MICRO CIRCUIT LABS
DTL DIGITAL TEMPERATURE LOGGER

The Digital Temperature Logger (DTL) is useful in a wide variety of temperature monitoring applications. It measures temperature from -40°F to 214°F and stores up to 254 readings in non-volatile memory. Logged data can later be transferred to a computer through an RS-232 serial port using a terminal program such as HyperTerminal.

Features

- Logs temperature for up to 5 days
- Stores up to 254 readings
- Selectable logging interval
- Battery life: 60 days (typical) at 77°F
- Measures from -40°F to +214°F
- Accuracy: ±3°F max from -10°F to 120°F
- Resolution: 1°F
- RS-232 serial interface

Assembly

You will need the following tools to assemble this kit:
Soldering iron with a small tip (power ~ 50W or less)
Electronics grade solder
Wire cutters
A digital multimeter is helpful but not essential

❑ 1. Start by taking an inventory of the parts.

Parts List

Reference	Qty	Description
Battery	1	Battery, 3V lithium coin cell battery, CR2032
BT1	1	Coin cell battery holder
C1, C2	2	Cap, 0.1uF, ceramic (marked "104")
D1	1	Red LED
D2, D3	2	Diode, small signal, 1N4148
J1	1	Connector, DB9 female, PCB mount
Q1	1	NPN transistor, 2N3904
Q2	1	PNP transistor, 2N3906
R1, R5, R6, R7	4	Res, 10K, 5%, 1/4W (brown-black-orange)
R2, R8	2	Res, 4.7K, 5%, 1/4W (yellow-purple-red)
R3	1	Res, 10K, 1%, 1/4W (brown-black-black-red)
R4	1	Thermistor, 10K, NTC, Thermometrics #RL0503-5820-97-MS
SW1, SW3, SW4	3	Switch, mini-slide, SPDT
SW2	1	Switch, push button, momentary on
U1	1	Microcontroller, Microchip, PIC12F683-I/P, pre-programmed
Misc.	1	8 pin socket for U1
Misc.	1	DTL printed circuit board (1.5" × 2.5")

The circuit board provided with this kit has plated through-holes but has no silk screen. To determine the location of components on the board, refer to the component layout and picture of the assembled board on the last page of this manual. Several components in this kit are polarized and the instructions will indicate the correct polarity when installing them. All components will be installed on the top side of the board. In the assembly steps that follow “install” should be taken to mean install the component, solder its leads to the board, and trim the leads after soldering.

❑ 2. Locate resistor R3, the 10K, 1% resistor. This is the one with a blue case. Bend both leads to make a staple and install at R3.

❑ 3. Locate R2, a 4.7K 5% resistor (tan case) and bend the leads to make a staple. Install at R2.

❑ 4. Install C1 and C2.

❑ 5. Locate diodes D2 and D3, marked 1N4148. Bend both leads to make a staple. These components are polarized. Install these diodes at D2 and D3 with the lead at the banded end inserted into the round hole.

❑ 6. Install the 8 pin IC socket at U1 so that the notched end of the socket is next to C1.

❑ 7. Locate Q1, the 2N3904 transistor. This component is polarized. Refer to the component outline and install at Q1 with the flat edge of the part facing toward J1 as shown.

❑ 8. Locate Q2, the 2N3906 transistor. This component is polarized and must. Again, refer to the component outline and install at Q2 with the flat edge of the part facing toward J1 as shown.

❑ 9. Locate the red LED D1. This component is polarized. Install this component at D1 with the longer lead inserted into the hole with the square pad.

❑10. Install the remaining 5 cylindrical resistors (tan cases). Keep one lead straight and bend the other 180 degrees so that it is in line with the straight lead:

- ❑ R5 (10K, 5%)
- ❑ R6 (10K, 5%)
- ❑ R7 (10K, 5%)
- ❑ R8 (4.7K, 5%)
- ❑ R1 (10K, 5%)

❑ 11. Install the push button switch at SW2.

❑ 12. Install the three slide switches at SW1, SW3 and SW4. Avoid bending the leads of these switches, if needed use masking tape to hold them in place while soldering.

❑ 13. Install the thermistor at R4 (a black bead with two red wires protruding).

❑ 14. Install the coin cell battery holder at BT1. Make sure to orient this part so that the tab is facing in the direction of the push button switch.

❑ 15. Install the DB9 connector at J1.

Now the soldering is finished. Before putting the soldering iron away, check over the board for any unwanted solder bridges or cold solder joints. Also double check that the polarized components are installed correctly (D2, D3, Q1, Q2). (Please note: the + and – terminals of BT1 may initially appear to be shorted because the + and – terminals of the battery holder are shorted together prior to installing a battery).

❑ 16. If all looks ok, place the power switch SW1 in the off position (see component outline) and install the coin cell battery (positive side up).

❑ 17. The 8-pin IC, U1 will be installed next. One end of the IC has a notch to indicate polarity. Insert the IC into the socket at U1 with the notch pointing toward C1.

Now the unit is ready to be tested. Position switches SW3 and SW4 with their actuators pointing left. Turn on the power switch (SW1). If you have a volt meter verify that you have about 3V between test points W1 (ground) and W3 (+3V). If not, verify U1 is installed correctly, check for solder bridges and confirm that the battery is not depleted.

Next, observe the red LED and press the start button (push button SW2). If the red LED blinks twice then so far so good. Follow the operating instructions in the next section to further test out the DTL.

Operating Instructions

The Digital Temperature Logger offers very simple operation.

To set up and deploy the DTL:

1. Starting with the power switch off, turn the power switch on (switch SW1)
2. Select a logging interval by setting switches A and B. The table below indicates sample interval versus switch position. Refer to the component outline for the location of switches A and B.

Sample Interval versus Switch Position

Switch B	Switch A	Sample Interval (min.)	Deployment Duration (hours)
0	0	1	4.2
0	1	6	25.3
1	0	15	63.2
1	1	30	126.5

3. Press the start button (SW2). The red LED blinks twice to indicate the start of logging.
4. Record the start time and date if an absolute time stamp is desired.

   The DTL will log temperature in degrees Fahrenheit for the deployment duration specified in the table above or until the power is turned off. Each reading is given a relative time stamp starting with reading zero. Reading zero is taken directly after the start button is pressed. Successive readings are spaced by a duration equal to the sample interval.

   Note: The DTL sample index is reset to zero whenever the power is turned off and then back on. Logging always begins at index zero after the start button is pressed and previously logged data will be overwritten. Therefore, be sure to offload previously logged data before pressing the start button to avoid losing data.

To offload data from the DTL:

1. Turn off the power switch.
2. Connect the DTL to an available serial port (or USB to serial adapter). The DTL may be plugged directly into a standard DB9 serial port or into a DB9 serial cable.
3. Start a terminal program such as Developer Terminal (available from www.smileymicros.com) or HyperTerminal (resident on Windows pre-Vista machines).

   Set up the terminal program as follows: set the COM port to the number of the port that the DTL is plugged in to. Configure the port as follows: baud rate: 9600; data bits: 8; parity: none; stop bits: 1 (9600,8,N,1). Set the handshaking (also called hardware flow control) to none and then open the port.

   Note when using HyperTerminal: the “Append line feeds to incoming line ends” option needs to be enabled. This option is in the ASCII Setup window found by clicking on `File > Properties > Settings`, check the first box under “ASCII Receiving” to enable “Append line feeds…”.

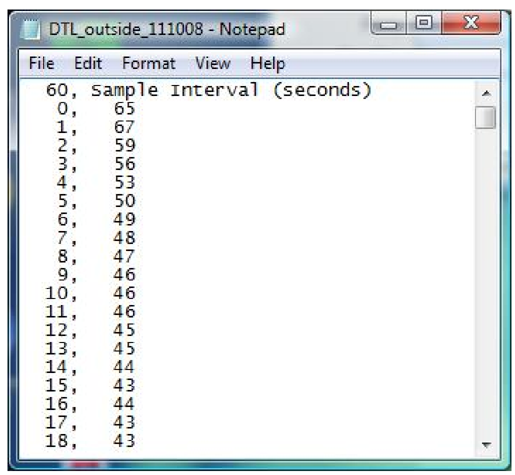
4. Turn on the DTL power switch. The logged data will stream by in the receive window of the terminal program. The red LED lights up while the data is streaming.

   After all the data has been received, save it to a file. Tip: use “.csv” as the filename extension. This allows Excel to automatically recognize the file as comma separated values. The raw data can now be placed into Excel (or any other spreadsheet program) and plotted. For easy plotting, an Excel template file is available on the DTL web page at http://www.microcircuitlabs.com/DTL.htm.

An example data file:

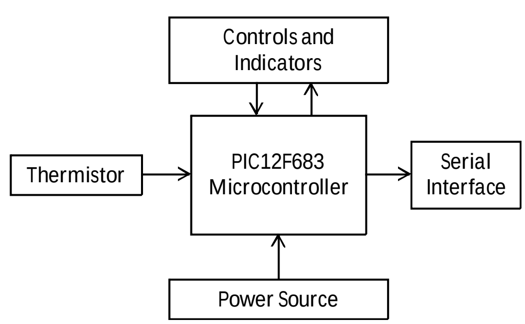
The first line gives the sample interval in seconds and the logged data begins on the second line with the following format:

<sample index>, <temperature in degrees Fahrenheit>



Circuit Description

The block diagram to the right shows the major sections of the Digital Temperature Logger. The microcontroller is the hub that controls circuit operation. It is programmed with firmware that coordinates reading of the thermistor, storage of the readings, serial data transfer and timing. A calibrated RC oscillator internal to the microcontroller provides the clock for program execution and system timing. Clock accuracy is temperature dependent and is ± 1% at 77F, ± 2% from



Block diagram of the Digital Temperature Logger.

32°F to 185°F and ± 5% from -40°F to 185°F. The microcontroller has a built in 10-bit analog to digital (A/D) converter that is used to read the thermistor. Also internal to the microcontroller is 256 bytes of EEPROM memory (non-volatile) which is used to store the temperature data.

Thermistor

Thermistor R4 is used as the temperature sensor in this circuit. It is a 10Kohm negative temperature coefficient type that is specified with an accuracy of ± 1.8°F at 77°F. Referring to the DTL schematic on page 6, the thermistor (R4) and the 10Kohm resistor (R3) form a voltage divider that feeds the analog input AN1 of the microcontroller. To take a temperature measurement, the A/D converter reads the voltage at the AN1 input and this voltage is represented by a 10-bit code that ranges from 0 to 1023. The code that is read is related to the values of R3 and R4 by the following relation:

$$\text{Code} = \text{Maxcode} \times (R4 / (R4+R3))$$

Where R4 is the thermistor resistance, R3 equals 10Kohms and Maxcode equals 1023. An Excel spreadsheet was used to compute the resistance of the thermistor versus temperature from equations provided in the thermistor datasheet. The equation above was then used to relate the value of Code to temperature. A plot of temperature versus Code was made and the resulting curve was fitted to a third order polynomial. The end result is an equation that allows the computation of temperature for a given value of Code. The polynomial fit was done in three sections from -40°F to 214°F and was tweaked until the error was less 0.3°F in each section.

Controls and Indicators

The controls and indicators include a number of switches and an LED. SW1 is the power on/off switch, SW3 and SW4 are the interval select switches and SW2 is the start button. The circuit consists of one indicator which is red LED D1. This LED blinks twice to indicate when data logging has started. It also turns on to indicate when data is being sent out on the serial interface.

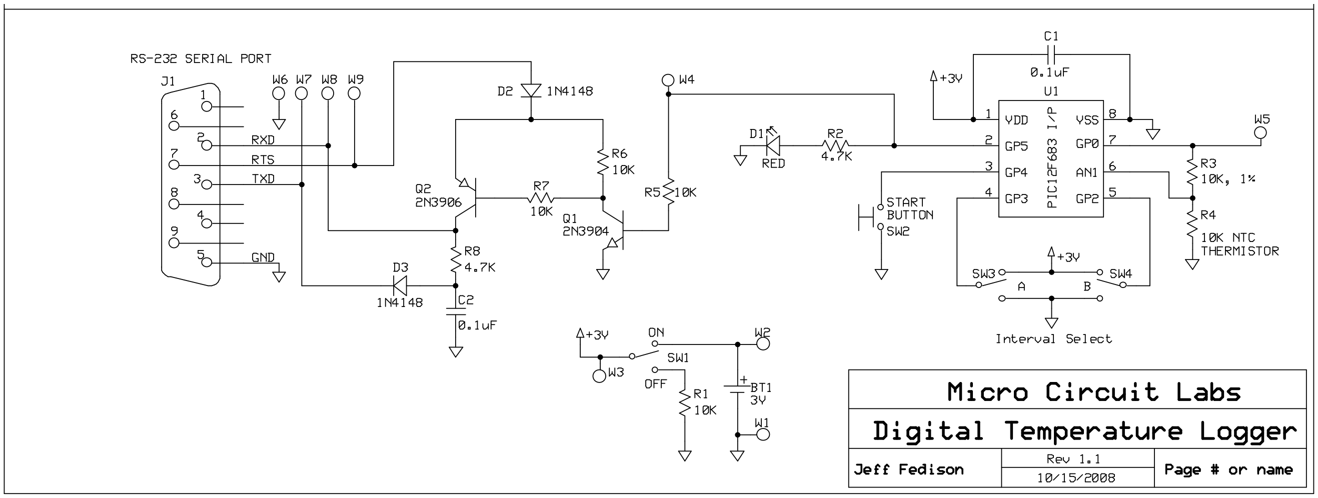
Serial Interface

The serial interface consists of the components to the left of test point W4 on the schematic. The microcontroller sends data out from GP5 (U1, pin 2) and the serial interface circuit level shifts the GP5 signal from a 0 to 3V signal to a -10V to +10V signal to satisfy the signal level requirements of the RS-232 interface.

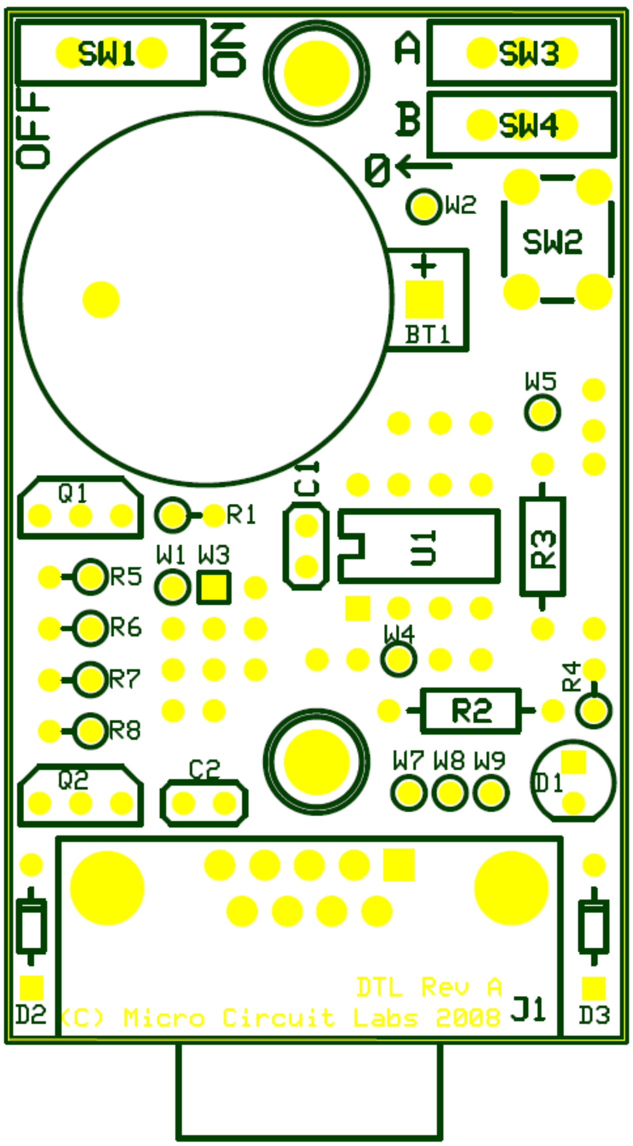
Power Source

The power source for the circuit consists of a non-rechargeable CR2032 3V lithium coin cell battery. This battery has an operating temperature of -22°F to +144°F. Its capacity is 220mAh at 77°F and 209mAh at 14°F. To conserve battery power, the power on/off switch (SW1) should be set to off when the DTL is not in use. When the DTL is on and logging data, the average supply current is 150uA and this yields a typical battery life of 1450 hours (60 days). The battery should be replaced when its voltage falls below approximately 2.5V.

Schematic



Component Layout



Assembled DTL