, ZX-24a, ZX-24p, ZX-24n, ZX-24r, ZX-24s, ZX-24e, ZX-24ae, ZX-24ne, ZX-24pe, ZX-24nu, ZX-24pu, ZX-24ru, ZX-24su, ZX-328nu, ZX-128e, ZX-128ne, ZX-1281e and ZX-1281ne). For ATxmega-based devices, the conversion is performed using a reference voltage of Vcc/1.6.

## Resource Usage

Only analog port pins may be used to perform an analog-to-digital conversion. The analog port pins vary depending on the ZX model and some ZX models have more analog input pins available. Also, on some devices (e.g. ZX-32n, ZX-32l and ZX-328nu) some of the pins are dedicated analog inputs; having no digital functions.

**Analog Ports and Pins**

ZX Models	Port	Pins	Port	Pins
ZX-24, ZX-24a, ZX-24p, ZX-24n, ZX-24r, ZX-24s	PortA	13-20	-	-
ZX-40, ZX-40a, ZX-40p, ZX-40n, ZX-40r, ZX-40s	PortA	33-40	-	-
ZX-44, ZX-44a, ZX-44p, ZX-44n, ZX-44r, ZX-44s	PortA	30-37	-	-
ZX-328n, ZX-328l	PortC	23-28	-	-
ZX-32n, ZX-32l	PortC	23-28, 19, 22	-	-
ZX-1281, ZX-1281n	PortF	54-61	-	-
ZX-1280, ZX-1280n	PortF	90-97	PortK	82-89
ZX-24x	PortA	13-20	PortB	7-9
ZX-32a4	PortA	40-44, 1-3	PortB	4-7
ZX-128a1	PortA	95-100, 1, 2	PortB	5-12
ZX-24e, ZX-24ae, ZX-24ne, ZX-24pe, ZX-24nu, ZX-24pu, ZX-24ru, ZX-24su	PortA	29-36	-	-
ZX-24xu	PortA	29-36	PortB	25-28
ZX-128e, ZX-128ne, ZX-1281e, ZX-1281ne	PortF	29-36	-	-
ZX-328nu	PortC	17-24	-	-

Most ZX processors contain a single analog-to-digital converter thus allowing only one conversion to be performed at a time. The conversion process takes approximately 220uS during which time the calling task will be awaiting conversion completion.

## Compatibility

Although the BasicX manual indicates that that it is not necessary to configure the pin to be an input before calling, tests indicate that it is, in fact, necessary to do so. Consequently, the behavior of this implementation matches the actual behavior of the BasicX platform.

# GetBit

---

**Type**                Function returning Byte

**Invocation**        GetBit(var, bitNumber)

Parameter	Method	Type	Description
var	ByRef	any type	The variable from which the bit will be read.
bitNumber	ByVal	int8/16	The bit number to read.

## Discussion

This function extracts a single bit from memory beginning at the location of the specified variable. Bit numbers 0-7 are taken from the byte at the specified location, bit numbers 8-15 are taken from the subsequent byte, etc. In each case, the lower bit number corresponds to the least significant bit of the byte while the higher bit number corresponds to the most significant bit.

The return value will always be 0 or 1.

## Compatibility

In BasicX compatibility mode the second parameter must be a `Byte` type.

**See Also**            PutBit

# GetDate

**Type** Subroutine

**Invocation** GetDate(year, month, day)  
GetDate(year, month, day, dayNum)

Parameter	Method	Type	Description
year	ByRef	int16	The variable in which to place the year value (1999-2177).
month	ByRef	Byte	The variable in which to place the month value (1-12).
day	ByRef	Byte	The variable in which to place the day value (1-31).
dayNum	ByVal	integral	The day number to convert to year, month, day.

## Discussion

This routine decomposes a day number into the corresponding year, month and day components. The month value of 1 corresponds to January while 12 corresponds to December. If the day number is omitted, the value of `Register.RTCDay` is used.

Note that `Register.RTCDay` is initialized to zero on power-up or reset. This day number corresponds to January 1, 1999.

## Compatibility

The second form of this subroutine is not available in BasicX compatibility mode.

**See Also** GetDayNumber, GetDayOfWeek, GetDayOfYear, PutDate

# GetDayNumber

---

**Type**                      Function returning UnsignedInteger

**Invocation**            GetDayNumber(dayOfYear, year)  
                              GetDayNumber(year, month, day)

Parameter	Method	Type	Description
dayOfYear	ByVal	integral	The ordinal day number of the year (Jan 1 = 1).
year	ByVal	integral	The year (1999 to 2178).
month	ByVal	integral	The month (1 to 12).
day	ByVal	integral	The day (1 to 31).

## Discussion

This routine computes the day number corresponding to the day of the year specified by the parameters. Day number 0 is January 1, 1999. The first form is used when you have a day number and year. (The days in a year are numbered beginning with 1.) The second form is used when you have the year, month and day.

## Examples

```
Dim dayNum as UnsignedInteger

dayNum = GetDayNumber(59, 2005)
dayNum = GetDayNumber(2006, 3, 20)
```

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also**                GetDate, GetDayOfWeek, GetDayOfYear, PutDate

# GetDayOfWeek

**Type**           Function returning Byte

**Invocation**    GetDayOfWeek()  
                  GetDayOfWeek(dayNum)

Parameter	Method	Type	Description
dayNum	ByVal	integral	The day number to convert to year, month, day.

## Discussion

This routine computes the day of the week corresponding to a day number. If the day number is omitted, the value of `Register.RTCDay` is used.. A return value of 1 corresponds to Sunday and a value of 7 corresponds to Saturday with the remaining days falling in order in between. There are built-in constants that represent the day numbers as shown in the table below.

Day of Week Constants	
Constant	Value
<code>zxSunday</code>	1
<code>zxMonday</code>	2
<code>zxTuesday</code>	3
<code>zxWednesday</code>	4
<code>zxThursday</code>	5
<code>zxFriday</code>	6
<code>zxSaturday</code>	7

Note that `Register.RTCDay` is initialized to zero on power-up or reset. This day number corresponds to Friday, January 1, 1999.

**See Also**       GetDate, GetDayNumber, GetDayOfYear

# GetDayOfYear

---

**Type**            Function returning UnsignedInteger

**Invocation**    GetDayOfYear(dayNum)  
                  GetDayOfYear(dayNum, year)

Parameter	Method	Type	Description
dayNum	ByVal	integral	The day number to convert to day of year and year.
year	ByRef	int16	The variable in which the year will be stored.

## Discussion

This routine computes the day of the year and the year corresponding to a day number (such as represented by `Register.RTCDay`). The first day of the year is numbered 1. If the second parameter is present, the variable to which it refers will receive the year value.

## Example

```
Dim dayOfYear as UnsignedInteger
Dim year as UnsignedInteger

dayOfYear = GetDayOfYear(Register.RTCDay, year)
```

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also**        `GetDate`, `GetDayNumber`, `GetDayOfWeek`

# GetEEPROM

---

**Type** Subroutine

**Invocation** GetEEPROM(addr, var, count)

Parameter	Method	Type	Description
addr	ByVal	Long	The Program Memory address from which to begin reading.
var	ByRef	any type	The variable in which to place the data read.
count	ByVal	int16	The number of bytes to read.

## Discussion

This routine is provided for compatibility with BasicX. The more aptly named GetProgMem() should be used by new applications.

**See Also** GetProgMem, PutProgMem

# GetElapsedMicroTime

**Type** Function returning UnsignedLong

**Invocation** GetElapsedMicroTime(timeBuf)  
GetElapsedMicroTime(timeBuf, timeBuf2)

Parameter	Method	Type	Description
timeBuf	ByRef	array of Byte	The earlier time data.
timeBuf2	ByRef	array of Byte	The later time data.

## Discussion

This function is useful for implementing higher precision timing than can be obtained using Register.RTCTick. It calculates the elapsed time between an earlier instant in time (as captured by GetMicroTime()) and a later instant in time. If the second parameter is not provided, the later instant is represented by the RTC time data at the time of the call.

The return value has units of the period of the frequency at which the TCNT register of the RTC timer changes, typically 1/230.4KHz or about 4.34uS. The value of Register.RTCTimerFrequency (typically 230.4KHz) may be useful for converting the return value to seconds.

The array is expected to contain at least 5 bytes, populated by a previous call to GetMicroTime(). The return value will range from 0 to the equivalent of about 15,000 seconds. A return value of &HFFFFFFF indicates that an overflow has occurred, i.e. an elapsed time that is too large to represent.

Although this function does not take into account the value of the “day” counter of the RTC, it does properly handle an elapsed time that spans one midnight rollover.

## Example

```
Dim t0(1 to 5) as Byte
Call GetMicroTime(t0)
<other code>
Dim delta as UnsignedLong
delta = GetElapsedMicroTime(t0)
```

## Compatibility

This function is not available on ZX models that are based on the ATmega32 processor (e.g. the ZX-24). Moreover, it is not available in BasicX compatibility mode.

**See Also** GetMicroTime

# GetMicroTime

**Type** Subroutine

**Invocation** GetMicroTime(timeBuf)

Parameter	Method	Type	Description
timeBuf	ByRef	array of Byte	A buffer to be populated with time data.

## Discussion

This routine populates the provided buffer, which must be at least 5 bytes long, with high resolution timing data. This information is most useful in conjunction with a subsequent call to `GetElapsedMicroTime()` to compute an elapsed time.

The low byte of the buffer is set to the value of the TCNT register at the moment of the call. The next four bytes of the buffer represent twice the RTC tick value plus the low bit of the RTC fast tick value, essentially an accumulator of the day's fast RTC ticks that typically occur at 1024Hz.

## Example

```
Dim start(1 to 5) as Byte
Call GetMicroTime(start)
```

## Compatibility

This subroutine is not available on ZX models that are based on the ATmega32 processor (e.g. the ZX-24). Moreover, it is not available in BasicX compatibility mode.

**See Also** GetElapsedMicroTime

# GetNibble

---

**Type**            Function returning Nibble

**Invocation**    GetNibble(var, nibbleNumber)

Parameter	Method	Type	Description
var	ByRef	any type	The variable from which the nibble will be read.
nibbleNumber	ByVal	int8/16	The nibble number to read.

## Discussion

This function extracts a nibble value from memory beginning at the location of the specified variable. Nibble numbers 0-1 are taken from the byte at the specified location, nibble numbers 2-3 are taken from the subsequent byte, etc. In each case, the lower nibble number corresponds to the least significant four bits of the byte while the higher nibble number corresponds to the most significant four bits of the byte.

The return value will always be in the range 0 to 15.

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also**        PutNibble

# GetPersistent

---

**Type** Subroutine

**Invocation** GetPersistent(addr, var, count)

Parameter	Method	Type	Description
addr	ByVal	int16	The address in Persistent Memory from which to read.
var	ByRef	any type	The variable in which to place the data read.
count	ByVal	int8/16	The number of bytes to read.

## Discussion

This routine reads one or more bytes from Persistent Memory and places them in RAM beginning at the location of the specified variable. Note that if a number of bytes is specified that is larger than the given variable, adjacent memory will be overwritten, possibly with detrimental results.

The DataAddress property is useful to get the address of a Persistent Memory data item.

## Example

```
Dim pvar(1 to 10) as PersistentByte
Dim var(1 to 10) as Byte

Call GetPersistent(pvar.DataAddress, var, SizeOf(pvar))
```

## Compatibility

This routine is not available in BasicX compatibility mode.

**See Also** PutPersistent

# GetPin

---

**Type**            Function returning Byte

**Invocation**    GetPin(pin)

Parameter	Method	Type	Description
pin	ByVal	Byte	The pin to read.

## Discussion

If the specified pin is configured to be an input, this function reads the state of the pin and returns the value 0 or 1 corresponding to logic zero and logic one. If the pin number is invalid the result is undefined. If the pin is configured to be an output, it is reconfigured to be an input in tri-state mode before reading the input value.

## Compatibility

The BasicX documentation says that the result is undefined if `GetPin()` is called for a pin that is configured as an output. Tests show that the pin is actually reconfigured to be an input in tri-state mode. The ZBasic implementation of `GetPin()` does the same.

**See Also**        PutPin

# GetProgMem

---

**Type** Subroutine

**Invocation** GetProgMem(addr, var, count)

Parameter	Method	Type	Description
addr	ByVal	Long	The Program Memory address from which to begin reading.
var	ByRef	any type	The variable in which to place the data read.
count	ByVal	int16	The number of bytes to read.

## Discussion

This routine reads one or more bytes from Program Memory (where the user program is stored) and places them in RAM beginning at the location of the specified variable. Note that if a number of bytes is specified that is larger than the given variable, adjacent memory will be overwritten, possibly with detrimental results.

**See Also** PutProgMem

# GetQueue

**Type** Subroutine

**Invocation** GetQueue(queue, var, count)  
GetQueue(queue, var, count, timeLimit, timeoutFlag)

Parameter	Method	Type	Description
queue	ByRef	array of Byte	The queue from which to read data.
var	ByRef	any type	The variable to which to write the data from the queue.
count	ByVal	int16	The number of bytes to read from the queue.
timeLimit	ByVal	Single	The amount of time to wait for data availability, in seconds.
timeoutFlag	ByRef	Boolean	A variable to indicate if the call timed out.

## Discussion

This routine has two forms. The first form simply attempts to read the given number of bytes from the specified queue and place them in RAM beginning at the location of the given variable. In this case, the routine will not return until requested number of bytes is available. If not enough data is placed in the queue, the routine will never return. Note that if the calling task is locked and the queue contains insufficient space for the data to be written data when this routine is called, the task will be unlocked to allow other tasks to run.

The second form specifies, additionally, a `timeLimit` and a `flag` variable. In this case, if the requested number of bytes does not become available within the specified time, the routine will return, having transferred zero bytes, and the `flag` variable will be set to `True` indicating that the routine timed out. If the requested number of bytes does become available before the specified time expires, that number of bytes will be removed from the queue and transferred to the specified memory location and the `flag` variable will be set to `False` indicating that the transfer did not time out. The resolution of the timeout value is the same as the RTC tick, approximately 1.95mS.

In either case, if data is removed from the queue it is written to RAM beginning at the location of the specified variable. Note that if the count specifies a number of bytes larger than the variable, the additional bytes will be written to subsequent RAM locations. This may have exactly the effect that you intended but depending on the function of those subsequent bytes it may have a deleterious effect on your program.

Note that before any queue operations are performed, the queue data structure must be initialized. See the discussion of `OpenQueue()` for more details. Also, attempting to retrieve data from a queue that has been assigned to a Com port as the transmit queue will produce undefined results.

Although this subroutine will accept a String variable as the second parameter it is generally not useful to do so because the control bytes at the beginning of the string will be overwritten. If you want to populate a string using data from a queue the alternatives are:

- 1) Build up the string by retrieving individual characters one by one and appending them to a string.
- 2) Retrieve a group of bytes to a Byte array and use the `MakeString()` function to create a string from the constituent bytes.
- 3) Use the `GetQueueStr()` function to obtain a string containing characters from the queue.

## Example

```
Dim inQueue(1 to 40) as Byte
Dim lval as Long

Call OpenQueue(inQueue, SizeOf(inQueue))
```

```
Call GetQueue(inQueue, lval, SizeOf(lval))
```

Alternately,

```
Dim inQueue(1 to 40) as Byte  
Dim lval as Long  
Dim timeOut as Boolean
```

```
Call OpenQueue(inQueue, SizeOf(inQueue))  
Call GetQueue(inQueue, lval, SizeOf(lval), 1.0, timeOut)
```

### Compatibility

BasicX allows any type for the first parameter. The ZBasic implementation requires that it be an array of Byte.

The BasicX manual indicates that the range of values for the timeLimit parameter is 0.0 to 65.536 seconds implying a 1ms resolution. This implementation has a 1.95ms resolution and a range of 0.0 to about 127.0 seconds.

**See Also**      GetQueueStr, OpenQueue

# GetQueueBufferSize

---

**Type**                Function returning Integer

**Invocation**        GetQueueBufferSize(queue)

Parameter	Method	Type	Description
queue	ByRef	array of Byte	The queue of interest.

## Discussion

This function returns the number of bytes of data space in a queue that has been properly initialized using `OpenQueue()`. Note that the data space in a queue is somewhat less than the number of bytes in the byte array comprising the queue due to space required for queue management information. See `OpenQueue()` for more details.

## Compatibility

BasicX allows any type for the first parameter. The ZBasic implementation requires that it be an array of `Byte`.

**See Also**            GetQueueCount, GetQueueSpace

# GetQueueCount

---

**Type**            Function returning Integer

**Invocation**    GetQueueCount(queue)

Parameter	Method	Type	Description
queue	ByRef	array of Byte	The queue of interest.

## Discussion

This function returns the number of bytes of data currently in the specified queue. It is useful to note that this value subtracted from that returned by `GetQueueBufferSize()` indicates the remaining available data space in the queue.

Note that before any queue operations are performed, the queue data structure must be initialized. See the discussion of `OpenQueue()` for more details.

## Compatibility

BasicX allows any type for the first parameter. The ZBasic implementation requires that it be an array of `Byte`.

**See Also**            `GetQueueBufferSize`, `GetQueueSpace`

# GetQueueSpace

---

**Type**                Function returning Integer

**Invocation**        GetQueueSpace(queue)

Parameter	Method	Type	Description
queue	ByRef	array of Byte	The queue of interest.

## Discussion

This function returns the number of bytes of space remaining in the specified queue, effectively the same result as the expression `GetQueueBufferSize() - GetQueueCount()`.

Note that before any queue operations are performed, the queue data structure must be initialized. See the discussion of `OpenQueue()` for more details.

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also**            GetQueueBufferSize, GetQueueCount

# GetQueueStr

---

**Type**                Function returning String

**Invocation**        GetQueueStr(queue) or  
                         GetQueueStr(queue, maxChars)

Parameter	Method	Type	Description
queue	ByRef	array of Byte	The queue of interest.
maxChars	ByVal	integral	The maximum number of characters to retrieve.

## Discussion

This function extracts a number of characters from the specified queue and returns a string populated with those characters. The number of characters is limited to the lesser of 1) the number of characters in the queue at the time of the call, 2) the value of `maxChars` (if specified), and 3) the maximum number of characters allowed in a string.

Note that before any queue operations are performed, the queue data structure must be initialized. See the discussion of `OpenQueue( )` for more details. Also, attempting to retrieve data from a queue that has been assigned to a Com port as the transmit queue will produce undefined results.

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also**            GetQueue, OpenQueue

# GetTime

---

**Type** Subroutine

**Invocation** GetTime(hour, minute, seconds)  
GetTime(hour, minute, seconds, tick)

Parameter	Method	Type	Description
hour	ByRef	Byte	The variable in which to place the hour value (0-23).
minute	ByRef	Byte	The variable in which to place the minutes value (0-59).
seconds	ByRef	Single	The variable in which to place the seconds value.
tick	ByVal	integral	The tick count to decompose.

## Discussion

This routine decomposes a tick count into the equivalent hour, minute and second components. If the tick count is omitted, the value of `Register.RTCTick` is used. The resolution of the `seconds` value is approximately 1.95ms.

Note that `Register.RTCTick` is initialized to zero on power-up or reset. This corresponds to 0:00:00.

## Compatibility

Explicitly specifying the tick count to use is not supported in BasicX compatibility mode.

# GetTimestamp

---

**Type** Subroutine

**Invocation** GetTimestamp(year, month, day, hour, minute, seconds)

Parameter	Method	Type	Description
year	ByRef	int16	The variable in which to place the year value (1999-2177).
month	ByRef	Byte	The variable in which to place the month value (1-12).
day	ByRef	Byte	The variable in which to place the day value (1-31).
hour	ByRef	Byte	The variable in which to place the hour value (0-23).
minute	ByRef	Byte	The variable in which to place the minutes value (0-59).
seconds	ByRef	Single	The variable in which to place the seconds value.

## Discussion

This routine decomposes the value of `Register.RTCDay` and `Register.RTCTick` into year, month, day, hour, minute and second components. See `GetDate()` and `GetTime()` for more details.

# HiByte

---

**Type**                Function returning Byte

**Invocation**        HiByte(val)

Parameter	Method	Type	Description
val	ByVal	numeric	The value of which the high byte is desired.

## Discussion

This function returns the most significant byte of the specified value except that if the specified value is a Byte value, the result will be zero.

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also**            HiWord, LoByte, LoWord, MidWord

# HiWord

---

**Type**            Function returning UnsignedInteger

**Invocation**    HiWord(val)

Parameter	Method	Type	Description
val	ByVal	numeric	The value of which the high word is desired.

## Discussion

This function returns the most significant word of the specified value except that if the specified value is a Byte, Integer or UnsignedInteger value, the result will be zero.

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also**        HiByte, LoByte, LoWord, MidWord

# I2CCmd

**Type** Function returning Integer

**Invocation** I2CCmd(channel, slaveID, writeCnt, writeData, readCnt, readData)

Parameter	Method	Type	Description
channel	ByVal	Byte	The I2C channel number (0-4).
slaveID	ByVal	Byte	The identifier of the I2C slave device (in the 7 high order bits).
writeCnt	ByVal	integral	The number of bytes to write (0 – 65535).
writeData	ByRef	any type	The variable containing the data to write.
readCnt	ByVal	integral	The number of bytes to read (0 – 65535).
readData	ByRef	any type	The variable in which to place the data read.

## Discussion

The routine allows you to send and/or receive data from an I2C device. The specified channel must have been previously opened with a call to `OpenI2C()`. If the channel has not been opened, the results are undefined. If an invalid channel is specified or if both `writeCnt` and `readCnt` are zero, the function returns immediately without doing anything and the return value is zero. You may specify the value 0 for `writeData` or `readData` if no data is being provided for writing or reading, respectively. If you do this, the corresponding data count parameter must also be zero or the compiler will issue an error message.

The execution of the I2C command sequence begins by issuing an I2C start condition on the SDA and SCL lines. Next, if `writeCnt` is non-zero the given `slaveID` value is transmitted (with the least significant bit being zero) followed by the specified number of bytes taken from `writeData`. Then, if `readCnt` is non-zero the `slaveID` value is transmitted again but with the least significant bit being one and the specified number of bytes is read from the slave and placed in `readData`. Finally, an I2C stop condition is issued followed by both the SDA and SCL lines returning to the idle state.

The return value may be negative, zero or positive. If the return value is negative it signifies that the slave failed to positively acknowledge one of the transmitted bytes. The value is the negative of the number of bytes that were not successfully transmitted. If the slave fails to positively acknowledge either the slave ID or the first data byte, the return value will be the negative of the `writeCnt` parameter value. If the return value is non-negative it represents the number of data bytes read from the slave and placed in `readData`.

## Example

```
Dim odata(1 to 2) as Byte, idata(1 to 10) as Byte
Dim ival as Integer

Call OpenI2C (1, 12, 13)
odata(1) = &H06
odata(2) = &H00
ival = I2CCmd(1, &H7e, 2, odata(1), 10, idata(1))
```

## Resource Usage

This function uses the I/O Timer for channels 1 to 4. If the timer is already in use, the result and the return value are both undefined. Interrupts are disabled for periods of about 9 times the selected I2C bit time plus additional amounts due to slave clock stretching for each byte sent and received (interrupts are reenabled between bytes). However, RTC ticks are accumulated during the process so the RTC should not lose time.

**Compatibility**

This function is not available in BasicX compatibility mode.

**See Also**      `OpenI2C`, `I2CGetByte`, `I2CPutByte`, `I2CStart`, `I2CStop`, `CloseI2C`

# I2CGetByte

**Type**                Function returning Byte

**Invocation**        I2CGetByte(channel, ackValue)

Parameter	Method	Type	Description
channel	ByVal	Byte	The I2C channel number (0-4).
ackValue	ByVal	Boolean	The value to send to the slave in acknowledgement of the data byte.

## Discussion

This function retrieves a data value from an I2C slave and responds to the receipt of that data by sending back the specified acknowledgement value. The value returned by this function is the data byte received from the slave.

This function can be used in conjunction with `I2CStart()`, `I2CPutByte()` and `I2CStop()` to perform a lower level interaction with an I2C slave device. Knowledge of the I2C protocol and the specifications of the particular I2C device are required in order to use this function.

If the specified I2C channel has not been properly prepared using `OpenI2C()`, the results are undefined. If an invalid channel number is specified, the function returns immediately without doing anything.

## Resource Usage

This function uses the I/O Timer for channels 1 to 4. If the timer is already in use, the function will do nothing and the return value is undefined. Interrupts are disabled for about 9 times the selected I2C bit time plus additional amounts due to slave clock stretching. However, RTC ticks are accumulated during the process so the RTC should not lose time.

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also**            `OpenI2C`, `Closel2C`, `I2CPutByte`, `I2CStart`, `I2CStop`, `I2CCmd`

# I2CPutByte

**Type**                Function return Boolean

**Invocation**        I2CPutByte(channel, dataVal)

Parameter	Method	Type	Description
channel	ByVal	Byte	The I2C channel number (0-4).
dataVal	ByVal	Byte	The data byte to send to the slave.

## Discussion

This function transmits a data value to an I2C slave and reads the acknowledgement bit returned by the slave. The value returned by this function is the value of the acknowledge bit received from the slave device – a positive acknowledgement results in a True value being returned.

This function can be used in conjunction with `I2CStart()`, `I2CGetByte()` and `I2CStop()` to perform a lower level interaction with an I2C slave device. Knowledge of the I2C protocol and the specifications of the particular I2C device are required in order to use this function.

If the specified I2C channel has not been properly prepared using `OpenI2C()`, the results are undefined. If an invalid channel number is specified, the function returns immediately without doing anything.

## Resource Usage

This function uses the for channels 1 to 4. If the timer is already in use, the function will do nothing and the return value is undefined. Interrupts are disabled for about 9 times the selected I2C bit time plus additional amounts due to slave clock stretching. However, RTC ticks are accumulated during the process so the RTC should not lose time.

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also**            `OpenI2C`, `Closel2C`, `I2CGetByte`, `I2CStart`, `I2CStop`, `I2CCmd`

# I2CStart

**Type** Subroutine

**Invocation** I2CStart(channel)

Parameter	Method	Type	Description
channel	ByVal	Byte	The I2C channel number (0-4).

## Discussion

This subroutine initiates an I2C bus cycle by implementing the proper sequence of transitions on the SDA and SCL lines.

This subroutine can be used in conjunction with `I2CGetByte()`, `I2CPutByte()` and `I2CStop()` to perform a lower level interaction with an I2C slave device. Knowledge of the I2C protocol and the specifications of the particular I2C device are required in order to use this function.

If the specified I2C channel has not been properly prepared using `OpenI2C()`, the results are undefined. If an invalid channel number is specified, the function returns immediately without doing anything.

## Compatibility

This subroutine is not available in BasicX compatibility mode.

**See Also** OpenI2C, CloseI2C, I2CGetByte, I2CPutByte, I2CStop, I2CCmd

# I2CStop

**Type** Subroutine

**Invocation** I2CStop(channel)

Parameter	Method	Type	Description
channel	ByVal	Byte	The I2C channel number (0-4).

## Discussion

This subroutine terminates an I2C bus cycle by implementing the proper sequence of transitions on the SDA and SCL lines.

This subroutine can be used in conjunction with `I2CStart()`, `I2CGetByte()` and `I2CPutByte()` to perform a lower level interaction with an I2C slave device. Knowledge of the I2C protocol and the specifications of the particular I2C device are required in order to use this function.

If the specified I2C channel has not been properly prepared using `OpenI2C()`, the results are undefined. If an invalid channel number is specified, the function returns immediately without doing anything.

## Compatibility

This subroutine is not available in BasicX compatibility mode.

**See Also** OpenI2C, CloseI2C, I2CGetByte, I2CPutByte, I2CStart, I2CCmd

# IIf

**Type** Function returning the same type as the second parameter

**Invocation** IIf(testExpr, trueExpr, falseExpr)

Parameter	Method	Type	Description
testExpr	ByVal	Boolean	The expression to evaluate, the result of which determine which expression value will be returned.
trueExpr	ByVal	any type	The value to return if <i>testExpr</i> evaluates to True.
falseExpr	ByVal	any type	The value to return if <i>testExpr</i> evaluates to False.

## Discussion

This function is adapted from VB6 where it is sometimes called “Immediate If”. It is used to select one of two values based on the result of a test. Employing this function will generally result in less code than an equivalent If-Then-Else structure. On the other hand, the execution of this function does use more stack space than an equivalent If-Then-Else structure. Also, it is important to note that using this function is not exactly the same as an If-Then-Else because both the *trueExpr* and the *falseExpr* are always evaluated. This difference is only significant if the evaluation of one or both of these expressions has side effects.

Note that *trueExpr* and *falseExpr* must have the same type or be of compatible types.

## Examples

```
Dim a as Byte
Dim b as UnsignedInteger
Dim u as UnsignedInteger

u = IIf(a > 3, 5, b)

Debug.Print IIf(a = 5, "Hello", "Goodbye")
```

## Compatibility

This function is not available in BasicX compatibility mode. Also, it is only supported by ZX firmware v1.1.0 or later.

# InputCapture

**Type** Subroutine

**Invocation** InputCapture(data, count, flags)  
InputCapture(data, count, flags, timeout)

Parameter	Method	Type	Description
data	ByRef	array of UnsignedInteger	The array in which pulse width information will be stored.
count	ByVal	int16	The number of pulse widths to store. This should be no larger than the number of entries in the passed array.
flags	ByVal	Byte	A value of zero requests that a falling edge begin the capture process while a value of 1 indicates a rising edge. All other values are reserved.
timeout	ByVal	Integral	If non-zero, this parameter specifies a timeout value that, if exceeded, will terminate the input capture process.

## Discussion

Invoking this routine is equivalent to the call `InputCaptureEx(pin, data, count, flags)` or `InputCaptureEx(pin, data, count, flags, timeout)` where `pin` is the default input capture pin for the device as shown in the table below. See the description of `InputCaptureEx()` for more detailed information.

Default Input Capture Pin	
ZX Models	Pin
ZX-24, ZX-24a, ZX-24p, ZX-24n, ZX-24r, ZX-24s	12, D.6
ZX-40, ZX-40a, ZX-40p, ZX-40n, ZX-40r, ZX-40s	20, D.6
ZX-44, ZX-44a, ZX-44p, ZX-44n, ZX-44r, ZX-44s	15, D.6
ZX-24e, ZX-24ae, ZX-24ne, ZX-24pe, ZX-24nu, ZX-24pu, ZX-24ru, ZX-24su	14, D.6
ZX-328n, ZX-328l	14, B.0
ZX-32n, ZX-32l	12, B.0
ZX-1281, ZX-1281n	29, D.4
ZX-1280, ZX-1280n	47, D.4
ZX-24x, ZX-24xu	12, C.0
ZX-32a4	10, C.0
ZX-128a1	15, C.0
ZX-128e, ZX-128ne, ZX-1281e, ZX-1281ne	8, D.4
ZX-328nu	11, B.0

## Example

```
Dim pd(1 to 5) as UnsignedInteger

Call PutPin(12, zxInputTriState)
Call InputCapture(pd, UBound(pd), 1)
```

## Compatibility

The BasicX compiler erroneously allows any variable for the first parameter. This implementation requires the data type to be `UnsignedInteger` or `Integer` although it needn't be an array. For practical purposes, an array will almost always be used.

In BasicX compatibility mode, the use of the optional fourth parameter is not supported. Also, because the processor runs at twice the speed of the BX-24 processor, the default time unit is one half of that provided for by BasicX.

See the description of InputCaptureEx() for a discussion of which ISRs are required.

# InputCaptureEx

**Type** Subroutine

**Invocation** InputCaptureEx(pin, data, count, flags)  
InputCaptureEx(pin, data, count, flags, timeout)

Parameter	Method	Type	Description
pin	ByVal	Byte	The input capture pin to use.
data	ByRef	array of UnsignedInteger	The array in which pulse width information will be stored.
count	ByVal	int16	The number of pulse widths to store. This should be no larger than the number of entries in the passed array.
flags	ByVal	Byte	A value of zero requests that a falling edge begin the capture process while a value of 1 indicates a rising edge. All other values are reserved.
timeout	ByVal	integral	If non-zero, this parameter specifies a timeout value that, if exceeded, will terminate the input capture process.

## Discussion

This routine collects timing data from a pulse train applied to the specified input capture pin and stores it in the specified array. The stored data reflects the width of the successive high and low portions of the pulse train. If any segment is longer than can be represented in a 16-bit value, the stored value will be 65535 (&Hffff) and the immediately following value, if any, will be meaningless.

Prior to commencing the input capture process all of the elements of the data array are initialized with the value 65534 (&Hffff). This fact can be used to determine the actual number of timing data stored in the array during input capture.

The stored values represent the number of I/O Timer ticks (by default about 67.8ns for 14.7MHz devices) measured for each segment of the pulse train. However, the value of `Register.TimerSpeed1` may be changed to allow longer pulse widths to be measured. See the section on Timers for more information.

Due to the overhead of servicing the input capture interrupt and possible RTC interrupts the shortest interval (high or low segment) that can be reliably measured corresponds to about 300 CPU cycles (about 21µs for 14.7MHz devices). If an input waveform had a 50% duty cycle this would correspond to about 24KHz. Additional interrupt sources may increase the minimum interval that can be measured reliably.

If the optional `timeout` parameter is specified and is non-zero, the Input Capture process will be terminated if  $N * 65536$  I/O Timer ticks occur (where N is the value of the `timeout` parameter) before the specified number of datapoints has been stored. This gives a range of possible timeout values from about 4.5mS to 290 seconds with a resolution of 4.5mS (using the default value of `Register.TimerSpeed1`) for 14.7MHz devices.

The calling task will be suspended until the specified number of datapoints has been stored, the timeout value is exceeded or the task is resumed using `ResumeTask()`. Other tasks will be allowed to run but you must be careful to not call any routines that may disable interrupts for long periods of time because that could interfere with the accuracy of the input capture timing.

## Resource Usage

This routine utilizes a timer to collect the timing information of the pulse train. The table below indicates which timer is used and the corresponding input pin for the supported channels. The corresponding timer busy flag (e.g. `Register.Timer1Busy`) will be set `True` for the duration of the input capture operation. Also, on the ZX-24, ZX-24a, ZX-24n, ZX-24p, ZX-24r and ZX-24s the input capture pin is common with

PortC bit 0. This means that you should set pin 12 to be an input (either tri-state or pull-up) when you want to use InputCapture() so that it doesn't interfere with the pulse train to be measured. This routine cannot be used at the same time as OutputCapture() or OutputCaptureEx() when that routine requires the same timer.

**Valid Input Capture Pins**

<b>ZX Models</b>	<b>Timer1</b>	<b>Timer3</b>	<b>Timer4</b>	<b>Timer5</b>
ZX-24, ZX-24a, ZX-24p, ZX-24n	12, D.6	-	-	-
ZX-40, ZX-40a, ZX-40p, ZX-40n	20, D.6	-	-	-
ZX-44, ZX-44a, ZX-44p, ZX-44n	15, D.6	-	-	-
ZX-24r, ZX-24s	12, D.6	B.5	-	-
ZX-40r, ZX-40s	20, D.6	6, B.5	-	-
ZX-44r, ZX-44s	15, D.6	1, B.5	-	-
ZX-24e, ZX-24ae, ZX-24ne, ZX-24pe, ZX-24nu, ZX-24pu	14, D.6	-	-	-
ZX-24ru, ZX-24su	14, D.6	23, B.5	-	-
ZX-328n, ZX-328l	14 B.0	-	-	-
ZX-32n, ZX-32l	12 B.0	-	-	-
ZX-1281, ZX-1281n	29, D.4	9, E.7	-	-
ZX-1280, ZX-1280n	47, D.4	9, E.7	35, L.0	36, L.1
ZX-128e, ZX-128ne, ZX-1281e, ZX-1281ne	8, D.4	13, E.7	-	-
ZX-328nu	11, B.0	-	-	-

**Valid Input Capture Pins**

<b>ZX Models</b>	<b>TimerC0</b>	<b>TimerD0</b>	<b>TimerD1</b>	<b>TimerE0</b>	<b>TimerE1</b>	<b>TimerF0</b>	<b>TimerF1</b>
ZX-24x	12, C.0	26, D.0	D.4	25, E.0	-	-	-
ZX-32a4	10, C.0	20, D.0	24, D.4	28, E.0	-	-	-
ZX-128a1	15, C.0	25, D.0	29, D.4	35, E.0	39, E.4	45, F.0	49, F.4
ZX-24xu	12, C.0	20, D.0	16, D.4	24, E.0	-	-	-

For native code devices, the table below gives the ISRs that may be loaded if your program uses InputCaptureEx(). If the compiler cannot determine which specific timer ISR is required by analyzing the parameters used, all listed ISRs will be included.

**ISRs Required**

<b>Underlying CPU</b>	<b>ISR Name</b>
mega328P, mega644P	Timer1_Capt, Timer1_OVF
mega1284P	Timer1_Capt, Timer1_OVF, Timer3_Capt, Timer3_OVF
mega1281, mega128	Timer1_Capt, Timer1_OVF, Timer3_Capt, Timer3_OVF
mega1280	Timer1_Capt, Timer1_OVF, Timer3_Capt, Timer3_OVF, Timer4_Capt, Timer4_OVF, Timer5_Capt, Timer5_OVF
xmega32A4	TimerC0_CCA, TimerC0_OVF, TimerD0_CCA, TimerD0_OVF, TimerD1_CCA, TimerD1_OVF, TimerE0_CCA, TimerE0_OVF
xmega128A1	TimerC0_CCA, TimerC0_OVF, TimerD0_CCA, TimerD0_OVF, TimerD1_CCA, TimerD1_OVF, TimerE0_CCA, TimerE0_OVF, TimerE1_CCA, TimerE1_OVF, TimerF0_CCA, TimerF0_OVF, TimerF1_CCA, TimerF1_OVF

### **Example**

```
Dim pd(1 to 5) as UnsignedInteger  
  
Call PutPin(D.6, zxInputTriState)  
Call InputCaptureEx(D.6, pd, UBound(pd), 1)
```

### **Compatibility**

This routine is not available in BasicX compatibility mode.

# LBound

**Type**            Function returning Integer

**Invocation**    LBound(array) or  
                  LBound(array, dimension)

Parameter	Method	Type	Description
array	ByRef	any array	The array about which the bound information is desired.
dimension	ByVal	int16	The dimension of interest. See the description for more details.

## Discussion

This function returns the lower bound of the specified array. There are two forms. The first requires only the array to be specified. In this case, the lower bound of the first dimension of the array is returned. The second form specifies a dimension number, the valid range of which is 1 to the number of dimensions of the array. The array may be located in RAM, Program Memory or Persistent Memory.

Note that the use of this function instead of hard-coding values makes your code easier to maintain.

## Example

```
Dim ba(1 to 20) as Byte
Dim ma(3 to 5, -6 to 7) as Byte
Dim i as Integer

i = LBound(ba)           ' the result is 1
i = LBound(ma)           ' the result is 3
i = LBound(ma, 1)        ' the result is 3
i = LBound(ma, 2)        ' the result is -6
```

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also**        UBound

# LCase

---

**Type**            Function returning String

**Invocation**    LCase(str)

Parameter	Method	Type	Description
str	ByVal	String	The string to be changed to lower case.

## Discussion

This function returns a new string containing the same characters as the passed string except that all upper case characters will be replaced with lower case characters.

## Example

```
Dim s as String, s1 as String
s = "Hello, world!"
s2 = LCase(s)                    ' the result will be "hello, world!"
```

**See Also**        UCase

# Left

**Type**            Function returning String

**Invocation**    Left(str, length)

Parameter	Method	Type	Description
Str	ByVal	String	The string from which to extract characters.
length	ByVal	int8/16	The number of characters to extract from the string.

## Discussion

This function returns a string consisting of the leftmost characters of the given string. The maximum number of characters in the returned string is the smaller of 1) the number of characters in the string passed as the first parameter and 2) the value of the second parameter. Internally, the length is interpreted as a 16-bit signed value and negative values are treated as zero.

This function produces the same result as `Mid(str, 1, length)`.

## Example

```
Dim s as String, s2 as String

s = "Hello, world!"
s2 = Left(s, 5)           ' the result will be "Hello"
```

**See Also**        Mid, Right, Trim

# Len

**Type**            Function returning Integer

**Invocation**    Len(str)

Parameter	Method	Type	Description
str	ByVal	String	The string of which the length is to be determined.

## Discussion

This function returns the length of the given string, in bytes. Note that the length may be zero.

## Example

```
Dim s as String
Dim i as Integer

s = "Hello, world!"
i = Len(s)           ' the result will be 13
```

# LoByte

---

**Type**            Function returning Byte

**Invocation**    LoByte(val)

Parameter	Method	Type	Description
val	ByVal	numeric	The value of which the low byte is desired.

## Discussion

This function returns the least significant byte of the specified value.

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also**        HiByte, HiWord, LoWord, MidWord

# LockTask

---

**Type**            Subroutine

**Invocation**     LockTask()

## Discussion

This routine causes the running task to become locked so that no other task can run. The one exception to this is a task that is awaiting an external interrupt or an interval interrupt. Note that a task may explicitly unlock itself by calling `UnlockTask()`. A task will also become unlocked if it calls any of the sleep or delay routines.

Note that multiple calls to `LockTask()` have the same effect as a single call to `LockTask()` assuming that no other calls are made that implicitly unlock the task.

## Compatibility

The BasicX documentation indicates that a locked task will yield to a task that is awaiting an interrupt when the interrupt occurs. However, testing indicates that this is, in fact, not the case. This implementation allows an interrupt task to have priority over a locked task.

**See Also**        UnlockTask, Delay, Sleep, WaitForInterrupt, WaitForInterval

# Log

---

**Type**            Function returning Single

**Invocation**    Log(arg)

Parameter	Method	Type	Description
arg	ByVal	Single	The value of which the natural log is to be computed.

## Discussion

This function returns the `Single` value corresponding to natural logarithm (base e) of the value provided. The transcendental value e, upon which the natural logarithm is based, is approximately 2.71828. This function is the inverse of the `Exp( )` function.

If the value of the argument provided is zero, the result is positive infinity. If the argument value is negative, the result is NaN.

**See Also**        Exp, Exp10, Log10

# Log10

---

**Type**            Function returning Single

**Invocation**    Log10(arg)

Parameter	Method	Type	Description
arg	ByVal	Single	The value of which the common log is to be computed.

## Discussion

This function returns the `Single` value corresponding to the common logarithm (base 10) of the value provided. This function is the inverse of the `Exp10()` function.

If the value of the argument provided is zero, the result is positive infinity. If the argument value is negative, the result is NaN.

**See Also**        Exp, Exp10, Log

# LongJump

**Type** Subroutine

**Invocation** LongJump(jmpbuf, val)

Parameter	Method	Type	Description
jmpbuf	ByRef	Array of Byte	A buffer holding the return context, see description below.
val	ByVal	int16	The value to be returned to the original SetJump() caller.

## Discussion

This subroutine, in conjunction with `SetJump()`, provides a way to circumvent the normal call-return structure and return directly to a distant caller. It is the equivalent of a non-local Goto function and can be used, among other purposes, to handle exceptions in your programs. The first parameter specifies a `Byte` array that has been previously initialized by a call to `SetJump()`. The second parameter specifies a value that will be seen by the original `SetJump()` caller as the return value. This value, which should be non-zero, can indicate the nature of the condition that led to the `LongJump()` call. See the section on Exception Handling in the ZBasic Reference Manual for more details.

## Caution

Passing a jump buffer that has not been prepared by a call to `SetJump()`, one that has been modified after the `SetJump()` call, or one that was prepared by a subroutine/function that is no longer active will have unpredictable and almost certainly undesirable effects.

## Compatibility

This routine is not available in BasicX compatibility mode.

**See Also** SetJump

# LoWord

---

**Type**                Function returning UnsignedInteger

**Invocation**        LoWord(val)

Parameter	Method	Type	Description
val	ByVal	numeric	The value of which the low word is desired.

## Discussion

This function returns the least significant word of the specified value. If the specified value is a Byte the return value will have zero in the high byte.

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also**            HiByte, HiWord, LoByte, MidWord

# MakeDword

---

**Type**            Function returning UnsignedLong

**Invocation**    MakeDword(loWord, hiWord)

Parameter	Method	Type	Description
loWord	ByVal	int16	The value for the low word of the double word value.
hiWord	ByVal	int16	The value for the high word of the double word value.

## Discussion

This function returns a value composed of the two word values.

## Example

```
Dim w1 as UnsignedInteger, w2 as UnsignedInteger
Dim ul as UnsignedLong

ul = MakeDword(w1, w2)
```

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also**        MakeWord

# MakeString

**Type**            Function returning String

**Invocation**    MakeString(address, length)

Parameter	Method	Type	Description
address	ByVal	int16	The address of bytes with which to populate the string.
length	ByVal	int8/16	The number of characters to place in the string.

## Discussion

This function populates a string with an arbitrary byte stream. It is most useful for composing or modifying strings but may have other uses as well.

## Example

```
Dim ba(1 to 10) as Byte
Dim i as Integer
Dim s as String

For i = LBound(ba) to UBound(ba)
    ba(i) = &H60 + CByte(i)
Next i
s = MakeString(MemAddress(ba), SizeOf(ba))
```

## Compatibility

This function is not available in BasicX compatibility mode.

# MakeWord

---

**Type**            Function returning UnsignedInteger

**Invocation**    MakeWord(loByte, hiByte)

Parameter	Method	Type	Description
loByte	ByVal	Byte	The value for the low byte of the word value.
hiByte	ByVal	Byte	The value for the high byte of the word value.

## Discussion

This function returns a value composed of the two byte values.

## Example

```
Dim b1 as Byte, b2 as Byte
Dim u as UnsignedInteger

u = MakeWord(b1, b2)
```

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also**        MakeDword

# Max

---

**Type**                Function (see discussion for the return type)

**Invocation**        Max(val1, val2)

Parameter	Method	Type	Description
val1	ByVal	numeric	One of two values of which the largest is desired.
val2	ByVal	numeric	One of two values of which the largest is desired.

## Discussion

This function returns the larger of the two supplied values, both of which must be of the same type. If the supplied values are signed, the determination of which is largest takes the sign of the values into account. The return value is the same type as the parameters.

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also**            Min

# MemAddress

**Type**            Function returning Integer

**Invocation**    MemAddress(var)

Parameter	Method	Type	Description
var	ByRef	any variable	The variable of which the address is desired.

## Discussion

This function returns the `Integer` representation of the RAM address of the specified variable. Note that for arrays, you may also specify subscript expressions for all of the array dimensions to yield the address of an individual array element. Without the subscript expressions, the resulting value will be the address of the first element of the array.

This function is useful for deriving the address to pass to the several functions that require a RAM address, e.g. `BitCopy()`, `RamPeek()`, `RamPoke()`, etc.

The address of any variable can also be obtained using the `DataAddress` property. For RAM-based variables, the `DataAddress` property is of type `UnsignedInteger`.

## Example

```
Dim addr as Integer
Dim ba(1 to 20) as Byte
Dim fval as Single

addr = MemAddress(fval)
addr = MemAddress(ba)
addr = MemAddress(ba(2))
addr = fval.DataAddress
addr = ba.DataAddress
addr = ba.DataAddress(2)
```

## Compatibility

BasicX only supports the `DataAddress` property for Program Memory data items.

**See Also**            MemAddressU, VarPtr

# MemAddressU

**Type**                      Function returning `UnsignedInteger`

**Invocation**            `MemAddressU(var)`

Parameter	Method	Type	Description
var	ByRef	any variable	The variable of which the address is desired.

## Discussion

This function returns the `UnsignedInteger` representation of the RAM address of the specified variable. Note that for arrays, you may also specify subscript expressions for all of the array dimensions to yield the address of an individual array element. Without the subscript expressions, the resulting value will be the address of the first element of the array.

This function is useful for deriving the address to pass to the several functions that require a RAM address, e.g. `BitCopy()`, `RamPeek()`, `RamPoke()`, etc.

The `DataAddress` property may also be used to determine the address of a variable (except in BasicX compatibility mode). The type of the resulting value is `UnsignedInteger`. See the examples below.

## Examples

```
Dim addr as UnsignedInteger
Dim ba(1 to 20) as Byte
Dim fval as Single

addr = MemAddressU(fval)
addr = MemAddressU(ba)
addr = MemAddressU(ba(2))
addr = ba.DataAddress
addr = ba.DataAddress(2)
```

**See Also**                      `MemAddress`, `VarPtr`

# MemCmp

**Type**            Function returning Integer

**Invocation**    MemCmp(addr1, addr2, count)

Parameter	Method	Type	Description
addr1	ByVal	integral	The address of the first block of memory to be compared.
addr2	ByVal	integral	The address of the second block of memory to be compared.
count	ByVal	integral	The number of bytes to compare.

## Discussion

This function can be used to compare two arbitrary sequences of data in RAM. If all of the bytes in the two blocks are the same (over the given number of bytes to compare) the value zero is returned. Otherwise, the return value will be greater than zero if at the position of the first mismatch the byte in the first block is greater than the corresponding byte in the second block. If the converse is true, the return value will be less than zero.

All three parameters are converted internally to `UnsignedInteger`.

## Example

```
Dim a1(1 to 10) as Byte
Dim a2(1 to 10) as Byte
Dim ival as Integer

ival = MemCmp(a1.DataAddress, a2.DataAddress, SizeOf(a1))
```

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also**        MemCopy, MemSet

# MemCopy

**Type** Subroutine

**Invocation** MemCopy(destination, source, count)

Parameter	Method	Type	Description
destination	ByVal	integral	The address to which to begin copying.
source	ByVal	integral	The address from which to begin copying.
count	ByVal	integral	The number of bytes to copy.

## Discussion

This subroutine can be used to copy a block of data from one location in RAM to another location. An overlapping copy (when the destination is in the midst of the data being copied) is handled correctly so that the data to be copied is not overwritten.

All three parameters are converted internally to `UnsignedInteger`. Note that `MemCopy()` has the same functionality as `BlockMove()` but has a different parameter order; one that you may be accustomed to.

## Caution

This subroutine should be used with care because it is possible to overwrite important data on the stack or other areas of memory which may cause your program to malfunction.

## Example

```
Dim ba(1 to 10) as Byte
Dim ival as Integer

ba(3) = &H48
ba(4) = &H55
Call MemCopy(ival.DataAddress, ba(3).DataAddress, SizeOf(ival))
```

After execution, `ival` will have the value `&H5548`. Note the use of the `SizeOf()` function. This is a better programming practice than using a specific value because it makes the code easier to maintain.

## Compatibility

This routine is not available in BasicX compatibility mode.

**See Also** BitCopy, MemCmp, MemSet

# MemFind

**Type**                      Function returning UnsignedInteger

**Invocation**            MemFind(dataAddr, dataLen, val)  
                             MemFind(dataAddr, dataLen, val, ignoreCase)

Parameter	Method	Type	Description
dataAddr	ByVal	array of Byte	The address in RAM of the block to search.
dataLen	ByVal	integral	The length of the block to search.
val	ByVal	Byte	The byte value for which to search.
ignoreCase	ByVal	Boolean	A flag controlling whether alphabetic case is significant.

## Discussion

This function attempts to find the first occurrence of the byte specified by the `val` parameter in a block of RAM beginning at the specified address. If it is found, the return value gives the 1-based index where the sought byte was found within the block. If the sought byte is not found, zero is returned. If the optional `ignoreCase` parameter is not given, the search is performed observing alphabetic case differences, otherwise alphabetic case differences are significant or not depending on the value specified for `ignoreCase`. For the purposes of this parameter only the characters A-Z and a-z (&H41 to &H5a and &H61 to &H7a) are considered to be alphabetic.

## Example

```
Dim buf(1 to 40) as Byte
Dim idx as UnsignedInteger

' search for a carriage return
idx = MemFind(buf.DataAddress, Ubound(buf), &H0d)
```

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also**                ProgMemFind, StrFind

# MemSet

**Type** Subroutine

**Invocation** MemSet(addr, count, val)

Parameter	Method	Type	Description
addr	ByVal	int16	The address of a block to initialize.
count	ByVal	int8/16	The number of bytes to initialize.
val	ByVal	Byte	The initialization value.

## Discussion

This routine is useful for initializing arrays, buffers, etc. that reside in RAM.

## Example

```
Dim ba(1 to 20) as Byte

Call MemSet(MemAddress(ba), Sizeof(ba), &H55)
Call MemSet(ba.DataAddress, Sizeof(ba), 0)
```

## Caution

Using this routine to initialize data other than your own program variables may have detrimental effects.

## Compatibility

This routine is not available in BasicX compatibility mode.

**See Also** MemCmp, MemCopy

# Mid

**Type** Function returning String

**Invocation** Mid(str, pos, length) or  
Mid(str, pos)

Parameter	Method	Type	Description
str	ByVal*	String	The string from which to extract or modify a substring.
pos	ByVal	int8/16	The position of the first character of the substring.
length	ByVal	int8/16	The length of the substring to extract or modify.

\* When used on the left hand side of an assignment, this parameter is passed ByRef.

## Discussion

This function can be used to extract a portion of a string or to modify a portion of a string, depending on how it is used. When it appears in the context of a function call, it returns a new string extracted from the string provided. The first character of the extracted substring will be the character at the position given by `pos` (where the first character of the string is position 1). The length of the returned string will be the number of characters in the source string beginning at the starting index through the end of the string or the specified length (if present), whichever is less. If the starting position is beyond the end of the string or if the specified length is less than or equal to zero, the returned string will be of zero length.

When used on the left hand side of an assignment operator, the `Mid()` function replaces a sequence of characters in a string with characters from the string value on the right hand side of the assignment operator.

```
Dim s as String
s = "abcdef"
Mid(str, 3) = "##" ' result is "ab##ef"
```

Note that when used in this way the first parameter is passed by reference so it cannot be a literal string or any other entity than cannot be passed by reference. Also, the length of the target string will never be changed. The number of characters overwritten in the destination string will be the lesser of a) the number of characters in the string on the right hand side of the assignment, b) the number of characters specified in the third parameter (if present), and c) the number of characters in the target string beginning at the position specified by the second parameter through the end of the string.

## Compatibility

In BasicX, the first parameter is pass-by-reference. This disallows any use of a string literal for the first parameter. Also, in BasicX the third parameter must always be provided.

The BasicX documentation suggests that using `Mid()` on the left hand side of an assignment might result in a change in the string length. Tests indicate that this is not the case. Moreover, execution of the code fragment below actually results in a garbage character being placed in the third character position.

```
Dim s as String
s = "abc"
Mid(s, 2, 2) = "!" ' result is "a!@" (@ is an indeterminate character)
```

**See Also** Left, Right, Trim

# MidWord

---

**Type**                Function returning UnsignedInteger

**Invocation**        MidWord(val)

Parameter	Method	Type	Description
val	ByVal	numeric	The value of which the middle word is desired.

## Discussion

This function returns the middle two bytes of a 4-byte value. If the specified value is a Byte the return value will be zero. If the specified value is contained in two bytes, the return value will have zero in the high byte.

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also**            HiByte, HiWord, LoByte, LoWord

# Min

---

**Type**               Function (see discussion for the return type)

**Invocation**       Min(val1, val2)

Parameter	Method	Type	Description
val1	ByVal	numeric	One of two values of which the smallest is desired.
val2	ByVal	numeric	One of two values of which the smallest is desired.

## Discussion

This function returns the smaller of the two supplied values, both of which must be of the same type. If the supplied values are signed, the determination of which is smallest takes the sign of the values into account. The return value is the same type as the parameters.

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also**           Max

# NoOp

---

**Type** Subroutine

**Invocation** NoOp()

## Discussion

This subroutine implements a delay of one CPU cycle, typically about 68nS.

## Compatibility

This function is only available for native code targets, e.g. the ZX-24n.

# OpenCom

**Type** Subroutine

**Invocation** OpenCom(channel, baud, inQueue, outQueue)

Parameter	Method	Type	Description
channel	ByVal	Byte	The serial channel to open.
baud	ByVal	Long	The desired baud rate.
inQueue	ByRef	array of Byte	The queue for incoming characters.
outQueue	ByRef	array of Byte	The queue for outgoing characters.

## Discussion

This subroutine prepares a serial channel for use. If the specified channel number is invalid, the call has no effect. Serial channels are either implemented in hardware (using an onboard UART) or in software. Depending on the device one, two or four hardware-based serial channels are supported, denoted by the channel numbers 1, 2, 7, 8, etc. (Com1, Com2, Com7, Com8, etc., respectively). All ZX devices can support as many as four software-based serial channels, denoted by the channel numbers 3-6 (Com3, Com4, Com5 and Com6). Note, however, that you must have previously called `ComChannels()` in order to use channels 4-6.

The supported baud rates for the hardware-based channels are the standard rates from 300 to 460,800 while the supported rates for software-based channels range from 300 to 19,200. However, if `ComChannels()` has been invoked, the maximum rate for channels 3-6 will be limited to that specified in the description of `ComChannels()`. Moreover, for channels 3-6 the baud rate for any given channel must be an integral divisor of the maximum rate.

The transmit and receive queues specified for the channel each must have been previously initialized by calling `OpenQueue()`. If you set up a transmit-only or receive-only serial channel you may use the value 0 for the unused queue. If you provide the value 0 for both queues, the channel will not be opened.

After opening the channel, flow control may be configured for either the transmit side, the receive side or both. See the description of the `ControlCom()` subroutine for more information.

## Example

```
Dim outQueue(1 to 40) as Byte

Call OpenQueue(outQueue, SizeOf(outQueue))
Call ComChannels(2, 9600)
Call DefineCom(4, 0, 12, &H08)
Call OpenCom(4, 9600, 0, outQueue)
```

The code above prepares Com4 as a transmit-only serial channel. If you wanted reception as well, you would have to declare and initialize a second queue and define the receive pin.

## Resource Usage

The hardware UARTs are assigned to channel numbers as shown in the table below.

### Hardware USART Channel Assignment and I/O Pin Usage

ZX Model	USART	Serial Chan	Tx Pin	Rx Pin
ZX-24, ZX-24a	USART0	Com1 <sup>1</sup>	1, D.3	2, D.2
ZX-24p, ZX-24n, ZX-24r, ZX-24s	USART0	Com1 <sup>1</sup>	1, D.1	2, D.0
	USART1	Com2	11, D.3	6, D.2
ZX-24x	USARTD0	Com1 <sup>1</sup>	1, D.3	2, D.2
	USARTD1	Com2	D.7	D.6
	USARTC0	Com7	9, C.3	10, C.2
	USARTC1	Com8	13, C.7	14, C.6
	USARTE0	Com9	19, E.3	18, E.2
ZX-32a4	USARTD0	Com1	23, D.3	22, D.2
	USARTD1	Com2	27, D.7	26, D.6
	USARTC0	Com7	13, C.3	12, C.2
	USARTC1	Com8	17, C.7	16, C.6
	USARTE0	Com9	33, E.3	32, E.2
ZX-128a1	USARTD0	Com1	28, D.3	27, D.2
	USARTD1	Com2	32, D.7	31, D.6
	USARTC0	Com7	18, C.3	17, C.2
	USARTC1	Com8	22, C.7	21, C.6
	USARTE0	Com9	38, E.3	37, E.2
	USARTE1	Com10	42, E.7	41, E.6
	USARTF0	Com11	48, F.3	47, F.2
	USARTF1	Com12	52, F.7	51, F.6
ZX-40, ZX-40a	USART0	Com1	15, D.1	14, D.0
ZX-40p, ZX-40n, ZX-40r, ZX-40s	USART0	Com1	15, D.1	14, D.0
	USART1	Com2	17, D.3	16, D.2
ZX-44, ZX-44a	USART0	Com1	10, D.1	9, D.0
ZX-44p, ZX-44n, ZX-44r, ZX-44s	USART0	Com1	10, D.1	9, D.0
	USART1	Com2	12, D.3	11, D.2
ZX-328n, ZX-328l	USART0	Com1	3, D.1	2, D.0
ZX-32n, ZX-32l	USART0	Com1	31, D.1	30, D.0
ZX-1281	USART1	Com1	28, D.3	27, D.2
	USART0	Com2	3, E.1	2, E.0
ZX-1280	USART0	Com1	3, E.1	2, E.0
	USART1	Com2	46, D.3	45, D.2
	USART2	Com7	13, H.1	12, H.0
	USART3	Com8	64, J.1	63, J.0
ZX-24e, ZX-24ae	USART0	Com1 <sup>1</sup>	1, D.1	2, D.0
ZX-24ne, ZX-24pe	USART0	Com1 <sup>1</sup>	1, D.1	2, D.0
	USART1	Com2	17, D.3	18, D.2
ZX-24nu, ZX-24pu, ZX-24ru, ZX-24su	USART0	Com1	1, D.1	2, D.0
	USART1	Com2	17, D.3	18, D.2
ZX-24xu	USARTD0	Com1	1, D.3	2, D.2
	USARTD1	Com2	13, D.7	14, D.6
	USARTC0	Com7	9, C.3	10, C.2
	USARTC1	Com8	5, C.7	6, C.6
	USARTE0	Com9	21, E.3	22, E.2
ZX-328nu	USART0	Com1 <sup>1</sup>	19, D.1	20, D.0
ZX-128e, ZX-128ne, ZX-1281e, ZX-1281ne	USART0	Com1 <sup>1</sup>	19, E.1	20, E.0
	USART1	Com2	9, D.3	10, D.2

<sup>1</sup>For these devices, the Com1 signals are logically inverted.

It is important to note that on the ZX-24p, ZX-24n, ZX-24r and ZX-24s, the Com2 serial channel cannot be used at the same time as the hardware I2C channel because the pin 11 is shared between the Tx pin of Com2 and the SDA signal.

The software-based serial channels are implemented using the Serial Timer (see table below) to regulate the bit timing. When one or more of the channels 3-6 are open the corresponding timer busy flag will be True indicating that Serial Timer is in use. When all of the channels 3-6 are closed, corresponding timer busy flag will again be False indicating that the Serial Timer is available for other uses.

**Serial Timer by Device**

<b>ZX Model</b>	<b>Serial Timer</b>
ZX-24, ZX40, ZX-44, ZX-24e	Timer2
ZX-24a, ZX40a, ZX-44a, ZX-24ae, ZX-24ne, ZX-24pe, ZX-24nu, ZX-24pu	Timer2
ZX-24p, ZX40p, ZX-44p, ZX-24n, ZX-40n, ZX-44n	Timer2
ZX-24r, ZX40r, ZX-44r, ZX-24s, ZX-40s, ZX-44s, ZX-24ru, ZX-24su	Timer2
ZX-328n, ZX-328l, ZX-32n, ZX-32l, ZX-328nu	Timer2
ZX-1281, ZX-1281n, ZX-1280, ZX-1280n, ZX-1281e, ZX-1281ne	Timer0
ZX-24x, ZX-32a4, ZX-128a1, ZX-24xu	TimerD1
ZX-128e, ZX-128ne	Timer2

For native code devices, the table below indicates which ISRs may be loaded by using OpenCom() in your program. If the compiler cannot determine which specific channel is being opened, all of the listed ISRs will be included.

**ISRs Required**

<b>Underlying CPU</b>	<b>Com Channel</b>	<b>ISR Name</b>
mega644P, mega1284P	Com1	USART0_RX, USART0_TX, USART0_UDRE
	Com2	USART1_RX, USART1_TX, USART1_UDRE
	Com3-Com6	Timer2_CompA
mega328P	Com1	USART0_RX, USART0_TX, USART0_UDRE
	Com3-Com6	Timer2_CompA
mega128	Com1	USART0_RX, USART0_TX, USART0_UDRE
	Com2	USART1_RX, USART1_TX, USART1_UDRE
	Com3-Com6	Timer2_CompA
mega1281	Com1	USART1_RX, USART1_TX, USART1_UDRE
	Com2	USART0_RX, USART0_TX, USART0_UDRE
	Com3-Com6	Timer0_CompA
mega1280	Com1	USART0_RX, USART0_TX, USART0_UDRE
	Com2	USART1_RX, USART1_TX, USART1_UDRE
	Com3-Com6	Timer0_CompA
	Com7	USART2_RX, USART2_TX, USART2_UDRE
	Com8	USART3_RX, USART3_TX, USART3_UDRE
xmega32A4	Com1	USARTD0_RXC, USARTD0_TXC, USARTD0_DRE
	Com2	USARTD1_RXC, USARTD1_TXC, USARTD1_DRE
	Com3-Com6	TimerD1_CCA
	Com7	USARTC0_RXC, USARTC0_TXC, USARTD0_DRE
	Com8	USARTC1_RXC, USARTC1_TXC, USARTD1_DRE
xmega128A1	Com9	USARTE0_RXC, USARTE0_TXC, USARTE0_DRE
	Com1	USARTD0_RXC, USARTD0_TXC, USARTD0_DRE
	Com2	USARTD1_RXC, USARTD1_TXC, USARTD1_DRE
	Com3-Com6	TimerD1_CCA
	Com7	USARTC0_RXC, USARTC0_TXC, USARTD0_DRE
	Com8	USARTC1_RXC, USARTC1_TXC, USARTD1_DRE
	Com9	USARTE0_RXC, USARTE0_TXC, USARTE0_DRE
	Com10	USARTE1_RXC, USARTE1_TXC, USARTE1_DRE
	Com11	USARTF0_RXC, USARTF0_TXC, USARTF0_DRE
	Com12	USARTF1_RXC, USARTF1_TXC, USARTF1_DRE

Note, particularly, that the ISRs for Com1 are always included in every program even if OpenCom() is not explicitly invoked.

## Compatibility

In BasicX, the supported channel numbers are 1 to 3, depending on the particular target chip. Also, BasicX doesn't support the use of zero to indicate that no queue is being supplied.

**See Also**      ComChannels, CloseCom, ControlCom, DefineCom, StatusCom

# OpenDAC

**Type** Subroutine

**Invocation** OpenDAC(channel, mode)  
OpenDAC(channel, mode, stat)

Parameter	Method	Type	Description
channel	ByVal	Byte	The channel to use for DAC generation.
mode	ByVal	integral	The desired DAC mode (see discussion below).
stat	ByRef	Boolean	The variable to receive the status code.

## Discussion

This subroutine prepares a DAC channel for generating an analog voltage level. The table below indicates the available channels and the corresponding DAC hardware used. See the description of DAC() for additional details on the DAC channels.

Supported DAC Channels		
ZX Models	DACB	DACA
ZX-24x	Chan 1, Pin 8 Chan 2, Pin 9	
ZX-32a4	Chan 1, Pin 6 (B.2) Chan 2, Pin 7 (B.3)	
ZX-128a1	Chan 1, Pin 7 (B.2) Chan 2, Pin 8 (B.3)	Chan 3, Pin 97 (A.2) Chan 4, Pin 98 (A.3)
ZX-24xu	Chan 1, Pin 26 (B.2) Chan 2, Pin 25 (B.3)	

Note, particularly, that the ATxmega can produce two analog outputs from a single DAC. In the table above, channels 1 and 2 are the two outputs from one DAC and channels 3 and 4 are the two outputs from the second DAC (if available). In order to use the second channel on a given DAC, the first channel must have been opened in dual output mode (see the table below). Also note that using both outputs from a DAC will result in analog levels with significantly more noise due to the sample-and-hold and automatic refresh circuitry employed. For this reason, it is generally recommended to use single output per DAC.

DAC Mode Constituent Values		
Function	Hex Value	Bit Mask
Dual Output	&H8000	1x xx xx xx xx xx xx xx
Single Output	&H0000	0x xx xx xx xx xx xx xx
Automatic Refresh	&H4000	x1 xx xx xx xx xx xx xx
Manual Refresh	&H0000	x0 xx xx xx xx xx xx xx
Internal 1-volt Reference	&H0000	xx xx xx xx xx xx xx 00
AVcc Reference	&H0001	xx xx xx xx xx xx xx 01
PortA Aref Reference	&H0002	xx xx xx xx xx xx xx 10
PortB Aref Reference	&H0003	xx xx xx xx xx xx xx 11

It is important to note that the `mode` parameter value is only used for the first OpenDAC() call for each channel pair. That is to say, if one channel of a pair is already open the OpenDAC() is called, the `mode` parameter is ignored.

For dual output mode, the DAC values must be updated at least every 30uS. This will be done automatically if the Automatic Refresh bit is set in the `mode` parameter. Otherwise, your application will need to ensure that the DAC values are updated frequently enough to prevent drooping if the DAC output.

The analog value output by the DAC will be approximately equal to the 12-bit digital value set for each channel (see the DAC() subroutine) divided by 4095 and multiplied by the reference voltage. The choice of four reference voltages available is made by the least significant two bits of the `mode` parameter value. For the PortA and PortB Aref Reference, the table below indicates the pin to which the desired reference voltage should be applied.

DAC Reference Voltage Pin		
ZX Device	Aref A	Aref B
ZX-24x	20, A.0	7, B.0
ZX-32a4	40, A.0	4, B.0
ZX-128a1	95, A.0	5, B.0
ZX-24xu	36, A.0	28, B.0

The `status` parameter, if supplied, receives a value to indicate success or failure of the call.

### Example

```
Call OpenDAC(1, &H01) ' prepare for DAC output using AVcc reference
Call DAC(1, 300)      ' set the DAC level to 300/4095*AVcc
```

### Compatibility

This subroutine is not available in BasicX compatibility mode nor is it available on ATmega-based ZX devices.

**See Also**      CloseDAC, DAC

# OpenI2C

**Type** Subroutine

**Invocation** OpenI2C(channel, sdaPin, sclPin) or  
OpenI2C(channel, sdaPin, sclPin, bitRate)

Parameter	Method	Type	Description
channel	ByVal	Byte	The I2C channel to open (0-4).
sdaPin	ByVal	Byte	The pin for the I2C data (SDA) signal.
sclPin	ByVal	Byte	The pin for the I2C clock (SCL) signal.
bitRate	ByVal	integral	The optional clock speed designation, see discussion.

## Discussion

This subroutine prepares an I2C channel for use. Five channels are supported, numbered 0 through 4. Channel zero uses the onboard hardware I2C controller while channels 1 through 4 are generally implemented in software. On devices with multiple I2C controllers (e.g. xmega-based devices) channels 1 to 4 can be used for the hardware I2C controllers by specifying the SCL and SDA pins as zero. The I2C implementation does not support multi-master arbitration when operating in Master mode. Slave clock stretching is supported on both hardware and software channels.

For channel 0, the `sdaPin` and `sclPin` parameters are ignored since the hardware uses specific pins for the SDA and SCL signals (e.g. Port C, bits 1 and 0, respectively). For channels 1-4 in software mode, the `sdaPin` and `sclPin` parameters specify the pins to use for the data and clock signals, respectively. In both cases, the clock and data pins are automatically configured for I2C operation. The I2C protocol requires pullup resistors on both of the lines, the value of which depends on characteristics of your system. A typical value is in the range of 1.5K to 4.7K.

The optional `bitRate` parameter allows you to control the speed of the data interchange. If the parameter is not given, the default speed is 100KHz. Each I2C device has a maximum clock rate at which it will operate reliably; check the datasheet of your selected device to determine the maximum rate.

The interpretation of the value of the `bitRate` parameter differs for channel 0 and channels 1-4. The tables below specify the values to use for several common clock speeds.

**I2C Channel 0 Clock Speeds**

bitRate Value	Approximate Clock Speed	Notes
140	50KHz	
66	100KHz	Standard Low Speed, default speed
29	200KHz	
11	388KHz	Closest to Standard High Speed (400KHz)
10	410KHz	Highest supported speed

**I2C Channels 1-4 Clock Speeds<sup>1</sup>**

bitRate Value	Approximate Clock Speed	Notes
295	50KHz	
148	100KHz	Standard Low Speed, default speed
74	200KHz	
59	250KHz	Highest supported speed

<sup>1</sup> The values given assume the default setting of `Register.TimerSpeed1`.

For channel 0, the `bitRate` parameter controls the hardware bit rate. For ATmega-based devices, the parameter is a composite of two values: the value in the lower 8 bits is known as BR and is written to the

processor's TWBR register. The low two bits of the high byte select a clock divisor according to the table below. The clock speed of the hardware channel is given by the formula  $F_{CPU} / (16 + 2 * BR * Divisor)$  where  $F_{CPU}$  is the device's operating frequency. If the `bitRate` parameter is omitted or is zero the value of 66 is used by default.

**Channel 0 Prescaler Selector Value**

Value	Divisor
0	1
1	4
2	16
3	64

For ATxmega-based devices, the I2C bit rate is given by the formula  $F_{CPU} / 2 / (5 + rateVal)$  where `rateVal` is the low 8 bits of the `bitRate` parameter. Rearranging this formula gives an equation for the `bitRate` parameter:  $bitRate = (F_{CPU} / 2 / F_{I2C}) - 5$  where  $F_{I2C}$  is the desired I2C clock frequency.

For channels 1-4 the `bitRate` parameter is interpreted as the number of I/O Timer ticks per bit. For I2C operations, the I/O Timer uses the prescaler specified by `Register.TimerSpeed1`. With the default prescaler of 1, each I/O Timer tick represents approximately 68nS. If the `bitRate` parameter is omitted or is zero the value of 74 is used by default. Due to processing overhead, the minimum attainable bit time is approximately 4µS.

For channel 0, the table below gives the pin numbers used for SDA and SCL.

**Channel 0 SCL and SDA Pins**

ZX Models	SCL	SDA
ZX-24, ZX-24a, ZX-24p, ZX-24n, ZX-24r, ZX-24s	12, C.0	11, C.1
ZX-40, ZX-40a, ZX-40p, ZX-40n, ZX-40r, ZX-40s	22, C.0	23, C.1
ZX-44, ZX-44a, ZX-44p, ZX-44n, ZX-44r, ZX-44s	19, C.0	20, C.1
ZX-24e, ZX-24ae, ZX-24ne, ZX-24pe, ZX-24nu, ZX-24pu, ZX-24ru, ZX-24su	12, C.0	11, C.1
ZX-328n, ZX-328l, ZX-32n, ZX-32l	28, C.5	27, C.4
ZX-1281, ZX-1281n	25, D.0	26, D.1
ZX-1280, ZX-1280n	43, D.0	44, D.1
ZX-24x, ZX-24xu	11, C.1	12, C.0
ZX-32a4	11, C.1	10, C.0
ZX-128a1	16, C.1	15, C.0
ZX-128e, ZX-128ne, ZX-1281e, ZX-1281ne	12, D.0	11, D.1
ZX-328nu	22, C.5	21, C.4

The table below specifies the pins used for SDA and SCL when the available additional hardware I2C controllers are used.

**SCL and SDA Pins for Additional Hardware Channels**

ZX Models	Chan 1 SCL	Chan 1 SDA	Chan 2 SCL	Chan 2 SDA	Chan 3 SCL	Chan 3 SDA
ZX-24x	17, E.1	25, E.0	-	-	-	-
ZX-24xu	23, E.1	24, E.0	-	-	-	-
ZX-32a4	29, E.1	28, E.0	-	-	-	-
ZX-128a1	36, E.1	35, E.0	26, D.1	25, D.0	46, F.1	45, F.0

## Examples

```
Call OpenI2C(0, 0, 0)      ' open the hardware channel at 100KHz
Call OpenI2C(2, 19, 20)   ' open channel 2 using pins 19, 20
Call OpenI2C(1, C.3, A.1, 74) ' open channel 1 at 200KHz
```

## Resource Usage

The I2C routines utilize the I/O Timer to regulate the bit timing for channels 1-4. While sending or receiving I2C data, the corresponding timer busy flag will be True indicating that the I/O Timer is in use. On the ZX-24n, ZX-24p, ZX-24r and ZX-24s, the hardware I2C channel cannot be used while Com2 is open since pin 11 is shared by the SDA signal and TxD for Com2.

## Compatibility

This subroutine is not available in BasicX compatibility mode.

**See Also**      CloseI2C, I2CGetByte, I2CPutByte, I2CStart, I2CStop, I2CCmd, OpenI2CSlave

# OpenI2CSlave

**Type** Subroutine

**Invocation** OpenI2CSlave(slaveAddr)  
OpenI2CSlave(slaveAddr, channel)

Parameter	Method	Type	Description
slaveAddr	ByVal	Byte	The I2C slave address to which to respond.
channel	ByVal	Byte	The I2C channel to open (0-4).

## Discussion

This subroutine immediately activates the I2C controller in slave mode. If the optional `channel` parameter is not given, channel 0 is assumed. Note that use of channels 1-4 are supported only on devices that have multiple I2C controllers. See the description of `OpenI2C` for more details about the correspondance between channel numbers and hardware controllers.

If you activate slave mode, you must also provide an interrupt handler for the `TWI` vector (aka the `I2C` vector). While slave mode is active, calls to `CmdI2C()` and the low level I2C commands are ineffective for the I2C channel in use. Slave mode can be canceled by calling `CloseI2C()`, specifying the channel number specified or implied in the call to `OpenI2CSlave()`.

While slave mode is active, the device will respond to reads and writes on the I2C bus referring to its slave address which is the value of the `slaveAddr` parameter with the least significant bit set to zero. If the least significant bit of the `slaveAddr` parameter is set, the slave can respond also to "general call" traffic on the bus.

The table below gives the pin numbers used for the SDA and SCL signals on various ZX devices.

SDA and SCL Pins		
ZX Models	SDA	SCL
ZX-24n, ZX-24s	11, C.1	12, C.0
ZX-40n, ZX-40s	23, C.1	22, C.0
ZX-44n, ZX-44s	20, C.1	19, C.0
ZX-24ne, ZX-24nu	11, C.1	12, C.0
ZX-328n, ZX-328l, ZX-32n, ZX-32l	27, C.4	28, C.5
ZX-1281n	26, D.1	25, D.0
ZX-1280n	44, D.1	43, D.0
ZX-24x, ZX-24xu	12, C.0	11, C.1
ZX-32a4	10, C.0	11, C.1
ZX-128a1	15, C.0	16, C.1
ZX-128ne, ZX-1281ne	11, D.1	12, D.0
ZX-328nu	21, C.4	22, C.5

## Example

```
Call OpenI2CSlave(&H50) ' activate I2C slave mode with address &H50
```

## Resource Usage

The I2C hardware channel in use cannot be opened by `OpenI2C()` while slave mode is active. On the ZX-24n, and ZX-24s, I2C slave mode cannot be used while Com2 is open since pin 11 is shared by the SDA signal and TxD for Com2.

**Compatibility**

This subroutine is only available for native mode devices.

**See Also**      ClosesI2C, OpenI2C

# OpenPWM

**Type** Subroutine

**Invocation** OpenPWM(channel, frequency, mode)  
OpenPWM(channel, frequency, mode, stat)

Parameter	Method	Type	Description
channel	ByVal	Byte	The channel to use for PWM generation.
frequency	ByVal	Single	The desired PWM frequency.
mode	ByVal	Byte	The desired PWM mode (see discussion below).
stat	ByRef	Boolean	The variable to receive the status code.

## Discussion

This subroutine prepares a PWM channel for generating a pulse width modulated (PWM) signal. PWM generation is performed using one of the CPU's 16-bit timers, the number of which varies depending on the ZX model. The table below indicates the available channels and the corresponding timer used. See the description of PWM() for additional details on the PWM channels.

Supported 16-bit PWM Channels		
ZX Models	Timer	Channels
ZX-24, ZX-24a, ZX-24p, ZX-24n, ZX-40, ZX-40a, ZX-40p, ZX-40n, ZX-44, ZX-44a, ZX-44p, ZX-44n, ZX-328n, ZX-328l, ZX-32n, ZX-32l, ZX-24e, ZX-24ae, ZX-24ne, ZX-24pe, ZX-24nu, ZX-24pu, ZX-328nu	Timer1	1, 2
ZX-24r, ZX-24s, ZX-40r, ZX-40s, ZX-44r, ZX-44s ZX-24ru, ZX-24su	Timer1 Timer3	1, 2 3, 4
ZX-1281, ZX-1281n, ZX-128e, ZX-128ne, ZX-1281e, ZX-1281ne	Timer1 Timer3	1, 2, 3 4, 5, 6
ZX-1280, ZX-1280n	Timer1 Timer3 Timer4 Timer5	1, 2, 3 4, 5, 6 7, 8, 9 10, 11, 12
ZX-24x, ZX-32a4, ZX-24xu	TimerD0 TimerD1 TimerC0 TimerE0	1, 2 3, 4 5, 6, 7, 8 9, 10, 11, 12
ZX-128a1	TimerD0 TimerD1 TimerC0 TimerE0 TimerE1 TimerF0 TimerF1	1, 2 3, 4 5, 6, 7, 8 9, 10, 11, 12 13, 14 15, 16, 17, 18 19, 20

The `frequency` parameter specifies the PWM base frequency in Hertz. Since the same frequency and generation mode will be used for all PWM channels based on the same timer, it is only necessary to call `OpenPWM()` once to prepare the timer for all of the PWM channels that are based on a given timer.

The `mode` parameter specifies the PWM generation mode. Two modes are supported: Fast PWM mode and Phase/Frequency Correct mode. The constants `zxFastPWM` and `zxCorrectPWM`, having the values 0 and 1 respectively, may be used to specify the mode. The Fast PWM mode has a maximum frequency of one-half of the CPU clock frequency and is intended for fixed-frequency applications. The Phase/Frequency Correct PWM mode has a maximum frequency of one-quarter of the CPU clock

frequency and may be used when the PWM frequency will be changed in the midst of PWM signal generation. Frequency changes are effected by making additional calls to `OpenPWM()` and the change is synchronized so that it takes effect at the beginning of a cycle.

The `status` parameter, if supplied, receives a value to indicate success or failure of the call.

A side effect of calling `OpenPWM()` is that the timer busy flag for the underlying timer (e.g. `Register.Timer1Busy`) will be set to `True` irrespective of its prior state. It is recommended that the initial call to `OpenPWM()` be preceded by a call to acquire the semaphore for the timer. This will ensure that an existing timer operation will not be disturbed.

### Example

```
Call OpenPWM(1, 50.0, zxFastPWM) 'prepare for 50Hz Fast PWM using channel 1
```

### Compatibility

This subroutine is not available in BasicX compatibility mode.

**See Also**      `ClosePWM`, `PWM`

# OpenPWM8

**Type** Subroutine

**Invocation** OpenPWM8(channel, frequency, mode)  
OpenPWM8(channel, frequency, mode, stat)

Parameter	Method	Type	Description
channel	ByVal	Byte	The channel to use for PWM generation.
frequency	ByVal	Single	The desired PWM frequency.
mode	ByVal	Byte	The desired PWM mode (see discussion below).
stat	ByRef	Boolean	The variable to receive the status code.

## Discussion

This subroutine prepares a PWM channel for generating a pulse width modulated (PWM) signal using one of the CPU's 8-bit timers. The table below indicates the available channels and the corresponding timer used. See the description of PWM8() for additional details on the PWM channels. Note that ZX devices based on ATxmega processors don't have any 8-bit timers so 8-bit PWM is not supported on those devices.

Supported 8-bit PWM Channels		
ZX Models	Timer0	Timer2
ZX-24, ZX-40, ZX-44, ZX-328n, ZX-328l, ZX-32n, ZX-32l, ZX-24e, ZX-128e, ZX-128ne, ZX-328nu	-	1
ZX-24a, ZX-24p, ZX-24n, ZX-24r, ZX-24s, ZX-40a, ZX-40p, ZX-40n, ZX-40r, ZX-40s, ZX-44a, ZX-44p, ZX-44n, ZX-44r, ZX-44s, ZX-24ae, ZX-24ne, ZX-24pe ZX-24nu, ZX-24pu, ZX-24ru, ZX-24su	-	1, 2
ZX-1281, ZX-1281n, ZX-1280, ZX-1280n, ZX-1281e, ZX-1281ne	1, 2	-

It is important to note that the timer used for 8-bit PWM generation is the same one used for generating the timing for the software UARTs (Com3-Com6). Consequently, these two features cannot be used at the same time.

The `frequency` parameter specifies the desired PWM base frequency in Hertz. Since the same frequency and generation mode will be used for all PWM channels based on the same timer, it is only necessary to call `OpenPWM8()` once to prepare the timer for all of the PWM channels that are based on a that timer.

The `mode` parameter specifies the PWM generation mode. Two modes are supported: Fast PWM mode and Phase/Frequency Correct mode. The constants `zxFastPWM` and `zxCorrectPWM`, having the values 0 and 1 respectively, may be used to specify the mode

The `status` parameter, if supplied, receives a value to indicate success or failure of the call.

A side effect of calling `OpenPWM8()` is that the timer busy flag for the underlying timer (e.g. `Register.Timer2Busy`) will be set to `True` irrespective of its prior state. It is recommended that the initial call to `OpenPWM8()` be preceded by a call to acquire the semaphore for the timer. This will ensure that an existing timer operation will not be disturbed.

The actual PWM frequency used will be the closest of the available frequencies as shown in the table below. The frequencies in the shaded rows are not available on ZX devices based on the mega128, mega1281 and mega1280 chips.

Available 8-bit PWM Frequencies	
FastPWM	Phase Correct PWM
57,600.0	28,912.9
7,200.0	3,614.1
1,800.0	903.5
900.0	451.8
450.0	225.9
225.0	112.9
56.3	28.8

The PWM frequencies in the table above apply to ZX devices with a main clock speed of 14.7456 MHz. For ZX devices operating at a different frequency, the available PWM frequencies will be proportionally higher or lower.

### Example

```
Call OpenPWM8(1, 50.0, zxFastPWM) 'prepare for 50Hz Fast PWM using channel 1
```

### Compatibility

This subroutine is not available in BasicX compatibility mode nor is it available on ATxmega-based ZX devices.

**See Also**      ClosePWM8, PWM8

# OpenQueue

---

<b>Type</b>	Subroutine
<b>Invocation</b>	OpenQueue(queue, size) OpenQueue(queue)

Parameter	Method	Type	Description
queue	ByRef	array of Byte	The queue to be initialized.
size	ByVal	int16	The size of the array, in bytes.

## Discussion

This routine prepares a queue for use by initializing the management information contained in the queue data structure. The number of bytes of space available for data in a queue is the specified size less the queue management overhead (9 bytes). It may be convenient to use the built-in constant `System.MinQueueSize` in the definition of an array intended to hold a queue.

If the compiler can deduce the size of the array element, e.g. an explicitly dimensioned Byte array is specified, the second parameter may be omitted. In this case, the compiler utilizes the size of the array as the size parameter. Otherwise, the compiler will issue an error message indicating that the size must be explicitly specified.

## Caution

If you specify a size parameter that is larger than the actual size of the array, data following the array may be overwritten, usually with undesirable consequences. For this reason, it is recommended that you use the `SizeOf()` function to specify the queue size so that it will automatically track any changes that you make to the actual queue size. See the example below.

`OpenQueue()` should only be called for a queue that is not in use. Invoking it for a queue that is in use has undefined results.

## Example

```
Dim inQueue(1 to System.MinQueueSize + 20) as Byte  
  
Call OpenQueue(inQueue, SizeOf(inQueue))
```

After the call to `OpenQueue()` the queue will ready to be used.

## Compatibility

BasicX allows any type for the first parameter. The ZBasic implementation requires that it be an array of `Byte`. The second parameter must always be supplied in BasicX mode.

# OpenSPI

**Type** Subroutine

**Invocation** OpenSPI(channel, flags, csPin)  
OpenSPI(channel, flags, csPin, rxDelay)

Parameter	Method	Type	Description
channel	ByVal	Byte	The SPI channel to open (1-4).
flags	ByVal	integral	Flags controlling the SPI communication.
csPin	ByVal	Byte	The pin for the chip select signal to the device.
rxDelay	ByVal	Byte	The delay time prior to each received byte.

## Discussion

This subroutine prepares an SPI channel for use as a master. By default, the hardware SPI controller is used to implement the SPI protocol but on some devices, a bit-bang implementation can be enabled (see DefineSPI).

Four channels are supported, numbered 1 through 4. It does not matter if the particular channel has been previously opened. The `flags` parameter specifies the characteristics of the SPI communication as shown in the table below. They must be set to be compatible with the device with which you want to communicate. See the table below for details. The `csPin` parameter specifies the pin number that you wish to control the device's chip select input. The pin will be made an output and set to the inactive state (as specified by bit 6 of the `flags` parameter). Note that any general purpose I/O pin of the device may be used as the slave select pin except for the SS pin of the device. The shaded entries in the table below do not apply to the software SPI implementation.

SPI Channel Control Bits		
Function	Hex Value	Binary Value
Bit Rate f/4	&H00	xx xx xx 00
Bit Rate f/16	&H01	xx xx xx 01
Bit Rate f/64	&H02	xx xx xx 10
Bit Rate f/128	&H03	xx xx xx 11
Clock Phase False	&H00	xx xx x0 xx
Clock Phase True	&H04	xx xx x1 xx
Clock Low at Idle	&H00	xx xx 0x xx
Clock High at Idle	&H08	xx xx 1x xx
Use Hardware SPI	&H00	xx x0 xx xx
Use Software SPI	&H10	xx x1 xx xx
Bit Order – MSB first	&H00	xx 0x xx xx
Bit Order – LSB first	&H20	xx 1x xx xx
Active Low Chip Select	&H00	x0 xx xx xx
Active High Chip Select	&H40	x1 xx xx xx
Double Speed	&H80	1x xx xx xx

The remaining bits are currently undefined but they may be employed in the future. Because of this possibility, the undefined flag bits should be zero. Bits 3 and 2 taken together specify the SPI mode 0-3, e.g. xx xx 00 xx specifies mode 0. When using the hardware SPI controller, if the Double Speed bit is set, the SPI channel will run at twice the frequency specified by the two low order flag bits. The value of  $f$  for the bit rate selector is the CPU frequency (typically 14.7456MHz). For the software SPI implementation, the number of cycles per bit is a minimum of about 50 so the implementation runs at full speed with either the f/4 or f/16 speed settings.

For devices that have multiple SPI controllers (e.g. xmega-based devices), the most significant byte of the `flags` parameter specifies the index of the SPI controller to use (0=PortD, 1=PortC, 2=PortE, 3=PortF). See the tables below for information about which pins of each port are used for the SPI control/data pins.

The `rxDelay` parameter, which defaults to zero if not present, specifies the amount of time to delay before beginning the SPI cycle for each byte received, if any, during the second half of the `SPICmd()` process. See the description of `SPICmd()` for more details.

**SPI Clock and Data Pins for the Primary SPI Controller (Index=0)**

<b>ZX Models</b>	<b>SCK</b>	<b>MISO</b>	<b>MOSI</b>
ZX-24, ZX-24a, ZX-24p, ZX-24n, ZX-24r, ZX-24s <sup>1</sup>	B.7	B.6	B.5
ZX-40, ZX-40a, ZX-40p, ZX-40n, ZX-40r, ZX-40s	8, B.7	7, B.6	6, B.5
ZX-44, ZX-44a, ZX-44p, ZX-44n, ZX-44r, ZX-44s	3, B.7	2, B.6	1, B.5
ZX-328n, ZX-328l	19, B.5	18, B.4	17, B.3
ZX-32n, ZX-32l	17, B.5	16, B.4	15, B.3
ZX-1281, ZX-1281n	11, B.1	13, B.3	12, B.2
ZX-1280, ZX-1280n	20, B.1	22, B.3	21, B.2
ZX-24x <sup>1</sup>	D.7	D.6	D.5
ZX-32a4	27, D.7	26, D.6	25, D.5
ZX-128a1	32, D.7	31, D.6	30, D.5
ZX-24e, ZX-24ae, ZX-24ne, ZX-24pe, ZX-24nu, ZX-24pu, ZX-24ru, ZX-24su	21, B.7	22, B.6	23, B.5
ZX-128e, ZX-128ne, ZX-1281e, ZX-1281ne	27, B.1	25, B.3	26, B.2
ZX-328nu	16, B.5	15, B.4	14, B.3
ZX-24xu	13, D.7	14, D.6	15, D.5

<sup>1</sup> The SPI pins are found along the edge of the board between pins 1 and 24.

**SPI Clock and Data Pins for the Available Alternate SPI Controllers**

<b>ZX Models</b>	<b>Index</b>	<b>SCK</b>	<b>MISO</b>	<b>MOSI</b>
ZX-24x, ZX-24xu	1	5, C.7	6, C.6	7, C.5
ZX-32a4	1	17, C.7	16, C.6	15, C.5
ZX-128a1	1	22, C.7	21, C.6	20, C.5
	2	42, E.7	41, E.6	40, E.5
	3	52, F.7	51, F.6	50, F.5

## Caution

For ZX devices that use an external SPI EEPROM for user program storage, you must avoid doing anything that will interfere with the SPI commands to that device. SPI communication by direct manipulation of the processor SPI control registers is not supported and may cause your program to malfunction.

## Compatibility

BasicX does not support the double speed option, the active high chip select, the optional `rxDelay` parameter, or the bit-bang mode. The same is true for ZX devices based on the ATmega32 processor.

**See Also**      `CloseSPI`, `DefineSPI`, `OpenSPISlave`, `SPICmd`

# OpenSPISlave

**Type** Subroutine

**Invocation** OpenSPISlave(flags)

Parameter	Method	Type	Description
flags	ByVal	integral	Flags controlling the SPI communication.

## Discussion

This subroutine, available only for native mode devices, immediately activates the hardware SPI controller in slave mode. The `flags` parameter specifies the characteristics of the SPI communication. They must be set to be compatible with the SPI master with which you want to communicate. See the table below for details.

**SPI Slave Mode Configuration Bits**

Function	Hex Value	Bit Mask
Clock Phase False	&H00	xx xx x0 xx
Clock Phase True	&H04	xx xx x1 xx
Clock Low at Idle	&H00	xx xx 0x xx
Clock High at Idle	&H08	xx xx 1x xx
Bit Order – MSB first	&H00	xx 0x xx xx
Bit Order – LSB first	&H20	xx 1x xx xx

For devices that have multiple SPI controllers (e.g. xmega-based devices), the most significant byte of the `flags` parameter specifies the index of the SPI controller to use (0=PortD, 1=PortC, 2=PortE, 3=PortF). See the tables below for information about which pins of each port are used for the SPI control/data pins.

The chip select pin for an SPI slave is a dedicated pin; see the table below. If you activate slave mode, you must also provide an interrupt handler for the corresponding interrupt vector. While slave mode is active, `SPICmd()` calls are ineffective for that channel. Slave mode can be canceled by calling `CloseSPI()`.

**Slave Mode CS Pin by Controller Index**

ZX Models	0	1	2	3
ZX-40n, ZX-40s	5, B.4			
ZX-44n, ZX-44s	44, B.4			
ZX-24ne	24, B.4			
ZX-328n, ZX-328l	16, B.2			
ZX-32n, ZX-32l	14, B.2			
ZX-1281n	10, B.0			
ZX-1280n	19, B.0			
ZX-24x	D.4	8, C.4		
ZX-32a4	24, D.4	14, C.4		
ZX-128a1	29, D.4	19, C.4	39, E.4	49, F.4
ZX-128ne, ZX-1281ne	28, B.0			
ZX-328nu	13, B.2			
ZX-24xu	16, D.4	8, C.4		

See `OpenSPI()` for information about which pins are used for the data and control signals for each SPI controller.

Note that the SPI master sets the SPI clock speed. The highest SPI clock speed that can be used reliably is one quarter of the CPU clock speed of a ZX slave device. Depending on how much computation the slave must perform to prepare data for sending back to the master, a substantially slower

SPI clock may need to be used. If a ZX device is being used as the master, it may be useful to set the `rxDelay` parameter on calls to `OpenSPI()` on the master to allow additional processing time.

### **Compatibility**

This subroutine is only supported for native mode devices.

**See Also**      `CloseSPI`, `OpenSPI`

# OpenWatchDog

**Type** Subroutine

**Invocation** OpenWatchDog(timeout)

Parameter	Method	Type	Description
timeout	ByVal	Byte	Specifies a timeout value (see discussion).

## Discussion

This subroutine prepares the watchdog timer for use. Once it is opened, the `WatchDog( )` routine must be called from time to time. If the period between `WatchDog( )` calls exceeds the timeout value, the system will be reset.

The approximate timeout value is  $T \times 2^N$  where  $T$  is the Timeout Base value and  $N$  is the value of the `timeout` parameter limited to the range shown in the table below. Note that the timeout value varies with processor voltage, being slightly longer at a lower operating voltage. Consult the Atmel documentation for more specific information.

WatchDog Timeout Parameter Range			
ZX Models	Timeout Base	Range	Max. Time
ZX-24, ZX-40, ZX-44	16mS	0-7	2 sec
ZX-24a, ZX-40a, ZX-44a, ZX-24p, ZX-40p, ZX-44p, ZX-24n, ZX-40n, ZX-44n, ZX-24r, ZX-40r, ZX-44r, ZX-24s, ZX-40s, ZX-44s	16mS	0-9	8 sec
ZX-24x, ZX-32a4, ZX-128a1, ZX-24xu	8mS	0-10	8 sec
ZX-328n, ZX-328l, ZX-32n, ZX-32l, ZX-1281, ZX-1281n, ZX-1280, ZX-1280n	16mS	0-9	8 sec
ZX-24e, ZX-128e, ZX-128ne	16mS	0-7	2 sec
ZX-24ae, ZX-24ne, ZX-24pe, ZX-24nu, ZX-24pu, ZX-24ru, ZX-24su, ZX-1281e, ZX-1281ne, ZX-328nu	16mS	0-9	8 sec

When the processor is reset, the register value `Register.ResetFlags` contains bit flags indicating the source of the reset. It is important to note that the occurrence of a system fault (e.g. a stack overflow) will also cause a WatchDog reset as will calling `ResetProcessor( )`. See the section on Run Time Stack Checking in the ZBasic Reference Manual for more information on stack overflow detection.

The watchdog timer can be turned off using `CloseWatchDog`.

## Compatibility

BasicX doesn't support `Register.ResetFlags` or `CloseWatchDog`.

**See Also** WatchDog, CloseWatchDog, ResetProcessor

# OpenX10

**Type** Subroutine

**Invocation** OpenX10(channel, inQueue, outQueue)

Parameter	Method	Type	Description
channel	ByVal	Byte	The X-10 communication channel to open.
inQueue	ByRef	array of Byte	The queue for incoming X-10 data.
outQueue	ByRef	array of Byte	The queue for outgoing X-10 data.

## Discussion

This subroutine prepares an X-10 communication channel for use. After the channel is opened you can send arbitrary X-10 command bit streams, which you must create in low-level form, by simply adding the constituent bytes to the outgoing queue. Similarly, the incoming queue will receive raw X-10 data which you must decode. Each X-10 command begins with the bit sequence 1110 which is followed by additional bit pairs. The bit pair 01 represents a logic zero while the bit pair 10 represents a logic one. The bit pair 11 is invalid and the bit pair 00 signifies the end of a command bit stream and also represents the idle condition. Additional information on X-10 commands may be found in various places on the Internet.

If the specified channel is already open or if the channel number is invalid, it has no effect. The supported channel numbers are 1-2. The channel must have been previously configured by a call to `DefineX10()`. Also, the queues specified for the receive and transmit channels each must have been previously initialized by calling `OpenQueue()`. If you set up a transmit-only or receive-only serial channel you may use the value 0 for the unused queue. If you provide the value 0 for both queues, the channel will not be opened.

## Example

```
Dim outQueue(1 to 40) as Byte

Call OpenQueue(outQueue, SizeOf(outQueue))
Call DefineX10(1, 0, 12, &H08)
Call OpenX10(1, 0, outQueue)
```

The code above prepares channel 1 as for transmit-only operation. If you wanted reception as well, you would have to declare and initialize a second queue and define the receive pin.

## Resource Usage

X-10 communication requires the use of a zero-crossing signal input to the ZX as noted in the table below. When one or more of the X-10 channels are open the zero-crossing input pin may not be used for any other purpose. When all X-10 channels are closed, zero-crossing input pin will again be available for other uses.

For native mode devices, the ISRs noted in the table below are automatically included.

Resources Required		
Underlying CPU	Zero Crossing Input	ISR Name
mega328P, mega644P, mega1284P	INT0	Timer0_CompB, INT0
mega1281, mega1280	INT0	Timer2_CompB, INT0
xmega128A1, xmega32A4	A.5	TCC1_CCB, ACA_AC0

For devices based on the ATmega chips, the default zero-crossing interrupt is INT0 as shown in the table above. If desired, an alternate interrupt may be specified using the Option X10Interrupt directive described in the ZBasic Language Reference Manual.

### **Compatibility**

This subroutine is not available on ZX models that are based on the ATmega32 processor (e.g. the ZX-24) or the ATmega128. Moreover, it is not available in BasicX compatibility mode.

**See Also**      CloseX10, DefineX10, StatusX10

# OutputCapture

**Type** Subroutine

**Invocation** OutputCapture(values, count, firstPulse)

Parameter	Method	Type	Description
intervals	ByRef	array of int16	The lengths of successive segments of the output waveform.
count	ByVal	int16	The number of entries in the value array.
flags	ByVal	Byte	Configuration bits controlling the generation process.

## Discussion

This subroutine produces a series of precisely timed logic levels on the OutputCapture pin (see table below) allowing you to produce an arbitrary waveform. Each entry in the `intervals` array specifies a time interval, in units of the I/O Timer period (by default, about 67.8ns for devices running at 14.7MHz), for each segment of the waveform. When called, the OutputCapture pin will be made an output and will be set to its initial state (the complement of the least significant bit of the `flags` parameter).

When waveform generation is begun, the OutputCapture pin will be changed to the opposite state for the interval specified by the first `intervals` element, changed to the opposite state again for the interval specified by the second `intervals` element, etc. for as many elements as specified. The final state of OutputCapture pin depends on whether the `count` parameter is odd or even. If it is odd the final state will be the complement of the least significant bit of the `flags` parameter; if it is even the final state will be the same as the least significant bit of the `flags` parameter.

The calling task will be suspended during the waveform generation process. If another task disables interrupts the accuracy of the generated waveform may suffer.

Due to processing overhead, the smallest pulse width that can be accommodated is about 6µS. This corresponds to a value of about 88 in the data array at the default timer speed. If the system has a heavy interrupt load (e.g. serial channels 3-6 are open) the minimum pulse width for reliable operation may be significantly larger. The maximum pulse width using the default timer speed is about 4.4mS. If you need to generate longer pulse widths, you may set the value of `Register.TimerSpeed1` so that a slower clock rate is used.

To avoid unwanted logic transitions on the OutputCapture pin during preparation for waveform generation, the OutputCapture pin should be configured as an input prior to the call. You'll probably need to employ a pullup or pulldown resistor on the pin to guarantee the desired logic state prior to the commencement of waveform generation.

## Resource Usage

This routine uses the I/O Timer. If the timer is already in use the routine will return immediately without performing the waveform generation. Also, this routine cannot be used at the same time as `InputCapture()`. See the description of `OutputCaptureEx()` for information about ISR requirements.

Output Capture Pin	
ZX Models	Pin
ZX-24, ZX-24a, ZX-24p, ZX-24n, ZX-24r, ZX-24s	27, D.4
ZX-40, ZX-40a, ZX-40p, ZX-40n, ZX-40r, ZX-40s	18, D.4
ZX-44, ZX-44a, ZX-44p, ZX-44n, ZX-44r, ZX-44s	13, D.4
ZX-24e, ZX-24ae, ZX-24ne, ZX-24pe, ZX-24nu, ZX-24pu, ZX-24ru, ZX-24su	16, D.4
ZX-328n, ZX-328l, ZX-32n, ZX-32l	16, B.2
ZX-1281, ZX-1281n	25, B.6
ZX-1280, ZX-1280n	16, B.6
ZX-24x, ZX-32a4, ZX-24xu	11, C.1
ZX-128a1	16, C.1
ZX-128e, ZX-1281e, ZX-128ne, ZX-1281ne	22, B.6
ZX-328nu	13, B.2

## Compatibility

For devices running at 14.7MHz, since the CPU runs at twice the rate as the BasicX CPU, the units of the pulse width are half as long. If you need to generate longer pulse widths, you may set the value of `Register.TimerSpeed1` so that a slower clock rate is used. Also, the BasicX documentation indicates that if the I/O Timer is already in use, that use will be terminated and the waveform generation will be performed.

**See Also**      `OutputCaptureEx`

# OutputCaptureEx

**Type** Subroutine

**Invocation** OutputCaptureEx(pin, intervals, count, flags)  
OutputCaptureEx(pin, intervals, count, flags, repeatCount)

Parameter	Method	Type	Description
pin	ByVal	Byte	Specifies the waveform output pin.
intervals	ByRef	array of int16	The lengths of successive segments of the output waveform.
count	ByVal	any int	The number of entries in the <code>intervals</code> array (1-65535).
flags	ByVal	Byte	Configuration bits controlling the generation process.
repeatCount	ByVal	any int	The number of times to repeat the pattern (1-65535).

## Discussion

This subroutine produces a series of precisely timed logic levels on the specified pin allowing you to produce an arbitrary waveform. Each entry in the `intervals` array specifies a time interval, in units of the I/O Timer clock period (by default, about 67.8ns for devices running at 14.7MHz), for each segment of the waveform. When called, the specified pin will be made an output and will be set to its initial state (the complement of the least significant bit of the `flags` parameter).

When waveform generation is begun, the specified pin will be changed to the opposite state for the interval specified by the first `intervals` element, changed to the opposite state again for the interval specified by the second `intervals` element, etc. for as many elements as specified. The final state of the output pin depends on whether the `count` parameter is odd or even. If it is odd the final state will be the complement of the least significant bit of the `flags` parameter; if it is even the final state will be the same as the least significant bit of the `flags` parameter.

If the optional `repeatCount` parameter is not given a repeat count of 1 is assumed. If the repeat count is 1 the `intervals` array should generally have an odd number of values. This allows the output to end in the same state as it started. If the repeat count is greater than one the `intervals` array should generally have an even number of values. This allows the output waveform to repeat at the same logic levels. Also, when the waveform is repeated the last interval of the last cycle is omitted so that the output ends up in the same state as it started.

The calling task will be suspended during the waveform generation process. If another task disables interrupts, the accuracy of the generated waveform will suffer.

Due to processing overhead, the smallest pulse width that can be accommodated is about 6.8μS. This corresponds to a value of about 100 in the data array at the default timer speed. If the system has a heavy interrupt load (e.g. serial channels 3-6 are open) the minimum pulse width for reliable operation may be significantly larger. The maximum pulse width using the default timer speed is about 4.4mS. If you need to generate longer pulse widths, you may set the value of `Register.TimerSpeed1` so that a slower clock rate is used.

To avoid unwanted logic transitions on the output pin during preparation for waveform generation, the output pin should either be configured as an input or as an output in the desired starting state prior to the call. If you configure it as an input you'll probably need to employ a pullup or pulldown resistor on the pin to guarantee the desired logic state prior to the commencement of waveform generation.

Although this subroutine can be invoked specifying the hardware OutputCapture pin (see the table below) or any other I/O pin, the behavior when using a general I/O pin may be slightly different than when using the hardware OutputCapture pin. The hardware OutputCapture pin uses features of the hardware to toggle the I/O pin while for general I/O pins the pin is toggled in software by directly setting the corresponding PORTx bit. During periods of high interrupt load the hardware toggling will be more accurate.

## Resource Usage

This routine uses the I/O Timer. If the timer is already in use the routine will return immediately without performing the waveform generation. Also, this routine cannot be used at the same time as `InputCapture()` or `InputCaptureEx()` that requires the same timer.

**Hardware Output Capture Pins**

<b>ZX Models</b>	<b>Timer 1 Pin</b>	<b>Timer 3 Pin</b>	<b>Timer 4 Pin</b>	<b>Timer 5 Pin</b>
ZX-24, ZX-24a, ZX-24p, ZX-24n	27, D.4	-	-	-
ZX-40, ZX-40a, ZX-40p, ZX-40n	18, D.4	-	-	-
ZX-44, ZX-44a, ZX-44p, ZX-44n	13, D.4	-	-	-
ZX-24r, ZX-24s	27, D.4	B.7	-	-
ZX-40r, ZX-40s	18, D.4	8, B.7	-	-
ZX-44r, ZX-44s	13, D.4	3, B.7	-	-
ZX-24e, ZX-24ae, ZX-24ne, ZX-24pe, ZX-24nu, ZX-24pu	13, D.4	-	-	-
ZX-24ru, ZX-24su	16, D.4	21, B.7	-	-
ZX-328n, ZX-328l	16, B.2	-	-	-
ZX-32n, ZX-32l	14, B.2	-	-	-
ZX-1281, ZX-1281n	16, B.6	6, E.4	-	-
ZX-1280, ZX-1280n	25, B.6	6, E.4	16, H.4	39, L.4
ZX-128e, ZX-128ne, ZX-1281e, ZX-1281ne	22, B.6	16, E.4	-	-
ZX-328nu	13, B.2	-	-	-

**Hardware Output Capture Pins**

<b>ZX Models</b>	<b>TimerC0</b>	<b>TimerD0</b>	<b>TimerD1</b>	<b>TimerE0</b>	<b>TimerE1</b>	<b>TimerF0</b>	<b>TimerF1</b>
ZX-24x	11, C.1	27, D.1	D.5	17, E.1	-	-	-
ZX-32a4	11, C.1	21, D.1	25, D.5	29, E.1	-	-	-
ZX-128a1	16, C.1	26, D.1	30, D.5	36, E.1	40, E.5	46, F.1	50, F.5
ZX-24xu	11, C.1	13, D.1	15, D.5	23, E.1	-	-	-

When performing an output capture on a general I/O pin, the IO Timer will be used to generate the required timing. On ZX devices that have other 16-bit timers, they will be used if the IO Timer is not available. If no 16-bit timer is available, the routine will return immediately.

For native code devices, the table below gives the ISRs that may be loaded if your program uses `OutputCapture()`. If the compiler cannot determine which specific timer ISR is required by analyzing the parameters used, all listed ISRs will be included.

**ISRs Required**

<b>Underlying CPU</b>	<b>ISR Name</b>
mega328P, mega644P	Timer1_CompB
mega128	Timer1_CompB, Timer3_CompB
mega1281, mega1284P	Timer1_CompB, Timer1_CompC, Timer3_CompB
mega1280	Timer1_CompB, Timer1_CompC, Timer3_CompB, Timer4_CompB Timer5_CompB
xmega32A4	TimerC0_CCB, TimerD0_CCB, TimerD1_CCB, TimerE0_CCB
xmega128A1	TimerC0_CCB, TimerD0_CCB, TimerD1_CCB,

---

TimerE0_CCB,
TimerE1_CCB,
TimerF0_CCB,
TimerF1_CCB

---

### Compatibility

This routine is not available in BasicX compatibility mode.

# ParityCheck

---

**Type**            Function returning Boolean

**Invocation**    ParityCheck(data, oddParity)

Parameter	Method	Type	Description
data	ByVal	Byte	The data value for which to check the parity.
oddParity	ByVal	Boolean	The desired parity: True -> odd parity, False -> even parity

## Discussion

This function computes the parity over the eight bits of the provided data value and compares that result to the desired result indicated by the `oddParity` parameter. The return value is a pass/fail indicator where True means that the parity matched the desired parity.

The data value has even parity if the number of one bits in the value is even.

## Example

```
Dim b as Byte

If Not ParityCheck(b, False) Then
    Debug.Print "Even parity check failed"
End If
```

## Compatibility

This routine is not available in BasicX compatibility mode.

# Pause

**Type** Subroutine

**Invocation** Pause(time)

Parameter	Method	Type	Description
time	ByVal	Single or int16	The amount of time to pause, in seconds (Single) or Timer 0 ticks (int16)

## Discussion

This routine suspends execution of the current task for approximately the period of time specified. No other task is allowed to run during the pause period. The resolution of the time period is approximately 4.34µS with a maximum pause time of about 284mS. Note that the accuracy of the pause may be affected by the time required for the processor to service interrupts (RTC, serial channel, etc.). Also note that the resolution of the pause is similar to the minimum execution time for user instructions. This means that timing using `Pause()` calls of less than 20 to 50 units or so will be affected significantly by the succeeding instructions.

This routine should be used instead of `Sleep()` or `Delay()` when higher resolution timing is required or you don't want a task switch to occur. If you need longer pauses than can be produced by this routine, you can implement them using `Register.RTCStopWatch`.

## Example

```
Do
    Call PutPin(12, 0)
    Call Pause(0.010)      ' a 10 millisecond delay
    Call PutPin(12, 1)
    Call Pause(2304)       ' a 10 millisecond delay
Loop
```

This loop produces a square wave signal on pin 12 at approximately 50Hz (with some jitter due to handling interrupts).

## Compatibility

This routine is not available in BasicX compatibility mode.

**See Also** Delay, DelayUntilClockTick, Sleep, WaitForInterval

# PeekQueue

**Type** Subroutine

**Invocation** PeekQueue(queue, var, count)

Parameter	Method	Type	Description
queue	ByRef	array of Byte	The queue from which to retrieve data.
var	ByRef	any type	The variable to receive the retrieved data.
count	ByVal	int16	The number of bytes to retrieve.

## Discussion

This routine will copy the specified number of bytes from the queue to the indicated variable but it does not remove them from the queue. The routine will not return until it can copy the entire number of bytes specified. Because of this, you should usually check the number of bytes available in the queue using `GetQueueCount()` before calling `PeekQueue()`.

Note that if the calling task is locked and the queue contains insufficient data when this routine is called, the task will be unlocked to allow other tasks to run.

## Caution

If the requested number of bytes is larger than the queue capacity, the routine will never return. Likewise, if not enough data is placed in the queue, the routine will never return. Also, if the variable to receive the data is smaller than the number of bytes indicated, adjacent memory will be overwritten, usually with undesirable results.

## Example

## Compatibility

BasicX allows any type for the first parameter. The ZBasic implementation requires that it be an array of `Byte`.

# PersistentPeek

---

**Type**            Function returning Byte

**Invocation**    PersistentPeek(address)

Parameter	Method	Type	Description
address	ByVal	int16	The persistent memory address from which to read.

## Discussion

This function will return the content of the specified persistent memory address.

The address of any persistent variable can also be obtained using the `DataAddress` property. For persistent variables, the `DataAddress` property is of type `UnsignedInteger`.

## Example

```
Dim pi as PersistentInteger
Dim b as Byte
b = PersistentPeek(1000)
b = PersistentPeek(pi.DataAddress + 1)
```

The second use of `PersistentPeek()` demonstrates how you can use the `DataAddress` property to read a byte value from any part of a persistent variable of any type.

## Compatibility

BasicX does not support the use of the `DataAddress` property for persistent items.

The BasicX system has only 512 bytes of persistent memory. This implementation has 1024 bytes of persistent memory of which the first 32 are reserved for system use.

**See Also**        PersistentPoke

# PersistentPoke

**Type** Subroutine

**Invocation** PersistentPoke(value, address)

Parameter	Method	Type	Description
value	ByVal	Byte	The to write to persistent memory.
address	ByVal	int16	The persistent memory address to which to write.

## Discussion

This routine will write the given value to the specified persistent memory address.

The address of any persistent variable can also be obtained using the `DataAddress` property. For persistent variables, the `DataAddress` property is of type `UnsignedInteger`.

## Caution

The first 32 bytes of persistent memory are reserved for the system. Modifying any of them may produce unpredictable results.

The persistent memory (on-board EEPROM) has a limit specified by the manufacturer of a million write cycles. When this limit is exceeded the memory may become unreliable.

## Example

```
Dim pi as PersistentInteger
Call PersistentPoke(&H55, 1000)
Call PersistentPoke(&H55, pi.DataAddress + 1)
```

The second use of `PersistentPoke()` demonstrates how you can use the `DataAddress` property to write a byte value to any part of a persistent variable of any type.

## Compatibility

BasicX does not support the use of the `DataAddress` property for persistent items.

The BasicX system has only 512 bytes of persistent memory. This implementation has 1024 bytes of persistent memory of which the first 32 are reserved for system use.

**See Also** PersistentPeek

# PlaySound

**Type** Subroutine

**Invocation** PlaySound(pin, address, length, rate, repeat)

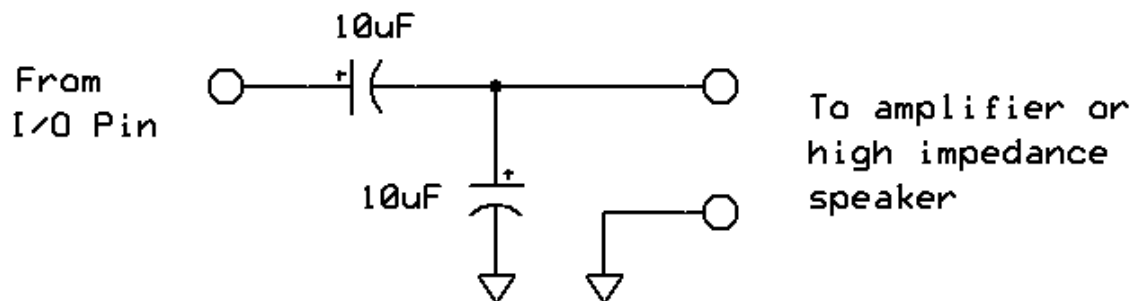
Parameter	Method	Type	Description
pin	ByVal	Byte	The output pin.
address	ByVal	int16	The Program Memory address of the sound data.
length	ByVal	int16	The number of bytes of sound data.
rate	ByVal	int16	The sample rate for the sound data.
repeat	ByVal	int16	The number of times to repeat the sound.

## Discussion

This routine uses a pseudo-PWM technique to create an approximation to a sine wave on the specified output pin. The frequency of the sine wave is given by successive bytes in Program Memory beginning at the specified address and continuing for the given length. The `rate` parameter specifies the rate at which the data elements will be utilized. It is equivalent to the sampling rate at which an original analog sound might have been digitized. Lastly, the `repeat` parameter tells how many times to repeat the production of the output using the supplied data. If zero is specified, the sound will be repeated 65,536 times.

The minimum supported sample rate is 250Hz. If a smaller value is specified, 250Hz will be used instead.

The actual output will be a pulse stream that has an average value that approximates the target analog signal. Because of the high frequency nature of the pulse train used to synthesize the waveform some filtering is required. The example circuit below may be used to couple the output to a high impedance speaker (> 40  $\Omega$ ) or an amplifier. Note, however, that the signal is too large to be fed to the microphone input of an amplifier. Instead, the Auxiliary or Line input should be used.



## Resource Usage

This routine uses the I/O Timer and disables interrupts during the generation process. In particular, this means that serial input that arrives during the generation will likely be missed and serial output on channels 3-6 will be disrupted.

Task switching is suspended and other interrupts are disabled while the sound is being produced. However, RTC ticks are accumulated during the process and the RTC is updated when the process has completed so that the RTC does not lose time.

### Example

```
Dim music as ByteVectorData("sound.txt")
```

```
Call PlaySound(12, LoWord(music.DataAddress), UBound(music), 11025, 1)
```

This example assumes that you have prepared the file “sound.txt” to contain the digitized music, sampled at 11025Hz.

### Compatibility

The BasicX documentation for `PlaySound()` does not explicitly indicate that a zero repeat count will result in 65,536 iterations. However, experimental evidence indicates that it does.

In the BasicX implementation the RTC will lose time if the duration is too long. It is not known if the BasicX implementation has a minimum sample rate.

# PortBit

**Type**                      Function returning Byte

**Invocation**            PortBit(portIdx, bitIdx)  
PortBit(pin)

Parameter	Method	Type	Description
portIdx	ByVal	integral	The I/O port designator (A=0, B=1, etc.)
bitIdx	ByVal	integral	The bit designator (0-7)
pin	ByVal	integral	A pin number

## Discussion

This function returns a composite value that describes a specific bit in a specific I/O port. The fields of the Byte value are as shown in the table below.

Bit(s)	Description
7	Always 1
6-3	The I/O port designator (A=0, B=1, etc.)
2-0	The bit designator (0-7)

When invoked in the first form with the parameter values 2 and 6 (representing Port C, bit 6) the return value will have the bit pattern &B10010110.

The second form of invocation converts a physical pin number to the composite value representing the port and bit corresponding to that pin. When passed an invalid pin, the return value is zero.

Values returned by the PortBit() function may be used anywhere that a pin number may be used, e.g. as the first parameter to PutPin(). The primary advantage to using the composite port/bit designator is that the same value may be used unchanged on any ZX device.

Note that the special port/bit designators like `C.2` are converted by the compiler to the same type of composite port/bit designator described here if the compiler directive `Option PortPinEncoding On` is specified.

## Compatibility

This function is not available in BasicX compatibility mode.

# PortMask

**Type**            Function returning Byte

**Invocation**    PortMask(pin)

Parameter	Method	Type	Description
pin	ByVal	integral	A pin number

## Discussion

This function returns a bit mask for the port with which the specified pin is associated. The resulting bit mask will have at most one bit set if the pin is valid and will be zero for an invalid pin. The bit mask can be used for directly manipulating the I/O registers associated with a pin.

Note that the value of this function is a compile-time constant if the compiler can determine the value of the pin parameter at compile-time.

For further information about how to use this function, see the discussion of `Register.Port()` in the ZBasic Reference Manual.

## Example

```
Dim mask as Byte

mask = PortMask(C.2)      ' the result will be &H04
```

## Compatibility

This function is not available in BasicX compatibility mode.

# Pow

**Type**            Function returning Single

**Invocation**    Pow(mantissa, exponent)

Parameter	Method	Type	Description
mantissa	ByVal	Single	The value to be raised to the power given by the exponent.
exponent	ByVal	Single	The exponent value.

## Discussion

This function returns the value of the first parameter raised to the power given by the second parameter. This is the same functionality as provided by the exponentiation operator ^.

Certain special cases are detected as shown in the table below.

Mantissa	Exponent	Result
any value	0.0	1.0
negative	non-integral value	NaN
0.0	Negative	+Infinity

## Example

```
Dim r as Single, f as Single  
  
f = 10.0  
r = Pow(f, 2.0)    ' result is 100.0
```

**See Also**        Exp, Exp10

# ProgMemFind

**Type**                      Function returning UnsignedInteger

**Invocation**            ProgMemFind(dataAddr, dataLen, val)  
                         ProgMemFind(dataAddr, dataLen, val, ignoreCase)

Parameter	Method	Type	Description
dataAddr	ByVal	Long	The address in Program Memory of the block to search.
dataLen	ByVal	integral	The length of the block to search.
val	ByVal	Byte	The byte value for which to search.
ignoreCase	ByVal	Boolean	A flag controlling whether alphabetic case is significant.

## Discussion

This function attempts to find the first occurrence of the byte specified by the `val` parameter in a block of data in Program Memory beginning at the specified address. If it is found, the return value gives the 1-based index where the sought byte was found within the block. If the sought byte is not found, zero is returned. If the optional `ignoreCase` parameter is not given, the search is performed observing alphabetic case differences, otherwise alphabetic case differences are significant or not depending on the value specified for `ignoreCase`. For the purposes of this parameter only the characters A-Z and a-z (&H41 to &H5a and &H61 to &H7a) are considered to be alphabetic.

## Example

```
Dim charSet as ByteVectorData ( { ". $ % ' _ @ ~ ` ! ( ) { } ^ # & " } )
Dim inCharSet as Boolean

If (ProgMemFind(charSet.DataAddress, SizeOf(charSet), c) <> 0) Then
    inCharSet = True
End If
```

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also**                MemFind, StrFind

# PulseIn (subroutine form)

**Type** Subroutine

**Invocation** PulseIn(pin, level, var)

Parameter	Method	Type	Description
pin	ByVal	Byte	The pin on a pulse width will be measured.
level	ByVal	Byte	The expected pulse logic value (high = 1).
var	ByRef	Single	The variable to receive the pulse width value.

## Discussion

This routine waits for the input pin to be in the idle state (the opposite of that specified by the `level` parameter), waits for it to change to the specified logic level and then measures the time that it stays at that level. The pulse width is stored in the specified variable and has units of seconds with a default resolution of approximately 1.085µs.

The pin is made an input if it is not already so. If the awaited logic transition never occurs or if the pulse width exceeds the maximum representable width the stored result will be zero.

The timing resolution may be adjusted using `Register.TimerSpeed2`. However, if this is done, the resulting pulse width value will need to be scaled proportionally. Note that for compatibility with BasicX, the timing resolution is one half of the period of the selected I/O Timer frequency.

## Resource Usage

This routine uses the I/O Timer and interrupts are disabled during the pulse measurement. However, RTC ticks will be accumulated during the pulse measurement and the RTC will be updated when the process is complete.

## Example

```
Dim width as Single
Call PulseIn(12, 1,width)      ' measure a positive-going pulse
```

## Compatibility

The BasicX implementation does not support adjustable timing resolution.

# PulseIn (function form)

**Type**                Function returning Integer

**Invocation**        PulseIn(pin, level)

Parameter	Method	Type	Description
pin	ByVal	Byte	The pin on a pulse width will be measured.
level	ByVal	Byte	The expected pulse logic value (high = 1).

## Discussion

This routine waits for the input pin to be in the idle state (the opposite of that specified by the `level` parameter), waits for it to change to the specified logic level and then measures the time that it stays at that level. The width of the pulse is returned by the function, the units of which are 2 times the I/O Timer period. At the default I/O Timer clock period of 0.54μS, the returned value has units of 1.08μS.

The pin is made an input if it is not already so. If the awaited logic transition never occurs or if the pulse width exceeds the maximum representable width the returned value will be zero.

The timing resolution may be adjusted using `Register.TimerSpeed2`. Note that for compatibility with BasicX, the timing resolution is one half of the period of the selected I/O Timer frequency.

## Resource Usage

This routine uses the I/O Timer and interrupts are disabled during the pulse measurement. However, RTC ticks will be accumulated during the pulse measurement and the RTC will be updated when the process is complete.

## Example

```
Dim width as Integer

i = PulseIn(12, 1)            ' measure a positive pulse
```

## Compatibility

The BasicX implementation does not support adjustable timing resolution.

# PulseOut

**Type** Subroutine

**Invocation** PulseOut(pin, duration, level)

Parameter	Method	Type	Description
pin	ByVal	Byte	The pin on which a pulse width will be generated.
duration	ByVal	int16 or Single	The width of the generated pulse.
level	ByVal	Byte	The desired pulse logic value (low = 0, high = 1).

## Discussion

This routine first makes the specified pin an output. (However, for practical purposes, you should generally make the pin an output and set it to the desired state before calling this routine.) Then it sets the pin to the active state (as indicated by the `level` parameter), waits the specified time and then sets the pin back to the inactive state. The pin will be left configured as an output.

The pulse width may be specified by a `Single` value with units of seconds and a resolution of approximately 1.085µs (however, due to processing overhead, the shortest pulse that can be generated is slightly less than 2µs). Alternately, the pulse width may be specified by an `Integer` or `UnsignedInteger` value with units of 2 x I/O Timer ticks (by default, 1.085µs). Note, however, that `Register.TimerSpeed2` may be modified to adjust the I/O Timer tick rate. If this is done, the `Single` value will have to be scaled proportionally.

If the output pin is specified as zero, this routine does not generate a pulse but will delay for approximately the specified period of time. This may be useful for generating a delay with better precision than can be obtained by using `Delay()` or `Sleep()`. Moreover, generating a delay in this manner does not cause the task to lose control.

## Resource Usage

This routine uses the I/O Timer and interrupts are disabled during the pulse generation. However, RTC ticks will be accumulated during the pulse generation and the RTC will be updated when the process is complete. If the pulse is too long characters being sent or received on serial channels 3-6 may be garbled.

## Example

```
Dim width as Integer
```

```
Call PutPin(12, zxOutputLow)
Call PulseOut(12, 2, 1)      ' generate a positive pulse about 2µS long
Call PulseOut(0, 1e-5, 0)    ' generate a delay of about 10µS
```

## Compatibility

In the BasicX implementation the RTC will lose time if the pulse is too long.

The BasicX implementation does not support adjustable timing resolution.

# Put1Wire

---

**Type** Subroutine

**Invocation** Put1Wire(pin, value)

Parameter	Method	Type	Description
pin	ByVal	Byte	The pin to be used for 1-Wire I/O.
value	ByVal	Byte	The bit value to write.

## Discussion

This routine sends the LSB of the given value using the 1-Wire protocol. To perform a 1-Wire operation, this function along with related 1-Wire routines must be used in the proper sequence. See the specifications of your 1-Wire device for more information.

## Resource Usage

This routine uses the I/O Timer and disables interrupts for about 100µS.

## Example

```
Call Put1Wire(12, 1)
```

**See Also** Get1Wire, Get1WireByte, Get1WireData, Put1WireByte, Put1WireData, Reset1Wire

# Put1WireByte

---

**Type** Subroutine

**Invocation** Put1WireByte(pin, value)

Parameter	Method	Type	Description
pin	ByVal	Byte	The pin to be used for 1-Wire I/O.
value	ByVal	Byte	The value to write.

## Discussion

This routine sends a byte (LSB first) using the 1-Wire protocol. To perform a 1-Wire operation, this function along with related 1-Wire routines must be used in the proper sequence. See the specifications of your 1-Wire device for more information.

## Example

```
Call Put1WireByte(12, &H55)
```

## Resource Usage

This routine uses the I/O Timer and disables interrupts for about 100µS for each bit sent.

## Compatibility

This routine is not available in BasicX compatibility mode.

**See Also** Get1Wire, Get1WireByte, Get1WireData, Put1Wire, Put1WireData, Reset1Wire

# Put1WireData

**Type** Subroutine

**Invocation** Put1WireData(pin, data, count)

Parameter	Method	Type	Description
pin	ByVal	Byte	The pin to be used for 1-Wire I/O.
data	ByRef	any type	A variable holding the bytes to write.
count	ByVal	Byte	The number of bytes to write.

## Discussion

This routine sends 1 or more bytes of data (each LSB first) using the 1-Wire protocol. To perform a 1-Wire operation, this function along with related 1-Wire routines must be used in the proper sequence. See the specifications of your 1-Wire device for more information.

## Example

```
Dim d(1 to 10) As Byte

Call Put1WireData(12, d, 5)
```

## Resource Usage

This routine uses the I/O Timer and disables interrupts for about 100µS for each bit sent.

## Compatibility

This routine is not available in BasicX compatibility mode.

**See Also** Get1Wire, Get1WireByte, Get1WireData, Put1Wire, Put1WireByte, Reset1Wire

# PutBit

**Type** Subroutine

**Invocation** PutBit(var, bitNumber, val)

Parameter	Method	Type	Description
var	ByRef	any type	The variable to which the bit will be written.
bitNumber	ByVal	int8/16	The bit number to write.
val	ByVal	Byte	The bit value.

## Discussion

This routine writes a single bit to memory beginning at the location of the specified variable. Bit numbers 0-7 are written to the byte at the specified location, bit numbers 8-15 are written to the subsequent byte, etc. In each case, the lower bit number corresponds to the least significant bit of the byte while the highest bit number corresponds to the most significant bit of a byte.

Only the least significant bit of the `val` parameter is used; the remaining bits are ignored.

## Caution

If you specify a bit number beyond the number of bits in the specified variable, a byte in memory following the variable will be modified, perhaps with undesirable results.

## Compatibility

In BasicX compatibility mode, the `bitNumber` parameter may only be specified using a `Byte` value.

**See Also** GetBit

# PutDAC

**Type** Subroutine

**Invocation** PutDAC(pin, dacValue, dacAccumulator)  
PutDAC(pin, dacValue, dacAccumulator, cycles)

Parameter	Method	Type	Description
pin	ByVal	Byte	The output pin.
dacValue	ByVal	numeric	The desired output value. See discussion below.
dacAccumulator	ByRef	Byte	A value used in the DAC process. See the discussion below.
cycles	ByVal	Byte	The number of PWM cycles to perform.

## Discussion

This routine creates a digital approximation of an analog signal on the specified pin using a pseudo-PWM technique. When called, the specified pin is made an output, a pulse train is generated having an average value equal to the `dacValue` parameter and then, after a fixed number of iterations, the pin is placed in the high impedance input state. If the output is filtered with a low pass filter, the voltage will, immediately after the process is completed, be at a level between zero and the processor voltage (usually +5 volts). However, the voltage will begin to decay at a rate dependent on the load presented to the filter. The voltage can be refreshed from time to time by calling `PutDAC()` again.

The `dacValue` parameter may be specified by a `Single` value or an integral value. If a `Single` value is supplied, it should be in the range 0.0 to 1.0 corresponding to the output range of 0 to the processor voltage (usually +5 volts). If an integral value is supplied, it should be in the range of 0 to 255 corresponding to the same output voltage range as above.

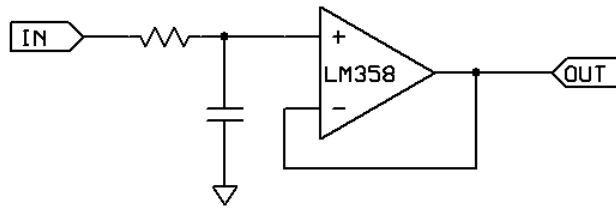
The `dacAccumulator` parameter is required to ensure continuity between successive calls to `PutDAC()`. The value of the parameter after the call should not be modified and the same parameter should be supplied on the next call. The initial value of the parameter is of no consequence. If your application uses `PutDAC()` to create an analog voltage on more than one pin at a time, a separate accumulator value must be used for each one.

If the `cycles` parameter is not specified, a single PWM cycle is performed. Each cycle will generate a burst of pulses for about 200 $\mu$ S during which time interrupts will be disabled. At the end of each cycle, the pin is put in high impedance mode and interrupts are re-enabled. The process is then repeated if the cycle count is greater than one. A cycle count of zero causes no cycles to be performed.

The selection of components for the required filter depends on several factors. A larger capacitor will allow the voltage to hold longer but also takes longer to bring up to the proper voltage. As a rule of thumb, the product of the resistance (in ohms) and the capacitance (in farads) should be on the order of the number of cycles times 50 $\mu$ S. For example, with a 100 resistor and a 1 $\mu$ F capacitor, the cycle count should probably be 2 in order to bring the capacitor up to the desired voltage level.

For best results, you should probably follow the filter with a high impedance buffer such as a unity gain op amp circuit, an example of which is shown below. The op amp chosen is not particularly critical, nearly any will do the job.

For ZX devices based on the ATxmega, a hardware DAC is available. In most applications requiring a DAC, using the hardware DAC will produce much better results.



## Examples

```
Dim acc as Byte
```

```
Call PutDAC(12, 0.5, acc)
```

```
Call PutDAC(12, 128, acc, 5)
```

## Compatibility

In BasicX compatibility mode, the `dacValue` parameter may only be specified using a `Single` value. Also, the fourth parameter is not supported.

## Resource Usage

This routine disables interrupts for about 200µS during the generation process. Interrupts are reenabled between each successive cycle.

**See Also**      DAC, DACPin, OpenDAC

# PutDate

---

**Type** Subroutine

**Invocation** PutDate(year, month, day)

Parameter	Method	Type	Description
year	ByVal	int16	The year value (1999-2177).
month	ByVal	Byte	The month value (1-12).
day	ByVal	Byte	The day value (1-31).

## Discussion

This routine composes a new value for `Register.RTCDay` using the provided parameters. The month value of 1 corresponds to January while 12 corresponds to December. If the year or month is invalid or if the day number is invalid for the specified month and year, `Register.RTCDay` will be set to zero.

Note that `Register.RTCDay` is initialized to zero on power-up or reset. This corresponds to January 1, 1999.

**See Also**      `GetDate`

# PutEEPROM

---

**Type** Subroutine

**Invocation** PutEEPROM(addr, var, count)

Parameter	Method	Type	Description
addr	ByVal	Long	The Program Memory address at which to begin writing.
var	ByRef	any type	The variable from which the data to be written will be taken.
count	ByVal	int16	The number of bytes to write.

## Discussion

This routine is provided for compatibility with BasicX. The more aptly named PutProgMem() should be used by new applications.

**See Also** GetProgMem, PutProgMem

# PutNibble

---

**Type** Subroutine

**Invocation** PutNibble(var, nibbleNumber, val)

Parameter	Method	Type	Description
var	ByRef	any type	The variable to which the nibble will be written.
nibbleNumber	ByVal	int8/16	The nibble number to write.
val	ByVal	Byte	The nibble value.

## Discussion

This routine writes a single nibble (four bits) to memory beginning at the location of the specified variable. Nibble numbers 0-1 are written to the byte at the specified location, nibble numbers 2-3 are written to the subsequent byte, etc. In each case, the lower nibble number corresponds to the least significant four bits of the byte while the higher nibble number corresponds to the most significant four bits of the byte.

Only the least significant four bits of the `val` parameter is used; the remaining bits are ignored.

## Caution

If you specify a nibble number beyond the number of nibbles in the specified variable, a byte in memory following the variable will be modified, perhaps with undesirable results.

## Compatibility

This routine is not available in BasicX compatibility mode.

**See Also** GetNibble

# PutPersistent

---

**Type** Subroutine

**Invocation** PutPersistent(addr, var, count)

Parameter	Method	Type	Description
addr	ByVal	int16	The Persistent Memory address to which to write.
var	ByRef	any type	The variable from which data will be taken.
count	ByVal	int8/16	The number of bytes to write.

## Discussion

This routine reads one or more bytes from RAM and writes them to Persistent Memory beginning at the address given.

## Caution

Persistent Memory has a write cycle limit of approximately a million writes. Writing to a particular address in excess of this limit may cause the memory to become unreliable.

A block of Persistent Memory starting at address zero is reserved for system use. When the compiler assigns addresses to persistent variables defined in your program, the lowest address used is the first address above this reserved block. The .map file generated by the compiler contains a section indicating the addresses assigned to persistent variables defined in your program. The built-in values `Register.PersistentStart`, `Register.PersistentSize` and `Register.PersistentUsed` may be useful for determining the allocated and unallocated portions of Persistent Memory.

This routine will write to any address in Persistent Memory. Generally, you should avoid writing to the reserved area of Persistent Memory.

## Example

```
Dim pvar(1 to 10) as PersistentByte
Dim var(1 to 10) as Byte

Call PutPersistent(pvar.DataAddress, var, SizeOf(pvar))
```

## Compatibility

This routine is not available in BasicX compatibility mode.

**See Also** GetPersistent

# PutPin

**Type** Subroutine

**Invocation** PutPin(pin, mode)

Parameter	Method	Type	Description
pin	ByVal	Byte	The pin to configure.
mode	ByVal	Byte	The configuration mode (see below).

## Discussion

This routine is used to configure a pin to be an input or an output or to effect a change in the output logic level. If the pin is configured as an input, it may be configured to be in “tri-state” mode or “pull-up” mode. If the pin is configured to be an output, the output level may be set to zero or 1. The table below gives the values for each of the possible modes. If an invalid mode is specified or an invalid pin is specified, the routine has no effect.

**Values for the mode Parameter**

Value	Built-in Constant	Description
0	zxOutputLow	The pin is an output at logic zero.
1	zxOutputHigh	The pin is an output at logic one.
2	zxInputTriState	The pin is an input with the pull-up/pull-down resistors disabled.
3	zxInputPullUp	The pin is an input with the pull-up resistor enabled.
4	zxOutputToggle	Change the logic level of the output.
5	zxOutputPulse	Pulse the output.
6	zxInputPullDown	The pin is an input with the pull-down resistor enabled
7	zxInvertIO	Input and output levels are inverted.
8	zxNormalIO	Input and output levels are normal (non-inverted).

Note that for modes 4 and 5 to be useful, the pin must have been previously set to be an output. Mode 4 (zxOutputToggle) will change the output to the opposite logic level. Mode 5 (zxOutputPulse) will change the output to the opposite level for a short period of time and then change it back to the original level. The duration of the pulse will be about 8 CPU cycles (approximately 0.5uS at 14.7456MHz).

Modes 6, 7 and 8 are only supported on ZX devices based on the xmega CPU. Modes 7 and 8 are to be used in conjunction with the other modes (in separate calls, of course) to achieve the desired configuration.

## Example

```
Call PutPin(12, zxOutputLow) ' pin 12 will be at logic zero
```

## Compatibility

In BasicX compatibility mode, *mode* values higher than 3 are not supported.

**See Also** GetPin

# PutProgMem

---

**Type** Subroutine

**Invocation** PutProgMem(addr, var, count)

Parameter	Method	Type	Description
addr	ByVal	Long	The Program Memory address to which to begin writing.
var	ByRef	any type	The variable from which the data to be written will be taken.
count	ByVal	int16	The number of bytes to write.

## Discussion

This routine writes one or more bytes to Program Memory (where the user program is stored) taking the data from RAM beginning at the location of the specified variable. Note that if a number of bytes is specified that is larger than the given variable, adjacent memory will be read.

## Caution

Program Memory has a write cycle limit specified by the manufacturer of a million cycles. Writing to a particular address in excess of this limit may result in unreliable operation.

**See Also** GetProgMem

# PutQueue

**Type** Subroutine

**Invocation** PutQueue(queue, var, count)

Parameter	Method	Type	Description
queue	ByRef	array of Byte	The queue to which to write data.
var	ByRef	any type	The variable from which to read data to be written to the queue.
count	ByVal	int16	The number of bytes to write to the queue.

## Discussion

This routine reads data from the variable and writes it to the specified queue. If there is insufficient space in the queue, the calling task will suspend until space becomes available. Note, particularly, that no data will be written until there is room for all the data to be written. This has two important ramifications.

Firstly, if the number of bytes to be written is larger than the data capacity of the queue, the write will never complete. Secondly, if data is never taken out of the queue thus making room for the additional data, the write will also never complete.

Note that the number of bytes to write may be larger than the named variable. If this is the case, data will be taken from subsequent memory locations until the write count is satisfied. This may or may not be what you intended to occur.

Note, also, that before any queue operations are performed, the queue data structure must be initialized. See the discussion of `OpenQueue()` for more details. Also, attempting to put data in a queue that has been assigned to a Com port as the receive queue will produce undefined results.

## Example

```
Dim outQueue(1 to 40) as Byte
Dim lval as Long

Call OpenQueue(outQueue, SizeOf(outQueue))
lval = &H55aa
Call PutQueue(outQueue, lval, SizeOf(lval))
```

## Compatibility

BasicX allows any type for the first parameter. The ZBasic implementation requires that it be an array of Byte.

**See Also** PutQueueByte, PutQueueStr

# PutQueueByte

**Type** Subroutine

**Invocation** PutQueueByte(queue, val)

Parameter	Method	Type	Description
queue	ByRef	array of Byte	The queue to which to write data.
val	ByVal	Byte	The byte value to be written to the queue.

## Discussion

This routine writes the given byte value to the specified queue. If there is insufficient space in the queue, the calling task will suspend until space becomes available. This means that if data is never taken out of the queue thus making room for additional data, the process will never complete.

Note that before any queue operations are performed, the queue data structure must be initialized. See the discussion of `OpenQueue()` for more details. Also, attempting to put data in a queue that has been assigned to a Com port as the receive queue will produce undefined results.

## Example

```
Dim outQueue(1 to 40) as Byte

Call OpenQueue(outQueue, SizeOf(outQueue))
Call PutQueueByte(outQueue, &H55)
```

## Compatibility

This routine is not available in BasicX compatibility mode.

**See Also** OpenQueue, PutQueue, PutQueueStr

# PutQueueStr

**Type** Subroutine

**Invocation** PutQueueStr(queue, str)

Parameter	Method	Type	Description
queue	ByRef	array of Byte	The queue to which to write data.
str	ByVal	String	The string to be written to the queue.

## Discussion

This routine writes the characters from the string to the specified queue. If there is insufficient space in the queue, the calling task will suspend until space becomes available. Note, particularly, that no data will be written until there is room for all the data to be written. This has two important ramifications. Firstly, if the number of bytes to be written is larger than the data capacity of the queue, the write will never complete. Secondly, if data is never taken out of the queue thus making room for the additional data, the write will also never complete.

Note that before any queue operations are performed, the queue data structure must be initialized. See the discussion of `OpenQueue()` for more details. Also, attempting to put data in a queue that has been assigned to a Com port as the receive queue will produce undefined results.

## Example

```
Dim outQueue(1 to 40) as Byte

Call OpenQueue(outQueue, SizeOf(outQueue))
Call PutQueueStr(outQueue, "Hello, world!")
```

## Compatibility

BasicX allows any type for the first parameter. The ZBasic implementation requires that it be an array of Byte.

**See Also** PutQueueByte, PutQueue, OpenQueue

# PutTime

---

**Type** Subroutine

**Invocation** PutTime(hour, minute, seconds)

Parameter	Method	Type	Description
hour	ByVal	Byte	The hour value (0-23).
minute	ByVal	Byte	The minutes value (0-59).
seconds	ByVal	Single	The seconds value (0.0 to 59.999)

## Discussion

This routine combines the given values into the corresponding RTC tick count and stores the result in `Register.RTCTick`. Each parameter that is outside its corresponding legal range is considered to be zero.

Note that `Register.RTCTick` is initialized to zero on power-up or reset. This corresponds to 0:00:00.

**See Also** GetTime

# PutTimeStamp

**Type** Subroutine

**Invocation** PutTimeStamp(year, month, day, hour, minute, seconds)

Parameter	Method	Type	Description
year	ByVal	int16	The year value (1999-2177).
month	ByVal	Byte	The month value (1-12).
day	ByVal	Byte	The day value (1-31).
hour	ByVal	Byte	The hour value (0-23).
minute	ByVal	Byte	The minutes value (0-59).
seconds	ByVal	Single	The seconds value.

## Discussion

This routine combines the given date values into the corresponding `Register.RTCDay` value and combines the given time values into the corresponding RTC tick count and stores the result in `Register.RTCTick`. The effect is the same as if `PutDate( )` and `PutTime( )` had been called with their respective parameters.

Note that `Register.RTCDay` and `Register.RTCTick` are initialized to zero on power-up or reset.

# PWM

**Type** Subroutine

**Invocation** PWM(channel, dutyCycle)  
PWM(channel, dutyCycle, status)

Parameter	Method	Type	Description
channel	ByVal	Byte	The channel to use for PWM generation.
dutyCycle	ByVal	Single or integral	The desired duty cycle.
status	ByRef	Boolean	The variable to receive the status value.

## Discussion

This subroutine begins or modifies the generation of a 16-bit PWM signal on the specified channel. The channel must have been previously prepared for PWM generation by calling `OpenPWM()`. PWM generation is performed using one of the CPU's 16-bit timers, the number of which varies depending on the ZX model. The table below indicates the output pin for each PWM supported channel.

**Output Pins for 16-bit PWM Channel Numbers**

ZX Models	1	2	3	4	5	6
ZX-24, ZX-24a, ZX-24p, ZX-24n	26, D.5	27, D.4	-	-	-	-
ZX-40, ZX-40a, ZX-40p, ZX-40n	19, D.5	18, D.4	-	-	-	-
ZX-44, ZX-44a, ZX-44p, ZX-44n	14, D.5	13, D.4	-	-	-	-
ZX-24r, ZX-24s	26, D.5	27, D.4	B.6	B.7	-	-
ZX-40r, ZX-40s	19, D.5	18, D.4	7, B.6	8, B.7	-	-
ZX-44r, ZX-44s	14, D.5	13, D.4	2, B.6	3, B.7	-	-
ZX-24e, ZX-24ae, ZX-24ne, ZX-24pe, ZX-24nu, ZX-24pu	15, D.5	16, D.4	-	-	-	-
ZX-24ru, ZX-24su	15, D.5	16, D.4	22, B.6	21, B.7	-	-
ZX-328n, ZX-328l	15, B.1	16, B.2	-	-	-	-
ZX-32n, ZX-32l	13, B.1	14, B.2	-	-	-	-
ZX-1281, ZX-1281n	15, B.5	16, B.6	17, B.7	5, E.3	6, E.4	7, E.5
ZX-1280, ZX-1280n	24, B.5	25, B.6	26, B.7	5, E.3	6, E.4	7, E.5
ZX-24x	26, D.0	27, D.1	D.4	D.5	12, C.0	11, C.1
ZX-32a4	20, D.0	21, D.1	24, D.4	25, D.5	10, C.0	11, C.1
ZX-24xu	20, D.0	19, D.1	16, D.4	15, D.5	12, C.0	11, C.1
ZX-128a1	25, D.0	26, D.1	27, D.4	28, D.5	15, C.0	16, C.1
ZX-128e, ZX-128ne, ZX-1281e, ZX-1281ne	23, B.5	22, B.6	21, B.7	17, E.3	16, E.4	15, E.5
ZX-328nu	12, B.1	13, B.2	-	-	-	-

ZX Models	7	8	9	10	11	12
ZX-1280, ZX-1280n	15, H.3	16, H.4	17, H.5	38, L.3	39, L.4	40, L.5
ZX-24x	10, C.2	9, C.3	25, E.0	17, E.1	18, E.2	19, E.3
ZX-32a4	12, C.2	13, C.3	28, E.0	29, E.1	32, E.2	33, E.3
ZX-24xu	10, C.2	9, C.3	24, E.0	23, E.1	22, E.2	21, E.3
ZX-128a1	17, C.2	18, C.3	35, E.0	36, E.1	37, E.2	38, E.3

ZX Models	13	14	15	16	17	18	19	20
ZX-128a1	39, E.4	40, E.5	45, F.0	46, F.1	47, F.2	48, F.3	49, F.4	50, F.5

The `dutyCycle` parameter specifies the desired duty cycle of the generated signal, expressing the percentage of time that the PWM signal will be at the logic 1 state. If the supplied parameter is of type `Single`, the value is in percent with a resolution of 0.01%. If the supplied parameter is integral, the units are percent, i.e., the value 100 means 100%. Specifying a `Single` value that is negative or any value greater than 100 will have an undefined effect.

The `status` parameter, if supplied, receives a value to indicate success or failure of the call.

If this subroutine is called without a preceding call to `OpenPWM( )` to prepare the timer, the call will have no effect. This subroutine may be called multiple times to effect changes to the PWM signal's duty cycle while the signal is being generated. The change in duty cycle is synchronized so that it takes effect at the beginning of the next PWM pulse.

### Example

```
Call OpenPWM(2, 50.0, zxFastPWM)' prepare for 50Hz Fast PWM using channel 2
Call PWM(2, 7.5)                ' generate PWM with 7.5% duty cycle (1.5mS)
Call Delay(1.0)
Call PWM(2, 6.25)               ' generate PWM with 6.25% duty cycle (1.25mS)
```

### Compatibility

This subroutine is not available in BasicX compatibility mode.

**See Also**      `ClosePWM`, `OpenPWM`

# PWM8

**Type** Subroutine

**Invocation** PWM8(channel, dutyCycle)  
PWM8(channel, dutyCycle, status)

Parameter	Method	Type	Description
channel	ByVal	Byte	The channel to use for 8-bit PWM generation.
dutyCycle	ByVal	Single or integral	The desired duty cycle.
status	ByRef	Boolean	The variable to receive the status value.

## Discussion

This subroutine begins or modifies the generation of an 8-bit PWM signal on the specified channel. The channel must have been previously prepared for PWM generation by calling `OpenPWM8 ( )`. Eight-bit PWM generation is performed using one of the CPU's 8-bit timers, the number of which varies depending on the ZX model. Note that ZX devices based on ATxmega processors don't have any 8-bit timers so 8-bit PWM is not supported on those devices. The table below indicates the output pin for each PWM supported channel.

**Output Pins for 8-bit PWM Channel Numbers**

ZX Models	Timer	Chan 1	Chan 2
ZX-24	Timer2	25, D.7	-
ZX-40	Timer2	21, D.7	-
ZX-44	Timer2	16, D.7	-
ZX-24a, ZX-24p, ZX-24n, ZX-24r, ZX-24s	Timer2	25, D.7	12, D.6
ZX-40a, ZX-40p, ZX-40n, ZX-40r, ZX-40s	Timer2	21, D.7	20, D.6
ZX-44a, ZX-44p, ZX-44n, ZX-44r, ZX-44s	Timer2	16, D.7	15, D.6
ZX-328n, ZX-328l	Timer2	17, B.3	5, D.3
ZX-32n, ZX-32l	Timer2	15, B.3	1, D.3
ZX-1281, ZX-1281n	Timer0	17, B.7	1, G.5
ZX-1280, ZX-1280n	Timer0	26, B.7	1, G.5
ZX-24e	Timer2	13, D.7	-
ZX-24ae, ZX-24ne, ZX-24pe, ZX-24nu, ZX-24pu, ZX-24ru, ZX-24su	Timer2	13, D.7	14, D.6
ZX-128e, ZX-128ne	Timer2	17, B.7	-
ZX-1281e, ZX-1281ne	Timer0	21, B.7	G.5
ZX-328nu	Timer2	14, B.3	6, D.3

The `dutyCycle` parameter specifies the desired duty cycle of the generated signal, expressing the percentage of time that the PWM signal will be at the logic 1 state. If the supplied parameter is of type `Single`, the value is in percent with a resolution of 0.01%. If the supplied parameter is integral, the units are percent, i.e., the value 100 means 100%. Specifying a `Single` value that is negative or any value greater than 100 will have an undefined effect.

The `status` parameter, if supplied, receives a value to indicate success or failure of the call.

If this subroutine is called without a preceding call to `OpenPWM8 ( )` to prepare the timer, the call will have no effect. This subroutine may be called multiple times to effect changes to the PWM signal's duty cycle while the signal is being generated. The change in duty cycle is synchronized so that it takes effect at the beginning of the next PWM pulse.

### Example

```
Call OpenPWM8(1, 50.0, zxFastPWM) ' prepare for 50Hz Fast PWM
Call PWM8(1, 50.0)                ' generate PWM with 50% duty cycle
```

### Compatibility

This subroutine is not available in BasicX compatibility mode nor is it available on ATxmega-based ZX devices.

**See Also**      ClosePWM8, OpenPWM8

# RadToDeg

---

**Type**                Function returning Single

**Invocation**        RadToDeg(angle)

Parameter	Method	Type	Description
angle	ByVal	Single	The angle, in radians, to convert to degrees.

## Discussion

The trigonometric functions in the System Library all use radian angle measure. Depending on the programming task, it is sometimes more convenient to think of angles in terms of degrees. This function and its inverse DegToRad() facilitate the conversion between the two systems.

Depending on optimization settings, if the parameter supplied to this function is known to be constant at compile time, the compiler will convert the value at compile time. Otherwise, code is generated to perform the conversion (multiplication by a conversion factor) at run time.

## Example

```
Dim f as Single
Dim theta as Single        ' the angle in degrees

theta = RadToDeg(Asin(f))
```

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also**            DegToRad

# RamPeek

---

**Type**            Function returning Byte

**Invocation**    RamPeek(address)

Parameter	Method	Type	Description
address	ByVal	int16	The RAM address from which to read.

## Discussion

This function will return the content of the specified RAM address.

## Example

```
Dim b as Byte
Dim i as Integer

b = RamPeek(MemAddress(i))
b = RamPeek(i.DataAddress)
```

**See Also**        RamPeekDword, RamPeekWord

# RamPeekDword

---

**Type**            Function returning UnsignedLong

**Invocation**    RamPeekDword(address)

Parameter	Method	Type	Description
address	ByVal	int16	The RAM address from which to read.

## Discussion

This function will return the 4-byte value at the specified RAM address. The first byte will be the low order byte and the last will be the high order byte.

## Example

```
Dim ul as UnsignedLong  
  
ul = RamPeekDWord(200)
```

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also**        RamPeek, RamPeekWord

# RamPeekWord

---

**Type**            Function returning UnsignedInteger

**Invocation**    RamPeekWord(address)

Parameter	Method	Type	Description
address	ByVal	int16	The RAM address from which to read.

## Discussion

This function will return the 2-byte value at the specified RAM address. The first byte will be the low order byte and the following will be the high order byte.

## Example

```
Dim u as UnsignedInteger  
  
u = RamPeekWord(200)
```

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also**        RamPeek, RamPeekDword

# RamPoke

**Type** Subroutine

**Invocation** RamPoke(value, address)

Parameter	Method	Type	Description
value	ByVal	Byte	The value to write to RAM.
address	ByVal	int16	The RAM address to which to write.

## Discussion

This routine will write the given value to the specified RAM address.

## Caution

Modifying user variables in this way may cause your program to malfunction. Writing to areas of RAM used by the system may cause your program to malfunction.

## Examples

```
Dim b as Byte
```

```
Call RamPoke(&H55, MemAddress(b))
```

```
Call RamPoke(&H55, b.DataAddress)
```

**See Also** RamPokeDword, RamPokeWord

# RamPokeDword

**Type** Subroutine

**Invocation** RamPokeDword(value, address)

Parameter	Method	Type	Description
value	ByVal	any 32-bit	The value to write to RAM.
address	ByVal	int16	The RAM address to which to write.

## Discussion

This routine will write the given value to the four bytes at the specified RAM address, least significant byte first.

## Caution

Modifying user variables in this way may cause your program to malfunction. Writing to areas of RAM used by the system may cause your program to malfunction.

## Example

```
Dim ul as UnsignedLong

Call RamPokeDword(&H117355aa, MemAddress(ul))
Call RamPokeDword(&H117355aa, ul.DataAddress)
```

## Compatibility

This routine is not available in BasicX compatibility mode.

**See Also** RamPoke, RamPokeWord

# RamPokeWord

**Type** Subroutine

**Invocation** RamPokeWord(value, address)

Parameter	Method	Type	Description
value	ByVal	int16	The value to write to RAM.
address	ByVal	int16	The RAM address to which to write.

## Discussion

This routine will write the given value to the two bytes at the specified RAM address, least significant byte first.

## Caution

Modifying user variables in this way may cause your program to malfunction. Writing to areas of RAM used by the system may cause your program to malfunction.

## Example

```
Dim u as UnsignedInteger  
  
Call RamPokeWord(&H55aa, MemAddress(u))
```

## Compatibility

This routine is not available in BasicX compatibility mode.

**See Also** RamPoke, RamPokeDword

# Randomize

---

**Type**            Subroutine

**Invocation**     Randomize()

## Discussion

This routine seeds the random number generator with the value of Register.RTCTick. This is can be used to introduce some randomness into the sequence of values returned by `Rnd ( )` especially if the time that `Randomize()` gets called has some uncertainty due to external events, e.g. the time that a user takes to press a key.

**See Also**        Rnd

# RCTime (subroutine form)

**Type** Subroutine

**Invocation** RCTime(pin, level, interval)

Parameter	Method	Type	Description
pin	ByVal	Byte	The pin to use.
level	ByVal	Byte	The expected initial logic level of the pin.
interval	ByRef	Single	The variable in which to return the charge/discharge interval.

## Discussion

This routine measures how long the specified pin stays at the given logic level after it is made a tri-state input. The return value is expressed in seconds with a resolution of about 1.085 $\mu$ s by default but this can be changed using `Register.TimerSpeed2`. If the maximum time elapses (32,767 units times the resolution) and the pin has not changed logic levels, the return value will be zero. If the pin is not at the specified level when called, the routine returns immediately with a value of approximately 1.085e-6. The pin will be left in the input tri-state mode.

This function can be used with an external resistor-capacitor circuit to measure the value of one element when the other one is known. The charge/discharge time depends on the values of R and C as well as the initial and final voltages. Before calling this routine, you should make the specified pin an output and set it to the level specified.

## Resource Usage

This routine uses the I/O Timer. If the timer is already in use when this routine is called, it will return immediately with a zero value. The same is true if the specified pin is invalid.

Task switching is suspended and interrupts are disabled while the charge/discharge time is being measured. However, RTC ticks are accumulated during the process and the RTC is updated when the process has completed so that the RTC does not lose time.

## Example

See the function form of this routine for more information.

## Compatibility

In BasicX, the ability to change the resolution using `Register.TimerSpeed2` is not supported.

The BasicX documentation indicates that the maximum value that can be returned is about 71ms. In this implementation, the maximum value that can be returned is about 35.6 corresponding to 35.6ms at standard resolution. The resolution can be changed by modifying `Register.TimerSpeed2` which will affect the maximum time value.

The BasicX implementation will miss RTC ticks if the charge/discharge time is too long.

# RCTime (function form)

**Type**                Function returning Integer

**Invocation**        RCTime(pin, level)

Parameter	Method	Type	Description
pin	ByVal	Byte	The pin to use.
level	ByVal	Byte	The expected initial logic level of the pin.

## Discussion

This function measures how long the specified pin stays at the given logic level after it is made a tri-state input. The return value has units of about 1.085 $\mu$ S by default but this can be changed using `Register.TimerSpeed2`. If the maximum time elapses (32,767 units) and the pin has not changed logic levels, the return value will be zero. If the pin is not at the specified level when called, the routine returns immediately with a value of 1. The pin will be left in the input tri-state mode.

As an example, this function can be used with an external resistor-capacitor circuit to measure the value of one element when the other one is known. The charge/discharge time depends on the values of R and C as well as the initial and final voltages. Before calling this routine, you should make the specified pin an output and set it to the level specified.

## Example

```
Const pin as Byte = 12
```

```
Call PutPin(pin, 1)    ' make the pin an output high to start charging
Call Delay(1.4e-4)    ' delay a bit to allow nearly full charging
i = RCTime(pin, 1)    ' measure the time to reach logic zero level
```

## Resource Usage

This routine uses the I/O Timer. If the timer is already in use when this routine is called, it will return immediately with a zero value. The same is true if the specified pin is invalid.

Task switching is suspended and interrupts are disabled while the charge/discharge time is being measured. However, RTC ticks are accumulated during the process and the RTC is updated when the process has completed so that the RTC does not lose time.

## Compatibility

In BasicX, the ability to change the resolution using `Register.TimerSpeed2` is not supported.

The BasicX implementation will miss RTC ticks if the charge/discharge time is too long.

# Reset1Wire

**Type**                Function returning Byte

**Invocation**        Reset1Wire(pin)

Parameter	Method	Type	Description
pin	ByVal	Byte	The pin to be used for 1-Wire I/O.

## Discussion

This function generates a reset signal on the given pin using the 1-Wire protocol. The return value is the “presence” bit sent by the attached 1-Wire device(s), if any. It will be zero if a 1-Wire device responded, 1 otherwise.

To perform a 1-Wire operation, this function along with related 1-Wire routines must be used in the proper sequence. See the specifications of your 1-Wire device for more information.

## Resource Usage

This routine uses the I/O Timer and disables interrupts for approximately 1mS.

## Example

```
Dim b as Byte  
  
b = Reset1Wire(12)
```

## Compatibility

This routine is not available in BasicX compatibility mode.

**See Also**            Get1Wire, Get1WireByte, Get1WireData,  
Put1Wire, Put1WireByte, Put1WireData

# ResetProcessor

---

<b>Type</b>	Subroutine
<b>Invocation</b>	ResetProcessor()

## Discussion

Calling this routine will cause a WatchDog reset of the processor within 40ms. When the processor begins running again, the value of `Register.ResetFlags` will indicate that a WatchDog reset has occurred. If you need to be able to distinguish between an actual WatchDog reset and a call to `ResetProcessor()` it is recommended that you define a persistent variable and set its value to indicate the source of the reset.

## Compatibility

BasicX does not support `Register.ResetFlags`.

# ResetX10

---

**Type** Subroutine

**Invocation** ResetX10(chan, mask)

Parameter	Method	Type	Description
chan	ByVal	Byte	The X-10 communication channel of interest.
mask	ByVal	Byte	A mask value indicating which state flags to clear.

## Discussion

Calling this routine will clear some of the flags that are returned by the StatusX10() function. The mask parameter should contain a value with a 1 in the bit positions corresponding to the state flags that you want to be cleared. Note that only a subset of the flags can be reset; asserted bits in the other bit positions are ignored. See the description of StatusX10() for more information.

## Compatibility

This subroutine is supported only for native mode devices and is not available in BasicX compatibility mode.

**See Also** StatusX10

# ResumeTask

**Type** Subroutine

**Invocation** ResumeTask(taskStack)  
ResumeTask()

Parameter	Method	Type	Description
taskStack	ByRef	array of Byte	The stack for a task of interest.

## Discussion

This routine attempts to change the status of a task to a ready-to-run state. If no task stack is explicitly given, the task stack for the `Main()` routine is assumed. The table below shows the effect for various task states (as returned by `StatusTask()`).

**Effect of Resuming a Task in Various States**

Status	State	Effect
0	Ready to run.	None, the task is already ready to run.
1	Sleeping.	The task is awakened.
2	Awaiting <code>InputCapture()</code> .	The task resumes as if the <code>InputCapture()</code> had completed.
3	Awaiting interrupt 0.	The task resumes as if the interrupt had occurred.
4	Awaiting interrupt 1.	The task resumes as if the interrupt had occurred.
5	Awaiting interrupt 2.	The task resumes as if the interrupt had occurred.
6	Awaiting interval expiration.	The task resumes as if the interval had expired.
7	Awaiting analog compare.	The task resumes as if the comparison interrupt had occurred.
8	Awaiting pin change event 0.	The task resumes as if the pin change had occurred.
9	Awaiting pin change event 1.	The task resumes as if the pin change had occurred.
10	Awaiting pin change event 2.	The task resumes as if the pin change had occurred.
11	Awaiting pin change event 3.	The task resumes as if the pin change had occurred.
12	Awaiting <code>OutputCapture()</code> .	The task resumes as if the <code>OutputCapture()</code> had completed.
13	Awaiting interrupt 3.	The task resumes as if the interrupt had occurred.
14	Awaiting interrupt 4.	The task resumes as if the interrupt had occurred.
15	Awaiting interrupt 5.	The task resumes as if the interrupt had occurred.
16	Awaiting interrupt 6.	The task resumes as if the interrupt had occurred.
18	Awaiting interrupt 7.	The task resumes as if the interrupt had occurred.
254	Task exiting.	None, exiting tasks can't be resumed.
255	Terminated.	None, halted tasks can't be resumed.

If this routine is invoked using an array other than one that is or was being used for a task stack the result is undefined. See the section on Task Management in the ZBasic Reference Manual for additional information regarding task management.

## Compatibility

This routine is not available in BasicX compatibility mode.

**See Also** ExitTask, RunTask, StatusTask

# Right

**Type**            Function returning String

**Invocation**    Right(str, length)

Parameter	Method	Type	Description
str	ByVal	String	The string from which to extract characters.
length	ByVal	int8/16	The number of characters to extract from the string.

## Discussion

This function returns a string consisting of the rightmost characters of the string passed as the first parameter. The maximum number of characters in the returned string is the smaller of 1) the number of characters in the passed string and 2) the value of the second parameter. Internally, the length is interpreted as a 16-bit signed value and negative values are treated as zero.

This function produces the same result as `Mid(str, Len(str) - length + 1, length)` assuming that the passed string is at least `length` characters long.

## Example

```
Dim s as String, s2 as String

s = "Hello, world!"
s2 = Right(s, 6)           ' the result will be "world!"
```

**See Also**        Left, Mid, Trim

# Rnd

---

**Type**            Function returning Single

**Invocation**    Rnd()

## Discussion

This function will return a pseudo-random value in the range of 0.0 to 1.0. The first time that `Rnd()` is called after the processor starts up the pseudo-random number generator is initialized with a seed value. The sequence of values returned will be repeatable when starting from the same seed.

You can alter the sequence of returned values in two ways. Firstly, you can set the value of `Register.SeedPRNG`. The next call to `Rnd()` will initialize the pseudo-random number generator with that seed value before returning the first random value. The second way to modify the sequence is to call the `Randomize()` subroutine. Doing so will initialize the pseudo-random number generator with the current value of `Register.RTCTick`. This provides a way to introduce some non-repeatability into the sequence of values returned by `Rnd()`. It is especially effective if the time at which `Randomize()` is called is controlled by some external, unpredictable event like a user pressing a key.

## Example

```
Dim i as Integer

' print 10 random values
For i = 1 to 10
    Debug.Print CStr(Rnd())
Next
```

## Compatibility

BasicX does not support `Register.seedPRNG`. Instead, it has a system global variable named `seedPRNG`. This built-in variable is also supported in ZBasic for compatibility.

**See Also**        Randomize

# RunTask

---

**Type** Subroutine

**Invocation** RunTask(taskStack)  
RunTask()

Parameter	Method	Type	Description
taskStack	ByRef	array of Byte	The stack for a task of interest.

## Discussion

Calling this routine alters the normal task rotation regimen by immediately attempting to run the specified task or, if no task stack is explicitly given, the `Main()` task. If the specified task cannot run (because it is sleeping, waiting for InputCapture, etc.) the list of tasks is examined in order beginning with the task immediately following the specified task and the first ready-to-run task that is found will be run.

Because this routine interferes with the normal task rotation it must be used carefully to avoid starving out one or more tasks. If this routine is invoked using an array other than one that is or was being used for a task stack the result is undefined.

See the section on Task Management in the ZBasic Reference Manual for additional information regarding task management.

## Compatibility

This routine is not available in BasicX compatibility mode.

**See Also** ExitTask, ResumeTask, StatusTask

# SearchQueue

**Type**                      Function returning UnsignedInteger

**Invocation**            SearchQueue(queue, val)  
                             SearchQueue(queue, dataLen, data)

Parameter	Method	Type	Description
queue	ByRef	array of Byte	The queue of interest.
val	ByVal	Byte	The byte value for which to search.
dataLen	ByVal	Integral	The length of the byte sequence for which to search.
data	ByRef	Any type	The byte sequence for which to search.

## Discussion

This function searches the data in a queue looking for the specified byte value (first form) or a sequence of bytes (second form). If the queue is empty or does not contain the byte value/byte sequence, zero is returned. Otherwise, the return value indicates the number of bytes in the queue up to and including the sought byte value/byte sequence.

Note that before any queue operations are performed, the queue data structure must be initialized. See the discussion of `OpenQueue()` for more details.

## Examples

```
Dim q(1 to 40) as Byte
Dim data(1 to 4) as Byte
Dim dataLen as UnsignedInteger

' search for a byte value (linefeed)
dataLen = SearchQueue(q, &H0a)

' search for a byte sequence (carriage return, linefeed)
data(1) = &H0d
data(2) = &H0a
dataLen = SearchQueue(q, 2, data)
```

## Compatibility

This function is not available on ZX models that are based on the ATmega32 processor (e.g. the ZX-24). Moreover, it is not available in BasicX compatibility mode.

**See Also**                GetQueue, GetQueueStr, OpenQueue

# Semaphore

**Type** Function returning Boolean

**Invocation** Semaphore(var)

Parameter	Method	Type	Description
var	ByRef	Boolean	A variable used as a semaphore.

## Discussion

This function will test the provided variable and if it is already True, the function will return False. Otherwise, if the semaphore variable is False, the call will set it to True and return True. This is referred to in computer science as an “atomic test and set” operation.

A semaphore is a signaling and synchronization mechanism used in multi-tasking systems. The idea is that if two or more tasks each want to use a particular resource they first request ownership of a semaphore. The request mechanism ensures that even if multiple requests occur near the same time, one and only one request will be satisfied. Therefore, the task that is granted the semaphore will have exclusive access to the resource until it has completed its objective. Subsequently, other tasks can request the semaphore and, if they receive it, they can perform their objective. Thus you can see that a particular semaphore can control access to some set of resources that you define. Your system may have multiple semaphores, each controlling access to a set of resources. Note, however, that if multiple semaphores are required to complete an operation the possibility of deadlock exists. This problem will occur if one task obtains one semaphore, another task obtains another semaphore and then both tasks wait for the other semaphore to be available.

In order for this mechanism to be effective, the same semaphore variable must be used by each task for gaining access to a particular set of resources. For this reason, the semaphore variable passed to `Semaphore()` will almost always be a global variable but it may be public or private as suits your application. The semaphore variable must be initially False, otherwise no `Semaphore()` request on that semaphore can ever succeed. Also, after a task has successfully gotten the semaphore and has finished using the related resources, the semaphore must be set False again so that a future `Semaphore()` call will succeed.

## Example

```
Dim serSem as Boolean

serSem = False

' wait until we get the semaphore
Do While (Not Semaphore(serSem))
    Call Delay(0.5)
Loop

' now we can use the controlled resources
[add code here]

' finished with the resources, release the semaphore
serSem = False
```

# SerialNumber

---

**Type**            Subroutine

**Invocation**     SerialNumber(serNum)

Parameter	Method	Type	Description
serNum	ByRef	array of Byte	The array to which the serial number will be written.

## Discussion

A call to this routine will copy six bytes of serial number information to the provided array. At present, only three of the bytes are defined, representing the version number of the system firmware (for VM mode devices) or the ZX library code (for native mode devices). The first byte is the major version number, the second is the minor version number and the third byte is the variant number. The remaining bytes are undefined.

## Caution

If the array provided is less than 6 bytes long, subsequent memory will be overwritten, possibly with detrimental results.

## Compatibility

The serial number of this implementation may be different than that of BasicX.

# SetBits

**Type** Subroutine

**Invocation** SetBits(target, mask, value)

Parameter	Method	Type	Description
target	ByRef	Byte	The byte to be modified.
mask	ByVal	Byte	The mask indicating which bits to modify.
value	ByVal	Byte	The value of the bits to store.

## Discussion

This subroutine allows you to set the value of one or more bits in a byte while leaving others unchanged. Effectively, the result is the same as using the statement below.

```
target = (target And Not mask) Or (value And mask)
```

The `mask` parameter governs which bits will get updated. For each bit of the `mask` parameter that is a 1, the corresponding bit of the `target` will be set to the state of the corresponding bit of the `value` parameter. Bits of the `target` that correspond to zero bits of the `mask` parameter will remain unchanged.

The advantage to using the `SetBits()` subroutine instead of the equivalent statement is twofold. Firstly, it is more efficient, resulting in less code and faster execution time. Secondly, and perhaps more importantly, it performs the action as an atomic operation, i.e. one that is guaranteed, once begun, to complete without an intervening task switch. This characteristic makes `SetBits()` useful for modifying I/O ports and other `Byte` values in a multi-tasking environment.

## Example

```
' set the middle 4 bits of Port C to the binary value &B0110  
Call SetBits(Register.PortC, &H3C, &H18)
```

## Compatibility

This routine is not available in BasicX compatibility mode. Also, it is only supported by ZX firmware later than v1.0.0.

**See Also** ToggleBits

# SetInterval

**Type** Subroutine

**Invocation** SetInterval(interval)

Parameter	Method	Type	Description
interval	ByVal	Single or int16	The interval counter period, in RTC ticks (if an integral value is specified) or seconds (if a <code>Single</code> value is given).

## Discussion

This routine sets the period of the built-in interval counter. On each RTC tick, the interval counter will be decremented. When it gets to zero, it is reloaded with the specified value and it begins to count down again. Furthermore, if a task is awaiting the interval expiration, it is immediately scheduled for execution (unless a higher priority task requires service). If no task is awaiting the interval expiration, the fact that the interval counter expired is recorded. Subsequently, a task may request a wait on the interval and, depending on the nature of the request, the task may be immediately triggered or it may await the next interval expiration.

Internally the interval period is stored as a 16-bit unsigned integer value. This limits the interval period to a maximum of slightly less than 128 seconds. Of course, longer interval periods may be effectively implemented by maintaining a counter and taking action after the expiration of a number interval periods.

## Example

```
Call SetInterval(200)      'about 391 milliseconds
Call SetInterval(10.0)    'about 10 seconds
```

## Compatibility

This routine is not available in BasicX compatibility mode.

**See Also**      WaitForInterval

# SetJump

**Type**            Function returning Integer

**Invocation**    SetJump(jmpbuf)

Parameter	Method	Type	Description
jmpbuf	ByRef	array of Byte	A buffer to hold the return context, see description below.

## Discussion

This function, in conjunction with `LongJump()`, provides a way to circumvent the normal call-return structure and return directly to a distant caller. It is the equivalent of a non-local Goto function and can be used, among other things, to handle exceptions in your programs. The parameter specifies a `Byte` array that will be initialized with context information to allow a direct return from deeply nested calls. The array must be a minimum size (either 6 bytes or 24 bytes for VM mode and native mode, respectively) to hold the context information for unwinding the call stack. You can use the built-in constant `System.JumpBufSize` to ensure that it is the proper size.

On the initial call to `SetJump()` the return value will always be zero. When control is returned via a call to `LongJump()`, the return value will be the value supplied as the second parameter to the `LongJump()` call. Generally, you should choose this value to indicate the nature of the exception condition and in most cases it should be non-zero.

The jump buffer needs to be accessible to the `LongJump()` caller. Often, this is realized by making it a global or module-level variable. If you want it to be a local variable, you'll have to pass the buffer as a parameter down the call chain. See the section on Exception Handling in the ZBasic Reference Manual for more details.

## Caution

If the provided array is less than minimum required size, adjacent memory locations will be modified usually with undesirable results. Your application should not directly modify the contents of the array. Doing so may cause unpredictable behavior.

## Compatibility

This routine is not available in BasicX compatibility mode.

**See Also**        `LongJump`

# ShiftIn

**Type**                Function returning Byte

**Invocation**        ShiftIn(dataPin, clkPin, bitCnt)

Parameter	Method	Type	Description
dataPin	ByVal	Byte	The pin used to input data.
clkPin	ByVal	Byte	The pin used to output a clocking signal.
bitCnt	ByVal	Byte	The number of bits to read in (1 to 8).

## Discussion

This function can be used to input data from a synchronous serial device like a shift register. The pin specified for input will be made an input but the pin specified for the clock signal must already be an output and be at the desired initial logic level.

For each of the number of bits specified, then the clock line will be pulsed by changing its logic level twice. The data line will be sampled approximately 2 CPU clock cycles after the leading edge of the clock pulse. With a 14.7456MHz CPU clock, this equates to about 135nS after the leading edge.

The returned value consists of the data bits read with the bit first read in the most significant bit position. This is referred to as MSB first. If fewer than 8 bits are read, the low order bits will be zero.

## Resource Usage

This subroutine uses the I/O Timer. If the I/O Timer is already in use, the function returns immediately and the return value is zero. No other use of this resource should be attempted while the shifting is in progress. Interrupts are disabled during the shifting process. However, RTC ticks are accumulated during the shifting process so the RTC should not lose time.

## Compatibility

For compatibility with I2C/TWI devices the clock rate is approximately 200kHz with `Register.TimerSpeed1` at its default value of 1. If the value of `Register.TimerSpeed1` is changed, the bit rate will be slower.

**See Also**            ShiftInEx, ShiftOut, ShiftOutEx

# ShiftInEx

**Type** Function returning UnsignedInteger

**Invocation** ShiftInEx(dataPin, clkPin, bitCnt, flags)  
ShiftInEx(dataPin, clkPin, bitCnt, flags, bitTime)

Parameter	Method	Type	Description
dataPin	ByVal	Byte	The pin used to input data.
clkPin	ByVal	Byte	The pin used to output a clocking signal.
bitCnt	ByVal	Byte	The number of bits to read in (1 to 16).
flags	ByVal	Byte	Flag bits controlling the operation.
bitTime	ByVal	int16	The optional duration of each bit in ticks (see description).

## Discussion

This function can be used to input data from a synchronous serial device like a shift register. The pin specified for input will be made an input but the pin specified for the clock signal must already be an output and be at the desired initial logic level. The `flags` parameter controls how the shifting process is performed as described in the table below.

Control Flag Definitions		
Function	Hex Value	Bit Mask
MSB first	&H00	xx xx xx x0
LSB first	&H01	xx xx xx x1
Sample the input after the active clock edge	&H00	xx xx xx 0x
Sample the input before the active clock edge	&H02	xx xx xx 1x
Fastest possible bit time	&H00	xx xx x0 xx
Use the provided <code>bitTime</code> parameter	&H04	xx xx x1 xx
The active clock edge is the leading clock edge	&H00	xx xx 0x xx
The active clock edge is the trailing clock edge	&H08	xx xx 1x xx

The remaining bits are currently undefined but may be employed in the future.

For each of the number of bits specified, either the state of the data pin will be read and saved first or the clock line will be changed to the opposite state first depending on bit 1 of the `flags` parameter. Finally, the clock line will be returned to the original state thus completing one bit cycle.

If the `flags` parameter so specifies, the `bitTime` parameter value will be used to control the bit rate of the shifting process. The units of the `bitTime` parameter are, by default, approximately 67.8ns. However, `Register.TimerSpeed1` may be changed to adjust the controlling clock speed. If the `bitTime` parameter is not provided or if the value given is zero, the shifting will occur at the maximum rate.

Due to processing overhead the minimum bit time in the controlled speed mode is approximately 4µS. Attempting faster bit times in the controlled speed mode will produce undefined results. Without speed control, the bit time is approximately 2.5µS. Note that the duty cycle of the clock signal will be closer to 50% in the controlled speed mode. Without speed control, the active clock phase can be as little as 20% of the period.

The returned value consists of the data bits read arranged in MSB or LSB order as specified by the `flags` parameter. If MSB order is specified, the first bit read will be in the most significant bit position of the result. If LSB order is specified, the first bit read will be in the least significant bit position. If fewer than 16 bits are read, the remaining bits will be zero.

For reference purposes, the `ShiftIn()` function is roughly equivalent to `ShiftInEx(dpin, cpin, bitCnt, &H04, 74)`. However, the value read will be in the high order 8 bits of the returned value.

## Resource Usage

This subroutine uses the I/O Timer if the `flags` parameter has bit 2 on. If the I/O Timer is already in use, the function returns immediately and the return value is zero. No other use of this resource should be attempted while the shifting is in progress. Interrupts are disabled during the shifting process. However, RTC ticks are accumulated during the shifting process so the RTC should not lose time.

## Timing

Bit 3 of the `flags` parameter specifies the active edge of the clock pulse, i.e. whether the data line will be sampled relative to the leading edge or the trailing edge of the clock pulse. Bit 1 of the `flags` parameter controls whether the sampling will be done before or after the active edge. When bit 1 of the `flags` parameter is zero, the data line will be sampled approximately 2 CPU clock cycles after the active edge of the clock pulse. When bit 1 of the `flags` parameter is one, the data line will be sampled approximately 5 CPU clock cycles before the active edge of the clock pulse. With a 14.7456MHz CPU clock, these intervals are approximately 135nS and 340nS, respectively.

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also**      `ShiftIn`, `ShiftOut`, `ShiftOutEx`

# ShiftOut

**Type** Subroutine

**Invocation** ShiftOut(dataPin, clkPin, bitCnt, val)

Parameter	Method	Type	Description
dataPin	ByVal	Byte	The pin used to output data.
clkPin	ByVal	Byte	The pin used to output a clocking signal.
bitCnt	ByVal	Byte	The number of bits to shift out (1 to 8).
val	ByVal	Byte	The value to shift out.

## Discussion

This function can be used to output data to a synchronous serial device like a shift register. The pin specified for output will be made an output but the pin specified for the clock signal must already be an output and be at the desired initial logic level.

For each of the number of bits specified, the data pin will be set to the state of the corresponding bit in the `val` parameter beginning with the most significant bit first. Then the clock line will be pulsed by changing its logic level twice.

Data is shifted out MSB first. If a data width of fewer than 8 data bits is specified, the data must be positioned in the most significant bits of the value and the state of the remaining low order bits in the value is of no consequence.

## Resource Usage

This subroutine uses the I/O Timer. If the I/O Timer is already in use, the subroutine returns immediately. No other use of this resource should be attempted while the shifting is in progress. Interrupts are disabled during the shifting process. However, RTC ticks are accumulated during the shifting process so the RTC should not lose time.

## Compatibility

For compatibility with I2C/TWI devices the clock rate is approximately 200kHz with `Register.TimerSpeed1` at its default value of 1. If the value of `Register.TimerSpeed1` is changed, the bit rate will be slower.

**See Also** ShiftIn, ShiftInEx, ShiftOutEx

# ShiftOutEx

**Type** Subroutine

**Invocation** ShiftOutEx(dataPin, clkPin, bitCnt, val, flags)  
ShiftOutEx(dataPin, clkPin, bitCnt, val, flags, bitTime)

Parameter	Method	Type	Description
dataPin	ByVal	Byte	The pin used to output data.
clkPin	ByVal	Byte	The pin used to output a clocking signal.
bitCnt	ByVal	Byte	The number of bits to shift out (1 to 16).
val	ByVal	int8/16	The value to shift out.
flags	ByVal	Byte	Flag bits controlling the operation.
bitTime	ByVal	int16	The optional duration of each bit in ticks (see description).

## Discussion

This function can be used to output data to a synchronous serial device like a shift register. The pin specified for output will be made an output but the pin specified for the clock signal must already be an output and be at the desired initial logic level. The `flags` parameter controls how the shifting process is performed as described in the table below.

Control Flag Definitions		
Function	Hex Value	Bit Mask
MSB first	&H00	xx xx xx x0
LSB first	&H01	xx xx xx x1
Fastest possible bit time	&H00	xx xx x0 xx
Use the provided <code>bitTime</code> parameter	&H04	xx xx x1 xx
Normal data pin output	&H00	xx xx 0x xx
Open drain data pin output	&H08	xx xx 1x xx

The remaining bits are currently undefined but may be employed in the future. For compatibility, the undefined bits should always be zero.

For each of the number of bits specified, the data pin will be set to the state of the corresponding bit in the `val` parameter beginning with the either the most significant bit first or the least significant bit first depending on bit 0 of the `flags` parameter. Then the clock line will be pulsed by changing its logic level twice.

Note that if a data width of fewer than 16 data bits is specified, the bits to be shifted out must be properly aligned in the value provided. If MSB order is specified, the data bits must be positioned in the most significant bits of the value provided. If LSB order is specified, the data bits must be positioned in the least significant bits of the value provided.

If the `flags` parameter so specifies, the `bitTime` parameter value will be used to control the bit rate of the shifting process. The units of the `bitTime` parameter are, by default, approximately 67.8ns. However, `Register.TimerSpeed1` may be changed to adjust the controlling clock speed. If the `bitTime` parameter is not provided or if the value given is zero, the shifting will occur at the maximum rate.

Due to processing overhead the minimum bit time in the controlled speed mode is approximately 4μS. Attempting faster bit times in the controlled speed mode will produce undefined results. Without speed control, the bit time is approximately 2.2μS. Note that the duty cycle of the clock signal will be closer to 50% in the controlled speed mode. Without speed control, the active clock phase can be as little as 20% of the period.

Normally, the data pin will be driven high or low according to the data bits being shifted out. For compatibility with certain data bus interfaces, the `flags` parameter bit 3 can be used to specify that the data pin should be put in high impedance input mode when outputting a one bit and actively pulled to ground for a zero bit. In this mode, an external pullup resistor will need to be used to obtain a voltage level corresponding to a logic one.

For reference purposes, the `ShiftOut()` routine is roughly equivalent to `ShiftOutEx(dpin, cpin, bitCnt, Shl(CInt(val), 8), &H04, 74)`.

### Resource Usage

This subroutine uses the I/O Timer if the `flags` parameter has bit 2 on. If the I/O Timer is already in use, the subroutine returns immediately. No other use of this resource should be attempted while the shifting is in progress. Interrupts are disabled during the shifting process. However, RTC ticks are accumulated during the shifting process so the RTC should not lose time.

### Compatibility

This function is not available in BasicX compatibility mode.

**See Also**      `ShiftIn`, `ShiftInEx`, `ShiftOut`

# Shl

**Type**                Function returning the same type as the first parameter.

**Invocation**        Shl(val, shiftCnt)

Parameter	Method	Type	Description
val	ByVal	integral	The value to be shifted.
shiftCnt	ByVal	int8/16	The number of bit positions to shift (0-16).

## Discussion

This function returns the value provided as the first parameter but shifted left the number of bit positions specified by the second parameter. If the `shiftCnt` is zero, the value is returned unchanged. If the `shiftCnt` is greater than or equal to the number of bits in the value provided, the return value will be zero. For signed types, the sign of the result will be the same as that of the provided value.

The type of the return value will be the same as the type of the first parameter.

## Example

```
Dim i as Integer, j as Integer

i = 23
j = Shl(i, 5)      ' result will be 736
```

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also**            Shr

# Shr

**Type**                Function returning the same type as the first parameter.

**Invocation**        Shr(val, shiftCnt)

Parameter	Method	Type	Description
val	ByVal	integral	The value to be shifted.
shiftCnt	ByVal	int8/16	The number of bit positions to shift (0-16).

## Discussion

This function returns the value provided as the first parameter but shifted right the number of bit positions specified by the second parameter. If the `shiftCnt` is zero, the value is returned unchanged. If the `shiftCnt` is greater than or equal to the number of bits in the value provided, the return value will be zero. For signed types, the sign of the result will be the same as that of the provided value.

The type of the return value will be the same as the type of the first parameter.

## Example

```
Dim i as Integer, j as Integer

i = 23
j = Shr(i, 2)            ' result will be 5
```

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also**            Shl

# Signum

**Type**                Function returning the same type as the first parameter.

**Invocation**        Signum(val)

Parameter	Method	Type	Description
val	ByVal	signed	The value to be tested for positive, zero, negative.

## Discussion

This function returns +1, 0 or −1 depending on whether the value provided is positive, zero or negative. The type of the return value will be the same as the type of the parameter value.

## Example

```
Dim i as Integer, j as Integer

i = -23
j = Signum(i)            ' result will be -1
```

## Compatibility

This function is not available in BasicX compatibility mode.

# Sin

**Type**            Function returning Single

**Invocation**    Sin(arg)

Parameter	Method	Type	Description
arg	ByVal	Single	The angle, in radians, of which the sine will be computed.

## Discussion

The return value will be the sine of the supplied value, in the range –1.0 to 1.0.

## Example

```
Const pi as Single = 3.14159
Dim val as Single

val = Sin(pi / 2.0)       ' result is approximately 1.0
```

**See Also**        Asin, DegToRad, RadToDeg

# SizeOf

**Type**            Function returning Integer

**Invocation**    SizeOf(var)

Parameter	Method	Type	Description
var	ByRef	any type	The variable whose size, in bytes, is desired.

## Discussion

This function returns the number of bytes constituting the supplied variable.

The primary purpose of this function is to allow writing code that is more easily maintained. For example, instead of hard coding the size value to pass to the `OpenQueue()` subroutine, you can use `SizeOf(queue)` instead. When you change the size of the queue there will be no need to update the `OpenQueue()` calls.

When used with arrays, you may give the array name without any index parameters and `SizeOf()` will return the total number of bytes occupied by the array. Alternately, you may specify constant expressions for all of the array dimensions and `SizeOf()` will return the number of bytes occupied by a single element of the array. This function is not particularly useful with sub-byte types (Bit and Nibble).

The `SizeOf()` function also allows the argument to name one of the fundamental data types (except `String`). In this case it returns the number of bytes comprising the type. For example, `Sizeof(Integer)` returns the value 2.

## Example

```
Dim cnt as Integer
Dim val as Single
Dim ia(1 to 20) as Integer

cnt = SizeOf(val)           ' result is 4
cnt = SizeOf(ia)            ' result is 40
```

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also**        SizeOfU

# SizeOfU

**Type**                      Function returning UnsignedInteger

**Invocation**            SizeOfU(var)

Parameter	Method	Type	Description
var	ByRef	any type	The variable whose size, in bytes, is desired.

## Discussion

This function returns the number of bytes constituting the supplied variable.

The primary purpose of this function is to allow writing code that is more easily maintained. For example, instead of hard coding the size value to pass to the `OpenQueue()` subroutine, you can use `SizeOfU(queue)` instead. When you change the size of the queue there will be no need to update the `OpenQueue()` calls.

When used with arrays, you may give the array name without any index parameters and `SizeOfU()` will return the total number of bytes occupied by the array. Alternately, you may specify constant expressions for all of the array dimensions and `SizeOfU()` will return the number of bytes occupied by a single element of the array. This function is not particularly useful with sub-byte types (Bit and Nibble).

The `SizeOfU()` function also allows the argument to name one of the fundamental data types (except `String`). In this case it returns the number of bytes comprising the type. For example, `SizeofU(Integer)` returns the value 2.

## Example

```
Dim cnt as UnsignedInteger
Dim val as Single
Dim ia(1 to 20) as Integer

cnt = SizeOfU(val)                ' result is 4
cnt = SizeOfU(ia)                ' result is 40
```

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also**                SizeOf

# Sleep

**Type** Subroutine

**Invocation** Sleep(time)

Parameter	Method	Type	Description
time	ByVal	Single or int16	The amount of time to delay, in seconds (Single) or RTC ticks (int16)

## Discussion

This routine suspends the current task for a period of time up to as long as specified. The actual delay depends on what other tasks actually do that may run in the interim. It is possible that the task will be suspended indefinitely depending on what another task might do.

Note that if the current task is locked, this call will unlock it.

There is a subtle difference between `Delay()` and `Sleep()` when the arguments are non-zero. For `Delay()` the specified time is the minimum amount of delay that the task will experience assuming that no other task is ready to run. The actual delay could be up to 1.95ms longer than the specified delay. For `Sleep()`, the specified time is the maximum amount of delay that the task will experience assuming that no other task is ready to run. The actual delay could be up to 1.95ms less than the specified delay.

## Example

```
Do
    Call PutPin(25, 0)
    Call Sleep(0.5)      ' a half-second delay
    Call PutPin(25, 1)
    Call Sleep(256)      ' a half-second delay
Loop
```

This loop causes the red LED to turn on an off alternately for a half second each.

## Compatibility

The BasicX documentation specifically indicates that `Sleep()` will unlock a locked task. However, tests indicate that this only happens if the parameter to `Sleep()` is non-zero. This implementation unlocks a task on any `Sleep()` call.

**See Also** Delay, DelayUntilClockTick, Pause, WaitForInterval, Register.RTCStopWatch

# SngClass

**Type** Function returning Byte

**Invocation** SngClass(arg)

Parameter	Method	Type	Description
arg	ByVal	Single	The value of which to determine the floating point classification.

## Discussion

The IEEE 754 standard floating point format used by ZBasic specifies a set of classifications for floating point values. This function returns a numeric value indicating the class to which the passed `Single` value belongs. The table below enumerates the return values and describes the meaning of each.

Floating Point Value Classes		
Class	Value	Description
ClassNormal	1	Normalized - This class represents "normal" floating point values such as 1.537 but does not include 0.0.
ClassZero	2	Zero - This class represents the zero value (positive and negative).
ClassInfinity	3	Infinity - This class represents positive and negative infinity. Dividing a positive value by zero results in positive infinity.
ClassDenormal	4	Denormalized - This class represents an internal form known as denormalized values. Such values should never be generated as a result of a floating point operation. However if you copy some random bytes into a floating point variable the result may be a denormalized value.
ClassNaN	5	NaN - This class represents values that are "Not A Number". Taking the square root of a negative value or the logarithm of zero results in a NaN.

The names in the first column are available as built-in constants. Except for `ClassNaN`, the return value may include the flag `&H80` to indicate a negative value. For example, `SngClass(-1.0)` returns the value `&H81` to indicate a negative `ClassNormal` value. The built-in constant representing the negative flag is `ClassNegative`. The built-in constant `ClassMask` may be used to remove the negative flag from the return value, e.g. `SngClass(fval) And ClassMask`.

## Examples

```
Dim class as Byte
```

```
class = SngClass(1.0)           ' result is 1
class = SngClass(-1.0)          ' result is &H81
class = SngClass(-1.0) And ClassMask ' result is 1
class = SngClass(Sqr(-1.0))      ' result is 5
class = SngClass(1.0 / 0.0)      ' result is 3
```

## Compatibility

This function is not available in BasicX compatibility mode.

# SPICmd

**Type** Subroutine

**Invocation** SPICmd(channel, writeCnt, writeData, readCnt, readData)

Parameter	Method	Type	Description
channel	ByVal	Byte	The SPI channel number (1-4).
writeCnt	ByVal	integral	The number of bytes to write (0 – 65535).
writeData	ByRef	any type	The variable containing the data to write to the device.
readCnt	ByVal	integral	The number of bytes to read (0 – 65535).
readData	ByRef	any type	The variable in which to place the data read from the device.

## Discussion

This routine allows you to send and/or receive data from a device using the SPI protocol. The specified channel must have been previously opened with a call to `OpenSPI()`. If the channel has not been opened, the results are undefined. If a hardware SPI controller is being used, the target device must be connected to the controller's SPI bus (on a 24-pin ZX device, the holes on the end of the device between pins 1 and 24). Otherwise, the pins most recently set by `DefineSPI` are used for the SPI clock and data.

If both `writeCnt` and `readCnt` are zero the routine returns immediately without doing anything. You may specify the value 0 for either `writeData` or `readData` if no data is being provided. If the value of `readCnt` exceeds the size of the `readData` variable, the additional bytes will be written to subsequent memory locations, possibly with undesirable results.

The execution of the SPI command occurs in four phases:

- The chip select is asserted by setting the previously specified pin to the active level. The active level (typically logic zero) is specified by bit 6 in the `flags` parameter passed to `OpenSPI()`.
- If the `writeCnt` parameter is non-zero, the data bytes at `writeData` are written sequentially to the SPI interface. The data returned by the SPI device during this phase is discarded.
- If the `readCnt` parameter is non-zero, the existing data beginning at `readData` are written to the SPI device and the returned bytes are stored sequentially in the specified variable. That is, the byte at `readData(1)` is sent to the device and the byte that the device sends back is stored at `readData(1)`. The same occurs for `readData(2)`, etc.
- Finally, the chip select is deasserted by setting the previously specified pin to the inactive level.

Whether you use `writeData` or `readData` or both depends on the particulars of the device you're using. In some cases, you'll need to populate `readData` and in other cases not. Careful study of the datasheet of the target device will be required to determine how `SPICmd()` can be used to communicate with it.

For an SPI channel that is opened with a non-zero `rxDelay` parameter specified (see `OpenSPI()`), a delay is implemented prior to each SPI cycle for which the data read is placed in the `readData` buffer, i.e., the third phase described above. The delay value specified is interpreted as the number of cycles of the SPI clock frequency (but ignoring the Double Speed configuration bit). Of course, during the delay time the SPI clock signal (SCK) will be idle. This delay is useful when communicating with slave devices that must compute data values to return, for example, a ZX-24n operating in SPI slave mode.

## Example

```
Dim odata(1 to 2) as Byte, idata(1 to 10) as Byte
Call OpenSPI (1, 0, 12)
odata(1) = &H06
odata(2) = &H00
Call SPICmd(1, 2, odata, 10, idata)
```

In this example `idata` is not initialized before calling `SPICmd( )`. If your SPI device needs specific data written to it during the read phase, `idata` would need to be initialized before the call.

### Compatibility

The use of a zero value to indicate that no data buffer is being supplied is not supported in BasicX compatibility mode. Also, in BasicX compatibility mode, both `writeCnt` and `readCnt` are Byte values and, thus, limited to a maximum of 255.

**See Also**      `CloseSPI`, `OpenSPI`

# Sqr

---

**Type**            Function returning Single

**Invocation**    Sqr(arg)

Parameter	Method	Type	Description
arg	ByVal	Single	The value of which the square root will be computed.

## Discussion

The return value will be the square root of the supplied value. Note that the `Sqr ( )` function will return NaN if the argument is negative.

## Example

```
Dim val as Single  
  
val = Sqr(2.0)       ' result is approximately 1.414
```

# StackCheck

---

**Type** Subroutine

**Invocation** StackCheck(enable)

Parameter	Method	Type	Description
enable	ByVal	Boolean	The enable/disable state desired.

## Discussion

This subroutine enables or disables stack checking. See the section on Run Time Stack Checking in the ZBasic Reference Manual for more information.

## Example

```
Call StackCheck(true)
```

## Compatibility

This routine is not available in BasicX compatibility mode nor is it available for native mode devices.

# StatusCom

**Type**                Function returning Byte

**Invocation**        StatusCom(chan)

Parameter	Method	Type	Description
chan	ByVal	Byte	The serial channel of interest.

## Discussion

This function returns a set of flag bits that indicate the status of the specified serial channel. The meaning of each of the flag bits is shown in the table below.

Serial Channel Status Bit Values	
Value	Meaning
&H01	The channel number is valid but may or may not be open.
&H02	The channel is open.
&H04	The channel has data yet to be transmitted.
&H08	The channel is a software UART channel.
&H10	The channel's receive flow control pin is in the inactive state.
&H20	The channel's transmit flow control pin is in the inactive state.

The remaining bits are currently undefined but may convey additional information in the future. It is strongly advised that you apply an AND mask to the returned value before comparing it to a fixed value. Doing so will prevent the future addition of bits from affecting your existing code.

Note that use of this function can be combined with `StatusQueue()` to determine when all characters have been completely transmitted on a serial channel. The example code below illustrates this technique.

## Example

```
' wait until all characters are transmitted
Do While StatusQueue(oq)
Loop
Do While CBool(StatusCom(chan) And &H04)
Loop
```

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also**            CloseCom, ComChannels, ControlCom, DefineCom, OpenCom

# StatusQueue

---

**Type**            Function returning Boolean

**Invocation**    StatusQueue(queue)

Parameter	Method	Type	Description
queue	ByRef	array of Byte	The queue of interest.

## Discussion

This function returns `True` if there data bytes in the queue, otherwise `False`.

Note that before any queue operations are performed, the queue data structure must be initialized. See the discussion of `OpenQueue ( )` for more details.

## Compatibility

BasicX allows any type for the first parameter. The ZBasic implementation requires that it be an array of `Byte`.

**See Also**            GetQueueCount, OpenQueue

# StatusTask

**Type** Function returning Byte

**Invocation** StatusTask(taskStack)  
StatusTask()

Parameter	Method	Type	Description
taskStack	ByRef	array of Byte	The stack for a task of interest.

## Discussion

This function returns a value indicating the status of the task associated with the given task stack. If no task stack is explicitly given, the task stack for the `Main()` routine is assumed. The return values and their respective meanings are shown in the table below.

Task Status Values		
Constant	Value	Meaning
TaskReady	0	The task is running or ready to run.
TaskSleeping	1	The task is sleeping.
TaskWaitInputCapture	2	The task is waiting for InputCapture() to complete.
TaskWaitInt0	3	The task is awaiting Interrupt 0.
TaskWaitInt1	4	The task is awaiting Interrupt 1.
TaskWaitInt2	5	The task is awaiting Interrupt 2.
TaskWaitInterval	6	The task is waiting for the interval counter to expire.
TaskWaitAnalogCompare	7	The task is waiting for an analog comparator event.
TaskWaitPinChange0	8	The task is waiting for a pin change event 0.
TaskWaitPinChange1	9	The task is waiting for a pin change event 1.
TaskWaitPinChange2	10	The task is waiting for a pin change event 2.
TaskWaitPinChange3	11	The task is waiting for a pin change event 3.
TaskWaitOutputCapture	12	The task is waiting for OutputCapture() to complete.
TaskWaitInt3	13	The task is awaiting Interrupt 3.
TaskWaitInt4	14	The task is awaiting Interrupt 4.
TaskWaitInt5	15	The task is awaiting Interrupt 5.
TaskWaitInt6	16	The task is awaiting Interrupt 6.
TaskWaitInt7	17	The task is awaiting Interrupt 7.
TaskWaitPinChangeA0	18	The task is waiting for a pin change event, port A.
TaskWaitPinChangeA1	19	The task is waiting for a pin change event, port A.
TaskWaitPinChangeB0	20	The task is waiting for a pin change event, port B.
TaskWaitPinChangeB1	21	The task is waiting for a pin change event, port B.
TaskWaitPinChangeC0	22	The task is waiting for a pin change event, port C.
TaskWaitPinChangeC1	23	The task is waiting for a pin change event, port C.
TaskWaitPinChangeD0	24	The task is waiting for a pin change event, port D.
TaskWaitPinChangeD1	25	The task is waiting for a pin change event, port D.
TaskWaitPinChangeE0	26	The task is waiting for a pin change event, port E.
TaskWaitPinChangeE1	27	The task is waiting for a pin change event, port E.
TaskWaitPinChangeF0	28	The task is waiting for a pin change event, port F.
TaskWaitPinChangeF1	29	The task is waiting for a pin change event, port F.
TaskWaitPinChangeH0	30	The task is waiting for a pin change event, port H.
TaskWaitPinChangeH1	31	The task is waiting for a pin change event, port H.
TaskWaitPinChangeJ0	32	The task is waiting for a pin change event, port J.
TaskWaitPinChangeJ1	33	The task is waiting for a pin change event, port J.
TaskWaitPinChangeK0	34	The task is waiting for a pin change event, port K.
TaskWaitPinChangeK1	35	The task is waiting for a pin change event, port K.
TaskWaitPinChangeQ0	36	The task is waiting for a pin change event, port Q.

TaskWaitPinChangeQ1	37	The task is waiting for a pin change event, port Q.
TaskWaitAnalogCompA0	38	The task is waiting for an analog comparator A event.
TaskWaitAnalogCompA1	39	The task is waiting for an analog comparator A event.
TaskWaitAnalogCompAW	40	The task is waiting for an analog comparator A window event.
TaskWaitAnalogCompB0	41	The task is waiting for an analog comparator B event.
TaskWaitAnalogCompB1	42	The task is waiting for an analog comparator B event.
TaskWaitAnalogCompBW	43	The task is waiting for an analog comparator B window event.
TaskHalting	254	The task is in the process of terminating.
TaskHalted	255	The task has terminated.

The shaded entries in the table above are specific to ZX devices based on ATmega processors. The values 18-43 are specific to ZX devices based on ATxmega processors. The table below shows the correspondance between pin change events and ports for ATmega-based devices.

ATmega Pin Change Event Ports				
Underlying CPU	PinChange0	PinChange1	PinChange2	PinChange3
mega644P, megal284P	PortA	PortB	PortC	PortD
mega328P	PortB	PortC	PortD	
megal281	PortB	PortE		
megal280	PortB	PortJ	PortK	

If this function is invoked using an array other than one that is or was being used for a task stack the result is undefined. See the section on Task Management in the ZBasic Reference Manual for additional information regarding task management.

**See Also**      ExitTask, ResumeTask, RunTask, TaskIsValid

# StatusX10

**Type**            Function returning Byte

**Invocation**    StatusX10(chan)

Parameter	Method	Type	Description
chan	ByVal	Byte	The X-10 communication channel of interest.

## Discussion

This function returns a set of flag bits that indicate the status of the specified X-10 channel. The bits and their meanings are shown in the table below. The return value may comprise zero or more of the status bits.

X-10 Channel Status Bit Values		
Value	Meaning	Cleared by ResetX10
&H01	The channel number is valid but may or may not be open.	No
&H02	The channel is open.	No
&H04	The channel has data yet to be transmitted.	No
&H40	An end-of-command condition was detected during reception.	Yes
&H80	A collision was detected during transmission.	Yes

The remaining bits are currently undefined but may convey additional information in the future. Some of the status bits represent state information for the channel that can be cleared by calling ResetX10(); see the third column of the table above.

## Compatibility

This function is not available on ZX models that are based on the ATmega32 processor (e.g. the ZX-24). Moreover, it is not available in BasicX compatibility mode.

**See Also**        CloseX10, DefineX10, OpenX10, ResetX10

# StrAddress

**Type**               Function returning UnsignedInteger

**Invocation**       StrAddress(str)

Parameter	Method	Type	Description
str	ByVal	String	The string variable whose string address is desired.

## Discussion

This function returns the memory address of the first character of a string stored in a string variable. Note that for dynamically allocated strings, the string address will be zero if the string is empty and the returned address may refer to RAM, Program Memory or Persistent memory. The function `StrType()` can be used to determine which address space contains the string's characters. For statically allocated strings, the string address will always be non-zero even if the string is empty.

See the section on Strings in the ZBasic Reference Manual for more details about dynamically vs. statically allocated strings.

## Example

```
Dim str as String
Dim addr as UnsignedInteger
Dim b as Byte

str = "Hello, world!"
addr = StrAddress(str)
b = RamPeek(addr)               ' result will be 72, the letter H
```

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also**           StrType

# StrCompare

**Type**               Function returning Integer

**Invocation**       StrCompare(str1, str2)  
                      StrCompare(str1, str2, ignoreCase)

Parameter	Method	Type	Description
str1	ByVal	String	The first string to compare.
str2	ByVal	String	The second string to compare.
ignoreCase	ByVal	Boolean	A flag controlling whether alphabetic case is significant.

## Discussion

This function returns a value indicating the “sort order” of the two strings. If the returned value is negative, the first string precedes the second in sort order, i.e. the first string would appear before the second in a list sorted alphabetically. If the returned value is zero, the strings have the same sort order and if it is greater than zero, the second string has a higher sort order. If the optional `ignoreCase` parameter is given, the comparison is done either observing or ignoring differences in alphabetic case depending on the value of the parameter. For the purposes of this parameter only the characters A-Z and a-z (&H41 to &H5a and &H61 to &H7a) are considered to be alphabetic. If the `ignoreCase` parameter is omitted, the comparison is performed observing case differences.

## Example

```
Dim str1 as String
Dim str2 as String

If (StrCompare(str1, str2, true) = 0) Then
    Debug.Print "The strings match"
End If
```

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also**           StrFind

# StrFind

**Type** Function returning Byte

**Invocation** StrFind(inStr, findStr)  
StrFind(inStr, findStr, startIdx)  
StrFind(inStr, findStr, startIdx, ignoreCase)

Parameter	Method	Type	Description
inStr	ByVal	String	The string to be searched.
findStr	ByVal	String	The string being sought.
startIdx	ByVal	integral	The index of inStr at which to begin the search.
ignoreCase	ByVal	Boolean	A flag controlling whether alphabetic case is significant.

## Discussion

This function attempts to find the first occurrence of the `findStr` string within the `inStr` string. If it is found, the return value gives the 1-based index where the sought string was found within the searched string. If the sought string is not found, zero is returned. If the optional `startIdx` parameter is not given, the search begins at the first character of the searched string, equivalent to specifying 1 for `startIdx`. If the optional `ignoreCase` parameter is not given, the search is performed observing alphabetic case differences, otherwise alphabetic case differences are significant or not depending on the value specified for `ignoreCase`. For the purposes of this parameter only the characters A-Z and a-z (&H41 to &H5a and &H61 to &H7a) are considered to be alphabetic.

Searching for a zero length string will always be successful and the return value will be the specified or implied starting index. Searching for a non-zero length string within a zero length string will always fail, returning 0.

## Examples

```
Dim idx as Byte
```

```
idx = StrFind("haystack", "needle")           ' returns 0
idx = StrFind("haystack with needle", "needle") ' returns 15
idx = StrFind("foo bar foo", "foo", 2)         ' returns 9
idx = StrFind("foo bar foo", "", 2)            ' returns 2
idx = StrFind("foo bar FOO", "FOO")            ' returns 9
idx = StrFind("foo bar FOO", "FOO", 1, true)   ' returns 1
```

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also** MemFind, ProgMemFind, StrCompare

# StrReplace

**Type**                      Function returning String

**Invocation**            StrReplace(str, findStr, replStr)  
StrReplace(str, findStr, replStr, startIdx)  
StrReplace(str, findStr, replStr, startIdx, replCount)  
StrReplace(str, findStr, replStr, startIdx, replCount, ignoreCase)

Parameter	Method	Type	Description
str	ByVal	String	The subject string in which to perform replacement.
findStr	ByVal	String	The sought string.
replStr	ByVal	String	The replacement string.
startIdx	ByVal	integral	The index of 'str' at which to begin the replacement.
replCount	ByVal	integral	The number of replacements to perform.
ignoreCase	ByVal	Boolean	A flag controlling whether alphabetic case is significant.

## Discussion

This routine produces a new string by replacing occurrences of the sought string with the replacement string in the subject string. If the optional `startIdx` parameter is not given, the search begins at the first character of the subject string, equivalent to specifying 1 for `startIdx`. If the optional `replCount` parameter is not given, all occurrences of the sought string will be replaced. If the optional `ignoreCase` parameter is not given, the search is performed observing alphabetic case differences, otherwise alphabetic case differences are significant or not depending on the value specified for `ignoreCase`. For the purposes of this parameter, only the characters A-Z and a-z (&H41 to &H5a and &H61 to &H7a) are considered to be alphabetic.

If the subject string contains no occurrences of the sought string, or if the sought string is zero length, or if the replacement count is zero, the returned string will be identical to the subject string. The replacement count and the start index are treated internally as signed 16-bit values. If the value of the start index is less than 1, a starting index of 1 is assumed.

## Compatibility

This function is not available in BasicX compatibility mode.

# StrType

**Type** Function returning Byte

**Invocation** StrType(str)

Parameter	Method	Type	Description
str	ByVal	String	The string variable whose string type is desired.

## Discussion

This function returns a value indicating the nature of a string variable. The values returned have the meaning shown in the table below.

Type	Meaning
&H00	The string is a standard statically allocated string or a bounded string. The value returned by StrAddress() is a RAM address and can be read using RamPeek() or MemCopy().
&He0	The string is dynamically allocated. The value returned by StrAddress() is a RAM address (which may be zero) and can be read using RamPeek() or MemCopy().
&He2	The string is in Program Memory. The value returned by StrAddress() is a Program Memory address and can be read using GetProgMem().
&He3	The string is in Persistent Memory. The value returned by StrAddress() is a Persistent Memory address and can be read using GetPersistent().
&He4	The string is in RAM. The value returned by StrAddress() is a RAM address (which may be zero) and can be read using RamPeek() or MemCopy().
&He5	The string is in RAM and is limited to 1 or 2 characters. The value returned by StrAddress() is a RAM address and can be read using RamPeek() or MemCopy().
&He6	The string is in RAM. The value returned by StrAddress() is a RAM address and can be read using RamPeek() or MemCopy(). This special string type is used for native-mode code to pass a bounded string or fixed-length string to a subroutine/function ByVal.
&Hff	The string is a statically allocated fixed-length string. The value returned by StrAddress() is a RAM address and the data can be read using RamPeek() or MemCopy().

See the section on strings in the ZBasic Reference Manual for more details about dynamically vs. statically allocated strings.

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also** StrAddress

# System.Alloc

**Type**                Function returning UnsignedInteger

**Invocation**        System.Alloc(numBytes)

Parameter	Method	Type	Description
numBytes	ByVal	integral	The size of the requested allocation.

## Discussion

This function allocates a block of memory from the heap of the specified size and returns the address of the first byte of the block. If a block of the specified size cannot be allocated, zero is returned. The block can be returned to the heap using the subroutine `System.Free()`.

This function and the block of memory it returns must be used with great care. If your program fails to deallocate the block using `System.Free()` when it is no longer needed, the heap may eventually be exhausted. Since space for strings is also allocated from the heap, exhaustion may cause string operations to fail. Moreover, if your program writes to memory outside of the bounds of the block, the heap data structures may be corrupted. This may cause future heap allocation requests to fail.

For native mode devices (e.g. the ZX-24n) a heap allocation may fail if the heap size is set too small compared to the needs of your application. To aid in determining a sufficient heap size the System Library function `System.HeapHeadRoom()` may be used to discover the amount of space in the heap that has not yet been used at the time of the call.

## Example

```
Dim addr as UnsignedInteger
addr = System.Alloc(50)
[other code here that uses the allocated block]
Call System.Free(addr)
addr = 0
```

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also**            System.Free

# System.DeviceID

**Type** Subroutine

**Invocation** System.DeviceID(buffer)

Parameter	Method	Type	Description
buffer	ByRef	array of Byte	The array to which the identification characters will be written.

## Discussion

A call to this routine will copy up to 10 bytes to the buffer provided. The data copied to the buffer comprise characters of a string that identify the ZX device on which the program is executing. The last byte of the identification is followed by a zero byte that serves to mark the end of the identification characters. The example below illustrates how the data can be used to create a string.

Although this subroutine is primarily intended for manufacturing test purposes, it may be useful for other purposes as well.

## Caution

If the array provided is less than 10 bytes long, subsequent memory may be overwritten, possibly with detrimental results.

## Example

```
Dim buf(1 to 10) as Byte
Dim idStr as String
Dim idx as Byte

Call System.DeviceID(buf)
idStr = MakeString(buf.DataAddress, SizeOf(buf))
idx = StrFind(idStr, Chr(0))
If (idx <> 0) Then
    idStr = Left(idStr, idx - 1)
End If
Debug.Print idStr ' Displays "ZX24" on a ZX-24
```

## Compatibility

This routine is not available in BasicX compatibility mode.

# System.Free

---

**Type** Subroutine

**Invocation** System.Free(addr)

Parameter	Method	Type	Description
addr	ByVal	UnsignedInteger	The address of the block to free.

## Discussion

This subroutine returns a block of allocated memory to the heap so that it may be later re-used. The `addr` parameter must be the value returned by an earlier call to `System.Alloc()` that has not yet been freed. Invoking this subroutine with `addr` equal to 0 is a special case that is benign.

This function and its companion, `System.Alloc()`, must be used with great care. If `System.Free()` is called with a non-zero value that is not one returned by `System.Alloc()` or a value that has already been freed, the heap management data structures will almost certainly be corrupted and future allocations will likely fail. It is a good practice to set an address to zero after it has been freed as illustrated in the example below.

## Example

```
Dim addr as UnsignedInteger
addr = System.Alloc(50)
[other code here that uses the allocated block]
Call System.Free(addr)
addr = 0
```

## Compatibility

This routine is not available in BasicX compatibility mode.

**See Also** System.Alloc

# System.HeapHeadRoom

---

**Type**            Function returning UnsignedInteger

**Invocation**     System.HeapHeadRoom()

## Discussion

This function determines the amount of space in the string heap that has never been used irrespective of the current end-of-heap position. The primary use for it is to determine the amount of heap space used by an application in order to balance the requirements of the heap and the various task stacks.

## Compatibility

For VM mode devices, this function will always return `&HFFFF` unless you have specified a heap limit value, directly or indirectly. See the `Option MainTaskStackSize`, `Option HeapSize`, and `Option HeapLimit` directives for more information.

**See Also**        System.TaskHeadRoom

# System.HeapSize

---

**Type**            Function returning UnsignedInteger

**Invocation**    System.HeapSize()

## Discussion

This function determines the amount of space reserved for the string heap. This value may be of use in special circumstances such as allocating extra buffers or dynamic task stacks.

**See Also**        System.HeapHeadRoom

# System.TaskHeadRoom

**Type**                Function returning UnsignedInteger

**Invocation**        System.TaskHeadRoom(taskStack)  
                         System.TaskHeadRoom()

Parameter	Method	Type	Description
taskStack	ByRef	array of Byte	The stack for a task of interest.

## Discussion

This function determines the amount of space in task stack of the specified task that has never been used, irrespective of the current position of the task stack pointer. The primary use for it is to determine the amount of task stack space used by a task in order to balance the requirements of the heap and the various task stacks. If the supplied parameter does not refer to a valid task stack (i.e. a stack for a task that is in the task list), the return value will be &Hffff.

For the second form, with no task stack specified, the stack of the calling task is examined. In either case, if zero is returned it is nearly certain that the task stack has overflowed, possibly overwriting adjacent data.

## Compatibility

For VM mode devices, calling this function for the `Main()` task will always return &HFFFF unless you have specified, directly or indirectly, a stack limit for `Main()`. See the `Option MainTaskStackSize`, `Option HeapLimit`, and `Option HeapSize` directives for more information.

**See Also**            System.HeapHeadRoom

# Tan

---

**Type**            Function returning Single

**Invocation**    Tan(arg)

Parameter	Method	Type	Description
arg	ByVal	Single	The angle, in radians, of which the tangent will be computed.

## Discussion

The return value will be the tangent of the supplied value. Note that the `Tan( )` function may return positive or negative infinity values.

## Example

```
Const pi as Single = 3.14159
Dim val as Single

val = Tan(pi / 4.0)       ' result is approximately 1.0
```

**See Also**        Atn, Atn2, DegToRad, RadToDeg

# TasksLocked

---

**Type**            Function returning Boolean

**Invocation**    TasksLocked()

## Discussion

This function will return `True` if the calling task is locked, `False` otherwise.

**See Also**        LockTask, UnlockTask

# TaskIsValid

---

**Type**               Function returning Boolean

**Invocation**       TaskIsValid(taskStack)

Parameter	Method	Type	Description
taskStack	ByRef	array of Byte	The stack for a task of interest.

## Discussion

This function will return `True` if the specified task stack is currently in the task list, `False` otherwise. This function can be used with allocated task stacks to determine when it is safe to deallocate the task stack memory.

**See Also**           StatusTask

# Timer

---

**Type**            Function returning Single

**Invocation**    Timer()

## Discussion

This function returns the current RTC time represented as the number of seconds since midnight with a best-case resolution of 1.95ms. Note that `Register.RTCTick` gives you the equivalent information albeit in the form of a 32-bit value representing the number of 1.95ms ticks since midnight. Depending on your needs, one or the other may be more efficient to use.

# To<enum>

**Type**                Function returning an Enum member

**Invocation**        To<enum>(val)

Parameter	Method	Type	Description
val	ByVal	integral	The value to convert to an Enum member.

## Discussion

This page describes a set of functions that convert the given value to a member of a specific enumeration. For each enumeration that you define in your program the compiler automatically provides a conversion function whose name is the name of the enumeration with the prefix *To*.

To use this conversion function, replace the <enum> portion of the function name as shown above with the actual enumeration name for which value-to-member conversion is desired. See below for an example of how this is done.

See the section on enumerations for more information.

## Compatibility

This function is provided for backward compatibility. It is recommended to use CType( ) for new applications.

## Example

```
Enum Color
    Red
    Green
    Blue
End Enum

Dim c as Color

c = ToColor(1)     ' c will have the value Green
```

**See Also**            CType

# ToggleBits

**Type** Subroutine

**Invocation** ToggleBits(target, mask)

Parameter	Method	Type	Description
target	ByRef	Byte	The byte to be modified.
mask	ByVal	Byte	The mask indicating which bits to modify.

## Discussion

This subroutine allows you to change the state of one or more bits in a byte while leaving others unchanged. Effectively, the result is the same as using the statement below.

```
target = target Xor mask
```

The `mask` parameter governs which bits will get changed. For each bit of the `mask` parameter that is a 1, the corresponding bit of the `target` will be set to the opposite of its current state. Bits of the `target` that correspond to zero bits of the `mask` parameter will remain unchanged.

The advantage to using the `ToggleBits()` subroutine instead of the equivalent statement is twofold. Firstly, it is more efficient, resulting in less code and faster execution time. Secondly, and perhaps more importantly, it performs the action as an atomic operation, i.e. one that is guaranteed, once begun, to complete without an intervening task switch. This characteristic makes `ToggleBits()` useful for modifying I/O ports and other `Byte` values in a multi-tasking environment.

## Example

```
' change the state of the two least significant bits of Port C
Call ToggleBits(Register.PortC, &H03)
```

## Compatibility

This routine is not available in BasicX compatibility mode. Also, it is only supported by ZX firmware later than v1.0.0.

**See Also** SetBits

# Trim

**Type**            Function returning String

**Invocation**    Trim(str)

Parameter	Method	Type	Description
str	ByVal	String	The string from which blanks will be stripped.

## Discussion

This function returns a new string containing the same characters as the passed string except that leading and trailing spaces will be removed. If the string consists solely of spaces, the resulting string will be zero length.

## Example

```
Dim s as String, s1 as String
s = "  Hello, world!  "
s2 = Trim(s)                       ' the result will be "Hello, world!"
```

**See Also**        Left, Mid, Right

# UBound

**Type**            Function returning Integer

**Invocation**    UBound(array) or  
                  UBound(array, dimension)

Parameter	Method	Type	Description
array	ByRef	any array	The array about which the bound information is desired.
dimension	ByVal	int16	The dimension of interest. See the discussion for more details.

## Discussion

This function returns the upper bound of the specified array. There are two forms. The first requires only the array to be specified. In this case, the upper bound of the first dimension of the array is returned. The second form specifies a dimension number, the valid range of which is 1 to the number of dimensions of the array. The array may be located in RAM, Program Memory or Persistent Memory.

In contrast to LBound( ), a parameter that is an array cannot be passed to UBound( ) since the return value of UBound( ) is computed at compile-time and many different sized arrays may be passed as a parameter.

Note that the use of this function instead of hard-coding values makes your code easier to maintain.

## Example

```
Dim ba(1 to 20) as Byte
Dim ma(3 to 5, -6 to 7) as Byte
Dim i as Integer

i = UBound(ba)           ' the result is 20
i = UBound(ma)           ' the result is 5
i = UBound(ma, 1)        ' the result is 5
i = UBound(ma, 2)        ' the result is 7
```

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also**        LBound

# UCase

---

**Type**                Function returning String

**Invocation**        UCase(str)

Parameter	Method	Type	Description
str	ByVal	String	The string to be changed to upper case.

## Discussion

This function returns a new string containing the same characters as the passed string except that all lower case characters will be replaced with upper case characters.

## Example

```
Dim s as String, s1 as String
s = "Hello, world!"
s2 = UCase(s)                        ' the result will be "HELLO, WORLD!"
```

**See Also**            LCase

# UnlockTask

---

**Type**            Subroutine

**Invocation**    UnlockTask()

## Discussion

This routine causes the running task to become unlocked so that other tasks can run. Calling `UnlockTask()` when a task is not actually locked has no effect.

**See Also**        LockTask

# UpdateRTC

**Type** Subroutine

**Invocation** UpdateRTC(fastTicks)

Parameter	Method	Type	Description
fastTicks	ByVal	int16	The number of fast ticks to add to the RTC.

## Discussion

This subroutine can be used to update the RTC with the number of fast ticks missed during a long operation performed with interrupts disabled. In order to determine the number of fast ticks that are missed, your code must periodically check the interrupt flag of the RTC timer and, if it is set, increment a local counter value and then reset the interrupt flag.

## Example

```
' This example is for ZX devices that use Timer0 for the RTC timer.
Atomic
    Dim missedTicks as UnsignedInteger
    Const TickFlag as Byte = &H02
    missedTicks = 0
    Do
        ' place code here that performs one iteration of a
        ' long process and eventually exits the loop

        ' check the RTC flag, reset it
        If (CBool(Register.TIFR0 And TickFlag)) Then
            missedTicks = missedTicks + 1
            Register.TIFR0 = TickFlag
        End If
    Loop
    Call UpdateRTC(missedTicks)
    Call Yield()
End Atomic
```

**See Also** Yield

# ValueI

**Type** Subroutine

**Invocation** ValueI(str, val, flag)

Parameter	Method	Type	Description
str	ByVal	String	The string from which to extract an Integer value.
val	ByRef	int16	The variable to receive the value.
flag	ByRef	Boolean	The variable to receive a success indicator.

## Discussion

This routine converts a character representation of an integral number, contained in the `str` parameter, to an `Integer` value returned in the `val` parameter. If the string is in an acceptable format, the `flag` parameter is set to `True`. Otherwise, the `flag` parameter is set to `False` and the `val` parameter will be 0.

The string may contain any number of leading and/or trailing spaces. The value itself may consist of an optional plus or minus sign, an optional radix indicator, and one or more digits. The supported radix indicators are `&H` for hexadecimal, `&O` for octal and `&B` or `&X` for binary (all case insensitive). If no radix indicator is present, decimal is assumed.

If the provided string has the proper format but represents a value that is too large or too small to be represented as an `Integer`, the result will be invalid but no such indication will be given.

Examples of integral values accepted by `ValueI()` are:

```
103
+123
&H55
-&B01101
```

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also** ValueL, ValueS

# ValueL

**Type** Subroutine

**Invocation** ValueL(str, val, flag)

Parameter	Method	Type	Description
Str	ByVal	String	The string from which to extract an <code>Long</code> value.
Val	ByRef	int32	The variable to receive the value.
Flag	ByRef	Boolean	The variable to receive a success indicator.

## Discussion

This routine converts a character representation of an integral number, contained in the `str` parameter, to a `Long` value returned in the `val` parameter. If the string is in an acceptable format, the `flag` parameter is set to `True`. Otherwise, the `flag` parameter is set to `False` and the `val` parameter will be 0.

The string may contain any number of leading and/or trailing spaces. The value itself may consist of an optional plus or minus sign, an optional radix indicator, and one or more digits. The supported radix indicators are `&H` for hexadecimal, `&O` for octal and `&B` or `&X` for binary (all case insensitive). If no radix indicator is present, decimal is assumed.

If the provided string has the proper format but represents a value that is too large or too small to be represented as a `Long`, the result will be invalid but no such indication will be given.

Examples of integral values accepted by `ValueL()` are:

```
103
+123
&H55
-&B01101
```

## Compatibility

This function is not available in BasicX compatibility mode.

**See Also** ValueI, ValueS

# ValueS

**Type** Subroutine

**Invocation** ValueS(str, val, flag)

Parameter	Method	Type	Description
str	ByVal	String	The string from which to extract a floating point value.
val	ByRef	Single	The variable to receive the value.
flag	ByRef	Boolean	The variable to receive a success indicator.

## Discussion

This routine converts a character representation of a floating pointer number, contained in the `str` parameter, to a `Single` value returned in the `val` parameter. If the string is in an acceptable format, the `flag` parameter is set to `True`. Otherwise, the `flag` parameter is set to `False` and the `val` parameter will be 0.0.

The string may contain any number of leading and/or trailing spaces. The value itself may consist solely of decimal digits or may have a leading plus or minus sign. The value may include a decimal point, with or without preceding digits. However, there must be a digit either preceding the decimal point or following it, or both. Optionally, there may be a multiplier value consisting of the letter E (upper or lower case), optionally followed by a plus or minus sign, followed by one or more digits. Note that the range of acceptable input is wider than that for real values in ZBasic statements.

If the provided string has the proper format but represents a value that is too large or too small to be represented as a `Single`, the result will be invalid but no such indication will be given.

Examples of floating point numbers accepted by `ValueS()` are:

```
.30103
3.14159
-200.
1e05
+6.02E+23
123
```

**See Also** ValueI, ValueL

# VarPtr

**Type**            Function returning `UnsignedInteger`

**Invocation**    `VarPtr(var)`

Parameter	Method	Type	Description
var	ByRef	any variable	The variable of which the address is desired.

## Discussion

This function returns the `UnsignedInteger` representation of the RAM address of the specified variable. Note that for arrays, you may also specify subscript expressions for all of the array dimensions to yield the address of an individual array element. Without the subscript expressions, the resulting value will be the address of the first element of the array.

This function is useful for deriving the address to pass to the several functions that require a RAM address, e.g. `BitCopy()`, `RamPeek()`, `RamPoke()`, etc.

This function is identical to `MemAddressU()` and is provided for BasicX compatibility.

**See Also**        `MemAddress`, `MemAddressU`

# WaitForInterrupt

**Type** Subroutine

**Invocation** WaitForInterrupt(mode)  
WaitForInterrupt(mode, intNum)

Parameter	Method	Type	Description
mode	ByVal	Byte	A value specifying what action will trigger the interrupt. See the discussion below.
intNum	ByVal	Byte	A designator for the interrupt to await (see discussion below).

## Discussion

This routine allows a task to suspend itself and wait for an interrupt. The particular interrupt awaited depends on the `intNum` designator combined with the `mode` value. There are three general sources of interrupts that can be awaited: external interrupts, analog comparator interrupts and pin change interrupts.

## External Interrupts 0-7 (ATmega-based devices)

A task may await an external interrupt by specifying the value 0 through 7 (corresponding to external interrupts 0-7, respectively) for the `intNum` parameter. In this case, the allowable values for the `mode` parameter and their respective meanings are given in the table below. Note, however, that some devices support only a subset of the hardware interrupt channels. See the table in the Resource Usage section for details of the supported interrupt channels and the interrupt input pin for each device.

Hardware Interrupt Mode Values		
Value	Built-in Constant	Interrupt Trigger
&H10	<code>zxPinLow</code>	A low level on the interrupt pin.
&H14	<code>zxPinChange</code>	Any logic level change on the interrupt pin.
&H18	<code>zxPinFallingEdge</code>	A high to low transition on the interrupt pin.
&H1C	<code>zxPinRisingEdge</code>	A low to high transition on the interrupt pin.

All other values are reserved for future use. For compatibility with BasicX, there are similarly named built-in constants that begin with the prefix `bx` instead of `zx` except that there is no equivalent for `zxPinChange`. Additionally, on mega32-based devices, Interrupt 2 is not capable of the first two trigger modes; it can only be triggered on a rising edge or a falling edge.

The built-in constants `WaitInt0` through `WaitInt7` may be used to specify the `intNum` parameter. If no `intNum` parameter is given, Interrupt 1 is assumed (for compatibility with BasicX). This is equivalent to using `WaitForInterrupt(mode, 1)`.

## Pin Change Interrupts (ATmega-based devices)

For some ZX models based on the ATmega processors, a task may await a state change on one or more pins of an I/O port. This mode is selected by specifying a special value for the `intNum` parameter according to the tables below for the respective processor types.

intNum Values for Pin Change Interrupts			
Value	Built-in Constant	Trigger – mega644, mega644P, mega1284P	Trigger – mega328P
&H20	<code>WaitPinChangeA</code>	Pin change on Port A	
&H21	<code>WaitPinChangeB</code>	Pin change on Port B	Pin change on Port B

&H22	<code>WaitPinChangeC</code>	Pin change on Port C	Pin change on Port C <sup>1</sup>
&H23	<code>WaitPinChangeD</code>	Pin change on Port D	Pin change on Port D <sup>2</sup>

<sup>1</sup>Bits 0-5 only.

<sup>2</sup>Bits 2-7 only.

**intNum Values for Pin Change Interrupts**

Value	Built-in Constant	Trigger – mega1281	Trigger – mega1280
&H20	<code>WaitPinChangeA</code>		
&H21	<code>WaitPinChangeB</code>	Pin change on Port B	Pin change on Port B
&H22	<code>WaitPinChangeC</code>		
&H23	<code>WaitPinChangeD</code>		
&H24	<code>WaitPinChangeE</code>	Change on Port Bit E.0 <sup>1</sup>	
&H29	<code>WaitPinChangeJ</code>		Pin change on Port J <sup>2</sup>
&H2a	<code>WaitPinChangeK</code>		Pin change on Port K

<sup>1</sup>Not available on the ZX-1281e.

<sup>2</sup>Bits 0-6 only.

For each of the `intNum` values in the tables above, the `mode` parameter specifies pin change interrupt enable bits corresponding to each pin of the port. For example, if the `mode` value is &H21, a pin change interrupt will be generated if either bit 0 or bit 5 of the specified port changes state. Clearly, a `mode` value of zero is useless since no pin change interrupt can ever occur in that case.

### Pin Change Interrupts (ATxmega-based devices)

For ZX models based on the ATxmega processors, a task may await a state change on one or more pins of an I/O port. Each port has two separate channels of pin-change detection, e.g. `WaitPinChangeA0` and `WaitPinChangeA1`. The channel is specified using values `intNum` parameter shown in the table below.

**intNum Values for Pin Change Interrupts**

Value	Built-in Constant	Trigger	Processors
&H20	<code>WaitPinChangeA0</code>	Pin change on Port A, channel 0	xmega128A1, xmega32A4
&H21	<code>WaitPinChangeA1</code>	Pin change on Port A, channel 1	xmega128A1, xmega32A4
&H22	<code>WaitPinChangeB0</code>	Pin change on Port B, channel 0	xmega128A1, xmega32A4
&H23	<code>WaitPinChangeB1</code>	Pin change on Port B, channel 1	xmega128A1, xmega32A4
&H24	<code>WaitPinChangeC0</code>	Pin change on Port C, channel 0	xmega128A1, xmega32A4
&H25	<code>WaitPinChangeC1</code>	Pin change on Port C, channel 1	xmega128A1, xmega32A4
&H26	<code>WaitPinChangeD0</code>	Pin change on Port D, channel 0	xmega128A1, xmega32A4
&H27	<code>WaitPinChangeD1</code>	Pin change on Port D, channel 1	xmega128A1, xmega32A4
&H28	<code>WaitPinChangeE0</code>	Pin change on Port E, channel 0	xmega128A1, xmega32A4
&H29	<code>WaitPinChangeE1</code>	Pin change on Port E, channel 1	xmega128A1, xmega32A4
&H2a	<code>WaitPinChangeF0</code>	Pin change on Port F, channel 0	xmega128A1
&H2b	<code>WaitPinChangeF1</code>	Pin change on Port F, channel 1	xmega128A1
&H2c	<code>WaitPinChangeH0</code>	Pin change on Port H, channel 0	xmega128A1
&H2d	<code>WaitPinChangeH1</code>	Pin change on Port H, channel 1	xmega128A1
&H2e	<code>WaitPinChangeJ0</code>	Pin change on Port J, channel 0	xmega128A1
&H2f	<code>WaitPinChangeJ1</code>	Pin change on Port J, channel 1	xmega128A1
&H30	<code>WaitPinChangeK0</code>	Pin change on Port K, channel 0	xmega128A1
&H31	<code>WaitPinChangeK1</code>	Pin change on Port K, channel 1	xmega128A1
&H32	<code>WaitPinChangeQ0</code>	Pin change on Port Q, channel 0	xmega128A1
&H33	<code>WaitPinChangeQ1</code>	Pin change on Port Q, channel 1	xmega128A1

For each of the `intNum` values in the tables above, the `mode` parameter specifies pin change interrupt enable bits corresponding to each pin of the port. For example, if the `mode` value is &H21, a pin change interrupt will be generated if either bit 0 or bit 5 of the specified port changes state. Clearly, a `mode` value of zero is useless since no pin change interrupt can ever occur in that case.

By default, each pin that is enabled for a pin change interrupt will trigger the interrupt on either edge. You may configure the sensitivity for each individual pin to trigger an interrupt on either edge, rising edge only, falling edge only or a low level. The setting for each pin change sensitivity is made in a “pin control” register specific to that pin. For example, the pin control register for bit 3 of port C is named `PORTC_PIN3CTRL`. Consult the ATxmega A datasheet for more information on these registers.

### Analog Comparator Interrupt (ATmega-based devices)

A task may await an analog comparator interrupt by specifying the value `&H10` for `intNum`. The corresponding built-in constant is `waitAnalogComp`. In this case, the `mode` parameter specifies the comparator output transition that will cause the interrupt to occur.

Analog Comparator Interrupt Mode Values		
Value	Built-in Constant	Interrupt Trigger
<code>&amp;H00</code>	<code>zxAnalogCompChange</code>	Comparator output rising edge or falling edge.
<code>&amp;H02</code>	<code>zxAnalogCompFalling</code>	Comparator output falling edge.
<code>&amp;H03</code>	<code>zxAnalogCompRising</code>	Comparator output rising edge.

With all of the `mode` values in the table above, the analog comparator's positive input is `AIN0` (Port B, bit 2) and the comparator's negative input is either `AIN1` (Port B, bit 3) or, if the `ACME` bit is set in a CPU register (see below), the analog input specified by the multiplexor select bits in `Register.ADMUX`. On the ZX-24 models, `AIN0` is common with Port A, bit 2 so the latter I/O pin will need to be configured to be an input in high-impedance mode. Also, on the ZX-24 models built using boards earlier than Rev 5 (see the bottom side of the board), `AIN1` has no external connection so the negative input must be supplied via the analog multiplexor. The `ACME` bit is in `Register.SFIOR` for the mega32 and mega128-based ZX models and in `Register.ADCSRB` in the mega644, mega644P, mega1284P, mega1280 and mega1281-based ZX models.

Another option for the positive comparator input is to select the internal “band gap” voltage. This voltage level (approximately 1.23 volts) is selected by adding `&H40` to the mode values in the table above. The built-in constant `zxAnalogReference` has this value.

See the section in the Atmel microcontroller documentation describing the analog comparator for further details.

### Analog Comparator Interrupt (ATxmega-based devices)

A task may await an analog comparator interrupt on one of the analog comparator channels by specifying the corresponding value shown in the table below for `intNum`.

Analog Comparator Interrupt Number Values			
IntNum	Built-in Constant	Interrupt Trigger	Processor
<code>&amp;H10</code>	<code>waitAnalogCompA0</code>	Analog Comp A, Channel 0	xmega128A1, xmega32A4
<code>&amp;H11</code>	<code>waitAnalogCompA1</code>	Analog Comp A, Channel 1	xmega128A1, xmega32A4
<code>&amp;H12</code>	<code>waitAnalogCompAW</code>	Analog Comp A, Window mode	xmega128A1, xmega32A4
<code>&amp;H13</code>	<code>waitAnalogCompB0</code>	Analog Comp B, Channel 0	xmega128A1
<code>&amp;H14</code>	<code>waitAnalogCompB1</code>	Analog Comp B, Channel 1	xmega128A1
<code>&amp;H15</code>	<code>waitAnalogCompBW</code>	Analog Comp B, Window mode	xmega128A1

In order to use any of the analog comparator interrupts, you must first configure positive and negative inputs to the corresponding comparator(s) using the processor registers `ACA_AC0MUXCTRL`, `ACA_AC1MUXCTRL`, `ACB_AC0MUXCTRL` and/or `ACB_AC1MUXCTRL`. Also, the high speed/low power control bit and the hysteresis control bits in the `ACA_AC0CTRL`, `ACA_AC1CTRL`, `ACB_AC0CTRL` and `ACB_AC1CTRL` registers may be configured as desired before invoking `WaitForInterrupt()`. Consult the ATxmega A datasheet for more information on these registers.

The window mode of the analog comparator utilizes both channels of the comparator, with channel 0 representing the high limit of the window and channel 1 representing the low limit of the window. The mode value to use differs depending on whether single channel or window mode is being used, see the tables below.

**Analog Comparator Interrupt Mode Values – Single Channel Mode**

Value	Built-in Constant	Interrupt Trigger
&H00	zxAnalogCompChange	Comparator output rising edge or falling edge.
&H02	zxAnalogCompFalling	Comparator output falling edge.
&H03	zxAnalogCompRising	Comparator output rising edge.

**Analog Comparator Interrupt Mode Values – Window Mode**

Value	Interrupt Trigger
&H00	Input signal above the window.
&H01	Input signal inside the window.
&H02	Input signal below the window.
&H03	Input signal outside the window.

## Operation

For all forms, when the trigger condition occurs an interrupt will be generated and the task awaiting the interrupt will rise to the highest priority. This will cause an immediate task switch meaning that the next instruction that executes will be the one following the `WaitForInterrupt()` invocation. Note that if another task performs an action that causes interrupts to be disabled, response to the interrupt will be delayed until interrupts are re-enabled. The fact that the current task is locked does not prevent the interrupt task from executing next.

If two or more interrupts occur simultaneously, the task awaiting the highest priority interrupt is activated first. For VM mode devices, the priorities of the various interrupts are given in the table below.

**VM Mode Devices  
Interrupt Priority (highest to lowest)**

Interrupt 0
Interrupt 1
Interrupt 2
Analog Comparator Interrupt
Interrupt 3
Interrupt 4
Interrupt 5
Interrupt 6
Interrupt 7
Pin Change Interrupt, Port A
Pin Change Interrupt, Port B
Pin Change Interrupt, Port C
Pin Change Interrupt, Port D
Pin Change Interrupt, Port E
Pin Change Interrupt, Port J
Pin Change Interrupt, Port K

For native mode devices, the interrupt priority corresponds to the order of the entries in the processor's interrupt vector table: the lower the vector number the higher the priority. Consult the ATmega or ATxmega processor datasheet for more information on this topic.

Note that a task awaiting an interrupt will exhibit some latency between the occurrence of the interrupt and when the waiting task begins execution. The latency depends on a number of factors including the specific instruction being executed at the time of the interrupt and the number and frequency of system interrupts that need to be handled. Instructions that may take a long time to execute such as

OutputCapture(), ShiftIn(), ShiftOut(), X10Cmd(), etc. will introduce more latency than simple instructions like assigning a value to a variable.

## Examples

```
Call WaitForInterrupt(zxPinChange)
Call WaitForInterrupt(zxPinRisingEdge, WaitInt2)
Call WaitForInterrupt(&H40, WaitPinChangeA) ' await a change on Port A, bit 6
```

## Resource Usage

Only one task can be awaiting each interrupt at any particular time. If a task is already awaiting the specified interrupt, another call to `WaitForInterrupt()` for that same interrupt will return immediately.

Also, on the ZX-24 the interrupt pins are common with I/O pins as shown in the table below. This means that you should set the corresponding pin to be an input (either tri-state or pull-up) when you want to use `WaitForInterrupt()`. Note, however, that if the pin is an output and a task is awaiting an interrupt, a transition on the corresponding output can generate the interrupt for the waiting task. This may be of use in special situations as a “software interrupt”.

**Interrupt and I/O Pin Sharing for  
ZX-24, ZX-24a, ZX-24p, ZX-24n, ZX-24r, ZX-24s**

Interrupt	Port/Bit	Pin
0	Port C, Bit 6	6
1	Port C, Bit 1	11
2	Port A, Bit 2	18

**Interrupt Input Pins (ATmega Devices)**

ZX Models	INT0	INT1	INT2	INT3	INT4	INT5	INT6	INT7	AIN0	AIN1
ZX-24, ZX-24a, ZX-24p, ZX-24n, ZX-24r, ZX-24s	6	11	18	-	-	-	-	-	18	-
ZX-40, ZX-40a, ZX-40p, ZX-40n, ZX-40r, ZX-40s	16	17	3	-	-	-	-	-	3	4
ZX-44, ZX-44a, ZX-44p, ZX-44n, ZX-44r, ZX-44s	11	12	42	-	-	-	-	-	42	43
ZX-24e, ZX-24ae, ZX-24ne, ZX-24pe, ZX-24nu, ZX-24pu, ZX-24ru, ZX-24su	18	17	26	-	-	-	-	-	26	25
ZX-328n, ZX-328l	4	5	-	-	-	-	-	-	12	13
ZX-32n, ZX-32l	32	1	-	-	-	-	-	-	10	11
ZX-1281, ZX-1281n	25	26	-	-	6	7	8	9	4	5
ZX-1280, ZX-1280n	43	44	45	46	6	7	8	9	4	5
ZX-128e, ZX-128ne, ZX-1281e, ZX-1281ne	12	11	10	9	16	15	14	13	18	17
ZX-328nu	5	6	-	-	-	-	-	-	9	10

In the Interrupt Input Pin table above, the columns for INT2 and INT3 indicate that these interrupts are not available for the ZX-1281. That is because the corresponding I/O pins are used for serial channel Com1. For the ZX-1280, ZX-128e and ZX-1281e, INT2 and INT 3 will not be available if serial channel Com2 is in use. Also, INT0 and INT1 are not available on mega128, mega1281 and mega1280-based devices when I2C channel 0 is in use since the same pins are used for the SCL and SDA signals.

For native code devices, the following table lists the ISRs that may be included in your program if it invokes `WaitForInterrupt()`. The compiler will attempt to include only those ISRs that are required based

on what it can determine from analysis of the various invocations. If the compiler is unable to determine which specific ISR is require, all those listed will be included.

ISRs Required		
Underlying CPU	Int Type	ISR Name
mega644P, mega1284P	External Interrupt	INT0, INT1, INT2
	Pin Change Interrupt	PCINT0, PCINT1, PCINT2, PCINT3
	Analog Comparator	Analog_Comp
mega328P	External Interrupt	INT0, INT1
	Pin Change Interrupt	PCINT0, PCINT1, PCINT2
	Analog Comparator	Analog_Comp
mega128	External Interrupt	INT0, INT1, INT2, INT3, INT4, INT5, INT6, INT7
	Analog Comparator	Analog_Comp
mega1281	External Interrupt	INT0, INT1, INT2, INT3, INT4, INT5, INT6, INT7
	Pin Change Interrupt	PCINT0, PCINT1, PCINT2
	Analog Comparator	Analog_Comp
mega1280	External Interrupt	INT0, INT1, INT2, INT3, INT4, INT5, INT6, INT7
	Pin Change Interrupt	PCINT0, PCINT1, PCINT2
	Analog Comparator	Analog_Comp
xmega32A4	Pin Change Interrupt	PORTA_INT0, PORTA_INT1, PORTB_INT0, PORTB_INT1, PORTC_INT0, PORTC_INT1, PORTD_INT0, PORTD_INT1, PORTE_INT0, PORTE_INT1
	Analog Comparator	ACA_AC0, ACA_AC1, ACA_ACW
xmega128A1	Pin Change Interrupt	PORTA_INT0, PORTA_INT1, PORTB_INT0, PORTB_INT1, PORTC_INT0, PORTC_INT1, PORTD_INT0, PORTD_INT1, PORTE_INT0, PORTE_INT1, PORTF_INT0, PORTF_INT1, PORTH_INT0, PORTH_INT1, PORTJ_INT0, PORTJ_INT1, PORTK_INT0, PORTK_INT1, PORTQ_INT0, PORTQ_INT1
		ACA_AC0, ACA_AC1, ACA_ACW, ACB_AC0, ACB_AC1, ACB_ACW
	Analog Comparator	

## Compatibility

The second parameter is not supported in BasicX compatibility mode. The built-in constant `zxPinChange` is not available in BasicX. It is not known if the capability is supported or not.

# WaitForInterval

**Type** Subroutine

**Invocation** WaitForInterval(flags)

Parameter	Method	Type	Description
flags	ByVal	Byte	A set of flag bits that control the operation. See the discussion below.

## Discussion

This routine allows a task to suspend itself and wait for an interval timer to expire. The length of the interval is set by the routine `SetInterval()`. Note that there is only one interval timer that is shared by all tasks. This means that at most one task may be awaiting the expiration of an interval at any one time. If another task is already awaiting an interval, calls to `WaitForInterval()` will return immediately.

The bit values for the `flags` parameter are described in the table below.

Interval Timer Flag Values	
Value	Description
&H01	Wait until the next interval expires.
&H02	Reset the interval counter to its original value.

The remaining bits are currently undefined but may be employed in the future.

After a call to `SetInterval()` the interval counter is decremented on every RTC tick. When it reaches zero, if a task is awaiting the expiration of the interval, that task will be scheduled to run immediately. If no task is awaiting the expiration of the interval, the fact that the interval expired is recorded and the interval counter is reset to the original value.

If the `flags` value is zero when a task calls `WaitForInterval()`, and an interval expiration has previously been recorded (with no waiting task), the call will return immediately. Otherwise, the task will be suspended until the interval expiration. If the `flags` value is &H01, the task will be suspended until the next expiration of the interval. If the `flags` value is &H03, interval counter will be reloaded and then the task will be suspended until the interval expires. The last mode of operation is similar to a task calling `Sleep()`. The difference is that when the interval expires, the task is immediately reactivated. With a `Sleep()` call, the task will execute again when its sequential turn comes up.

A task awaiting the expiration of an interval has lower priority than one awaiting an interrupt. Note that a task awaiting the expiration of an interval will exhibit some latency between the expiration of the interval and when the waiting task begins execution. The latency depends on a number of factors including the specific instruction being executed at the time and the number and frequency of system interrupts that need to be handled. Instructions that may take a long time to execute such as `OutputCapture()`, `ShiftIn()`, `ShiftOut()`, `X10Cmd()`, etc. will introduce more latency than simple instructions like assigning a value to a variable.

## Example

```
Call SetInterval(1.0)
Do
    Call WaitForInterval(0)
    <other code here>
Loop
```

## Resource Usage

The interval counter is driven off of the real time clock. If interrupts are disabled for long periods of time, the timing won't be accurate. I/O routines that disable interrupts typically track RTC ticks and then update the RTC when the I/O process has completed. At this same time, the interval counter will be updated as well accounting for, at most, one missed expiration.

There is a single, system-wide interval timer. Only one task can be awaiting an interval at a time. If a task is already waiting, another call to `WaitForInterval()` will return immediately.

## Compatibility

This routine is not available in BasicX compatibility mode.

**See Also**      `SetInterval`

# WatchDog

---

**Type** Subroutine

**Invocation** WatchDog()

## Discussion

This routine resets the watchdog timer, preventing it from resetting the system. A watchdog timer is useful to ensure that your program continues to operate normally.

To implement a watchdog timer you first call `OpenWatchDog ( )` to prepare the watchdog timer for use. Thereafter, if your program doesn't call `WatchDog ( )` often enough, the watchdog will eventually time out and cause a system reset.

**See Also** CloseWatchDog, OpenWatchDog

# X10Cmd

**Type** Subroutine

**Invocation** X10Cmd(outPin, syncPin, house, devCmd, count)  
X10Cmd(outPin, syncPin, house, devCmd, count, flags)

Parameter	Method	Type	Description
outPin	ByVal	Byte	The pin on which the X10 signal will be generated.
syncPin	ByVal	Byte	The pin on which the 60Hz sync signal will be received.
house	ByVal	Byte	The house code.
devCmd	ByVal	Byte	The device code or command code.
count	ByVal	Byte	The number of times to repeat the transmission.
flags	ByVal	Byte	Flag bits to control the operation of the command.

## Discussion

This routine produces an X-10 compatible signal on the pin specified by `outPin`. The signal is synchronized to the zero-crossing signal on the pin specified by `syncPin`. The generated signal will include the specified house code and command/device code and will be repeated the specified number of times without any spacing between the code sequences. The X-10 specification indicates that most commands should be repeated twice and that successive commands should be separated by at least 3 power line cycles (~50 milliseconds). The exception is for bright and dim commands that can be repeated any number of times.

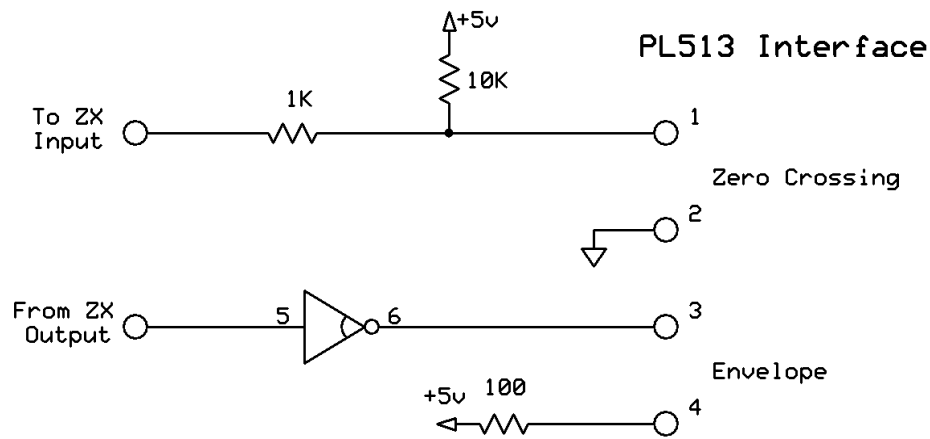
If the `flags` parameter is not present, the transmission is implemented as a single 1millisecond pulse near the edge of the zero crossing signal. If the `flags` parameter is present it has the effects shown in the table below depending on the value of the parameter.

Function	Hex Value	Bit Mask
Three-phase output	&H01	xx xx xx x1
50Hz timing	&H02	xx xx xx 1x

If the three-phase output flag bit is asserted, three 1 millisecond pulses will be output during each half-cycle. The 50Hz timing flag is used to control the phase timing of the three-phase output. If the flag bit is not asserted, 60Hz timing is utilized. This flag bit is only used when generating three-phase output.

## External Circuitry

In order to control X-10 devices, you will need a power line interface device such as the PL513 or the TW523, both of which are available from a variety of sources. The technical documentation for both interface devices is available on the Internet. A simplified interface between the ZX and the PL513 is shown below. Note that this circuit will not work for the TW523. The suggested OEM circuit in the X10 Technical Note, or something similar, should be used.



**Simple PL513 Interface**

### Example

The code below sends the commands to turn on device A1.

```
Const HouseCodeA as Byte = &H06
Const DeviceCode1 as Byte = &H0c
Const DeviceOn as Byte = &H05

Call X10Cmd(20, 19, HouseCodeA, DeviceCode1, 2)
Call Delay(0.50)
Call X10Cmd(20, 19, HouseCodeA, DeviceOn, 2)
```

### Compatibility

The BasicX documentation indicates that the transmission process is done in the background. On this implementation X10Cmd( ) will not return until the transmission is complete. In BasicX compatibility mode the flags parameter is not supported.

# Yield

---

**Type** Subroutine

**Invocation** Yield()

## Discussion

This routine is can be called whenever it is desirable to allow another task to run that is ready to run. One particular situation in which it is useful is at the end of a long process during which UpdateRTC() has been called one or more times. Normally, when an RTC interrupt occurs a task switch is performed immediately if the current task's time slice has expired or if a task is awaiting the expiration of an interval and the interval period has elapsed. However, if interrupts are disabled this automatic task switch cannot be performed. A call to UpdateRTC() will prepare the system for an eventual task switch which is then triggered by a call to Yield().

## Example

See the example at UpdateRTC.

**See Also** UpdateRTC

# ZXCmdMode

<b>Type</b>	Subroutine
<b>Invocation</b>	ZXCmdMode() ZXCmdMode(highSpeed)

Parameter	Method	Type	Description
highSpeed	ByVal	Boolean	A flag controlling the communication speed in command mode.

## Discussion

This routine causes the ZX to stop executing your application and enter “command mode”. When in command mode, the ZX will respond to download commands and other special commands. If the `highSpeed` parameter is specified and it is `True`, command mode is invoked and the baud rate of Com1 is changed to 115.2K baud (the standard download baud rate). If the `highSpeed` parameter is `False` or omitted, command mode is invoked and the baud rate is left unchanged (however, see the Compatibility section, below).

Note: for compatibility with the IDE and the zload utility, this subroutine must be invoked with a `False` or omitted parameter. The `highSpeed` parameter is provided in case a custom downloader might require it.

You can use this routine in your application to facilitate downloading triggered by some particular event, e.g. receipt of a certain character or sequence of characters, the occurrence of an external signal, etc. You can use the downloader DLL source code (installed as part of ZBasic) to construct a special purpose downloader for your application. Alternately, if your application detects receipt of an “ATN character” and then invokes `ZXCmdMode()`, you can use the ZLoad command line utility or the ZBasic IDE to perform downloading without needing to have DTR connected to the device.

## Example

```
Call ZXCmdMode()
```

## Compatibility

With VM versions prior to v3.0.4 and with native mode bootloaders prior to v1.4, invoking this subroutine with a `False` or omitted parameter results in the baud rate switching to 19.2K, the standard debug baud rate. In most cases, this change will be insignificant because in order for the download to succeed the serial channel would be set to 19.2K baud and the Com1 baud rate would be 19.2K baud as well. Since the new behavior does not change the Com1 baud rate, existing applications should continue to work as they did before. The new behavior was implemented for compatibility with fixed-speed communication links such as BlueTooth and XBee. Since the baud rate doesn’t get changed, you can configure your system for any desirable baud rate and perform downloading over the fixed-speed link.

The VM version can be determined using the `SerialNumber()` subroutine. The bootloader version number can be determined using `Register.BootVersion`.