Let's build…
An NTP Server

By Bruce Hall, W8BH

PART 3: BUILD IT.

This device is a GPS-disciplined clock *with microsecond resolution*. It provides stunningly accurate time information to any device on the local wireless network.

Part 1 introduced the hardware and software for GPS timekeeping. Part 2 explained how this time is distributed on a computer network. The 3rd and final part will describe how to build your own NTP server.

NOT A KIT

Forgive me for starting these notes with a disclaimer: this is not a kit, I am not selling anything, and there is no guarantee of success or suitability for any particular purpose. Still interested?

THE PCB

The first step is to order one or more of the printed circuit boards. To order a circuit board from a manufacturer you must provide a digital set of design files, called 'Gerbers'. You can obtain the Gerbers on my GitHub account. Almost all board fabricators' websites allow Gerber-file uploads. Choose the manufacturer you like. I've used OSH Park (USA, excellent quality) in the past and have been very satisfied. For this project I used JLCPCB (China). Choose the default 2-layer options, get your quote, and choose whatever shipping option you want.

STEP-BY-STEP BUILDING

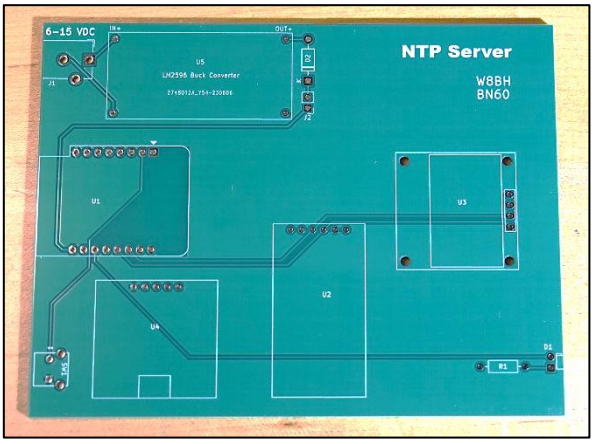
Before you start, make sure to obtain all the components you need. It is frustrating to get half-way through a build, only to realize that you are missing a key component! You will need a decent soldering iron, solder, and a voltmeter. You should be familiar with soldering and have successfully kitted other projects using ICs and other through-hole components. You should have sufficient lighting, magnification, and workspace area.

BILL OF MATERIALS

Next, order the parts that you need for the build. The following is a list of parts with part numbers for my favorite suppliers. Please note any part can go out of production or change in specification over its lifetime. There is also an interactive BOM for the circuit board.

Qty	Description	Source/Part #
1	DC Power Jack PJ-102A	DigiKey #CP-102A-ND
1	HW-411 DC Buck Power Supply	Amazon #B07PDGG84B
1	1N4007 diode	DigiKey #1N4007RLG
1	3mm LED - Yellow	Adafruit #4202
1	1K 5% ¼ w resistor	DigiKey #CF14JT1K00
1	Tactile SPST-NO switch, right angle	DigiKey #1-1825027-2-ND
1	Wemos D1 mini PRO	Amazon #B0B5GTGWC7
1	DS32321 RTC clock module	Amazon #B09LLMYBM1
1	SSD1306 0.96” OLED display module – white	Amazon #B08VNNCLHD
1	GT-U7 GPS module	Amazon #B0B31NRSD2
2	Wi-Fi antenna with SMA-u.FL cable	Amazon #B00ZBJNO9O
1	40-pin 0.1” male & female header	Amazon #B01MQ48T2V
1	40-pin 0.1” right-angle female header	Amazon #B08X374GFR
1	Shorting block 0.1”	Amazon #B07RRTQTW3
1	Eightwood Aluminum Enclosure 120 x 97 x 40mm	Amazon #B010DHQPVW

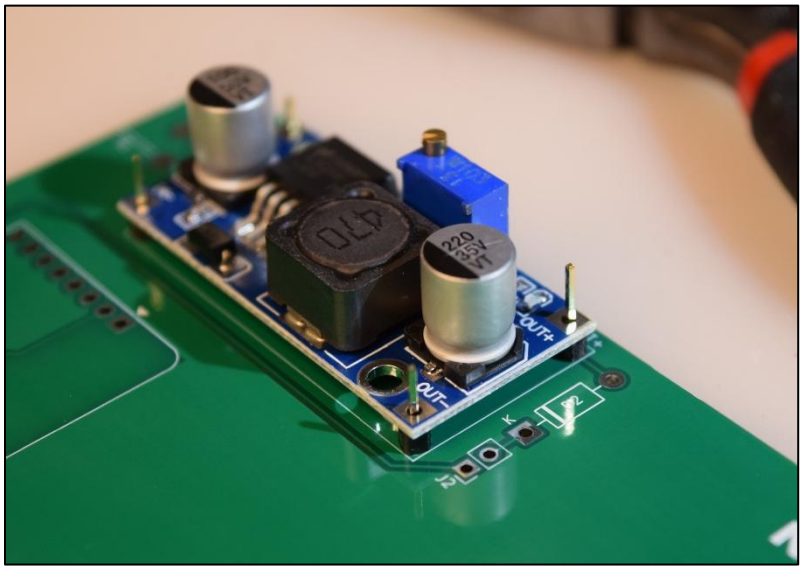
STEP 0: PREPARATION



- Read Parts 1 and 2 of this series. Program your ESP8266 microcontroller with a current copy of the sketch.
- Obtain the PCB and necessary parts as outlined above. Familiarize yourself with the circuit board, comparing it against the interactive BOM. Inspect the board for manufacturing defects. These build instructions apply to circuit board “BN61”.
- Consider how you intend to power the board. The voltage input is 7-15 VDC with a current draw of about 150 mA. I recommend a 9 VDC power adapter. The power connector should be a 2.1mm barrel jack, center pin positive.
- Consider the enclosure. The front and rear faces of the enclosure will need openings for the power jack, switch, antennas, and display.

- The microcontroller board has a 0-ohm link that selects either the chip antenna or the u.FL connector. Move the link so that the u.FL connector is selected. Review the procedure here (video), or obtain a board with the u.FL connector already selected (one vendor here).

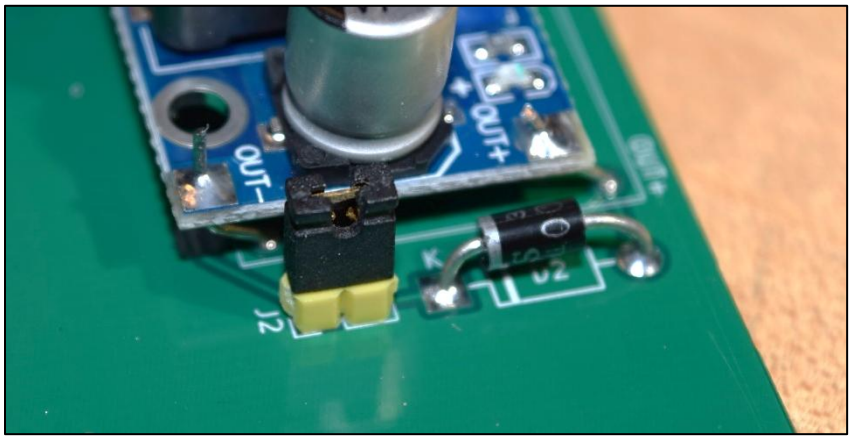
STEP 1: POWER SUPPLY



- Orientation: all the parts in this project are soldered to the front face of the board – the face with component outlines and labels. As you look at the board facing you, I refer to the four edges as left and right, top and bottom.

- Solder the buck converter module using 4 individual male header pins. Orient these pins with the longer end "up", as shown in the photograph. Place the converter on the loose pins. Make sure that the word 'IN' on the converter matches the word 'IN' on the PCB. Solder the topside first, then flip the board over and solder the bottom-side. Don't clip the header pins; we will use these to check the voltage output.

- Solder the barrel connector near the top-left corner of the board.



- Solder the 1N4007 diode, making sure that the white band on the diode body faces jumper J2.

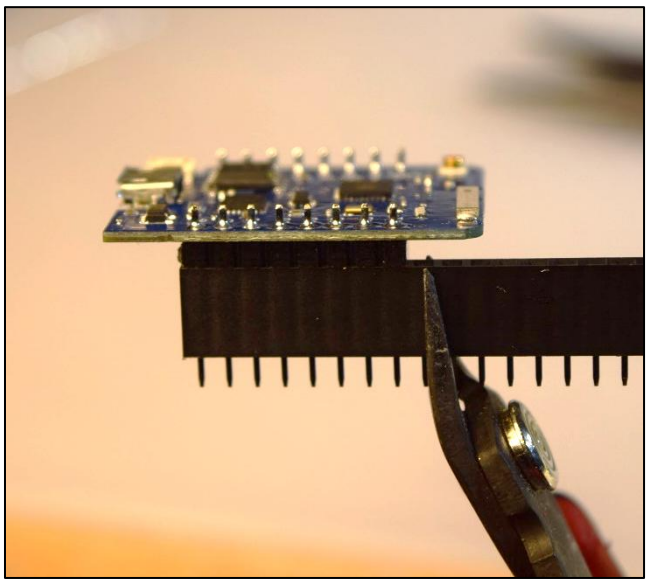
- Cut and install a 2-pin male header at J2.

- Install a shorting jumper across the J2 pins you just installed. IMPORTANT: the circuit board will not have power unless you install the jumper. Don't omit this jumper.

- **Test:** plug your DC power supply into the barrel connector and apply power. The LED on the buck converter should light up. If not, disconnect power. If the LED lights, then the converter is getting power. Clip your voltmeter across its OUT- and OUT+ pins on the buck converter module.

- Use a jeweler's screwdriver to adjust the blue square potentiometer until you get a reading of 5.0V. Unplug your power adapter.

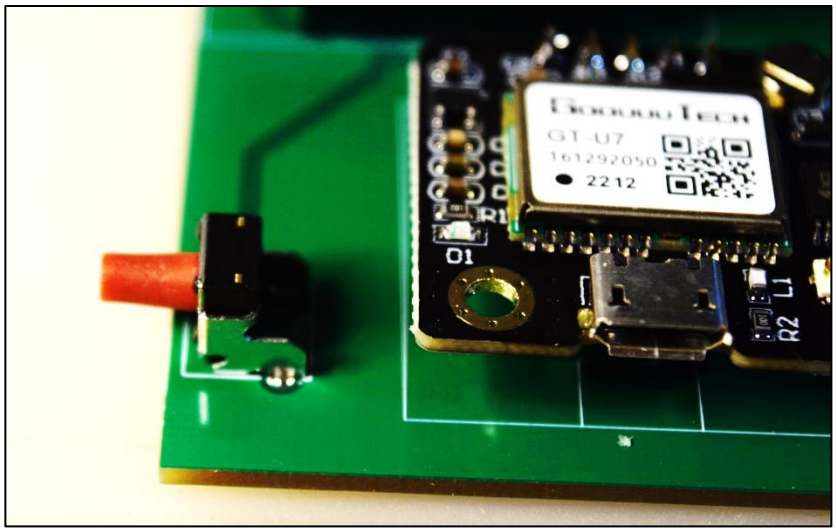
STEP 2: INSTALL THE MICROCONTROLLER



- Cut two lengths of 0.1" female header, each with 8 pins, to match the microcontroller pins. It is difficult to make a perfect cut between pins using diagonal cutters, so try this: cut directly over a pin, sacrificing it. The metal pin will fall out, leaving excess plastic on the side you just cut. You may file/sand this down, if you like, or leave it as is.

- Attach the headers to the microcontroller pins, which will hold them in square, and then solder the headers to the PCB.

STEP 3: INSTALL GPS MODULE and SWITCH



- Solder a 4-pin male header to the GT-U7 GPS module, if not already in place. Then install the GPS module in the lower-left corner of the PCB. I recommend soldering the male pins directly to the PCB, but a 4-pin female header could also be used.

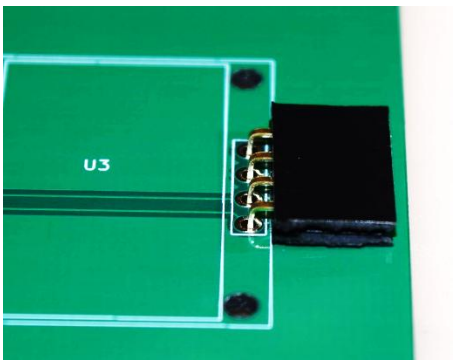
- Solder the right-angle switch, as shown.

STEP 4: INSTALL REAL-TIME CLOCK (optional)

- The optional real-time clock provides time backup in instances when a GPS signal is unavailable. The module must be installed with the CR2032 coin cell battery facing up. Note that some modules are sold with right-angle male headers already installed. Use wide-jaw pliers or a small vise and carefully bend the header pins, as a group, until they are straight. Then install the module and solder.

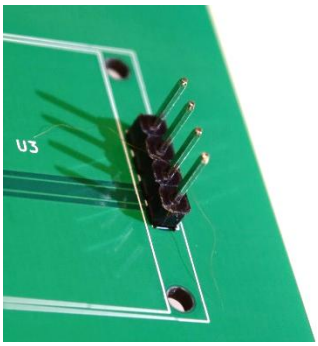
STEP 4: INSTALL OLED DISPLAY

- Method 1: The first and easiest method is to install a 4-pin right-angle female header to the board, and then plug the display into this header. The display will be perpendicular to the board and just behind the front panel.



- Method 2: Install the female header as in method #1 and mount the OLED display directly to the front panel using 4 M2 or M2.5 bolts. This method requires good alignment between the panel-mounted display and the PCB-mounted header.

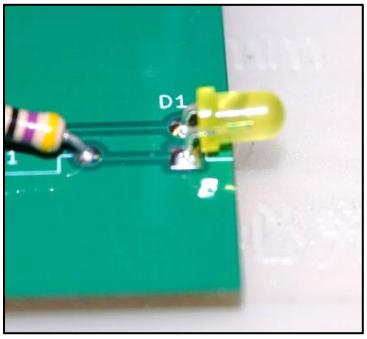
- Method 3: Solder a 4-pin male header to the PCB and attach a 4-wire cable with female connectors to the display. Then mount the display on the front panel with M2/M2.5 bolts.



STEP 5: INSTALL STATUS LED & RESISTOR

- The status LED must be mounted with the correct polarity. Otherwise, it will not work. Inspect the LED and observe:

  - ✓ It has a long lead and a short lead. The short lead is the cathode and goes to ground.
  - ✓ Its epoxy base has a slightly flattened edge. The flattened edge marks the cathode.



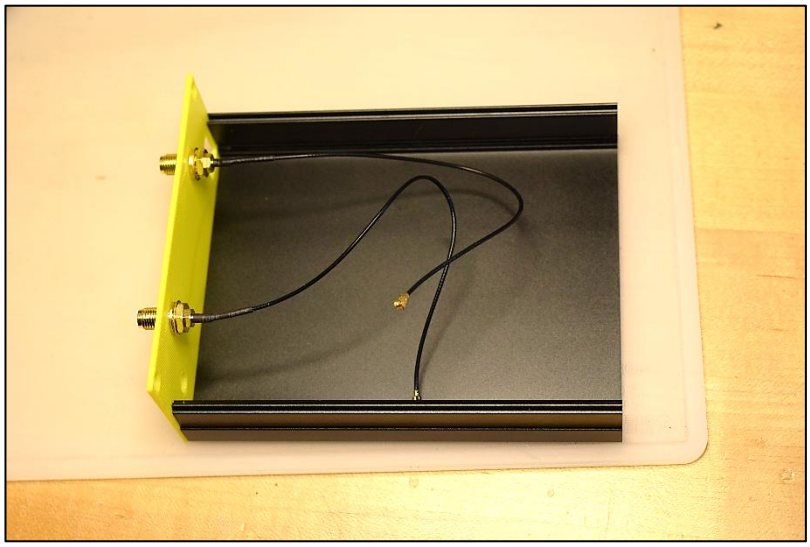
- Bend both leads at a 90-degree angle, as close to the LED as possible. Insert the short lead (the cathode) into the square pad, which goes to R1.

- Solder the LED in place. The rounded tip of the LED will extend beyond the board-edge.

- Install and solder R1. The value of R1 is nominally 1K (brown, black, red, gold). Use a 470R resistor (yellow, purple, brown, gold) if you want a brighter LED.

STEP 6: FINAL ASSEMBLY

- Inspect the completed board. Are all components securely soldered in place?
- Inspect the solder joints under magnification and good light. Looks for any dull or bridged joints, and resolder as needed.
- Prepare the front and rear panels, drilling (or 3D printing) them as needed.
- Partially join the rear panel and bottom enclosure panels with two screws.
- Mount the SMA connectors to the rear panel, as shown.
- Insert the PCB into the mounting slot from the front of the enclosure. Check the alignment of the DC power jack and switch.



- Carefully attach the u.FL connectors on the SMA cables to the D1 mini pro and GPS module.
- Attach front panel to base with two screws. Check alignment of forward-facing status LED and display.
- Connect a stubby Wi-Fi antenna to each SMA connector, making sure that the SMA connector remains secure and does not rotate. Retighten SMA connectors as needed.

End of Build. *Congratulations!* Proceed to checkout.

STEP 7: CHECKOUT

- Place your server near a window, plug in a DC adapter, and apply power.

- Verify power to all components:
  - ✓ Observe the microcontroller LED. It should illuminate and remain lit during operation, although it may briefly extinguish to mark seconds. If the LED is not on, check power to the circuit board and solder joints to the microcontroller.
  - ✓ Observe the LED on the GPS unit. It should illuminate and remain lit during operation, although it may briefly extinguish to mark seconds. If the LED is not on, check solder joints to the GPS unit. Verify that the GPS is receiving 3.3V power.
  - ✓ Observe the display. Does it display the splash screen when powered on? If not, verify that it is receiving 3.3V power.

- Verify OLED display information:
  - ✓ The first display line is the current time. On the first power-up, the displayed time will be 00:00 on 01/01 (Jan 1st). It will adjust to the correct time when the GPS signal is acquired. It may take 5 minutes or more to acquire the GPS signal.
  - ✓ The second display line shows Wi-Fi information. If Wi-Fi is present, the IP address will be displayed, along with a signal strength indicator. 3 to 5 bars indicate a reliable connection. If you see less than 3 bars, check the Wi-Fi SMA cable, adjust the Wi-Fi antenna and/or relocate closer to your Wi-Fi server.
  - ✓ The 'S' on the third display line indicates GPS satellite reception. The NTP server requires at least 4 satellites to deliver accurate time. Wait 10 minutes after initial power-on to evaluate satellite count. If the count remains below 5, check the SMA GPS cable, adjust the GPS antenna and/or relocate the unit near a window with a clear view of the sky.

- Verify GPS lock:
  - ✓ After several minutes of operation, the GPS module should receive enough satellites signals to acquire "lock" and determine time.
  - ✓ Unlocked time, usually with a satellite count of 3, it is shown on the display in white-on-black lettering. This time should not be considered reliable or accurate.
  - ✓ Once GPS lock occurs, the time displayed is accurate to within a microsecond. Locked time is shown with inverted black-on-white lettering. Also, the status LED will flash once per second. Each flash is 150mS in duration, starting at the top of the second.

Consult the Operating Guide for details about the operation of your NTP server.

Last Updated: April 23, 2026

TROUBLESHOOTING

Problem	Suggestions
The buck converter LED doesn't light	a) Make sure that your power adapter is in working condition and the wall plug has power. b) Use a voltmeter to test across the front and back barrel connector pins. You should see your input voltage. If not, check your adapter again. c) Test the voltage across the buck converter's IN+ and IN- pins. You should see the same input voltage as in (b). d) Check the converter output voltage by putting your voltmeter across the OUT+ and OUT- pins. You should see 5V here. If you see some other voltage, try adjusting the blue potentiometer on the buck converter. If you have a normal input voltage above but no output voltage, your converter may be faulty.
The OLED display is blank	a) Check power to the board. Do you see the LED lights on the buck converter, microcontroller, RTC, and GPS modules? b) Check 3.3V power to the OLED module itself. c) Run I2C scanner sketch to verify that the I2C connection to the OLED module is detected. d) Run OLED diagnostic sketch.
No GPS time	a) Ensure good connections between the antenna, SMA cable, and GPS module. b) Try an active antenna placed outside or near a window. c) Run the GPS diagnostic sketch to ensure that ASCII data is being transmitted to the MCU.
No GPS lock	a) Is the GPS module working as expected: is the time correct? Is the satellite count at least 4? b) Remember it may take 5-10 minutes to obtain a GPS lock. c) Review steps for "No GPS time" above. d) Check the OLED display. There is GPS lock if the time is displayed in inverse (black on white) and/or the GPS module LED is flashing. e) If there is GPS lock but the status LED is not flashing, make sure the LED was not installed backwards (lead next to flattened edge of LED should go into square pad).
No Wi-Fi connection	a) Check connections between Wi-Fi antenna, SMA cable, and the microcontroller. b) Ensure the microcontroller's 0-ohm link is selecting the external antenna instead of the chip antenna. c) Place the NTP server closer to your Wi-Fi router. d) Consult Operating Guide for more troubleshooting tips