Flight Data Recorder Hardware Version 1.2

By R. G. Sparber

Scope

The Flight Data Recorder (FDR) hardware is described here. The software is described in a separate document. This document will guide the reader through all the steps necessary to build and test the recorder including etching the circuit board[1], drilling all holes, populating the board with components, soldering, and testing all functionality.

A 2018 cost estimate of the circuit board and all of its components is $50.

Overview

The Flight Data Recorder can record up to 7 voltages at the same time. The voltage must be limited to the range 0 to 5VDC. Data is saved every 2 seconds for up to 4.55 hours[2].

Additionally, the battery voltage is recorded. A 7.4 volt Li-Po is used but any source from 7 to 10 volts DC is fine.

The board has three voltage regulators. One is inside the Pro Micro Arduino processor board and powers the Arduino and its external memory. The second regulator outputs +5V available at each port plus at a power plug. The third regulator outputs +3.3V and is available at a power plug. Maximum output current depends on ambient temperature but can easily source 500 mA.

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[1] It is not necessary to etch the board. You can wire it up on a perf board.
[2] It is possible to change this sample rate. If a reading is stored every 60 seconds, we can run for 136.5 hours.

File Map

The Software Description:
https://rick.sparber.org/FlightDataRecorderSoftwareDescription.pdf

The article you are reading:
https://rick.sparber.org/FlightDataRecorderHardwareDescription.pdf

The Software in a .txt File:
https://rick.sparber.org/FDR.txt

The Circuit Board Artwork:
https://rick.sparber.org/FDRartwork.pdf

Contents

Etch and Cut The Board

The artwork (https://rick.sparber.org/FDRartwork.pdf) used to etch the FDR board looks like this:

Wrong Side!

Wrong Side!
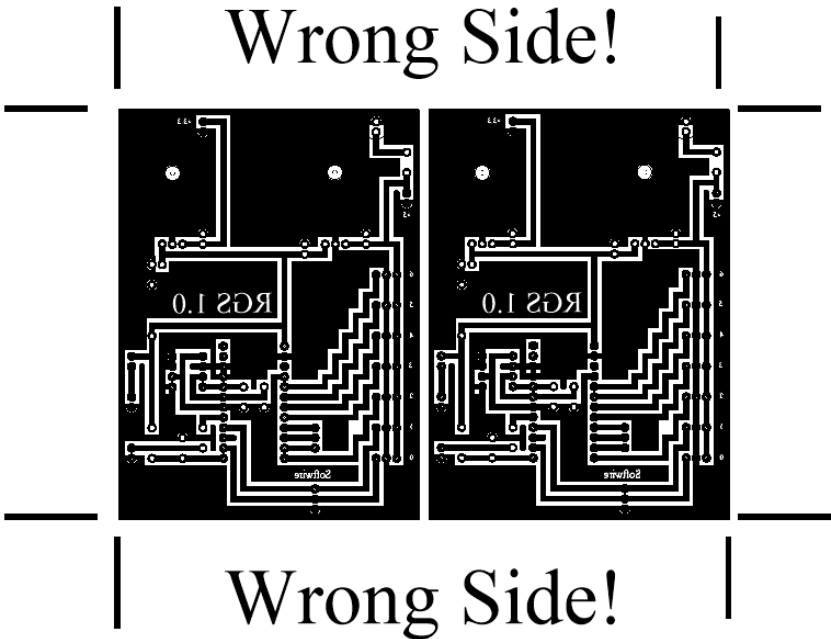
This artwork will cover a single 4" by 6" single sided copper clad board and produce two copies of the circuit. We then saw them apart.

Next, we use four different size drills to cut the holes.

If you are not able to etch the board, it can be wired up using the schematic shown on page 9.

Drill the Board

After the board has been etched and sawed in half, we are ready to drill it.
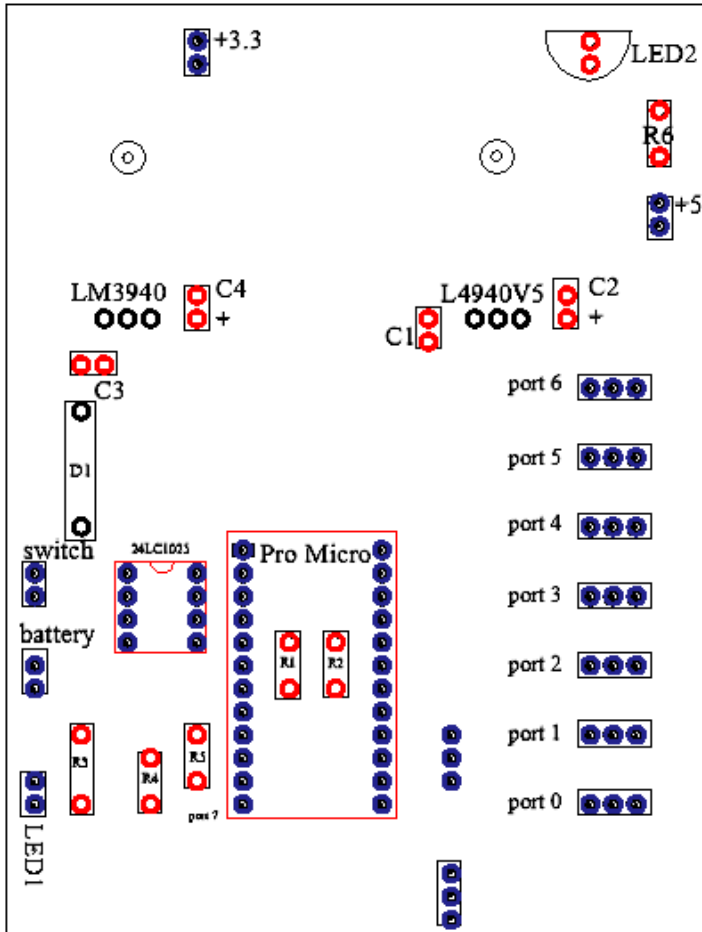
Check off each task only when done.

☐ The smallest holes (**in red**) are for small discrete components: LED2, C1, C2, C3, C4, R1, R2, R3, R4, R5, R6. Use a 0.6 mm drill which might be marked 0.024" or #72-74.

☐ Next, we have the holes for pins (**in blue**). They are used for the +3.3, +5, switch, battery, LED1, 24LC1025, Pro Micro, and all of the port sockets. Use a 0.8 mm drill which might be marked 1/32, 0.03125" or #66-68.

☐ The next larger holes are for the large discrete components (**in black**): LM3940, L4940V5, and D1. Use a 1.0 mm drill which might be marked 0.040" or #59-61.

☐ Near the top of the board are two large holes ⊙ . These pass 6-32 screws that hold the LM3940, L4940VS, and their heatsinks to the board. Select a drill that will permit this screw to easily go through.

☐ Compare all drilled holes to the above figure to ensure that none were missed.

☐ Use a green 3M pad to scrub the copper until it shines.

Populate the Board

First, be sure you have all parts:

[ ]Part numbers are for Mouser.com. To order, go[3] to https://tinyurl.com/GCCparts1 and input the access ID 57254b3299

(( )) is from Circuit Specialist (circuitspecialists.com).

{{ }} is for Sparkfun.com.

| Name	Quantity	Description
Circuit board	1	((3.91" x 5.91" x1/16" Positive Photo Resist Pre-Sensitized Single-Sided Copper Clad Printed Circuit Board))
Pro Micro	1	{{5V/16 MHz from Sparkfun.com}}
EEPROM	1	24LC1025 [579-24LC1025-E/P]
5V regulator	1	L4940V5 [511-L4940V5]
3.3V regulator	1	[926-LM3940IT-3.3NOPB]
C1	1	0.1 uf 21RZ310-RC
C2	1	22 uf [74-199D226X9010C1VE3]
C3	1	0.47 uf[810-FG14X7R1E474KNT6]
C4	1	33 uf [581-TAP336K006SRW]
R1, R2, R3, R4	4	4.7K 0.125W [299-4.7K-RC]
R5, R6	2	330 ohms 0.125W [299-330/REEL-RC]
LED1	1	high intensity LED with plug (supplied)
LED2	1	red LED [859-LTL2R3KRD-EM]
D1	1	power protection diode [512-1N4448]
12 pin female strip	2	{{PRT-00115}} must be cut[4]
12 pin strip	2	attach to circuit board {{ Break Away Headers – Straight PRT-00116}}
8 pin IC socket	1	for EEPROM
3 pin male socket	9	for data ports {{PRT-08096}}
2 pin male socket	5	3.3V, 5.0V, external LED, power in, and Switch {{PRT-08233}}
Heatsink	2	5V and 3.3V [507302B00000G]
Mounting hardware	2	3/8" long 6-32 screws, nuts, and spring washers

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https://www.mouser.com/ProjectManager/ProjectDetail.aspx?AccessID=57254b3299https://www.mouser.com/ProjectManager/ProjectDetail.aspx?AccessID=57254b3299

[4] One way to do this is to pull out the 13th pin and saw at this location with a hacksaw. Then sand down the sharp edges.

This is my first prototype. Not the best job of drilling the holes so most connectors are crooked.
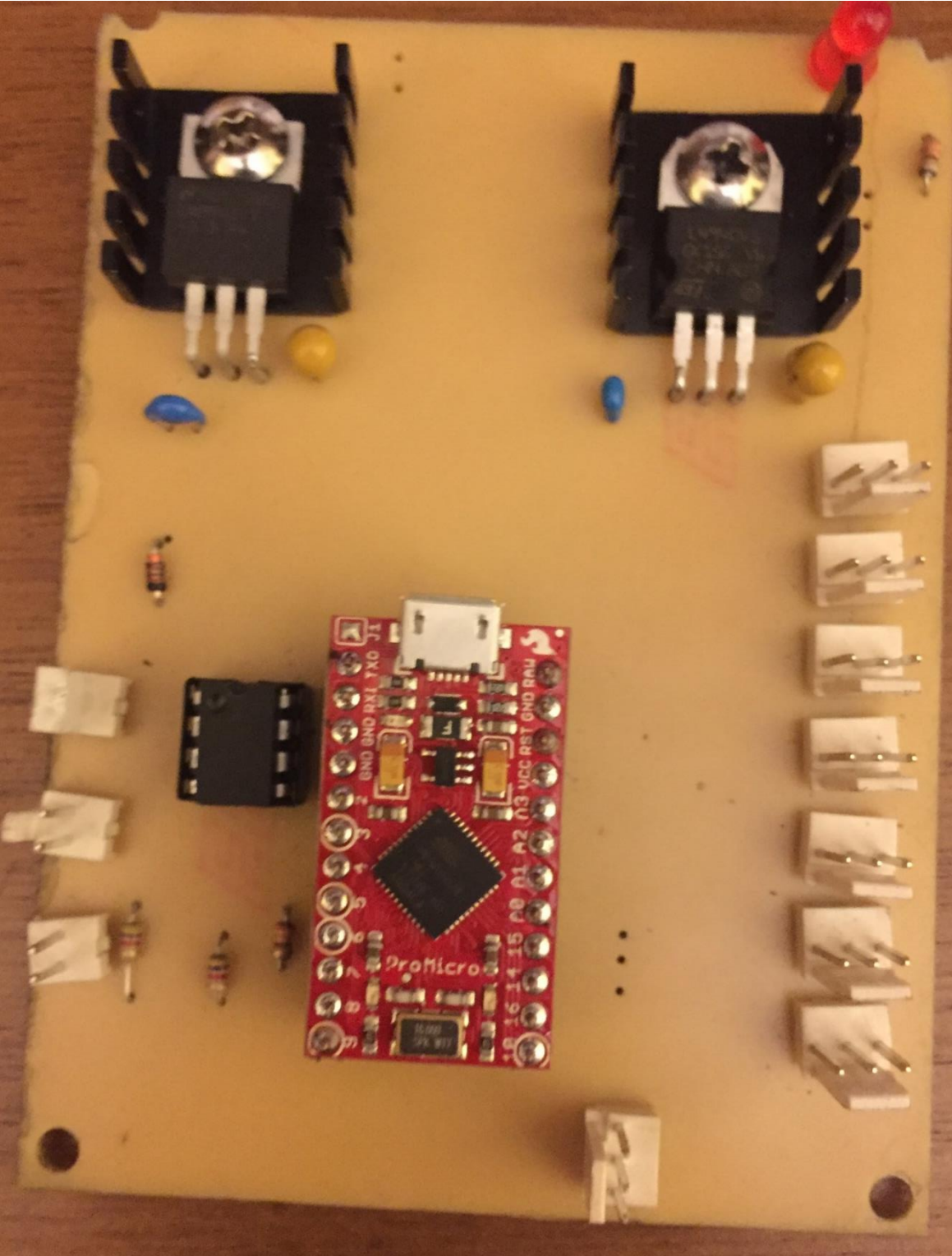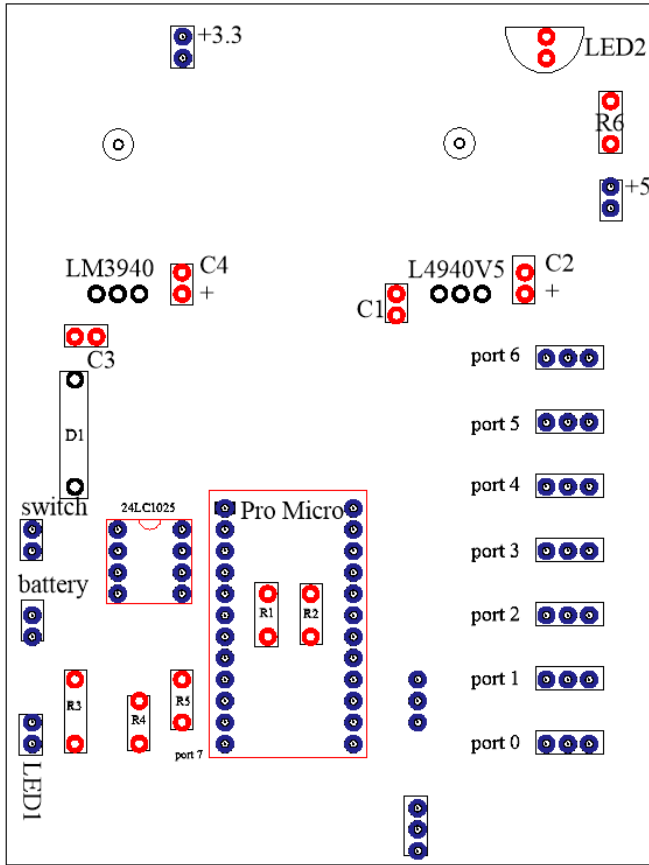
The following is best done with the above picture of the physical sample in hand. **Do not install the 24LC1025 integrated circuit or the Pro Micro board yet.**
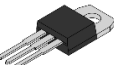
Check off each task only when done soldering.

Insert the parts into the board from the non-copper side.

☐ Note that C2, C4, and LED2 have a positive and negative terminal. The negative terminal connects to the large copper area and not the thin trace. C2 and C4 will have a "+" or "-" stamped on them. LED2 will have a small flat on its base that must match the flat shown in the component outline .

☐Be sure you have the correct three terminal regulator in each location. Form the leads on these devices so the mounting hole in the regulator lines up with the hole on the board and its three leads fit into their holes . Put a heatsink between the device and the board and secure with a 3/8 inch long 6-32 screw, spring washer, and nut.

☐Take two strips of 12 pins and solder them into the column of holes under where the Pro Micro goes. The longer end of the pin faces up.

☐Solder an 8 pin socket into the position where the 24LC1025 (the EEPROM) goes. The notch in the socket points towards the top of the board.

All cable sockets have a specific orientation. The tabs either face down

or to the left

☐ Install all nine cable sockets. Refer to page 9 for the location of these sockets.

The Pro Micro comes with a USB cable attached. ***The connector on the board is very delicate and is easily broken off.*** Once the Pro Micro is installed on the board, secure the USB cable so it does not pull on the connector. During flight, this cable is rolled up and left inside the payload.

Schematic
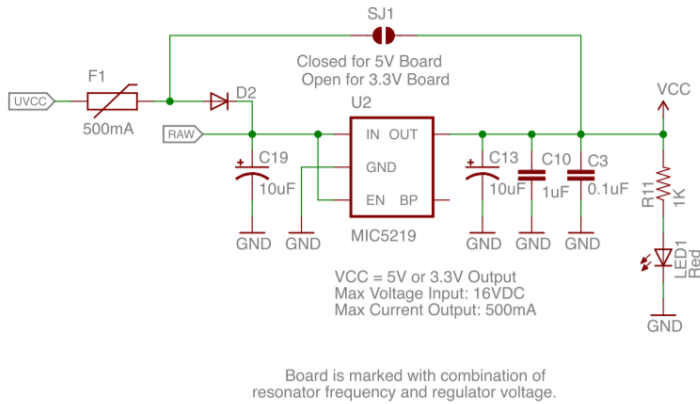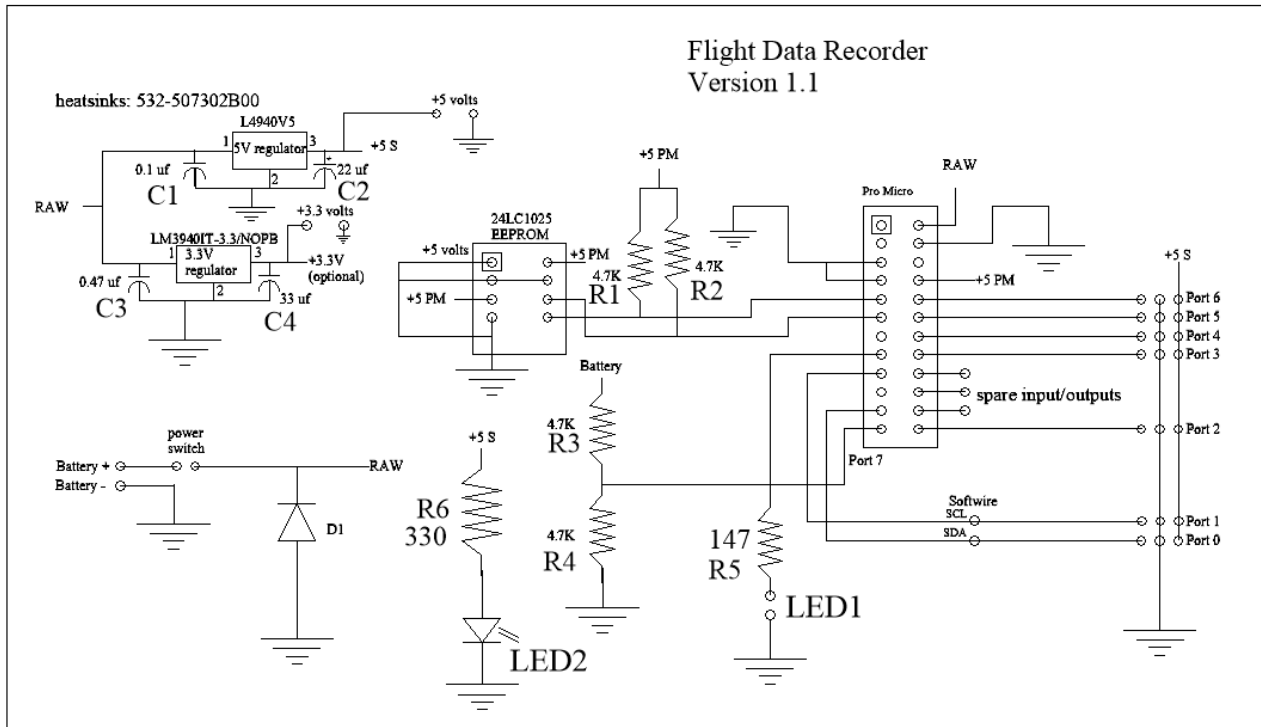
This is the power circuit inside the Pro Micro. UVCC is 5V from the USB cable. D2 is a Schottky diode so has a voltage drop of about 0.3V. Note that if the USB is connected to the board without the battery, RAW will be at approximately 4.6V. This is not enough to power the sensor's regulator but it will pass this voltage to the sensor's 5V bus.

I have supplied the schematic for those that are advanced enough to understand it. You can build and use the Flight Data Recorder without this knowledge.

Testing

☐ With the 24LC1025 integrated circuit and the Pro Micro board *not* installed, we will first test power. Connect the battery and power switch cables. If LED2 lights up, the sensor's 5V supply is working and the battery and switch are connected correctly. If LED2 does *not* light up, quickly remove power and ask for help.

If LED2 *does* light, remove power and install the 24LC1025 integrated circuit, the Pro Micro board, and the cable that connects to LED1.

☐ Refer to the software document in order to interface with the software. Place a ground on each of the 7 port inputs and use the **D** command to display port voltages. You should see 0.00 to 0.02 volts for the grounded port and all other ports should be between 4.95 and 5.00 volts.

☐ Measure the battery voltage and verify that its value which is displayed by the **D** command is within ± 10%.

☐ The timer constant may need to be set. Refer to the **C** command in the software document. If the EEPROM or the Pro Micro is changed, this constant must be reestablished.

☐ Run the system for at least an hour and dump out the data. Inspect the data to see that port 0 through 6 measured voltages are constant and the battery voltage stays above 7V.
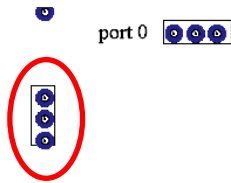
Spare Inputs/Outputs

Three General Purpose Input/Output (GPIO) pins have been brought out to a connector:
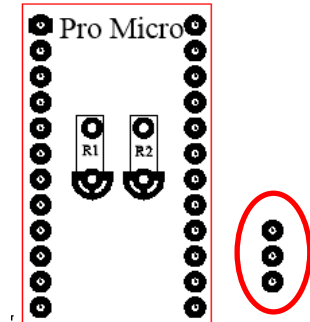
Pro Micro Logical pin name	Connector pin location
15	Top
14	Middle
16	Bottom

In order to use these pins, the software must be modified. Each pin must be defined as an input or output plus logic added to interface to the pin.

Softwire

In order to use these pins, the software must be modified. They provide the I2C interface to digital sensors.

Acknowledgment

Thanks to John Herrmann for reviewing this document and providing invaluable insights.

Rick Sparber