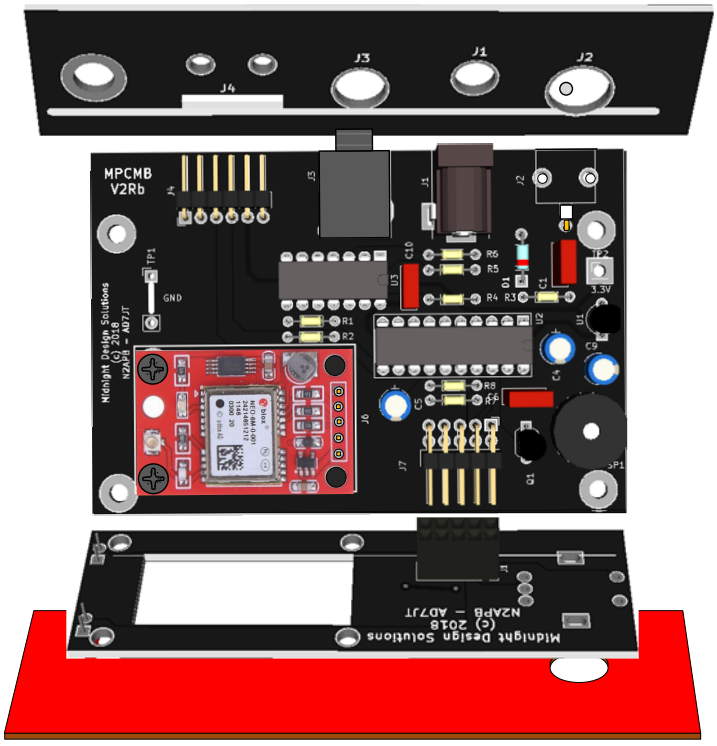
MIDNIGHT PRECISION CLOCK

ASSEMBLY INSTRUCTIONS

David Collins, AD7JT
George Heron, N2APB
September 2020



The Midnight Precision Clock (MPC) consists of these pieces:

- ***Rear Panel*** with legends and cutouts for the interface connectors.
- ***Main Board*** Contains most of the MPC circuitry plus connectors for the front board, GPS receiver, environmental sensor and interface connectors.
- ***Front Board*** Contains the front panel controls and displays.
- ***Front Panel*** Translucent red lens through which the displays can be seen plus a hole for the rotary control shaft.
- ***Enclosure*** 4.5 x 3 x 1.25 inches black ABS plastic.

This document provides step-by-step instructions for assembling the two PCBAs and the MPC final assembly.

TABLE OF CONTENTS

1 GENERAL DESCRIPTION

Follow the following major steps to completely assemble the MPC:

1. Prep the GPS receiver and Environment sensor modules
2. Assemble the Main Board PCBA
3. Assemble the Front Board PCBA
4. Install the Main Board, Rear Panel, and Front Board in the MPC enclosure base.
5. Install the MCU in the main board.
6. Test the MPC operation.
7. Close the MPC enclosure and complete final assembly.

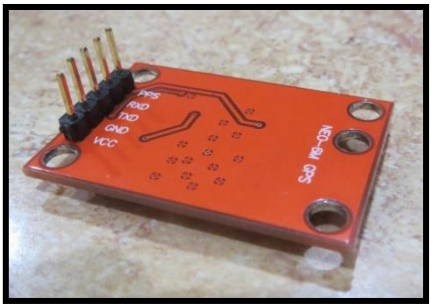
The MPC contains only through-hole devices. There are no surface mount devices so PCBA assembly is straight forward and relatively easy.

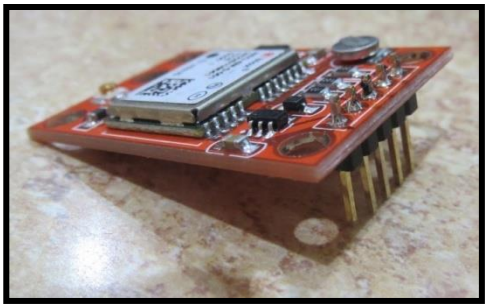
The MPC kit includes three printed circuit board assemblies (PCBAs): The Main Board PCBA contains all the active circuitry, the Front Board PCBA contains the front panel controls and indicators, and the Rear PCBA contains the connectors and the environmental sensor.

2 PREP THE GPS RECEIVER AND ENVIRONMENT SENSOR MODULES

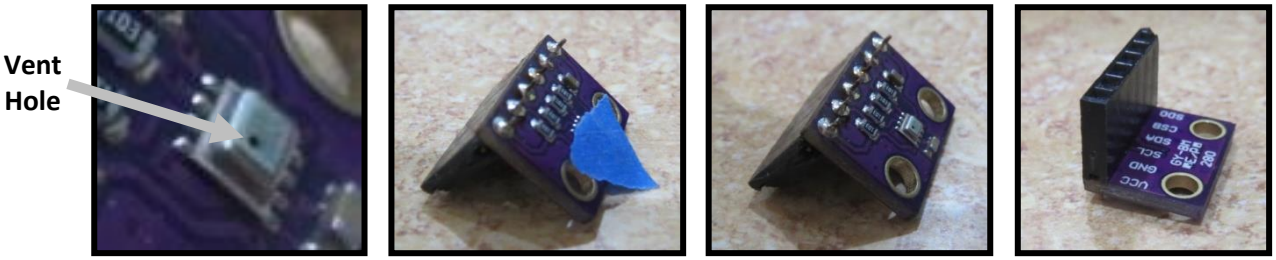
Interface connectors need to be installed on these two modules.

The GPS receiver uses a 5-pin straight header on the back side of the board.



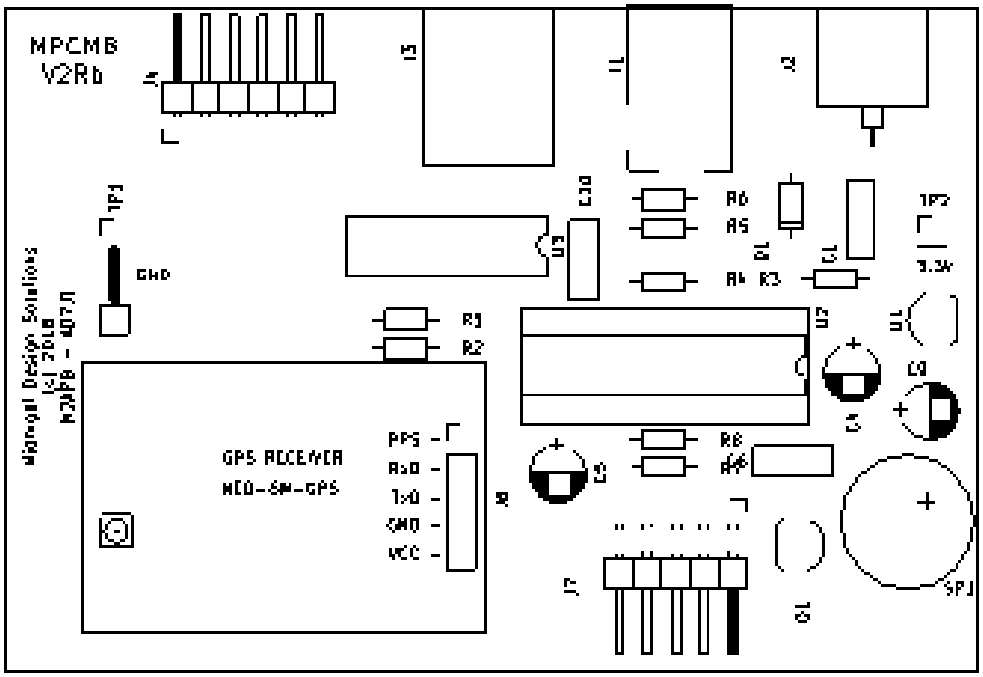


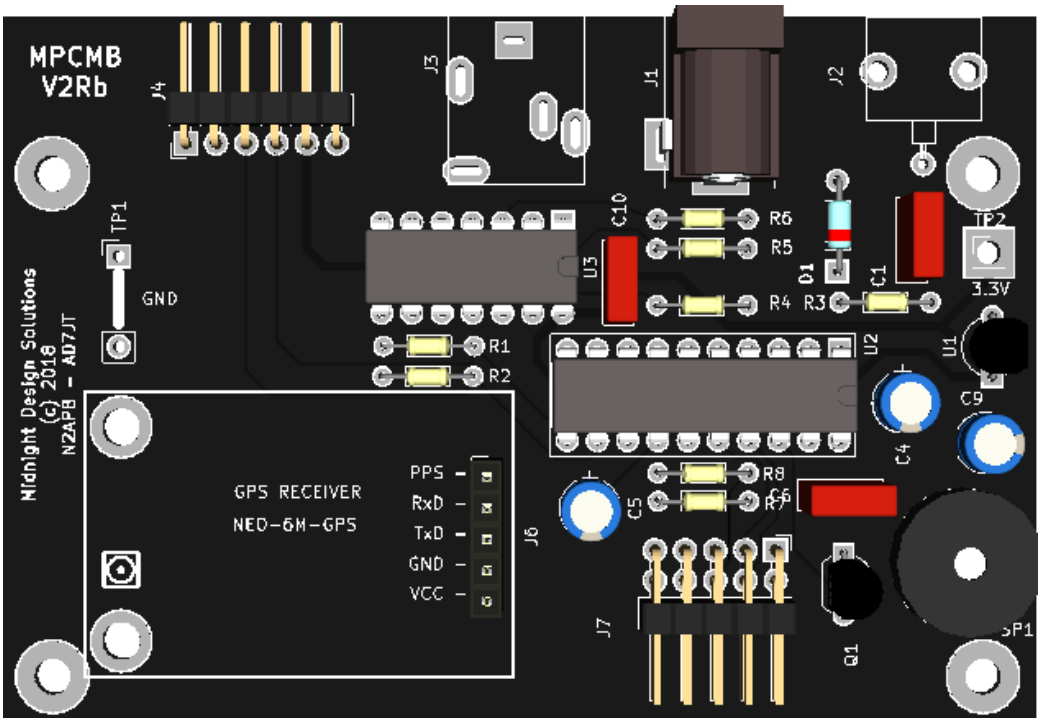
The Environment Sensor has a 6-pin, straight female header soldered on the back side of the board. The actual sensor is not hermetically sealed; it has a vent hole to "sniff" the air for humidity and pressure measurements. Be careful not to get any flux or cleaner in this hole. We recommend you cover the hole with masking tape while installing the connector.



3 MAIN BOARD PCB ASSEMBLY

The Main Board PCB is a double-sided board silk screened on top. The silk screen shows each component's outline and reference designation as shown on the schematic and listed in the Parts List.





MAIN BOARD		
REF	QTY	DESCRIPTION
MB-pcb	1	PCB, MPC main board, 3.43"x2.33"
U1 (on Foam)	1	Voltage Regulator, L78L33ACZ, 3.3V, TO-92-3
U3 (on Foam)	1	IC, SN74HC125N, Quad bus driver, DIP-14
Q1 (on Foam)	1	Transistor, 2N7000, JFET, TO-92
U2 (on Foam)	1	MCU, PIC24FV32KA301-I/P, DIP-20
D1	1	Diode, 1N5817, Schottky , DO-41, Thru-hole
C1	1	Capacitor, 1uF, 50V, MCC, 10%, Radial
C4,C5	2	Capacitor, 10uF, 50V, electrolytic, 20%, Radial
C6,C10, C7	3	Capacitor, 0.1uF, 50V, MCC, 10%, Radial
C9	1	Capacitor, 100 uF, 25V electrolytic, 20%, Radial
J1	1	DC Power Jack, PCB, 2.1mm
IC Socket	1	IC socket, 20-pin, DIP-20
J3+Nut	1	Audio Jack, 3.5mm, Stereo
J4	1	Male Header, 1x6, 0.1" pitch, Right angle
J6	1	Female Header, 1x5, 0.1" pitch, straight
J7	1	Male Header, 2x5, 0.1" pitch
R1,R2, R7,R8	4	Resistor, 1K ohms, Thick Film, 1%
R3	1	Resistor, 10K ohms, Thick Film, 1%
R4,R5, R6	3	Resistor, 150 ohms, Thick Film, 1%
SP1	1	Piezo Speaker, 1.5V, 75 dBa, 2048 Hz
J2	1	Connector, BNC, Right Angle
P6	1	Male Header, 1x5. 0.1" pitch, Straight
GPS1	1	GPS Receiver Module, GYNEO6MV2
P4	1	Header, Female, 1x6, 0.1" pitch, Straight

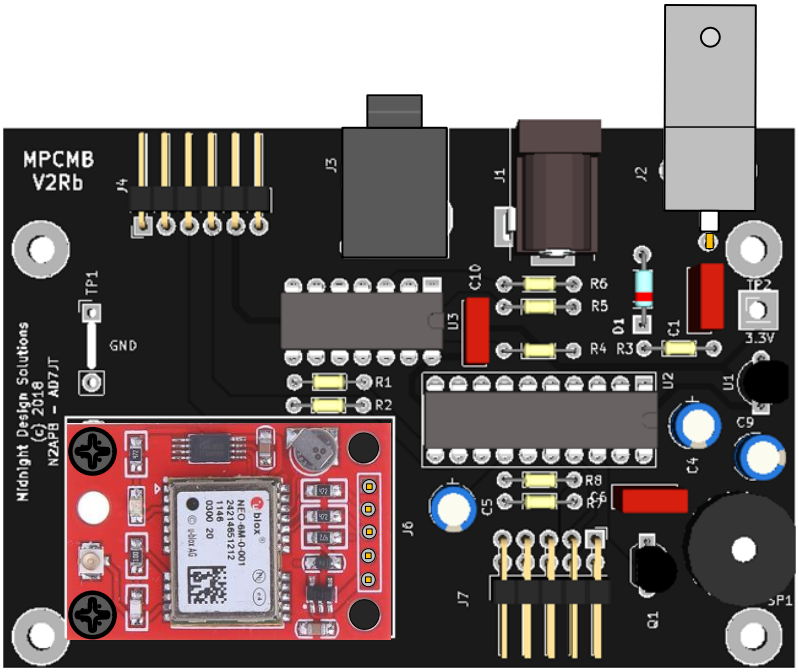
Before starting to assemble the PCBA assembly, it is a good idea to inventory the parts and organize them so they are easy to find after you start the soldering operation. I generally organize the smaller parts in an 18-egg egg carton. I number each position with a number corresponding to the item number on the BOM. I number them 1-18 in one color then 19 through 36 in another color. This allows me to make double usage of the compartments when I have more than 18 parts. (Make sure it is easy to distinguish between the parts sharing a compartment.)

First install the power regulation and filtering components (J1, D1, U1, C1 and C4), test the voltage regulation by applying power to J1 and measure the regulated voltage level between TP1 (GND) and TP2 (3.3V). If a variable supply is available, start measurements at about 3V and gradually increase the voltage to the maximum. When the input voltage is over about 4 volts, the regulated voltage should remain at 3.3V ± 5%.

Note that he audio jack (J3) comes with a round M4 nut. For now, set this nut aside, it will be used during final assembly.

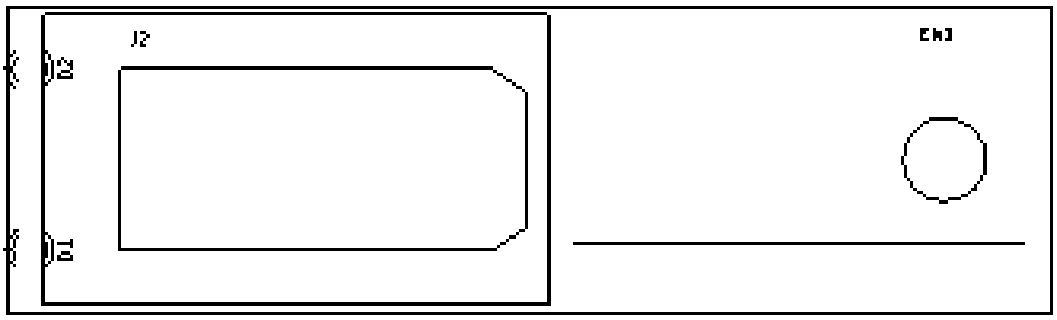
Install the components listed in the BOM. After assembly, solder a wire loop between the two GND pads of TP1. This loop is to provide a convenient ground for clip leads such as scope probe grounds. Repeat the power regulation test after all components have been installed.

Your completed Main Board should look something like this:

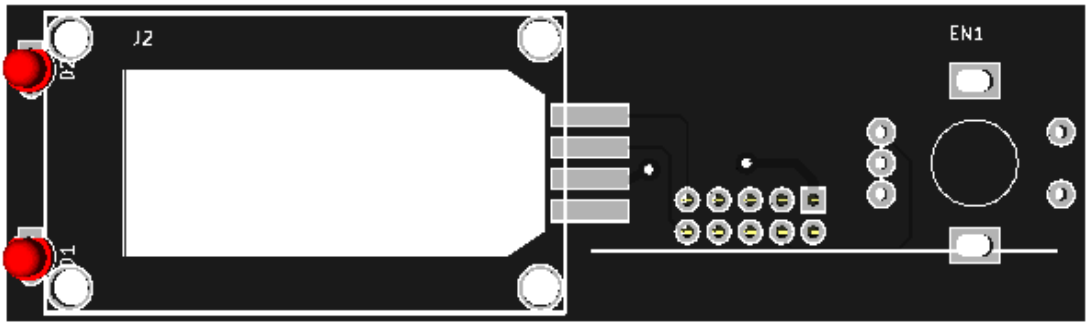


4 FRONT BOARD PCB ASSEMBLY

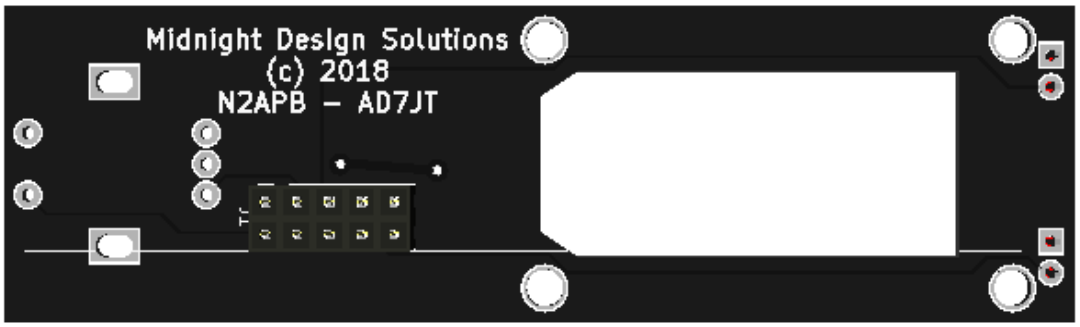
The Front Board PCB is a double-sided board silk screened on top. The silk screen shows each component's outline and reference designation as shown on the schematic and listed in the Parts List.



Silk Screen



Front

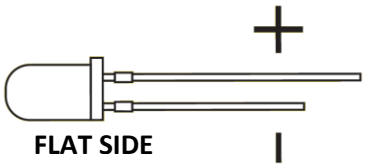


Back

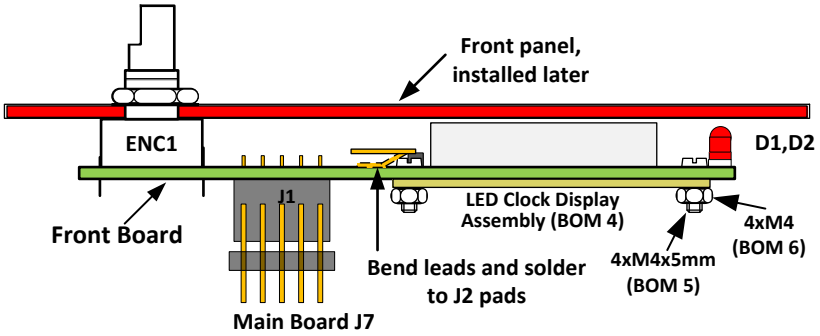
The horizontal lines on the front and back silk screens indicate the location of the top of the Main Board when mounted in the enclosure.

FRONT & REAR BOARD		
REF	QTY	DESCRIPTION
PCB	1	PCB, Front Board, 3.43" x 1.0"
EN1	1	Encoder, Rotary, 24PPR
J1	1	Header, Female, 2x5, 0.1" pitch,
D1,D2	2	LED, Red
LED1	1	LED clock display assembly, 4-digit, 7-seg
Red Lens	1	Lens, Red, 4.18" x 1.07" x .110"
KNB	1	Knob, Aluminum, 6mm shaft
RB-pcb	1	PCB for MPC rear panel
ES1	1	Env Sensor, GY-91_BME280, PTH
ENC	1	Enclosure, 4" x 2" x 1", ABS, Black
Small Plastic Bag:		
Screw	4	Screw, M2x6mm, Pan Head, Black
Nut	4	Nut, M2, black carb
Plug	1	Hole plug, 1/4", rubber

* Make sure the individual LEDs (D1 and D2) are installed correctly. On the PCB, the square pad is ground or negative. The LED lead for the Anode (positive) connection is longer that the cathode (negative) one. Many LEDs also use a flat side on the base to indicate the negative (cathode) lead.



** Install the LED clock display (BOM item 4) buy sliding it in the cutout in the Front Board PCB with the interface connector towards the center of the Front Board. Then use the supplied hardware (BOM items 5 and 6) to attach the LED clock display to the Front PCB. Bend the leads on the LED clock display down and solder them to the J2 pads as shown here:



Install the parts on the Front Board. Your completed board should look like this:

5 INSTALLATION

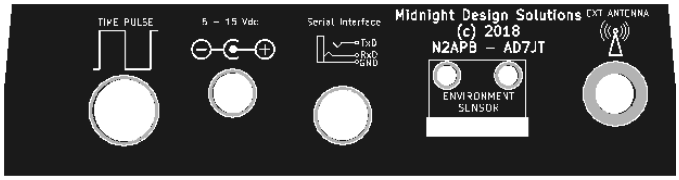
The MPC Main Board is screwed to the base of the enclosure using the four black screws included in the plastic case, with the Front Board plugged into the Main Board and the I/O connectors extended through the holes in the rear panel. The rear panel is held in position by a grove around the rear of the enclosure. The encoder (ENC1) is soldered to the Front Board and the lens is attached to it by the encoder's mounting nut at the base of the shaft.

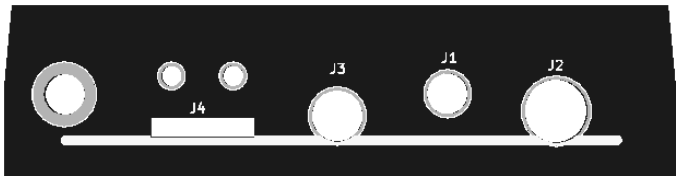
5.1 Enclosure

The MPC enclosure is approximately 4.5 x 3 x 1.5 inches and is made of ABS plastic. It consists of four pieces as shown in the following illustration. The top cover and base fit together clam shell style and are held together with two self-tapping screws inserted from the bottom through and into tall bosses molded in the top and base. The enclosure comes with front and rear panels that fit in groves around the front and back of the enclosure. These panels can be discarded as they are replaced with the MPC Front Lens and Rear Panel.

5.2 Rear Panel

The rear panel is a two-sided PCB with no circuitry on it other than ground planes on each side. Each hole in the Rear Panel is plated through. The serial interface (J3) and the external antenna connectors use mounting nuts to ground the Rear Panel ground planes. Reliable ground connections are not made or necessary to the remaining holes.





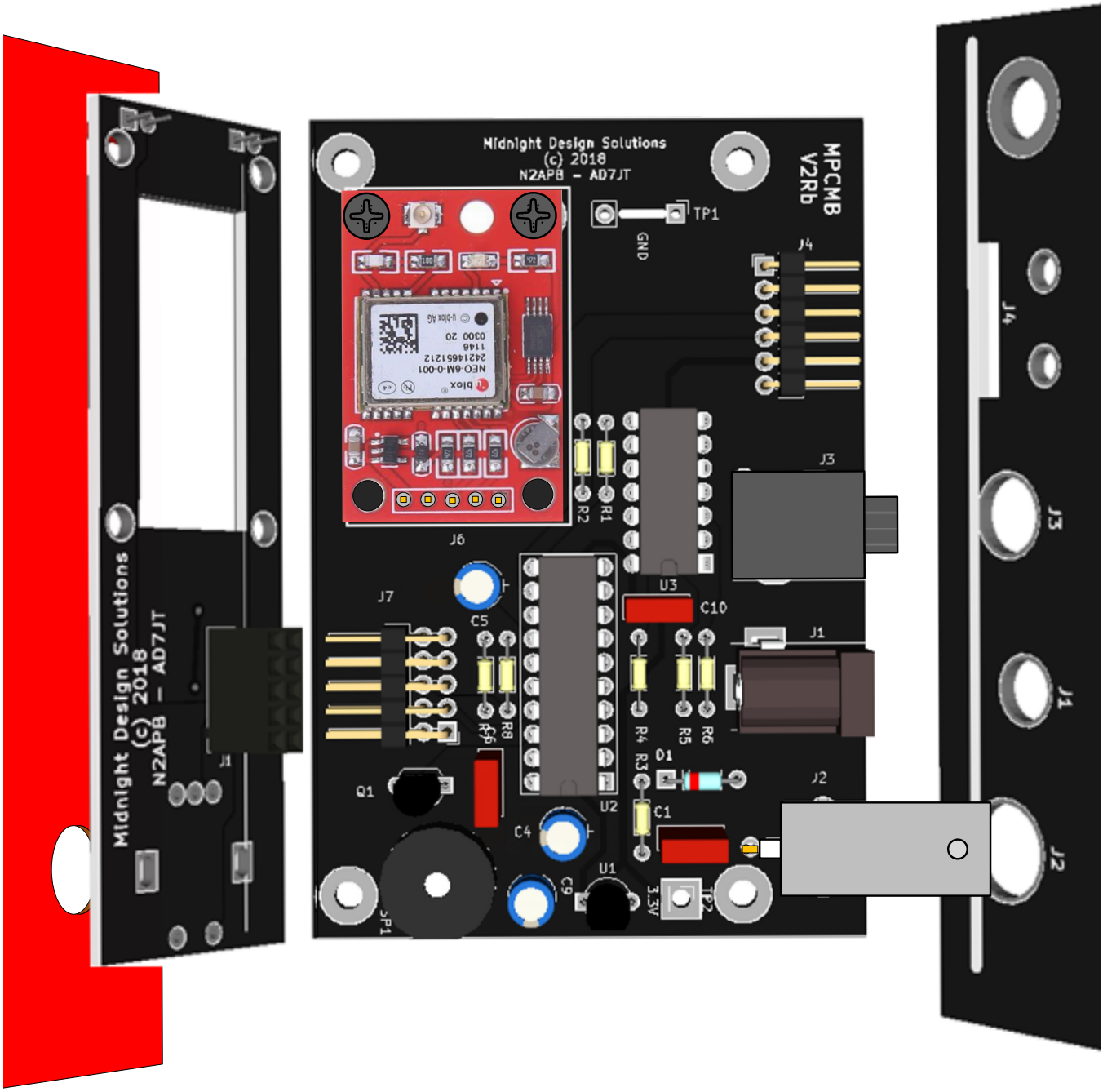
The silk screen on the back side of the Rear Panel identifies the connectors pictorially. The silk screen on the inside of the rear Panel identifies the connectors by reference number. The horizontal line on the inside shows where the Main Board is located relative to the Rear Panel. The sides of the Rear Panel are tapered slightly to aid in aligning the Rear Panel in the groves in the enclosure top.

5.3 Front Lens

The Front Lens is transparent, red (#2423) acrylic. It is 0.060” (1.524 mm) thick and has a single 9/32” (7.14 mm) hole positioned to align with the shaft of the encoder on the Front Board.

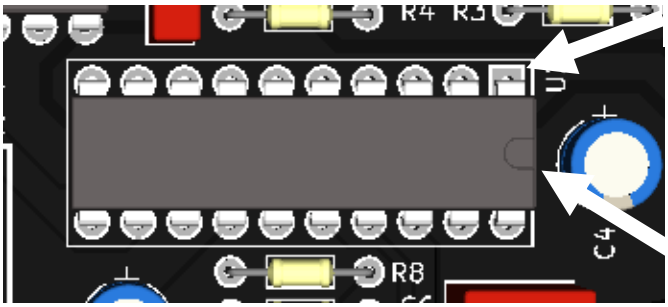
5.4 Board Installation

The following illustrates the relative positions of the lens and the three PCBs.



To mount these pieces in the base, proceed as follows:

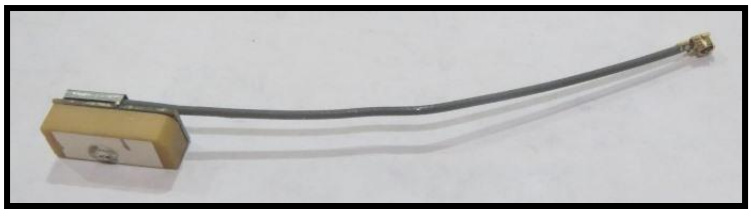
1. Position the Rear Panel over the connectors and use the serial interface connector's (J3) mounting nut (BOM 9) to hold it in position. Do not tighten the nut at this time.
2. Plug the Front Panel into J7.
3. Position the Front Lens over the encoder's shaft and hold it in position with the encoder's mounting nut. Do not tighten the nut at this time.
4. Fit the Rear Panel and the Front Lens in the rear and front groves in the enclosure base.
5. Position the Main Board over the four mounting bosses in the enclosure base and install the four 4-20 mounting screws (BOM 5). Do not tighten the screws at this time.
6. Tighten the encoder mounting nut. Tighten the encoder mounting nut by hand followed by a quarter turn with a wrench or socket. The Front Lens is acrylic and is fairly brittle. Over tightening the nut could crack the lens.
7. Tighten the four Main Board mounting screws using the black screws included in the plastic case.
8. Install the PIC MCU (U2, BOM 10) in the IC socket. Make sure pin 1 is properly positioned. Pin one on the MCU footprint is identified by a square pad and is the pin nearest to the "U2" reference on the silk screen. Pin 1 on the MCU is usually identified by an indentation on the IC package at the pin 1 end. Normally the IC pins are spread too wide to plug directly into the IC socket. They should be bent in slightly on a flat surface (like a desk or table top). To install the MPU, line up and start one side of pins (e.g., pins 1 - 10) and use a straight edge (e.g., the straight edge of an X-ACTO knife blade) to gently push the pins on the other side into the pin sockets



PIN 1

PIN 1 INDICATOR

9. If using the internal antenna, plug the supplied antenna's ulf/ipx connector into the antenna connector on the GPS receiver. Locate the antenna in the enclosure base alongside the Main Board. You can tape it down or use double-sided tape to hold it in position. Install the 1/4" hole plug (BOM 12) in the External Antenna position in the Rear Panel. [NOTE: We have included an effective 'ground plane' to enhance antenna performance. See Appendix C in this document.]



10. **OPTIONAL:** If better reception of the GPS signal is required, you may us an external antenna (**not supplied**) by installing an SMA to ufl.ipx adaptor cable **(also not supplied)**. Install the SMA connector in the External Antenna

position in the Rear Panel. Coil the 6" cable and plug the ufl.ipx connector into the antenna connector on the GPS Receiver.

11. Plug the environment sensor into J4. The female header on the environment sensor goes through the rectangular hole in the Rear panel to mate with J4. If desired, you can use 4-40 hardware (not included in the kit) to secure the environment sensor to the Rear Panel but that should not be necessary.

NOTE:
At this point you may want to skip to the next section (SYSTEM TEST) and return here after you have verified that the MPC is working properly.

12. Install the enclosure cover. Carefully align the Front Lens and the Rear Panel with the grooves in the enclosure top and slide the cover down to mate with the enclosure base. Note that there is a rounded tab on one end of the enclosure base that must be aligned with a similar shaped cutout in the cover. Make sure the antenna cable is clear of the tall bosses used to join the two enclosure halves. Once the cover is mated with the base, turn the enclosure over and join the two enclosure halves with the 3/4" long screws supplied with the enclosure. Attach the four rubber feet supplied with the enclosure at the four corners of the bottom of the base.

13. Install the encoder control knob (BOM 6) by pressing it onto the encoder shaft. With the switch activated, press the knob on as far as it will go. Press and release the knob a couple times to make sure the switch is activating. If it does not, pull the knob back until there is enough clearance for switch activation.

Congratulations, you have completed the assembly of your Midnight Precision Clock!

6 SYSTEM TEST

To test the MPC operation it is recommended you just follow the QUICK START instructions in the MPC Quick Reference. At startup, the time display will oscillate between full and half intensity until the GPS receiver has located and is tracking satellites. This can take several minutes the first time you start the MPC. Once satellites are located, the GPS receiver saves the satellite information and uses it the next time the MPC is started.

If, after several minutes, the time display continues to flash, you may have to move the antenna to a better "viewing" location. Move the antenna to a location where it has an unobstructed "view" of the sky (such as a window sill). If you cannot find a convenient location for the MPC using the internal antenna, you may have to use an external antenna.

Once your MPC is running and tracking satellites, we recommend you take a few minutes and go through all the examples in the MPC Quick Reference to familiarize yourself with the setup functions and set up your preferences.

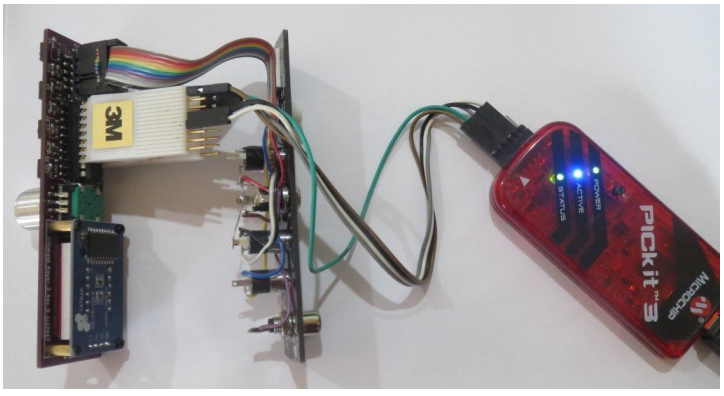
7 FIRMWARE VERSIONS

The earliest released MPC firmware is version 2.00. No additional releases are planned but may be done to add new features to the MPC or correct bugs in previous releases. The version of the installed firmware is indicated when the MPC first power up. The released firmware includes a boot loader that can be used to update the firmware in the field. If the firmware is corrupted, it may be necessary to use a programmer to update it. If a programmer is not available, contact Midnight Design Solutions for a pre-programmed replacement MCU.

The firmware object code is published on our web site as a .HEX file. The .HEX file is generated by Microchip's MPLAB IDE C compiler. The boot loader accepts the .HEX file as generated; no conversion is required. The .HEX file includes both the MPC application and the boot loader. The boot loader protects itself so it will only load the application firmware.

The following describe three methods to update the firmware:

a. If the firmware is corrupted and the boot loader will not run, a direct program memory write will be required to update the firmware. This will require an MCU programmer and support software for a Microchip PIC24FV32KA301. This MCU has been in production for some time and is supported by all the Microchip PICKits and ICDs (In Circuit Debuggers) with software support by the MPLAB 8 and MPLAB X IDEs (Integrated Development Environments) and the MPLAB IPE (Integrated Program Environment) applications. The MPC Main Card does not include an ICD interface connector. Connections to five MCU pins can be made using a DIP clip and jumper wires to the interface connector on the programmer. The picture shows the connection using a PICKit3 programmer. The attached MPC Main Board schematic contains a table defining which pins are available for programming. We usually use



the first set which uses pins 4 and 5 for data transfer. Note that these pins are all at one end of the 20-pin DIP package so that a DIP clip with ten or more pins can be used; it is not necessary to have a 20- pin DIP clip. The HEX file for the latest firmware can be down loaded from http://midnightdesignsolutions.com/mpc/index.html. The HEX file will include the boot loader.

b. If you do not have access to a PIC programmer, contact Midnight Design Solutions at:

n2apb@midnightdesignsolutions.com

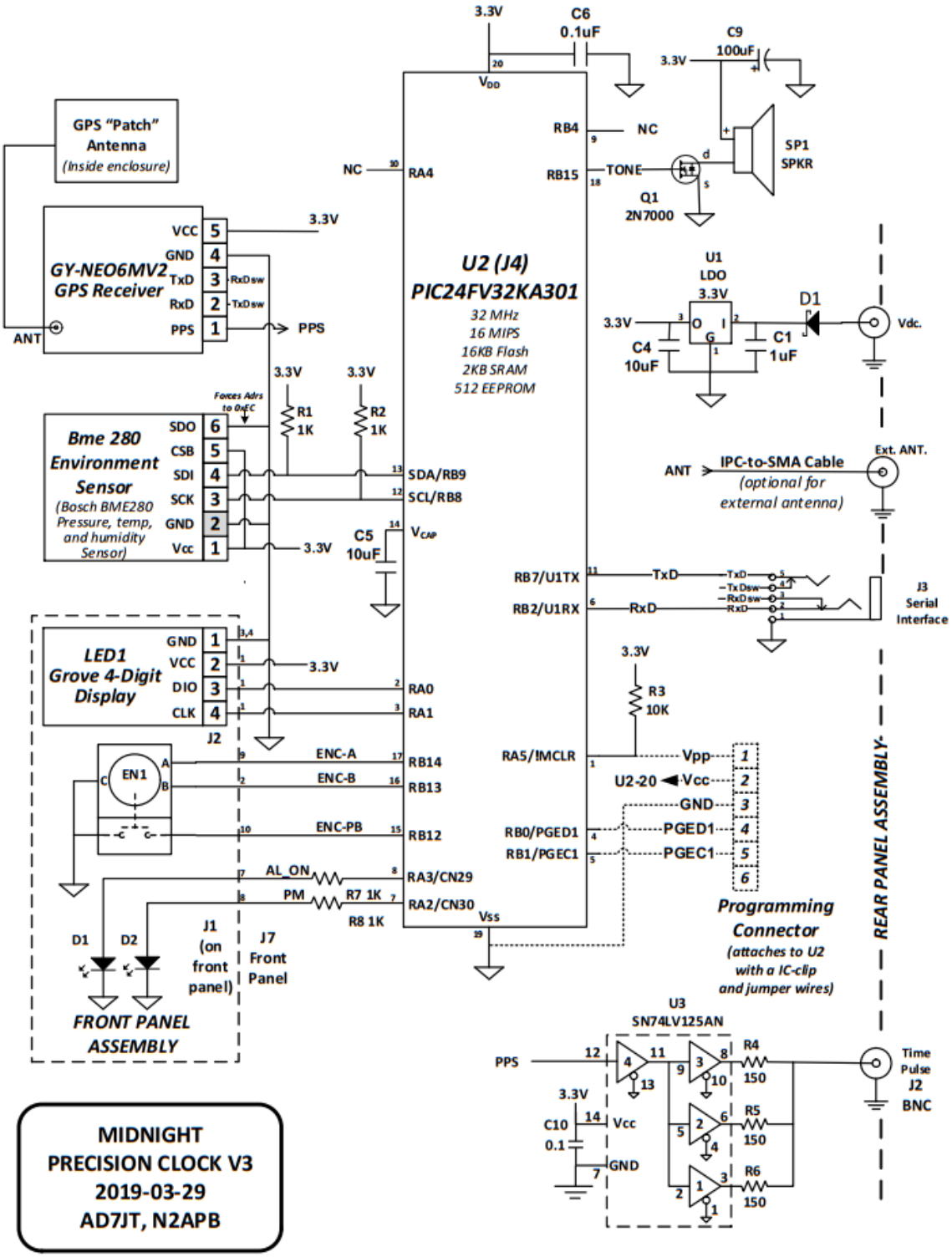
to obtain a new MCU preprogrammed with the latest firmware.

c. If the boot loader is not corrupted, the firmware can be loaded through the serial interface from either an MSNA or a PC running an ASCII terminal capable of file transfers (e.g., term232.exe free from https://www.industrologic.com/resource.htm). If needed, you can obtain an USB to serial port adaptor from several sources on eBay.

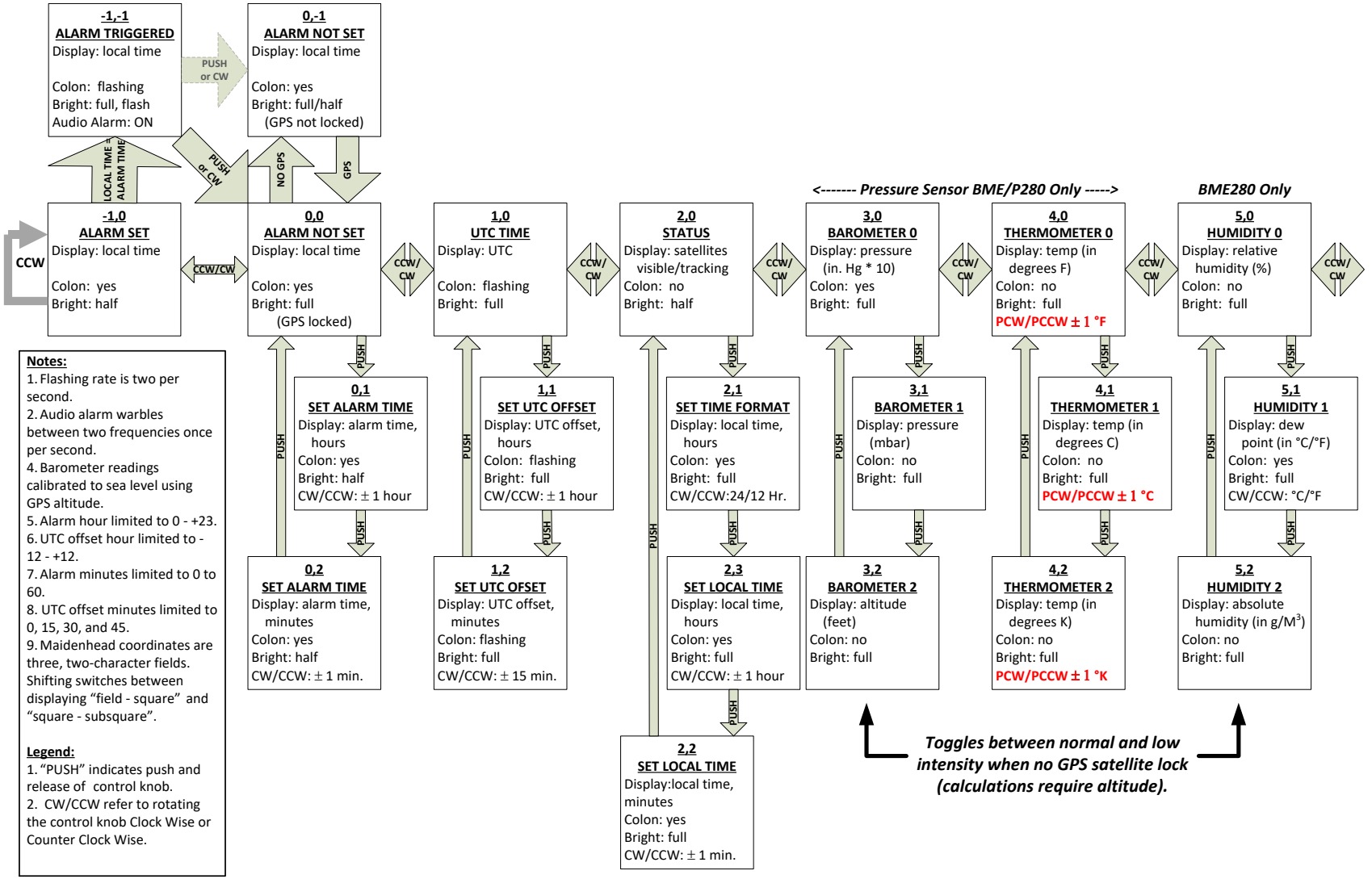
https://www.ebay.com/sch/i.html?_odkw=usb+to+serial+converter&_sop=15&LH_BIN=1&_osacat=0&_from=R40&_trksid=p2045573.m570.l1311.R1.TR12.TRC2.A0.H1.Xusb+to+ttl.TRS0&_nkw=usb+to+ttl&_sacat=0

To update the firmware, download the latest version from our web site and unzip it (if necessary) and save the .HEX file to a know location on your hard disk. Start the terminal emulator and initialize it to transfer the HEX file but do not start the transfer. Make sure the emulator baud rate matches the MPC's baud rate. To activate the boot loader, press and hold the MPC control knob down when you apply power to the MPC. Release the control knob when the display shows "**boot**". Start the file transfer. When the transfer is complete, the new firmware will start automatically.

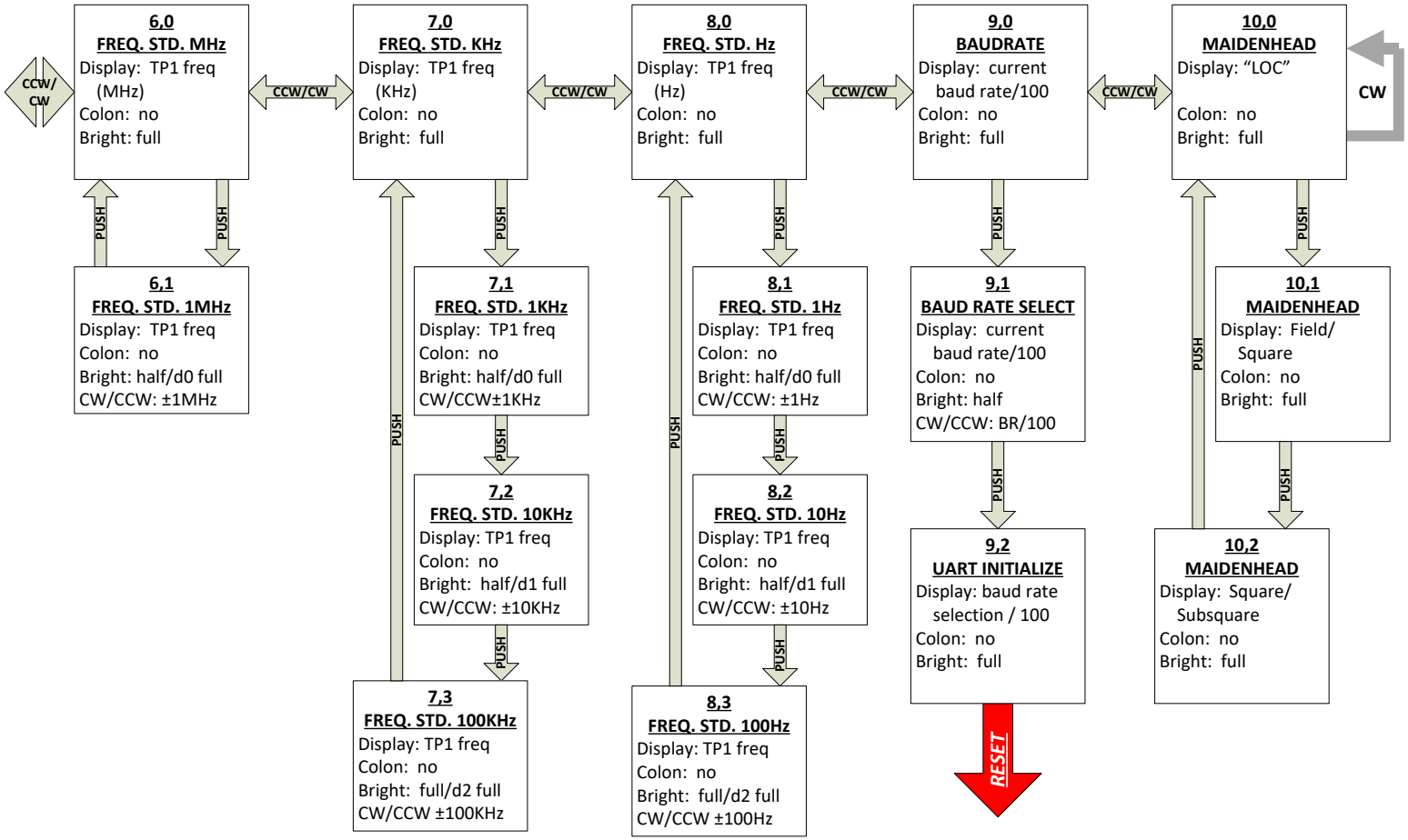
APPENDIX A. MPC SCHEMATIC



APPENDIX B. CONTROL FUNCTION MAP



APPENDIX B. CONTROL FUNCTION MAP (cont.)

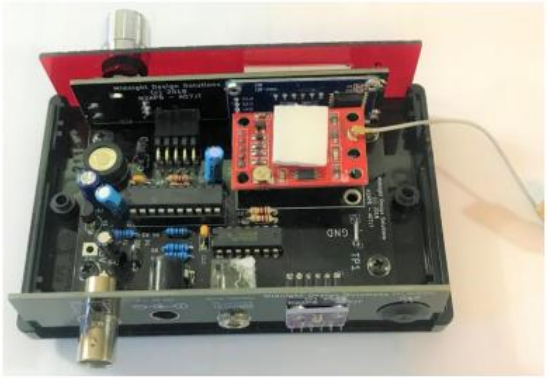


APPENDIX C. IMPROVED GPS RECEPTION

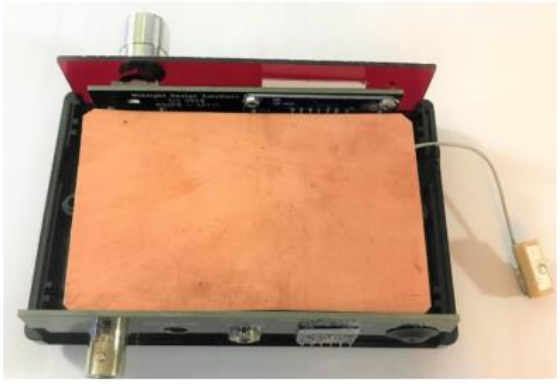
Improving the sensitivity of the GPS Receiver in the Midnight Precision Clock

(allowing faster sync and display of local time)

The size of the ground plane placed beneath the small ceramic GPS receiver antenna has a great effect on its sensitivity. If you indeed wish to just use this "internal" GPS antenna with your MPC (instead of using an external antenna plugged into the back panel), the technique illustrated here will definitely improve the ease with which your GPS Clock will sync with satelltes and display the proper local time



Remove the top clamshell half of the MPC enclosure and place a small piece of double-sticky foam tape on the GPS receiver chip.



Place a piece of thin copperclad pcb material on the double-sticky foam tape. Don't worry, even thin flexible copperclad material will not short to anything below it on the circuit board. (The capacitors, BNC connector, IC and the GPS board itself will keep the board mounted high enough over the motherboard.)

Use another piece of double-sticky foam tape in the middle of the copperclad board to hold the small GPS ceramic chip antenna as shown. Attach the top clamshell of the enclosure, power up the GPS Clock and place it close to a window. It should acquire enough satellites within 15 minutes and display the correct local time (with a steady, non-blinking display).