TAB Electronics' Build Your Own Robot Kit with a NetMedia BasicX-24 microcontroller

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TAB Electronics' BYORK

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  - E-mail: sales@wirz.com
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- Element Products, Inc. is provider of two educational robot kits for the McGraw-Hill Companies. These kits are available from Barnes & Noble and Amazon.com ...
TAB Electronics' BYORK

- BYORK Robot Anatomy

Differential drive robot, 5” long x4” wide
TAB Electronics' BYORK

- BYORK Robot Anatomy

Single 9-volt alkaline (20-30 min/batt)
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- BYORK Robot Anatomy

Full H-bridge for both motors
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- BYORK Robot Anatomy

Sensors

CDS cells for light level detection

I/R LEDs for collision detection
TAB Electronics' BYORK

- BYORK Robot Anatomy

- BS2 socket
- BS2 programming connector
- "AppMod" socket
- PIC16C505-controlled peripherals
- I/R TV remote control (not shown)

Control
NetMedia BasicX-24

- **NetMedia Inc.**
  - 10940 N. Stallard Pl., Tucson, Arizona 85737
  - Tel. 520-544-4567
  - Fax 520-544-0800
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  - URL: http://netmedia.com

- NetMedia Inc. is a leading manufacturer in Video Distribution and Camera equipment, embedded micro-control products, and embedded Ethernet web products.
NetMedia BasicX-24

- **What is BasicX?**
  - A BX-24 system combines
    - **BX-24 Hardware** – fast Atmel AT90S8535 core processor with a ROM for the BasicX OS, 400 B RAM, 32 KB EEPROM, lots of I/O devices such as timers, UARTs, ADCs, digital I/O pins, SPI peripheral bus, and more.
    - **BasicX Operating System (BOS)** – on-chip OS that provides multitasking and a high-speed BasicX execution engine.
    - **BasicX Development Environment** – true 32-bit Windows IDE.
NetMedia BasicX-24

- **BasicX-24 Specifications:**

  - **Speed**: 65,000 IPS
  - **EEPROM**: 32K bytes
  - **Max program length**: 8000+ lines
  - **RAM**: 400 bytes
  - **Available I/O pins**: 21 (16 standard + 2 serial only + 3 accessed outside standard dip pin area)
  - **Analog Inputs (ADCs)**: 8
  - **Serial I/O speed**: 1200 - 460.8K Baud
  - **Programming interface**: High speed Serial
  - **Physical Package**: 24 pin DIP module
NetMedia BasicX-24

- Other features:
  - Pin-for-pin compatible with BS2 & BS2SX
  - Built-in SPI interface
  - On-chip voltage regulator
  - 2 user controllable on-chip surface-mount LEDs
  - System clock/calendar
  - Multitasking
  - Full IEEE floating point math
# NetMedia BasicX-24

<table>
<thead>
<tr>
<th>Features</th>
<th>BasicX-24</th>
<th>BS2</th>
<th>BS2SX</th>
</tr>
</thead>
<tbody>
<tr>
<td>I/O Lines</td>
<td>16+</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>EEPROM</td>
<td>32 KB</td>
<td>2 KB</td>
<td>16 K Bank Switched</td>
</tr>
<tr>
<td>RAM</td>
<td>400 B</td>
<td>32 B</td>
<td>96 B</td>
</tr>
<tr>
<td>Speed (IPS)</td>
<td>65,000</td>
<td>4000</td>
<td>10,000</td>
</tr>
<tr>
<td>Max Prog Length</td>
<td>8000+</td>
<td>~500</td>
<td>~500 inst/2K Bank</td>
</tr>
<tr>
<td>Analog Inputs</td>
<td>8 (10 Bit ADCs)</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Multitasking OS</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>FP Math</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>PC Prog Intrfc</td>
<td>Serial</td>
<td>Serial</td>
<td>Serial</td>
</tr>
<tr>
<td>Serial I/O</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>On-Chip LEDs</td>
<td>2 (Red &amp; Green)</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>SPI Interface</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>On-Chip Regltr</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Package</td>
<td>24-pin DIP</td>
<td>24-pin DIP</td>
<td>24-pin DIP</td>
</tr>
</tbody>
</table>
The BasicX Dev't Environment

- In a nutshell ...

* .BAS
Source Code

* .BXB
BasicX binary file

* .PRF
BasicX preferences
The Basic Express Language

- General
  - Modules
    - allow one to split a program into multiple files.
    - facilitate user control of the visibility of constants, variables, and subprograms, which can be public (global) or private to a module.

- Note: Module names are taken from filenames, which means filenames (minus extensions) must be legal Basic Identifiers.

- Note: All BasicX identifiers must start with a letter, and all other characters must be letters, digits, or underscores. Identifiers are case-sensitive and can be up to 255 characters long.
The Basic Express Language

• Example Module:

```basic
Public  A As Integer
Private B As Single ' Module level code ends here

Public  Sub Main()
    Dim K As Integer
    A = 1
    For K = 1 to 10
        A = A + 1
    Next
    B = CSng(A)
    Call Square(B)
End Sub

Private Sub Square(X As Single)
    X = X * X
End Sub
```
The Basic Express Language

- General
  - Main program
    - Program starts execution with a procedure called Main, which must be a public procedure.
  - Statement format
    - The underscore character is used as a line continuation character for long statements extended between two or more lines.
  - Comment format
    - An apostrophe character is used to denote comments.
The Basic Express Language

• Subprograms

  - General
    • A subprogram allows you to take a group of related statements and treat them as a single unit.
    • Subprograms consist of procedures and functions.
    • The difference between a procedure and function is that a function can appear as part of an expression, but a procedure must be called in a standalone statement.
The Basic Express Language

- Subprograms
  - Sub procedures
    - Definition syntax:
      \[
      \text{[Private|Public]} \text{ Sub procedure\_name(\text{arguments})} \\
      \text{[\text{statements}]} \\
      \text{End Sub}
      \]
    - Invocation syntax:
      \[
      \text{Call procedure\_name(\text{arguments})} \\
      \text{or procedure\_name \text{arguments}}
      \]
  - You can also exit a procedure by using an Exit Sub statement.
• Example Subprogram:

```basic
Private Sub GetPosition(ByRef X As Single)

    Call ReadDevice(X)
    If (X > 100.0) Then
        Exit Sub
    End If
    X = X * X

End Sub
```

The Basic Express Language
The Basic Express Language

- Subprograms
  - Functions
    - Definition syntax:
      ```
      [Private|Public] Function
          function_name(arguments) As type
      [statements]
      End Function
      ```
    - **Note**: The function return value can be defined by assigning to the function name inside the function itself.
The *Basic Express* Language

- **Example Function:**

  ```vbnet
  Public Function F(ByVal i As Integer) As Integer
      F = 2 * i ' defines the function return value
      F = F * F ' can also read the function name
  End Function
  ```

- **Example with `Exit Function` statement:**

  ```vbnet
  Function F(ByVal i As Integer) As Single
      If (i = 3) Then
          F = 92.0
          Exit Function
      End If
      F = CSng(i) + 1.0
  End Function
  ```
The *Basic Express* Language

**Subprograms**

- **Function return type**
  - Functions can return non-persistent scalar types or string types.
  - Example string function:
    ```Basic
    Function F() As String
        F = "Hello, world"  ' F is write-only
    End Function
    ```

- **Note:** Every assignment to the function return must be immediately followed by an “Exit Function” or “End Function” statement.
The Basic Express Language

- Subprograms

  - Function return type

    - Note: If a function returns an UnsignedInteger or UnsignedLong object, the first statement in the function must be a Set statement.

    - Example:
      ```basic
      Function F() As UnsignedInteger
        Set F = New UnsignedInteger
        [statements]
      End Function
      ```
The Basic Express Language

● Subprograms

  – Parameter passing
    ● Parameters can be passed to a subprogram by reference (ByRef) or by value (ByVal).
    ● Pass by reference is the default.

    ● Exceptions: For types String, UnsignedInteger, and UnsignedLong passed by value, these parameters are write-protected in the called subprograms for efficiency.
The *Basic Express* Language

- **Subprograms**

  - Parameter passing summary:

    | Parameter                          | ByRef | ByVal |
    |------------------------------------|-------|-------|
    | Scalar variable                    | Yes   | Yes   |
    | Array element                      | Yes   | Yes   |
    | 1D array, lower bound = 1          | Yes   | No    |
    | Multidimensional array             | No    | No    |
    | Array with lower bound not 1       | No    | No    |
    | Numeric expression                 | No    | Yes   |
    | Numeric literal                    | No    | Yes   |
    | Boolean expression                 | No    | Yes   |
    | Boolean literal                    | No    | Yes   |
    | Persistent variable                | No    | Yes   |
The Basic Express Language

- Control structures
  - The If-Then statement

  - Syntax:

    ```
    If (boolean_expression) Then
        [statements]
    ElseIf (boolean_expression) Then
        [statements]
    Else
        [statements]
    End If
    ```
The Basic Express Language

- Control structures
  - The Do-Loop statement
    - Syntax and variants:

```
Do
  [statements]
Loop

Do [While|Until] (boolean_expression)
  [statements]
Loop

Do
  [statements]
Loop [While|Until] (boolean_expression)
```
The Basic Express Language

- Control structures
  - The **Do-Loop** statement
    - **Note:** The “Exit Do” statement can be used to exit any of the Do-Loops.
    - **Note:** Do-Loops can be nested up to a level of ten.
The Basic Express Language

- Control structures
  - The **For-Next** statement
    - Syntax:
      ```plaintext
      For index = beg_val To end_val [Step 1 | -1] [statements] Next
      ```
    - **Note:** `index` must be a local variable of a discrete type.
    - **Note:** Loop counters cannot be changed inside the loop; loop counters are treated as if they were a constant within a loop.
The Basic Express Language

- Control structures
  - The `For-Next` statement
    - Note: The “Exit For” statement can be used to exit a `For-Next` loop.
    - Note: `For-Next` loops can be nested up to a level of ten.
The *Basic Express* Language

- **Control structures**
  - The *Select-Case* statement
    - **Syntax:**

      ```vbnet
      Select Case test_expression
        Case expression_list1
          [statements]
        [Case expression_list2
          [statements]]
        [Case Else
          [statements]]
      End Select
      ```

    - **Note:** `test_expression` must be a discrete, non-string type (boolean or discrete numeric).
The *Basic Express* Language

- Example:

```
Select Case BinNumber(Count)
  Case 1
    Call UpdateBin(1)
  Case 2
    Call UpdateBin(2)
  Case 3,4
    Call EmptyBin(1)
    Call EmptyBin(2)
  Case 5 To 7
    Call UpdateBin(7)
  Case Else
    Call UpdateBin(8)
End Select
```
The Basic Express Language

- Control structures

  - The **GoTo** statement
    - A GoTo branches unconditionally to a specified label.
    - Example:

      ```
      GoTo label_name
      [statements]
      label_name:
      [statements]
      ```

    - **Note:** Labels must be followed by a colon.
## The Basic Express Language

- **Variables, Constants, and Data Types**
  - **Data types**

<table>
<thead>
<tr>
<th>Type</th>
<th>Storage</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boolean</td>
<td>8 bits</td>
<td>True .. False</td>
</tr>
<tr>
<td>Byte</td>
<td>8 bits</td>
<td>0 .. 255</td>
</tr>
<tr>
<td>Integer</td>
<td>16 bits</td>
<td>-32,768 .. 32,767</td>
</tr>
<tr>
<td>Long</td>
<td>32 bits</td>
<td>-2,147,483,648 .. 2,147,483,647</td>
</tr>
<tr>
<td>Single</td>
<td>32 bits</td>
<td>-3.402823E+38 .. 3.402823E+38</td>
</tr>
<tr>
<td>String</td>
<td>Varies</td>
<td>0 to 64 characters</td>
</tr>
<tr>
<td>BoundedString</td>
<td>Varies</td>
<td>0 to 64 characters</td>
</tr>
</tbody>
</table>
The Basic Express Language

- Variables, Constants, and Data Types
  - Declarations
    - All variables must be declared before they are used.
    - In module-level code (default is private):
      
      \[
      \text{[Public|Private|Dim]} \ \text{variable As type}
      \]
    - Inside a subprogram:
      
      \[
      \text{Dim variable As type}
      \]
The Basic Express Language

- Variables, Constants, and Data Types
  - Declarations

  - Example:

    ```plaintext
    Public Distance As Integer ' global
    Private Temperature As Single ' local to module

    Sub ReadPin()
      Dim PinNumber As Byte ' local to sub
      Dim S1 As String ' variable length
      Dim S2 As String * 1 ' 1-char string
      Dim S3 As String * 64 ' 64-char string
      [statements]
    End Sub
    ```
The Basic Express Language

Variables, Constants, and Data Types

- Constants

  - In module-level code (default is private):
    ```vbnet
    [Public|Private] Const
    constant_name As type = literal
    ```

  - Inside a subprogram:
    ```vbnet
    Const constant_name As type = literal
    ```

  - Examples:
    ```vbnet
    Const PI As Single = 3.14159
    Private Const ROOMTEMP As Single = 70.0
    Public Const MAXSIZE As Byte = 20
    ```
The Basic Express Language

- Variables, Constants, and Data Types
  - Numeric literals
    - Decimal integer examples:
      1
      -1
      10
      255
    - Decimal floating point examples:
      1.0
      -0.05
      1.53E20
      -978.3E-3
The Basic Express Language

- Variables, Constants, and Data Types
  - Numeric literals
    - Hexadecimal integer examples:
      &H3
      &HFF
      &H7FFF ' 32767
      -&H8000& ' -32768 (note trailing ampersand)
      * Trailing ampersands are required for hex numbers in range &H8000 (32,768) to &HFFFF (65,535)
    - Binary examples:
      bx00000001 ' 1
      bx00001111 ' 15
      bx11111111 ' 255
### Variables, Constants, and Data Types

- Converting data types

<table>
<thead>
<tr>
<th>Function</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBool</td>
<td>Boolean</td>
</tr>
<tr>
<td>CByte</td>
<td>Byte</td>
</tr>
<tr>
<td>CInt</td>
<td>Integer</td>
</tr>
<tr>
<td>CLng</td>
<td>Long</td>
</tr>
<tr>
<td>CSng</td>
<td>Single</td>
</tr>
<tr>
<td>CStr</td>
<td>String</td>
</tr>
<tr>
<td>FixB</td>
<td>Byte</td>
</tr>
<tr>
<td>FixI</td>
<td>Integer</td>
</tr>
<tr>
<td>FixL</td>
<td>Long</td>
</tr>
</tbody>
</table>

- **Note:** `CBool` allows only a `Byte` type as an operand.
- **Note:** `FixB`, `FixI`, and `FixL` allow only floating point types as operands.
The Basic Express Language

- Variables, Constants, and Data Types
  - Type declaration characters
    - For floating point numbers, the exclamation point (!) and pound sign (#) are allowable as type declaration characters, but only if they replace a trailing “.0” in floating point numeric literals. The following are equivalent:
      
      12.0
      12!
      12#

    - In VB and other Basic dialects, (!) signifies single precision, and (#) signifies double precision.
The Basic Express Language

- Variables, Constants, and Data Types
  - Type declaration characters
    - As indicated earlier, hexadecimal numeric literals in range 32,768 (&H8000) to 65,535 (&HFFFF) are required to have ampersand type declaration characters.
    - **Note**: It is illegal to append type declaration characters to variable names or to numeric literals with fractional parts.
The *Basic Express* Language

- **Variables, Constants, and Data Types**
  - Arrays
    - Arrays can be declared for all data types except strings and other arrays.
    - Examples:
      ```basic
      Dim I(1 To 3) As Integer, _
          J(-5 To 10, 2 To 3) As Boolean
      Dim X(1 To 2, 3 To 5, 5 To 6, 1 To 2, 1 To 2, _
          1 To 2, -5 To -4) As Single
      ```
    - Arrays can have 1 to 8 dimensions, and both upper and lower bound of each index must be declared.
    - For parameter passing:
      ```basic
      Dim I(1 To 5) As Byte    ' Can be passed
      Dim J(0 To 5) As Byte   ' Can't - lower bound not 1
      Dim K(1 To 2, 1 To 3) As Byte ' Can't - not 1D
      ```
The **Basic Express** Language

- **Variables, Constants, and Data Types**
  - **Persistent variables**
    - are stored in EEPROM memory; hence, they retain their values even after power is turned off.
    - must be declared at module level and are not allowed as local variables.

- **Declaration syntax:**
  
  ```
  [Public | Private | Dim] variable
  As New persistent_type
  ```

  where `persistent_type` is:
  
  ```
  PersistentBoolean | PersistentByte | PersistentInteger | PersistentLong | PersistentSingle
  ```
The Basic Express Language

Variables, Constants, and Data Types

- Rules for Persistent variables:
  1. All persistent variables should be declared in one module.
  2. The ordering of declarations of persistent variables must match the order in which the variables are accessed (via read or write operation).
  3. All persistent variables should be private.

Note: These rules guarantee the ordering of persistent variables in EEPROM so that the location of each variable is the same after cycling power on and off.
The Basic Express Language

• Expressions
  – General
    • BasicX uses strong typing, which means binary operators must operate on equivalent types.
    • Both sides of an assignment statement must be of the same type; hence, each argument passed to a subprogram must have the correct type.
The Basic Express Language

• Expressions
  
  – Relational operators
    
    Equality    =
    Inequality  <>
    Less        <
    Greater     >
    Less or equal  <=
    Greater or equal  >=

• Relational operators yield a Boolean type.
• The equality and inequality operators require operands of Boolean or numeric types; all other operators require numeric types.
The *Basic Express* Language

- **Expressions**
  - Logical operators
    - And
    - Or
    - Not
    - Xor

- Logical operators require operands of Boolean type or unsigned discrete types (Byte, UnsignedInteger, or UnsignedLong), and the resulting type matches that of the operands.
- When operands are numeric types, bitwise operations are done.
The Basic Express Language

• Expressions

  – Arithmetic operators

    Addition +
    Subtraction −
    Multiplication *
    Division (float) /
    Division (integer) \n    Modulus Mod
    Absolute value Abs

• Arithmetic operators require numeric operands.
• Note that there are separate operator symbols for floating point and discrete operands.
The Basic Express Language

• Expressions
  – String operators
    Concatenation &
    • Strings can be concatenated.
    • Generally, if the destination string is larger than the resulting string, the result is left-justified and blank-filled. If the destination string is smaller, the result is truncated.
### The Basic Express Language

#### Expressions

- **Operator precedence**

  - (Highest)
    - Abs
    - Not
  - (2)
    - * 
    - \ 
    - / 
    - Mod
    - And
  - (3)
    - + 
    - - 
    - Or
    - Xor
  - (Lowest)
    - = 
    - > 
    - < 
    - <>
    - <=
    - >=
The Basic Express Language

- Expressions
  - Assignment statements
    - Syntax:
      \[
      \text{variable} = \text{expression}
      \]
    - The types of both sides of an assignment statement must match. No implicit type conversions are done.
The *Basic Express* Language

- **Unsigned Types**
  - General
    - The following unsigned integer types are provided:

<table>
<thead>
<tr>
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<th>Storage</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Byte</td>
<td>8 bits</td>
<td>0 .. 255</td>
</tr>
<tr>
<td>UnsignedInteger</td>
<td>16 bits</td>
<td>0 .. 65,535</td>
</tr>
<tr>
<td>UnsignedLong</td>
<td>32 bits</td>
<td>0 .. 4,294,967,295</td>
</tr>
</tbody>
</table>
The Basic Express Language

- Unsigned Types
  - `UnsignedInteger` and `UnsignedLong` are treated as classes, and are subject to the following rules:
    1. If you want to declare unsigned objects as local or module-level variables, you need to use the `New` keyword:

        Dim I As New UnsignedInteger

    However, the `New` keyword is not required in subprogram parameter lists:

        Private Sub S(ByRef I As UnsignedInteger)
The Basic Express Language

• Unsigned Types

2. Functions that use unsigned object returns must have a `Set` statement as the first line of the function.

```basic
Function F() As UnsignedInteger
    Set F = New UnsignedInteger
    F = 65535
End Function
```

3. Unsigned objects cannot be used in `Const` statements.

3. If you pass an unsigned object by value, the object is treated as if it were write-protected within the called subprogram.
The Basic Express Language

- **Unsigned Types**
  - Type conversions
    - **CuInt**: Converts any discrete type to `UnsignedInteger`
    - **CuLng**: Converts any discrete type to `UnsignedLong`
    - **FixUI**: Truncates FP type, converts to `UnsignedInteger`
    - **FixUL**: Truncates FP type, converts to `UnsignedLong`
The Basic Express Language

• Unsigned Types

  - Known bugs

  1. The following arithmetic operations are not allowed for `UnsignedLong` types:

     *    \    Mod

  2. Portability issue – if an `UnsignedInteger` or `UnsignedLong` is used as a formal parameter, and if the object is passed by value, the actual parameter is supposed to be restricted to a single object. BasicX erroneously allows numeric literals and expressions as actual parameters.
The *Basic Express* Language

- **Strict vs. Permissive Syntax Rules**
  
  - Compiler option
    
    - The compiler can be configured to use either *strict* or *permissive* syntax rules.
    
    - This option affects how numeric literals, logical expressions, and For-Next loop counters are treated.
    
    - The default is to use *strict* rules.
The *Basic Express* Language

- **Strict vs. Permissive Syntax Rules**
  - Permissive rules
    - For-Next loop counters
      - Counters are not required to be local variables.
      - Counters are not write-protected inside loops.
      - The scope of a counter is not restricted to its loop.
The *Basic Express* Language

- **Strict vs. Permissive Syntax Rules**
  
  - **Permissive rules**
    
    - Numeric literals and logical operations
      
      - Signed discrete types (*Integer* and *Long*) are allowed to appear in bitwise-logical expressions.
      
      - A wider choice of type declaration characters that can be appended to hexadecimal numeric literals are available. You can use ampersand or percent characters, or no characters.
The Basic Express Language

- **Strict vs. Permissive Syntax Rules**
  - Known bugs

  - In permissive mode, some hexadecimal numeric literals result in incorrect values for `UnsignedLong` types. For example, if `X` is type `UnsignedLong`, the assignment `X=&HFFFFFFFF` sets `X` to 65,535 rather than the correct 4,294,967,295.

  - A workaround is to turn on strict syntax checking.
The Basic Express Language

• Miscellaneous statements
  
  – Attribute statement

  • Attribute VB_Name statements are ignored. All other attribute statements are illegal.

  • Example:

    Attribute VB_Name = "MyFirstModule"

  • Note: In Visual Basic, module names are taken from the VB_Name attribute; BasicX derives module names directly from module filenames.
The *Basic Express* Language

- Miscellaneous statements
  - Option statement
    - **Option Explicit** requires that variables are declared before use, which is the default in BasicX. All other Option statements are illegal.
    - Syntax:
      
      ```
      Option Explicit
      ```
The *Basic Express* Language

- Miscellaneous statements
  - With statement
    - A `With` statement facilitates use of shorthand identifiers for objects, which means the object name qualifier can be omitted from an object reference.
    - Currently, these statements can only be used with `Register` objects. No other objects are allowed in `With` statements.
The Basic Express Language

- Miscellaneous statements
  - With statement

  - A **With** statement can only be used inside a subprogram, and a **With** statement that precedes a block of code must be terminated by an **End With** statement at the end of the block, but before the end of the subprogram.

  - Nested **With** statements are not allowed.
The Basic Express Language

- With statement

  • Syntax:

    ```
    With Register
    [statements]
    End With
    ```

  • Example code:

    ```vba
    ' The following assignments are equivalent.

    Register.OCR1AH = 255
    
    With Register
    .OCR1AH = 255
    End With
    ```
The Basic Express Compiler

- **BasicX Programming Environment**
  - **BasicX Software – Complete**
    - Includes Downloader/Compiler/Editor, BasicX Documentation, Example Files, Application Notes, and ATMEL docs.
  - **BasicX Software – Program Only**
    - Includes Downloader/Compiler/Editor only.
  - **BasicX Software – Documents Only**
    - Includes BasicX Documentation, Example Files, Application Notes, and ATMEL docs only.
The Basic Express Compiler

- **Downloader**
  - The BasicX Downloader is where executable files are downloaded and run on the BasicX system.
The Basic Express Compiler

- The File Menu allows one to open BXB and PRF files.
The **Basic Express Compiler**

- **The Processor Menu**
  - allows one to select which BasicX system type to use.
The Basic Express Compiler

- The I/O Ports Menu
  - allows one to configure communications ports.
The Basic Express Compiler

- The About Menu
The Basic Express Compiler

- The BasicX Editor/Compiler

The Basic Express Compiler

Currently open project
Module name

```basic
Public Sub Main()
' EX-24 serial port and LED demonstration.

Dim Toggle As Boolean
Toggle = True
Call Delay(0.5)
Do
    Debug.Print "Hello, world"
    If (Toggle) Then
        Debug.Print " BX-24"
    End If
    Toggle = Not Toggle
    Debug.Print ' <CR><LF>
    Call BlinkLEDs
    Call Delay(0.5)
Loop
```

Line: 1, Col 1  INS
The Basic Express Compiler

- The BasicX Editor/Compiler
  - The File Menu
The Basic Express Compiler

- The BasicX Editor/Compiler
  - The Edit Menu
The Basic Express Compiler

- The BasicX Editor/Compiler
  - The Compile Menu
The Basic Express Compiler

- The BasicX Editor/Compiler
  - The Options Menu
The Basic Express Compiler

- The BasicX Editor/Compiler
  - The **Project** Menu

```basic
Public Sub Main()

' BX-24 serial port and LED demonstration.

Dim Toggle As Boolean

Toggle = True

Call Delay(0.5)

Do
  Debug.Print "Hello, world"

Loop

End Sub
```
The Basic Express Compiler

- The BasicX Editor/Compiler
  - The Chip Dialog Box of the Project Menu
Basic Express OS Reference

- **Limitations on Persistent Variables:**
  - Write cycle limits
    - Typically the EEPROM inside a BasicX chip is guaranteed for 100,000 write cycles; reading, however, is practically infinite.
  - Write time
    - Each byte takes approximately 4ms to write – much longer than a RAM-based variable.
  - Parameter passing
    - Persistent variables can only be passed by value.
  - Module level declarations
    - All persistent variables must be declared in module-level code.
Basic Express OS Reference

• Block Data Classes
  – Array initialization issues
    • BasicX provides the following system-defined block data classes (must be declared at module level):
      1-Dimensional array classes (byte only):
      ByteVectorData[RW]
      2-Dimensional array classes:
      [Byte | Integer | Long | Single] TableData[RW]

• Example object declarations:
  ' B is a 1D byte array, read-only
  Dim B As New ByteVectorData
  ' BRW is a 1D byte array, read-write
  Public BRW As New ByteVectorDataRW
  ' S is a 2D float array, read-only
  Private S As New SingleTableData
Block Data Classes

Source method

- defines the data file from which an object gets its data; the file is read at compile time, then loaded into EEPROM at the same time the BasicX program is downloaded.

Example:

' B is a 1D byte array, read-only
Call B.Source("ByteVector.txt")
' BRW is a 1D byte array, read-write
Call BRW.Source("C:\Temperatures.dat")
' S is a 2D float array, read-only
Call S.Source("CalibrationCurve.dat")

The Source method must be called before reading or writing the object's internal data.
Basic Express OS Reference

• Block Data Classes
  – Value property
    • 1D block data objects are treated similar to 1D arrays, where the index corresponds to the row number. Row numbering starts at 1.
    • 2D block data objects are treated similar to 2D arrays, where the first index corresponds to the column number and the second index is the row number. Column and row numbering starts at 1.
    • **Note**: A block data object is similar to a persistent variable in regards to write cycle limitations and the amount of time it takes to write to the object.
Basic Express OS Reference

- Block Data Classes
  - DataAddress property
    - The DataAddress property returns the starting EEPROM address of the object's internal data.
    - DataAddress is type Long and is read-only.
    - Example:
      ```vbnet
      Dim T As New IntegerTableData, Addr As Long
      Dim A1 As Integer, A2 As Integer
      [...]
      Addr = T.DataAddress
      ' These two statements are equivalent
      A1 = T(1,1)
      Call GetEEPROM(Addr,A2,2)
      ' At this point A1 and A2 are equal
      ```
Basic Express OS Reference

- Multitasking
  - One of the most powerful features in BasicX is its ability to have multiple tasks running at the same time.
  - Multitasking programs typically need more RAM than programs with a single task.
    - Each task (other than the main program) needs its own explicit stack.
    - Each task stack is a byte array that must be located in module-level (static) code.
    - You may need to empirically determine the task stack size ...
Basic Express OS Reference

● Multitasking
  – In BasicX:
    • Tasks are timeshared on a first-come, first-served basis, except for tasks triggered by hardware interrupts.
    • Under normal conditions, tasks are switched every clock tick (the tick frequency is 512Hz).
    • A user can explicitly allow the next task to run with a Call Sleep\((0.0)\) statement, which returns immediately if no other task is ready.
    • Tasks are like ordinary procedures without parameters; tasks are called with the CallTask instruction.
    • Refer to pages 13-19 of the Basic Express Operating System Reference for additional information ...
Basic Express OS Reference

• Semaphores
  – can be used to keep two tasks from using the same variable at the same time.
  – implementation, if written in Basic:

```basic
Function Semaphore(ByRef Flag As Boolean) As Boolean
' Is the flag available?
If Not Flag Then
  ' Take possession of the flag
  Flag = True
  ' Tell the world we have it
  Semaphore = True
Else
  ' Someone else has the flag
  Semaphore = False
End If
End Function
```
Queues

- useful as data buffers in serial communications.
- ideal for transmitting data between tasks.

- Queues are internally implemented as a circular buffer, and pointers for the queue are maintained within the queue itself.
- Internal pointer overhead requires 9 bytes; hence, defining a 20 byte queue array leaves 11 bytes available for data.

Example:

```basic
Dim MyQueue(1 To 12) As Byte, B As Byte
Call OpenQueue (MyQueue, 12)
Call PutQueue (MyQueue, 3, 1)
Call GetQueue (MyQueue, B, 1)
```
Basic Express OS Reference

• Real Time Clock
  – The OS has a built-in Real Time Clock (RTC) that automatically keeps track of date and time.
  • A group of system calls is available to read or set the clock.

• Example:
  
  Dim Hr As Byte, Mn As Byte, Sc As Single
  Call GetTime(Hr,Mn,Sc)
  If (Hr = 21) And (Mn = 0) Then
    Call TurnOnIrrigation
  End If
## Math functions

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abs</td>
<td>Absolute value</td>
</tr>
<tr>
<td>ACos</td>
<td>Arc cosine</td>
</tr>
<tr>
<td>ASin</td>
<td>Arc sine</td>
</tr>
<tr>
<td>Atan</td>
<td>Arc tangent</td>
</tr>
<tr>
<td>Cos</td>
<td>Cosine</td>
</tr>
<tr>
<td>Exp</td>
<td>Raises $e$ to a specified power</td>
</tr>
<tr>
<td>Exp10</td>
<td>Raises $10$ to a specified power</td>
</tr>
<tr>
<td>Fix</td>
<td>Truncates a floating point value</td>
</tr>
<tr>
<td>Log</td>
<td>Natural logarithm</td>
</tr>
<tr>
<td>Log10</td>
<td>Logarithm base $10$</td>
</tr>
<tr>
<td>Pow</td>
<td>Raises an operand to a power</td>
</tr>
<tr>
<td>Randomize</td>
<td>Sets the seed for Rnd</td>
</tr>
<tr>
<td>Rnd</td>
<td>Generates a random number</td>
</tr>
<tr>
<td>Sin</td>
<td>Sine</td>
</tr>
<tr>
<td>Sqr</td>
<td>Square root</td>
</tr>
<tr>
<td>Sqr</td>
<td>Square root</td>
</tr>
<tr>
<td>Tan</td>
<td>Tangent</td>
</tr>
</tbody>
</table>
Basic Express System Library

- String functions

  - **Asc**: Returns ASCII code of a character
  - **Chr**: Converts a numeric value to a character
  - **LCase**: Converts a string to lowercase
  - **Len**: Returns the length of a string
  - **Mid**: Copies a substring
  - **Trim**: Trims leading and trailing blanks
  - **UCase**: Converts a string to uppercase
Basic Express System Library

- Memory-related functions

  - BlockMove: Copies a block of data from one RAM location to another
  - FlipBits: Generates mirror image of bit pattern
  - GetBit: Reads a single bit from a variable
  - GetEEPROM: Reads data from EEPROM
  - MemAddress: Returns the address of a variable or array
  - MemAddressU: Returns the address of a variable or array
  - PersistentPeek: Reads a byte from EEPROM
  - PersistentPoke: Writes a byte to EEPROM
  - PutBit: Writes a single bit to a variable
  - PutEEPROM: Writes data to EEPROM
  - RAMPeek: Reads a byte from RAM
  - RAMPoke: Writes a byte to RAM
  - SerialNumber: Returns the version number of a BasicX chip
Basic Express System Library

- **Queue functions**
  - GetQueue: Reads data from a queue
  - OpenQueue: Defines an array as a queue
  - PeekQueue: Looks at queue data without removing data
  - PutQueue: Writes data to a queue
  - PutQueueStr: Writes a string to a queue
  - StatusQueue: Determines if a queue has data available
Basic Express System Library

- Tasking functions
  - CallTask
  - CPUSleep
  - Delay
  - DelayUntilClockTick
  - FirstTime
  - LockTask
  - OpenWatchDog
  - ResetProcessor
  - Semaphore
  - Sleep
  - TaskIsLocked
  - UnlockTask
  - WaitForInterrupt
  - WatchDog

  Starts a task
  Puts processor in various low-power modes
  Pauses task and allows other tasks to run
  Pauses task until next RTC tick
  Determines whether program has been run
  Locks task; prevents other tasks from running
  Starts the watchdog timer
  Resets and reboots the processor
  Coordinates data sharing via semaphores
  Pauses task and allows other tasks to run
  Determine whether a task is locked
  Unlocks a task
  Allows a task to respond to a hardware interrupt
  Resets the watchdog timer
Basic Express System Library

- Type conversion functions

  - CBool: Convert **Byte** to **Boolean**
  - CByte: Convert to **Byte**
  - CInt: Convert to **Integer**
  - CLng: Convert to **Long**
  - CSng: Convert to floating point (**Single**) type
  - CStr: Convert to **String**
  - CuInt: Convert to **UnsignedInteger**
  - CuLng: Convert to **UnsignedLong**
  - FixB: Truncate FP value, converts to **Byte**
  - FixI: Truncate FP value, converts to **Integer**
  - FixL: Truncate FP value, converts to **Long**
  - FixUI: Truncate FP value, converts to **UnsignedInteger**
  - FixUL: Truncate FP value, converts to **UnsignedLong**
  - ValueS: Convert to **String** to a float (**Single**) type
Basic Express System Library

• Real time clock functions

- **GetDate**
  Returns the date

- **GetDayOfWeek**
  Returns the day of week

- **GetTime**
  Returns the time of day

- **GetTimestamp**
  Returns the date and time of day

- **PutDate**
  Sets the date

- **PutTime**
  Sets the time of day

- **PutTimestamp**
  Sets the date, day of week, and time of day

- **Timer**
  Returns floating point seconds since midnight
<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADCToCom1</td>
<td>Streams data from ADC to serial port</td>
</tr>
<tr>
<td>Com1ToDAC</td>
<td>Streams data from serial port to DAC</td>
</tr>
<tr>
<td>CountTransitions</td>
<td>Count logic transitions on an input pin</td>
</tr>
<tr>
<td>DACPin</td>
<td>Generate pseudo-analog voltage at output pin</td>
</tr>
<tr>
<td>FreqOut</td>
<td>Generate dual sine waves on output pin</td>
</tr>
<tr>
<td>GetADC</td>
<td>Returns analog voltage</td>
</tr>
<tr>
<td>GetPin</td>
<td>Returns logic level of an input pin</td>
</tr>
<tr>
<td>InputCapture</td>
<td>Records pulse train on the input capture pin</td>
</tr>
<tr>
<td>OutputCapture</td>
<td>Sends pulse train to the output capture pin</td>
</tr>
<tr>
<td>PlaySound</td>
<td>Plays sound from sampled data in EEPROM</td>
</tr>
<tr>
<td>PulseIn</td>
<td>Measures pulse width on an input pin</td>
</tr>
<tr>
<td>PulseOut</td>
<td>Sends a pulse to an output pin</td>
</tr>
<tr>
<td>PutDAC</td>
<td>Send pseudo-analog voltage to an output pin</td>
</tr>
<tr>
<td>PutPin</td>
<td>Configure pin to 1 of 4 input or output states</td>
</tr>
<tr>
<td>RCTime</td>
<td>Measures time delay until pin transition occurs</td>
</tr>
<tr>
<td>ShiftIn</td>
<td>Shifts bits from an I/O pin into a byte variable</td>
</tr>
<tr>
<td>ShiftOut</td>
<td>Shifts bits out of a byte variable to an I/O pin</td>
</tr>
</tbody>
</table>
Basic Express System Library

- Communications functions
  - `Debug.Print` Sends `String` to Com1 serial port
  - `DefineCom3` Defines parameters for serial I/O on arbitrary pin
  - `Get1Wire` Receives data bit using Dallas 1-Wire protocol
  - `OpenCom` Opens an RS-232 serial port
  - `OpenSPI` Opens SPI communications
  - `Put1Wire` Transmits data bit using Dallas 1-Wire protocol
  - `SPICmd` SPI communications
  - `X10Cmd` Transmits X-10 data
References

- Intelligent Systems Lab website, http://isl.ecst.csuchico.edu
- NetMedia Inc. website, http://netmedia.com
- TAB Electronics, Build Your Own Robot Kit website, http://www.tabrobotkit.com