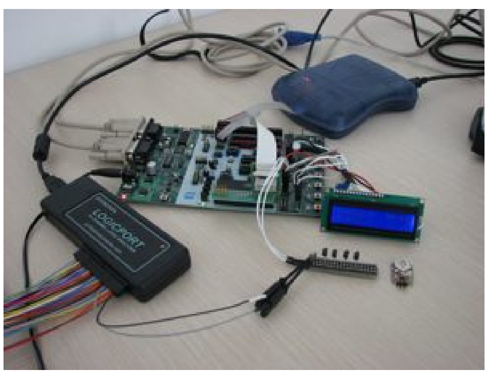
Mutitherm

OVERVIEW

This began as a simple monitor for a friend to keep track of the temperature of his bicycle dynamometer. It was envisioned as a device to grab the temperature information from a couple of Dallas Semiconductor DS18x20 1-Wire® Thermometers and send the information to a serial port of a laptop computer for logging and subsequent graphing and analysis. It evolved into what is presented here.

The current device, based on an Atmel AVRMega168 microcontroller can monitor up to 16 DS18x20 thermometers, with a variable logging rate of 5 to 9999 seconds. The data is displayed on a multi-page LCD display for immediate viewing as well as being sent via RS232 at 19200 baud for recording. Data is time-stamped with an optional on-board 1-Wire real time clock.

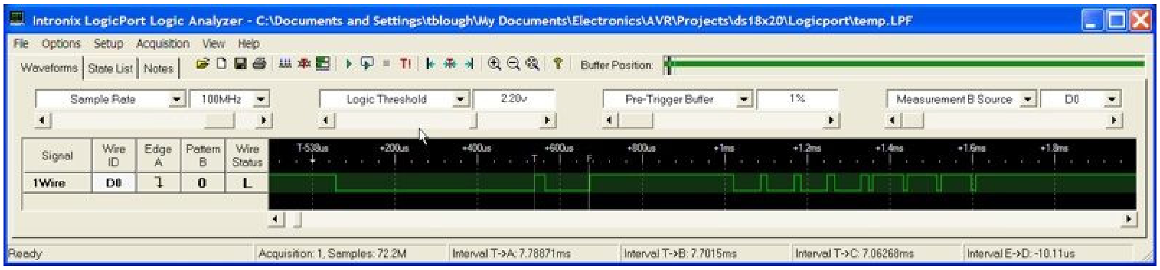
THE DEVELOPMENT AND TEST SETUP



Development work was done on an Atmel STK500 development board, using AVR Studio 4, and the AVR-GCC "C" programming environment plug-in. The development board, in the center of the photo, has common things like LEDs, switches, serial ports, and power regulators already on it so you can just concentrate writing your program.

At the top of the photo is an Atmel JTAGICE MkII for programming and debugging support. Critical timing analysis of the 1-Wire bus signals was accomplished with an Intronix Logicport 32-channel logic analyzer located in the lower left. The Logicport was instrumental in debugging the timing critical 1-Wire communication routines.

In this image, we see the 1-Wire attention signal containing a presence pulse, followed by four 0s and four 1s. That's the 1-wire command to search the 1-wire bus for sensors.



If you are going to develop your own 1-Wire communication routines, the following 1-Wire application notes, in addition to the Dallas Semiconductor datasheets for your devices, will be helpful:

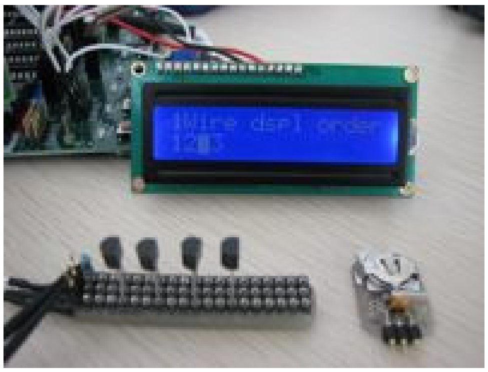
- 1-wire design guide.pdf
- AN126 1-Wire Communication Through Software.pdf
- AN187 1-Wire Search Algorithm.pdf
- AVR318 Dallas 1-Wire master.pdf

OPERATION

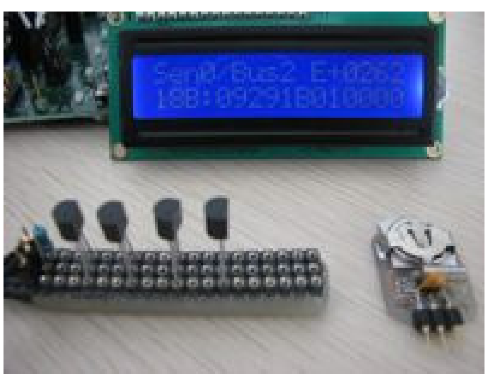
The software for the Multitherm logger is based on a state machine. There are multiple operating modes or "states" of which the logger will in one at any given time. Upon startup, the current version of the firmware will be displayed followed by the number of DS18x20 (either DS1820 [discontinued], DS18B20, or DS18S20) temperature sensors discovered on the 1-Wire bus. A few seconds later a message will be displayed if the optional 1-Wire Real Time Clock (RTC) has been discovered on the bus. If the RTC is present, temperature data sent out the serial port will be time-stamped with the actual date and time of the temperature reading. If the RTC is not present, the time-stamp will be the number of seconds elapsed since the logging process was begun. The device will halt at this point if no temperature devices or RTC are found. You must power off and power back on the device if the number of temperature sensors is changed before the change will be recognized.

Next, if active Temperature sensors were discovered on the 1-Wire bus, the start-up screen is displayed. If no temperature sensors are present, but the RTC is active, the start-up screen is skipped and we go directly to the time-set display. At this point, the four navigation buttons become active. Pressing MODE will advance to the next screen. Any other button will start the logging process.

The 1-Wire search algorithm is deterministic and repeatable, but the order in which the 1-Wire devices is discovered is not intuitive. Pressing the MODE button will advance to the device ordering screen. The numbers on the bottom line represent the order in which the devices were discovered on the 1-Wire bus. Using a combination of the UP, DOWN, and SELECTION buttons, we can rearrange this order into a more meaningful representation. UP and DOWN move the selected item within the list. Use the SELECTION button to change the selected item. The final configuration will be the order the temperatures are displayed on the logging screen, and the order they are output on the serial port at each logging interval. This final order will be remembered for each logging session until changed, even if the device is powered off. Use the MODE button at any time to save the changes and advance to the interval adjustment screen.



All temperature devices are read, and their data output to the serial port, at periodic intervals. This interval can be set anywhere from 5 seconds between readings up to 9999 seconds (a little over 2 hours and 45 minutes). To rapidly change the interval value, press and hold either the UP or DOWN button. Release the button to revert back to a slow interval change. The selected value will be used for all subsequent logging sessions until changed, even if the power to the device is turned off. Pressing MODE stores the selected value and moves to the raw device data display.



This next screen display the raw data for the 1-Wire devices. The display shows the search order discover number, and the currently selected display order number on the first line. Next to the ordering information is the raw device count. This value is converted by the program into the Celsius temperature that is displayed and logged. For more information on the temperature conversion routine, consult the DS18x20 data sheet. The bottom line of this display shows the device type, either DS**18B**20 or DS**18S**20, and the 6-byte device ID number. The 6-byte ID number is unique to each Dallas Semiconductor 1-Wire device. UP or DOWN will cycle through the information of all the 1-Wire devices present.

Pressing MODE again allows us to adjust the backlight level of the LCD display. Values in the range of 0 to 255 may be selected with 0 being no backlight, and 255 is full on. This value will also be retained when the device is switched off.

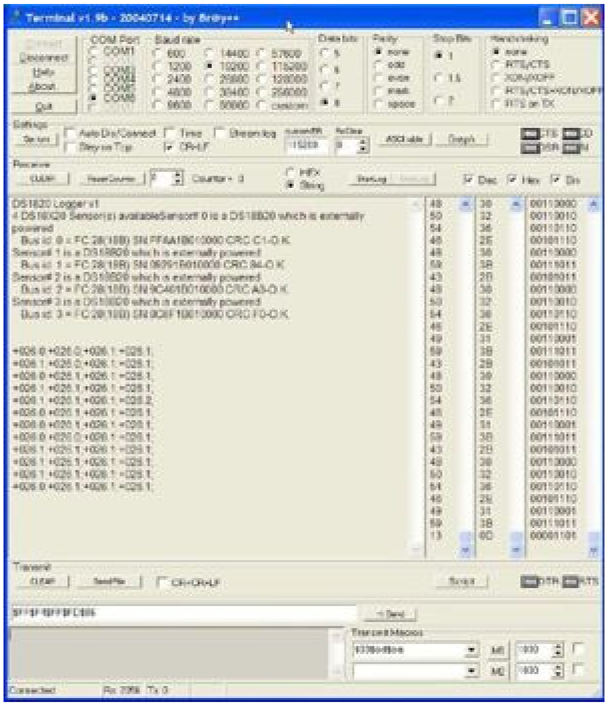
The contrast of the LCD display is adjusted by turning a small potentiometer located on the circuit board between the SELECTION and DOWN buttons. If the RTC is present, pressing MODE advances to the time setting screens. It the RTC is not installed, pressing MODE returns to the startup screen.

Setting the time on the RTC is controlled by the next display page. Initially, the current RTC clock value is shown. Pressing MODE at this point will return you to the startup screen to begin logging. Pressing SELECT will advance, in turn, through the year, month, day, hour, minute, and seconds settings. Pressing SELECT one more time will allow you to save the displayed time to the RTC by pressing both the UP and DOWN buttons simultaneously. Pressing MODE at any time while setting the time aborts the time change and returns to the current time display.

LOGGING

The logging mode is entered by pressing any button other than MODE while on the startup screen. Along the left-hand side of the screen are either one or two device numbers and temperature readings in °C. These readings are the result of the previous temperature scan. The time of the last scan is displayed in the upper right, and the time until the next reading is displayed in the lower right. While in logging mode, the UP and DOWN keys page through the available sensor data. The data is displayed in the order determined from the device ordering screen.

Each time the countdown reaches zero, another reading of every thermometer on the 1-Wire bus is performed. In addition to displaying these latest reading data on the LCD, a record of each reading is transmitted out the built-in serial port. Serial communication occurs at 19200 baud, 8 data bits, no parity, and 1 stop bit. An example of the out put is shown to the left. Following the header section are a series of temperature records. Each temperature record consist of a time-stamp of when the data was taken, followed buy a series of semicolon (;) separated temperature values. The values are ordered from left to right in the same order established on the device ordering screen.



You can use almost any terminal program, such as Window's Hyperterminal or the popular freeware package Br@y++ Terminal, to view and save the serial output. In the Sources section below, I've included a sample Java program to demonstrate how to parse and graph the temperature data from a saved file.

DEMONSTRATION BOARD

Below are photos of a sample demonstration board constructed to test the finished design. The board artwork and schematic in the sources section are designed for easy fabrication by hobbyist board techniques. The double-sided board in the photos was actually constructed using the toner-transfer technique. A mixture of through-hole and SMD components was used to reduce the number of vias and holes required.

DISCLAIMER AND LICENSE

It worked for me so it should work for you, but no guarantees. Feel free to use the schematics and source code on this page as you see fit, but a little attribution would be appreciated.