
**Column #82 February 2002 by Jon Williams:**

# Weather On the Wire

*I've always had an interest in the weather. As a boy I would read books on basic meteorology and simple weather forecasting. There was a moment, albeit brief, when I thought about being a TV weather man. After high school and a couple of years in the military, I went to work in the irrigation industry and spent most of that time in the golf course business – a business tied very directly to the weather.*

Even though I've been out of that business for a couple of years, ,my morning routine is the same: I wake, I stretch, I go out onto the front porch to see what the weather is like and what I can expect for the day. Today (early January as I write) was really nice. It's clear in Dallas and the temperature on my front porch was 65 degrees and the air is clear. You can't beat that.

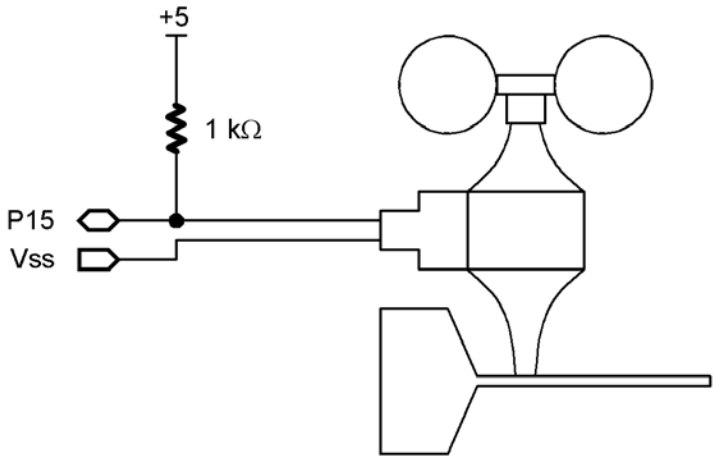
A couple of months ago I was contacted by a Stamp programmer named Tim. He lives in Tucson and has a big interest in the weather – very big. He told me about a low-cost weather station that used Dallas Semiconductor 1-Wire technology. I was under the impression that these stations were no longer available, but I was wrong. A company called AAG in Mexico has them and you can order them via the Internet using PayPal. A 1-Wire weather station seems like a neat add-on for a BS2p, so I bought a few.

**Figure 82.1: Dallas Semiconductor 1-Wire Weather Station**


### 1-Wire Weather Station

Since we don't have to build the station, I'm not going to include the schematic here. It is available on the AAG web site if you'd like to review it as we go through the code. The key thing to understand is that there are three devices connected to the 1-Wire bus: a DS1820 thermometer, a DS2423 counter for the anemometer (wind speed) and a DS2450 quad analog-to-digital converter that is connected to the wind vane.

**Figure 82.2: 1-Wire Weather Station BS2p Schematic**



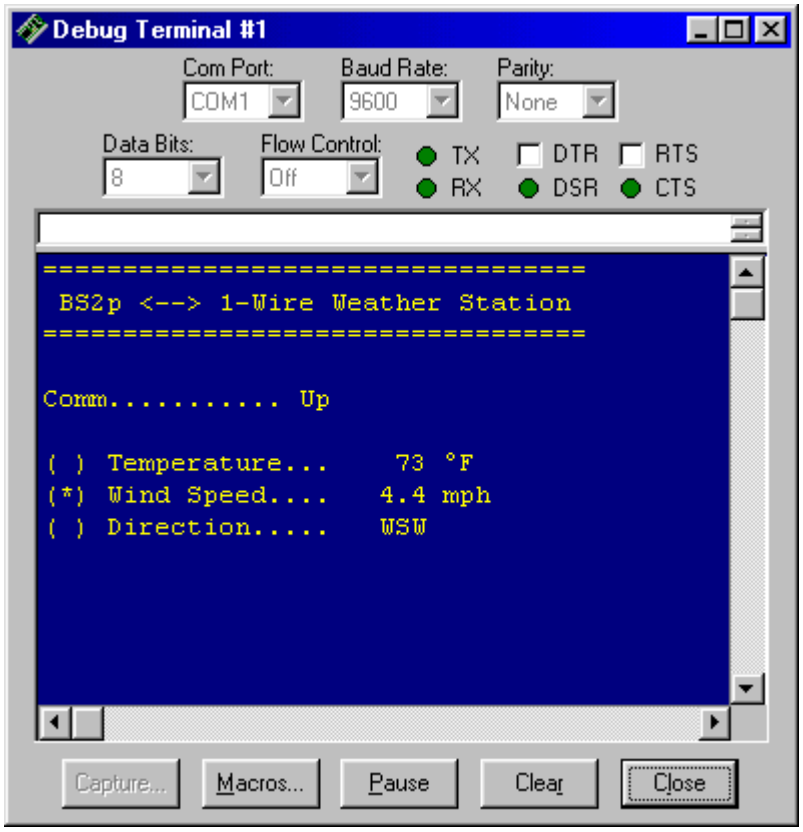

The connection to the weather station is an RJ-11 (telephone) connector. If you have a BS2p Demo Board this project is easy since there is an RJ-11 on the board. Even if you're making your own connections, please note that the 1-Wire pull-up is very stiff, 1 kOhm. This is necessary to overcome the impedance of the cable connecting the Stamp to the weather station. If you are using the Demo Board, remove jumper B2 and connect a 1 kOhm pull-up to the 1-Wire bus.

**Weather Code**

With nothing to build, let's jump right into the code. Now ... before we even start we need to know what the 1-Wire serial numbers are. I've worked with two of these stations and neither came with the serial numbers printed on the side of the box (nor was I expecting it). This is not a problem. What we need to do is run the 1-Wire SearchRom code we developed last April. If you don't have it, you can download the code from the Nuts & Volts web site.

When you run SEARCHDEMO.BSP you'll see that it doesn't know what a DS2423 is and lists it as an "Unknown Device." Don't worry about this. Just copy the serial numbers so that they can be plugged into the weather station code.

**Figure 82.3: BS2p Debug Screen with 1-Wire Code Running**




Okay, this listing is pretty long so we better jump right into it. The Initialization section opens the **DEBUG** window, displays a header for the screen the gets down to work. The first piece of real work is to make sure that the 1-Wire bus is not shorted. This is done by making the 1-Wire comm pin an input then reading it to make sure we see it pulled up to +5 (will read 1). If zero is returned, the program is aborted to an error handler.

The next section of code is the reason we just did that check. There's a small power supply in the weather station. Okay, okay, it's just a diode and a capacitor. The cap provides Vdd to the 1-Wire devices and to pull-ups connected to the A2D converter. Since the supply "borrows" power from the 1-Wire bus, we start the program by charging it. This is done by making the 1-Wire bus pin

high and waiting for ten seconds. In our program a message is displayed showing the charging time left.

Once the station is charged, labels for communication status and each of the sensors is printed. The program then enters the main loop. In the main loop, the program checks to see that the station is connected the branches to the current sensor. So long as the station stays connected, the program will run the main loop. If the station gets disconnected, the initialization sequence will be re-run until contact with the station is reestablished.

We can check to see if the station is connected by issuing the SearchROM command and reading back two bits. If nothing is connected all we'll see is the pulled-up bus and a value of %11. If there are devices connected we'll get another pattern. The reason for checking is the same as looking for a short: there's probably a lot of wire between your desk and the station and accidents can happen. We'll assume that the world is a perfect place for wires and that there are not shorts and the station is connected. Now we can read and display the sensors.

**Temperature**

The first sensor is the DS1820 temperature sensor. We've used this before so we'll brief in the coverage. The routine starts by loading the device serial number into an array called *romData*. This process is facilitated by a small sub-routine called **Load_SN**. What we'll do is load the **DATA** address of the device into *eeData*, then call this routine. The serial number is read out of EEPROM and place into the array.

With the serial number loaded, we'll issue a MatchROM command with the serial number, then the temperature conversion command. All of this happens in a singe **OWOUT** statement. Then the 1-Wire bus pin is taken high and we wait for 750 milliseconds. This is the worst-case conversion time for the DS1820 and making the bus high provides power during the conversion process.

The 9-bit Celsius temperature is retrieved with **OWIN** and converted to Fahrenheit for display. Note that the temperature is a signed value. This time of year the temperature in many areas of the country fall below zero Celsius (32 Fahrenheit).

The temperature is displayed using a subroutine, **RJ_Print**, developed by Stamp guru, Stamp list contributor and all-around-nice-guy, Dr. Tracy Allen. To use this routine, we need to pass the width out of field in the variable *width* and our value to print in *rjNum*. Tracy's routine makes clever use of **LOOKDOWN** to determine how many spaces to print (pad) before the actual number. If the number is negative a minus sign will be printed in front of the number.

## Wind Speed

The 1-Wire weather station measures wind by counting the number of pulses during a known time window. Mechanically, there is an arm connected to the anemometer cups that carries a couple of magnets to trip a reed switch connected to the DS2423 counter. Since the counter cannot be reset, what we'll have to do is get the current count, delay for some period, read the count again and then subtract the first reading from the second to obtain difference.

What Tim noticed and I confirmed is that the counter only seems to work properly when used in overdrive mode. Neither one of us can explain it, but I wanted to make you aware in case you decide to make modifications to the program.

To put the DS2423 in overdrive mode, we send the ODMatchROM value by itself. After that, we send additional data using the high speed setting of the **OWOUT** command. Since the DS2423 is actually a memory plus counter, we're forced to read the final byte of the page that precedes the counter value. It's a quirk of the DS2423 that you cannot reset the counter (it is reset on power-up) nor read it directly. There are actually two independent counters in the DS2423. The weather station ties the inputs together so reading either will give us the same value.

Our **OWIN** ends up reading the lower 16 bits of a 32-bit counter. Then the program pauses for 2500 milliseconds and reads the counter again. The difference is computed and the wind speed is calculated.

The general formula for wind speed is given as:

Speed (mph) = Revolutions_Per_Second * 2.453

There are two magnets on the t-bar that rotates above the wind speed counter switch, so each revolution actually gives us two counts. If we paused for one second, our wind speed resolution would be 1.23 mph (2.453 mph / 2). Since I wanted a little better resolution than that, I used a **PAUSE** value of 2500. This brings the resolution down to 0.49 mph – much better. What this means, though, is we have to wait for the wind speed reading. This is the reason the sensor indication was developed.

In order to maintain our resolution within the Stamp's integer math system, what we're actually going to is use 24.53 to get tenths. Since our **PAUSE** value us 2500 – equivalvant to waiting five seconds if one revolution equaled one count -- we divide that by five and get 4.906. For use with the Stamp we multiply 4.906 by 256 and use the */ (star-slash) operator. The result is multiplication by a fractional value.

The variable *speed* now holds the wind speed in tenths of a mile per hour. For display, we extract the whole part by dividing the wind speed value by ten, then sending it off to **RJ_Print**. Then we print a decimal point and the tenths digit by using the **DEC1** modifier.

**Wind Direction**

While many weather stations use a free-rotating poteniometer to determine wind direction, the 1-Wire station takes a different approach. It uses eight reed switches connected to a resistor array that is read by an DS2450 quad A2D converter. The way the resistors are connected means that a given A2D channel will either see full scale, half-scale or ground. Our trick will be to convert these four analog readings into a 1-of-16 direction value.

The DS2450 is configured to read all four channels, using 8-bit values with a 5.12 volt reference. Since the actual voltage at the station is going to be a bit less than five volts, our highest reading will be slightly less than 255 (full scale at 5.12 volts). I wrote a quick test program to view an decode the values for each of the 16 compass directions. High values tended to be around 235 to 240, middle values around 120 and low values between 0 and 3.

To get the A2D data, we issue a ReadMem command starting at address 0. We need retrieve eight bytes of data since the DS2450 can be configured for 16-bit values. Since we don't need the *romData* array anymore, the A2D data is read into it. Next we'll grab every other byte to create a single word value that can be used in a table to determine direction.

As each A2D channel is retrieved from *romData* it is divided by 90. With integer math, this division will always return a value of two (high readings), one (middle readings) or zero. The result of each division is placed into a separate Nib in the variable *direction*. At this point *direction* holds a value that tells us the direction from which the wind is blowing. **LOOKDOWN** is used to convert this value into a zero to 15 value that can be used to point to a string. You can see how the large lookup table was split in two pieces and that the variable *dFlag* is set to an out-of-range value before **LOOKDOWN** is used.

If the value returned in *direction* is invalid (it happens – one of my stations has a bad part) the value of *dFlag* will not be changed by **LOOKDOWN**. This can be used to flag an error as we've done with this program. If value was good, the **LOOKDOWN** tables will convert it to a value between zero and 15. We use this value to calculate the address of the string that tells us the direction and print it with the subroutine called **Print_String**.

## That's A Wrap

Well, that about wraps it up for this month. For those of you interested in the weather this should get you started. Be sure to take a look at Tim's site and the Dallas Semiconductor site for more sensors.

Next month ... GPS. Yes, I said I wouldn't write about it but I've been convinced that I should. We'll be using the BS2p again and taking advantage of the SPSTR modifier of **SERIN**.

Until then, Happy Stamping.

## (Additional) Resources

Tim Bitson's Weather Page
www.timbitson.com/weather/index.html

AAG
www.aag.com.mx

```
' -----[ Title ]-----------------------------------------------------------------
' Program Listing 82.1
' File..... OW WEATHER.BSP
' Purpose... 1-Wire Weather Station Interface
' Author.... Jon Williams / Parallax (portions by Tim Bitson)
' E-mail.... jonwms@aol.com
' Started... 13 DEC 2001
' Updated... 06 JAN 2002

' { $STAMP BS2p }


' -----[ Program Description ]---------------------------------------------------
'
' This program reads and displays the sensors from a Dallas 1-Wire Weather
' Station.
'
' NOTE: The 1-Wire bus requires a very stiff pull-up -- 1 kOhm or less.


' -----[ Revision History ]------------------------------------------------------
'
' 15 DEC 2001 - Version 1 working
' 06 JAN 2002 - Updated error handling for bad wind vane


' -----[ I/O Definitions ]--------------------------------------------------------
'
OWpin           CON     15                      ' 1-Wire bus


' -----[ Constants ]-------------------------------------------------------------
'
' 1-Wire Support
'
OW_NoRst        CON     %0000                   ' no Reset
OW_FERst        CON     %0001                   ' Front-End Reset
OW_BERst        CON     %0010                   ' Back-End Reset
OW_BitMode      CON     %0100
OW_HighSpd      CON     %1000

ReadROM         CON     $33                     ' read ID, serial num, CRC
MatchROM        CON     $55                     ' look for specific device
ODMatchROM      CON     $69                     ' overdrive match rom
SkipROM         CON     $CC                     ' skip rom (one device)
SearchROM       CON     $F0                     ' search

' DS1820 control
'
CnvrtTemp       CON     $44                     ' do temperature conversion
```

```
RdScratch       CON     $BE                     ' read scratchpad

' DS2423 control
'
ReadMemCntr     CON     $A5                     ' read memory + counter

' DS2450 control
'
ReadMem         CON     $AA                     ' read memory
WriteMem        CON     $55                     ' write memory
Convert         CON     $3C                     ' do conversion

NoDevice        CON     %11                     ' no device present
CommOkay        CON     1
NoComm          CON     0

Celsius         CON     0
Fahrenheit      CON     1
TMode           CON     Fahrenheit              ' temperature display mode
DegSym          CON     176

MoveTo          CON     2                       ' DEBUG cursor positioning
LF              CON     10                      ' linefeed


' -----[ Variables ]------------------------------------------------------------
'
devCheck        VAR     Nib                     ' device check return ocde
commStat        VAR     Bit                     ' comm status
sensor          VAR     Nib                     ' current sensor to display
eeAddr          VAR     Word                    ' string pointer in EE
char            VAR     Byte                    ' character to print
idx             VAR     Nib                     ' loop counter
romData         VAR     Byte(8)                 ' ROM data to devices

tempIn          VAR     Word                    ' raw temperature
sign            VAR     tempIn.Bit11            ' 1 = negative temperature
tLo             VAR     tempIn.LowByte
tHi             VAR     tempIn.HighByte
tSign           VAR     Bit
tempC           VAR     Word                    ' Celsius
tempF           VAR     Word                    ' Fahrenheit

cntrA           VAR     Word                    ' wind count start
cntrB           VAR     tempIn                  ' wind count end
rps             VAR     tempC                   ' revs per second
speed           VAR     tempF                   ' wind speed

crc16           VAR     tempIn
verify          VAR     char
direction       VAR     tempC
```

```
dFlag           VAR     tempF.LowByte

rjNum           VAR     Word                    ' number to right justify
width           VAR     Nib                     ' width of field
rjSign          VAR     Bit
digits          VAR     Nib



' -----[ EEPROM Data ]------------------------------------------------------
'
DS1820          DATA    $10,$15,$32,$09,$00,$08,$00,$A9         ' temp sensor
DS2423          DATA    $1D,$82,$43,$01,$00,$00,$00,$6F         ' wind speed
DS2450          DATA    $20,$AF,$FF,$00,$00,$00,$00,$5E         ' wind direction

CommUp          DATA    "... Up", 0
CommDn          DATA    ". Down", 0

WindDir         DATA    "    N", 0, "  NNE", 0, "   NE", 0, "  ENE", 0
                DATA    "    E", 0, "  ESE", 0, "   SE", 0, "  SSE", 0
                DATA    "    S", 0, "  SSW", 0, "   SW", 0, "  WSW", 0
                DATA    "    W", 0, "  WNW", 0, "   NW", 0, "  NNW", 0

BadDir          DATA    "Error", 0



' -----[ Initialization ]---------------------------------------------------
'
Initialize:
  DEBUG CLS                                     ' open DEBUG window
  PAUSE 250

Splash Screen:
  DEBUG Home
  DEBUG "================================", CR
  DEBUG " BS2p <--> 1-Wire Weather Station ", CR
  DEBUG "================================", CR

Charge Station:
  INPUT OWpin
  IF (Ins.LowBit(OWpin) = 0) THEN Bus_Shorted   ' possible wiring problem

  HIGH OWpin
  DEBUG MoveTo, 0, 4, "Charging station..."
  FOR idx = 10 TO 1
    DEBUG MoveTo, 20, 4, DEC idx, "  "
    PAUSE 1000
  NEXT
  INPUT OWpin
  DEBUG MoveTo, 0, 4, REP " "\25
```

```
Weather Labels:
  DEBUG MoveTo, 0, 4, "Comm.......... "
  DEBUG MoveTo, 0, 6, "( ) Temperature... ", CR
  DEBUG MoveTo, 0, 7, "( ) Wind Speed.... ", CR
  DEBUG MoveTo, 0, 8, "( ) Direction..... ", CR


' -----[ Main Code ]----------------------------------------------------------
'
Main:
  GOSUB Comm_Status                             ' check 1-Wire comm
  IF (commStat = CommOkay) THEN Show_Sensors
  PAUSE 2000
  GOTO Initialize                               ' "reboot" if comm went down

Show_Sensors:
  GOSUB Flag_Sensor                             ' show sensor in use
  BRANCH sensor, [Show_Temp, Show_Wind_Speed, Show_Wind_Dir]

Main2:
  sensor = sensor + 1 // 3                      ' select next sensor
  GOTO Main
  END


' -----[ Subroutines ]--------------------------------------------------------
'

' ****************************************************
' A shorted condition on the 1-Wire bus has been detected
' -- we can't charge the station cap in this condition
' ****************************************************
'
Bus_Shorted:
  DEBUG CLS, "The 1-Wire bus is shorted.", CR
  DEBUG "Please repair before continuing.", CR
  END


' ****************************
' Print status of 1-Wire comms
' ****************************
'
Comm_Status:
  eeAddr = CommUp                               ' assume bus is up
  commStat = CommOkay
  GOSUB Device_Check                            ' check bus for devices
  IF (devCheck <> NoDevice) THEN Print_Comm
  eeAddr = CommDn
  commStat = NoComm
```

```
  DEBUG MoveTo, 19, 6, REP " "\15               ' clear station data if down
  DEBUG MoveTo, 19, 7, REP " "\15
  DEBUG MoveTo, 19, 8, REP " "\15

Print Comm:
  DEBUG MoveTo, 12, 4                           ' show comm status
  GOSUB Print_String
  RETURN


' ***********************************
' Check for presence of 1-Wire devices
' -- does not search for ROM codes
' ***********************************
'
Device Check:
  devCheck = 0
  OWOUT OWpin, OW_FERst, [SearchROM]
  OWIN  OWpin, OW_BitMode, [devCheck.Bit1,devCheck.Bit0]
  RETURN


' **********************
' Indicate sensor in use
' **********************
'
Flag Sensor:
  DEBUG MoveTo, 1, 6, " "                       ' clear previous mark
  DEBUG MoveTo, 1, 7, " "
  DEBUG MoveTo, 1, 8, " "
  DEBUG MoveTo, 1, (6 + sensor), "*"            ' mark current sensor
  RETURN


' ******************************
' Transfer OW serial number to RAM
' -- point to SN with eeAddr
' ******************************
'
Load SN:
  FOR idx = 0 TO 7                              ' load ROM pattern
    READ (eeAddr + idx), romData(idx)
  NEXT
  RETURN


' ******************************
' Retrieve and display temperature
' ******************************
'
Show_Temp:
```

```
  eeAddr = DS1820                                ' load device serial number
  GOSUB Load SN

  OWOUT OWpin, OW FERst,[MatchROM, STR romData\8, CnvrtTemp]

  HIGH OWpin                                     ' extra juice during conversion
  PAUSE 750
  INPUT OWpin

  OWOUT OWpin, OW FERst,[MatchROM, STR romData\8, RdScratch]
  OWIN  OWpin, OW BERst,[tLo, tHi]

  tSign = sign                                   ' save sign bit
  tempIn = tempIn >> 1                           ' round to whole degrees
  IF (tSign = 0) THEN NoNeg1
  tempIn = tempIn | $FF00                        ' extend sign bits for negs

NoNeg1:
  tempC = tempIn                                 ' save Celsius value
  tempIn = tempIn */ $01CC                       ' multiply by 1.8
  IF (tSign = 0) THEN NoNeg2                     ' if neg, extend sign bits
  tempIn = tempIn | $FF00

NoNeg2:
  tempF = tempIn + 32                            ' finish C -> F conversion

  DEBUG MoveTo, 19, 6                            ' move cursor to temp display
  rjNum = tempF                                  ' prep for right justified print
  width = 5                                      ' five digits wide
  GOSUB RJ_Print
  DEBUG " ", DegSym, "F"
  GOTO Main2


' ******************************
' Retrieve and display wind speed
' -- mph = rps * 2.453
' ******************************
'
Show Wind Speed:
  eeAddr = DS2423
  GOSUB Load_SN

  ' get starting count
  '
  OWOUT OWpin, OW FERst, [ODMatchROM]
  OWOUT OWpin, OW HighSpd, [STR romData\8, ReadMemCntr, $DF, $01]
  OWIN  OWpin, (OW_HighSpd | OW_BERst), [cntrA.LowByte, cntrA.LowByte,
cntrA.HighByte]

  PAUSE 2500                                     ' = revs for 5 seconds
```

```
  GOSUB Comm_Status
  IF (commStat = CommOkay) THEN Get End Count
  GOTO Main2                                    ' abort if comm down

  ' get ending count
  '
Get_End_Count:
  OWOUT OWpin, OW FERst, [ODMatchROM]
  OWOUT OWpin, OW HighSpd, [STR romData\8, ReadMemCntr, $DF, $01]
  OWIN  OWpin, (OW HighSpd | OW BERst), [cntrB.LowByte, cntrB.LowByte,
cntrB.HighByte]

Calc_CPS:
  rps = cntrB - cntrA                           ' get diffential count
  IF (cntrB >= cntrA) THEN Calc Speed
  rps = rps + $FFFF                             ' correct for rollover

Calc_Speed:
  speed = rps */ $04E7                          ' rps * 4.906 (tenths @ 5 seconds)
  DEBUG MoveTo, 19, 7
  width = 3                                     ' width of whole portion
  rjNum = speed / 10                            ' get whole portion
  GOSUB RJ Print                                ' print it
  DEBUG ".", DEC1 speed, " mph "                ' then print tenths
  GOTO Main2


' ***********************************
' Retrieve and display Wind direction
' ***********************************
'
Show Wind Dir:
  eeAddr = DS2450
  GOSUB Load SN
  OWOUT OWpin, OW FERst, [MatchROM, STR romData\8, WriteMem, $08, $00]

  FOR idx = 1 TO 4                              ' setup four channels
    OWOUT OWpin, OW NoRst, [$08]                ' 8-bit values
    OWIN  OWpin, OW NoRst, [crc16.LowByte, crc16.HighByte, verify]
    OWOUT OWpin, OW NoRst, [$01]                ' 5.12 volt scale
    OWIN  OWpin, OW NoRst, [crc16.LowByte, crc16.HighByte, verify]
  NEXT

Start Conversion:
  OWOUT OWpin, OW FERst, [MatchROM, STR romData\8, Convert, $0F, $55]
  OWIN  OWpin, OW NoRst, [crc16.LowByte, crc16.HighByte]

  HIGH OWpin                                    ' juice during conversion
  PAUSE 10
  INPUT OWpin
```

```
Get_A2D:
  OWOUT OWpin, OW FERst, [MatchROM, STR romData\8, ReadMem, $00, $00]
  OWIN  OWpin, OW BERst, [STR romData\8]

Calc Direction:
  FOR idx = 0 TO 3                                ' convert readings to word
    direction.LowNib(idx) = romData(idx * 2 + 1) / 90
  NEXT

  ' convert word to 1 of 16

  dFlag = 99                                      ' preset for error inidcation
  LOOKDOWN direction, [$2220,$1220,$1222,$1122,$2122,$2112,$2212,$2211], dFlag
  IF (dFlag < 8) THEN Show Direction              ' found in first table

  LOOKDOWN direction, [$2221,$0221,$0222,$0022,$2022,$2002,$2202,$2200], dFlag
  dFlag = dFlag + 8                               ' adjust for second table

Show_Direction:
  DEBUG MoveTo, 19, 8
  eeAddr = BadDir
  IF (dFlag < 16) THEN Good Dir                   ' found in either table?
  GOTO Dir To Screen

Good_Dir:
  eeAddr = WindDir + (6 * dFlag)                  ' address of direction string

Dir To Screen:
  GOSUB Print String
  GOTO Main2


' ******************************
' Print a right-justified number
' ******************************
'
RJ_Print:
  rjSign = rjNum.Bit15
  rjNum = ABS(rjNum)
  digits = width
  LOOKDOWN rjNum,<[0,10,100,1000,65535],digits
  DEBUG REP " "\(width-digits-1), 13 * rjSign + " ", DEC rjNum
  RETURN


' ************************************
' Print string at current cursor position
' -- point to string with eeAddr
' -- string is zero-terminated
' ************************************
'
```

```
Print_String:
  READ eeAddr, char                             ' get character from EEPROM
  IF (char = 0) THEN Print String Done          ' if 0, string is done
  DEBUG char                                    ' print it
  eeAddr = eeAddr + 1                           ' point to next character
  GOTO Print_String

Print String Done:
  RETURN
```