



599 Menlo Drive, Suite 100  
Rocklin, California 95765, USA  
Office: (916) 624-8333  
Fax: (916) 624-8003

General: info@parallax.com  
Technical: support@parallax.com  
Web Site: www.parallax.com  
Educational: www.stampsinclass.com

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# DS2760 Thermocouple Kit (#28022)

## 1-Wire<sup>®</sup> Thermocouple Interface

### Introduction

Thermocouples provide a low-cost, reliable means of measuring temperature over a wide range. The challenge when using a thermocouple is accurately measuring the very low Seebeck output voltage (fractional to low millivolts) from the element, and providing for cold junction temperature compensation.

The Dallas/Maxim DS2760 High Precision Li+ Battery Monitor is very easily configured into an effective thermocouple interface. The Parallax DS2760 Thermocouple Module capitalizes on this application and provides a complete connection between the BASIC Stamp and a standard thermocouple element.

### Features

- 1-Wire<sup>®</sup> interface allows multiple devices with just one Stamp IO pin
- Cold Junction measurement: 0°C to +127°C (0.125°C resolution)
- Low power consumption:
  - Active current: 90  $\mu$ A max
  - Sleep current: 2  $\mu$ A max

### Packing List

Verify that your DS2760 kit is complete in accordance with the list below:

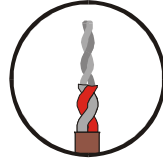
- DS2760 Thermocouple Module #550-28022
- (3) Thermocouple elements:
  - (1) K-type (Chromel / Alumel) #800-00011
  - (1) J-type (Iron / Constantan) #800-00012
  - (1) T-type (Copper / Constantan) #800-00010
- This documentation

Note: DS2760 demonstration software may be downloaded from [www.parallax.com](http://www.parallax.com).

## Connections

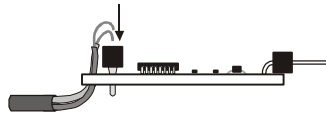
Before connecting the DS2760 Thermocouple Module to the BASIC Stamp you will need to prepare a thermocouple element, and then connect it to the cold junction port of the module. Start by carefully removing about one inch (25 mm) of the outer sleeve from each end of the element. From each lead on the temperature measurement end, remove about ½ inch (125 mm) of insulation and then carefully twist together (using pliers if necessary) and trim as shown in Figure 1.

**Figure 1: Thermocouple Junction**



On the cold junction (DS2760 module) end of the element, remove only ¼ inch (60 mm) of insulation from each lead. Route these leads through the bottom of the thermocouple module PCB and insert snugly into the pin sockets as shown in Figure 2.

**Figure 2: Cold Junction Connection to DS2760 PCB**

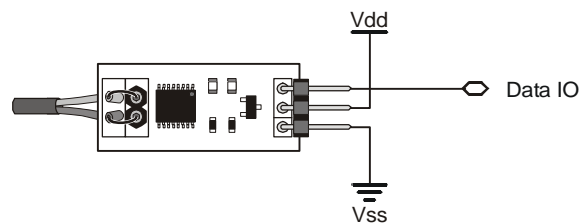


Use this table to ensure that you make the proper thermocouple connections to the module. If the leads are reversed, the measured temperature will be incorrect.

Type	Materials	SNS	Vss
K	Chromel / Alumel	Red	Yellow
J	Iron / Constantan	Red	White
T	Copper / Constantan	Red	Blue

Finally, the DS2760 Thermocouple Module is connected to the BASIC Stamp as shown in Figure 3 below (Note that the module includes a 4.7 KΩ pull-up on the 1-Wire® data line).

**Figure 3: DS2760 Connections to BASIC Stamp**



## BASIC Stamp Application

The following BASIC Stamp application will run on either the BS2p or BS2pe and demonstrates how easy measuring wide-range temperatures can be when using the DS2760 Thermocouple Module. Other Stamps will require a Serial-to-1-Wire protocol converter, as well as code to manage the large tables across program slots, and are not covered in this document.

A little background: When two dissimilar metal wires are joined, a voltage will be developed across the open end that is proportional to the temperature difference between the joined and open ends. This effect was discovered by Thomas Seebeck in 1821. Through empirical testing, voltage tables have been established that correspond to the thermocouple junction temperature. These tables, however, use a cold junction (voltage measurement point) reference of zero degrees Celsius, forcing electronic devices to employ cold junction compensation.

Using the DS2760 we can measure the Seebeck voltage from the thermocouple with a resolution of 15.625 microvolts, then measure the cold junction temperature with a resolution of 0.125 degrees Celsius. A simple table look-up using the cold junction temperature will give us the cold junction compensation voltage. This is combined with the Seebeck voltage and, using a modified binary search algorithm, we can determine the compensated temperature from the thermocouple data table.

```
' =====  
'  
' File..... DS2760TC_Demo.BPE  
' Purpose... Thermocouple temperature measurement using the DS2760  
' Author.... Parallax, Inc. (Copyright 2004, All Rights Reserved)  
' E-mail.... support@parallax.com  
' Started...  
' Updated... 19 JAN 2004  
'  
' {$STAMP BS2pe, KTablePos.BPE, JTablePos.BPE, TTablePos.BPE}  
' {$PBASIC 2.5}  
'  
' =====  
'  
' -----[ Program Description ]-----  
'  
' This program lets a BS2p or BS2pe read the temperature from the Parallax  
' DS2760 thermocouple module. User input of thermocouple type (K, J, or T)  
' and temperature display is via the DEBUG window.  
'  
' -----[ Revision History ]-----  
'  
' -----[ I/O Definitions ]-----  
  
OW                PIN      8                ' 1-Wire buss pin
```

```

' -----[ Constants ]-----
ReadNet      CON      $33          ' read OW net address
SkipNet      CON      $CC          ' skip OW net address
RdReg        CON      $69          ' read register

' -----[ Variables ]-----

idx          VAR      Nib          ' loop counter
type         VAR      Nib          ' device type
char         VAR      Byte         ' display byte/char

vIn          VAR      Word         ' in millivolts
tmpCJ        VAR      Word         ' device temp in C
tCuV         VAR      Word         ' thermocouple millivolts
sign         VAR      Word         ' TC sign bit

cjComp       VAR      Word         ' temp compensation
tempC        VAR      Word         ' temp in Celsius
tempF        VAR      Word         ' temp in Fahrenheit

tblLo        VAR      Word         ' table pointers
tblHi        VAR      Word
eePntr       VAR      Word
testVal      VAR      Word         ' test value from table
error        VAR      Bit         ' 1 = out of range

' -----[ EEPROM Data ]-----

' -----[ Initialization ]-----

Stamp_Check:
  #IF ($stamp < BS2P) #THEN
    #ERROR "This program requires BS2p or BS2pe"
  #ENDIF

Check_Device:
  OWOUT OW, %0001, [ReadNet]      ' get serial number
  OWIN  OW, %0010, [SPSTR 8]      ' store in SPRAM
  GET idx, char                   ' read device type
  IF (char <> $30) THEN           ' if not $30, wrong device
    DEBUG "No DS2760 found."
    STOP                          ' stop program
  #ENDIF

```

```

Menu:
  DEBUG CLS,
    "===== ", CR,
    " DS2760 Thermocouple Interface ", CR,
    "===== ", CR,
  CR,
  "Select TC Type (1 - 3)", CR,
  CR,
  "(1) K - Chromel/Alumel", CR,
  "(2) J - Iron/Constantan", CR,
  "(3) T - Copper/Constantan", CR,
  CR,
  ">>> "

  DEBUGIN DEC1 type ' get selection
  IF (type < 1) OR (type > 3) THEN Menu ' validate selection
  DEBUG CRSRXY, 0, 3, CLRDN ' remove selections
  STORE type ' point READ to table

Show_SN:
  DEBUG CRSRXY, 0, 4, "Device SN... "
  FOR idx = 0 TO 7
    GET idx, char
    DEBUG HEX2 char
  NEXT

Show_Type:
  DEBUG CRSRXY, 0, 6, "TC Type..... "
  LOOKUP (type - 1), ["KJT"], char
  DEBUG char

' -----[ Program Code ]-----

Main:
  DO
    GOSUB Read_TC_Volts ' read Seebeck voltage
    GOSUB Read_CJ_Temp ' read cold junction temp
    READ (tmpCJ * 2), Word cjComp ' get compensation voltage

    ' combine cjComp and tCuV
    '
    IF sign THEN
      ' TC below cold junction
      IF (tCuV < cjComp) THEN
        cjComp = cjComp - tCuV
      ELSE
        cjComp = 0 ' limit to 0C
      ENDIF
  
```

```

ELSE
  ' TC above cold junction
  cjComp = cjComp + tCuV
ENDIF

LOOKUP type, [1023, 1023, 400], tblHi      ' set high end of search
GOSUB TC_Lookup                          ' reverse lookup of table
tempF = tempC * 9 / 5 + 32                ' x 1.8 + 32

IF (error = 0) THEN
  DEBUG CRSRXY, 0, 7,
    "Temp °C..... ", SDEC tempC, CLREOL
  DEBUG CRSRXY, 0, 8,
    "Temp °F..... ", SDEC tempF, CLREOL
ELSE
  DEBUG CRSRXY, 0, 7,
    "Temp °C..... Out of Range", CLREOL
  DEBUG CRSRXY, 0, 8,
    "Temp °F..... Out of Range", CLREOL
ENDIF

PAUSE 1000
LOOP
END

' -----[ Subroutines ]-----
' Reads device input voltage (Vin pin)
' -- mV in millivolts (max reading is 4.75 volts)

Read_Vin:
  OWOUT OW, %0001, [SkipNet, RdReg, $0C]
  OWIN  OW, %0010, [vIn.BYTE1, vIn.BYTE0]
  IF (vIn.BIT15) THEN                          ' check sign
    vIn = 0                                    ' disallow negative
  ELSE
    vIn = vIn >> 5 */ $4E1                      ' x 4.88 millivolts
  ENDIF
  RETURN

' Reads current register to get TC voltage
' -- each raw bit = 15.625 uV
' -- tCuV in microvolts

Read_TC_Volts:
  OWOUT OW, %0001, [SkipNet, RdReg, $0E]      ' read current register
  OWIN  OW, %0010, [tCuV.BYTE1, tCuV.BYTE0]

```

```

sign = tCuV.BIT15           ' save sign bit
tCuV = tCuV >> 3           ' correct alignment
IF sign THEN
    tCuV = tCuV | $F000    ' pad 2's-compliment bits
ENDIF
tCuV = ABS tCuV */ 4000    ' x 15.625 uV
RETURN

' Reads cold junction (device) temperature
' -- each raw bit = 0.125 degrees C
' -- returns tmpCJ in whole degrees C

Read_CJ_Temp:
    OWOUT OW, %0001, [SkipNet, RdReg, $18]
    OWIN  OW, %0010, [tmpCJ.BYTE1, tmpCJ.BYTE0]
    IF (tmpCJ.BIT15) THEN    ' check sign
        tmpCJ = 0           ' disallow negative
    ELSE
        tmpCJ = tmpCJ.HIGHBYTE ' >> 5 x 0.125 (>> 3)
    ENDIF
    RETURN

' Search currently selected TC table for nearest entry
' -- uses modified binary algorithm to find cjComp
' -- high end of search set before calling (tblHi)
' -- successful search sets tempC

TC_Lookup:
    tblLo = 0               ' low entry of table
    tempC = 22              ' default to room temp

    READ (tblHi * 2), Word testVal ' check max temp
    IF (cjComp > testVal) THEN
        error = 1           ' out of range
    ELSE
        DO
            eePntr = (tblLo + tblHi) / 2 ' midpoint of search span
            READ (eePntr * 2), Word testVal ' read value from midpoint

            IF (cjComp = testVal) THEN
                EXIT         ' found it!
            ELSEIF (cjComp < testVal) THEN
                tblHi = eePntr ' search lower half
            ELSE
                tblLo = eePntr ' search upper half
            ENDIF
        DO
    ENDIF

```

```

IF ((tblHi - tblLo) < 2) THEN          ' span at minimum
    eePntr = tblLo
    EXIT
ENDIF
LOOP
tempC = eePntr
ENDIF
RETURN

```

## Additional Resources

- Advanced thermocouple interface software (download from Parallax)
- Web Links:
  - [www.maxim-ic.com/quick\\_view2.cfm/qv\\_pk/2931](http://www.maxim-ic.com/quick_view2.cfm/qv_pk/2931)
  - [www.capgo.com/Resources/Sensors/Temperature/Thermocouple/Thermocouple.html](http://www.capgo.com/Resources/Sensors/Temperature/Thermocouple/Thermocouple.html)
  - [instserv.com/rmocoupl.htm](http://instserv.com/rmocoupl.htm)
  - [instrumentation-central.com/pages/thermocouple\\_reference\\_table.htm](http://instrumentation-central.com/pages/thermocouple_reference_table.htm)

## DS2760 Module Schematic

