The Barb-A-Watt

PCB Version 2.0

QRP Power Meter, SWR Meter and Dummy Load

Construction and Operations Manual

The latest version of this manual can be downloaded from:

GitHub - WB2CBA/Barb-A-Watt-QRP-POWER-and-SWR-Monitor

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Version 3.0.1 24th October 2024 Initial Release PCB Version 2.0

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Introduction

The Barb-A-Watt was designed by Barbaros Asuroglu WB2CBA (Aka 'Barb') as a companion measuring device for QRP operations, and QRP project development. The Barb-A-Watt overcomes the accuracy limitations of higher power SWR and Power meters when used with QRP power levels and simultaneously measures:

- RF power output from a QRP transceiver.
- RF power to the antenna.
- SWR.
- Power output efficiency; and
- Has a dummy load that can be used to measure up to 15 Watts of RF output power.

This version of the Barb-A-Watt uses a combination of surface mounted devices (SMD's) and through hole devices (THD's). Whilst providing the same functionality as earlier versions the major changes for this version include:

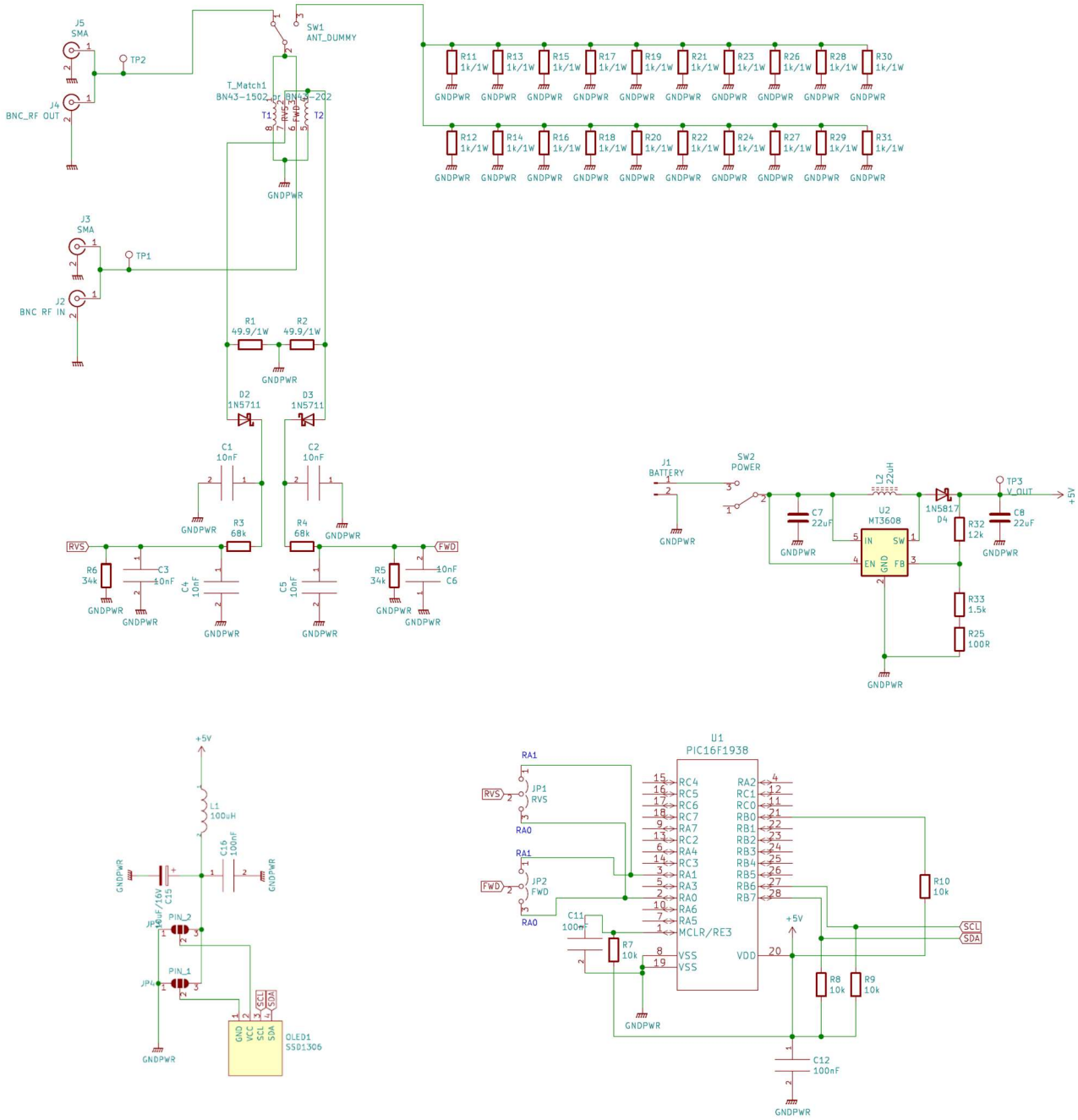
- Replacement of the 9v battery and the 5v regulator, with 2 x AAA batteries and a buck-converter to supply the required 5v for operation. The increased efficiency of the power supply and battery capacity provides approximately double the battery life of the earlier version.
- Relocating the components on the PCB to enable use of the 2 x AAA battery pack which provides a slimmer (reduced height) Barb-A-Watt.

The Barb-A-Watt is based on the N7DDC (David Fainitski's) ATU-100 project. David was kind enough to modify ATU-100 firmware specifically for the Barb-A-Watt to create an accurate RF power and SWR measuring device at QRP levels.

The power meter is rated at 20 Watts when connected to an antenna or external load, however the internal dummy load is limited to 15 Watts.

CAUTION: DO NOT EXCEED 15 WATTS with the built in Dummy Load!

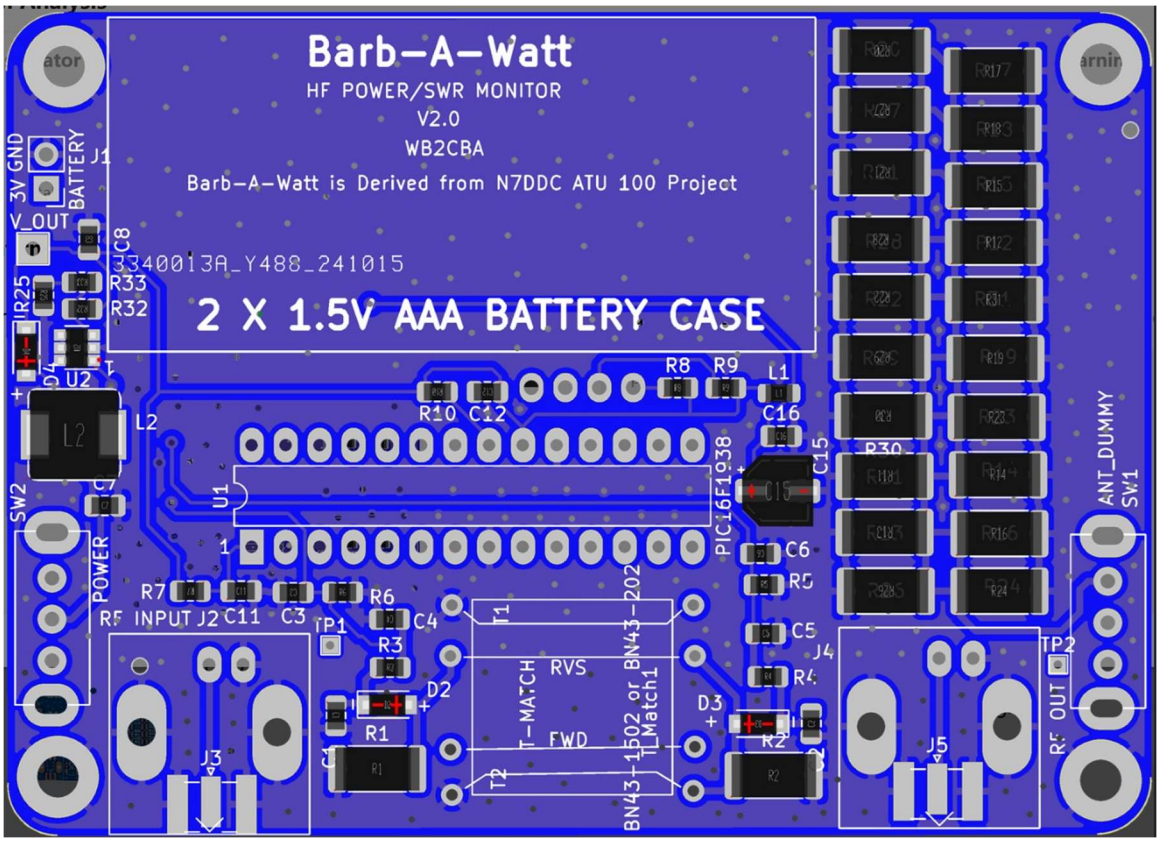
Schematic Diagram



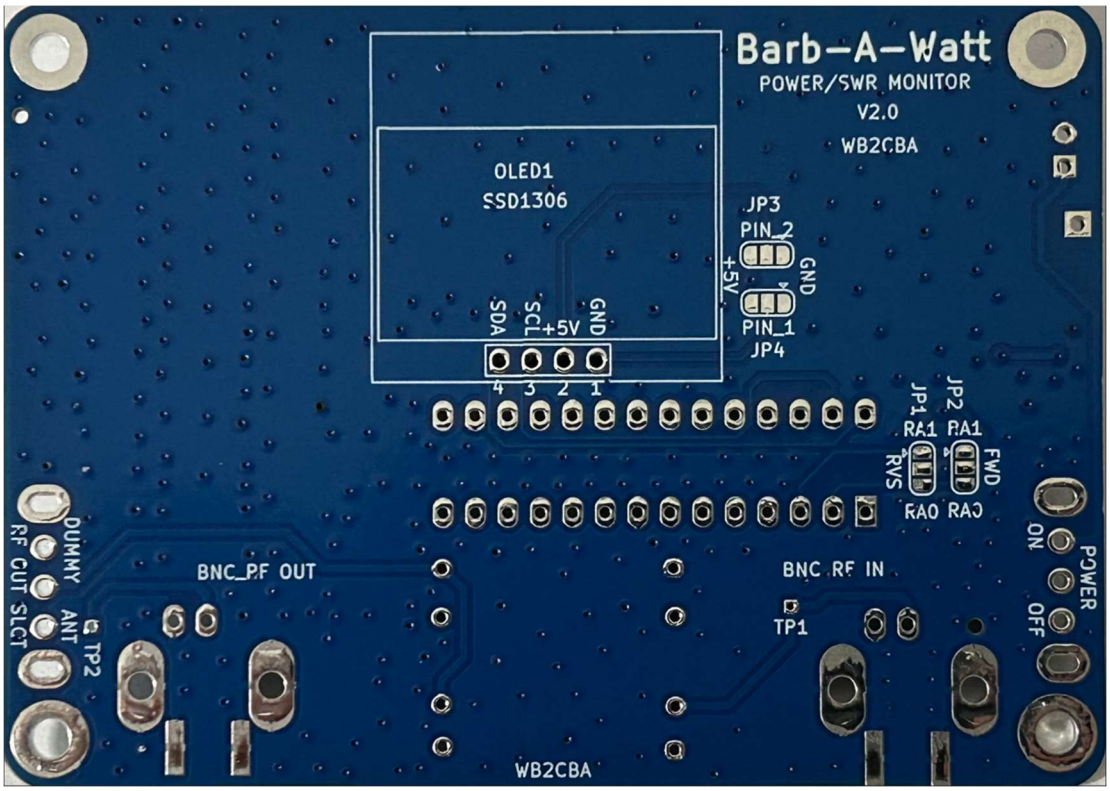
WB2CBA		
Sheet: /		
File: uSDX_ATU_V1_0.sch		
Title: Barb-A-Watt SWR/PWR Meter -Derived from N7DDC ATU Design		
Size: A3	Date: 11/02/2020	**Rev: V2.00**
KiCad E.D.A. kicad (5.1.12)-1		Id: 1/1

SMD PCB Layout

Component Side



Solder Side:



Brief Description

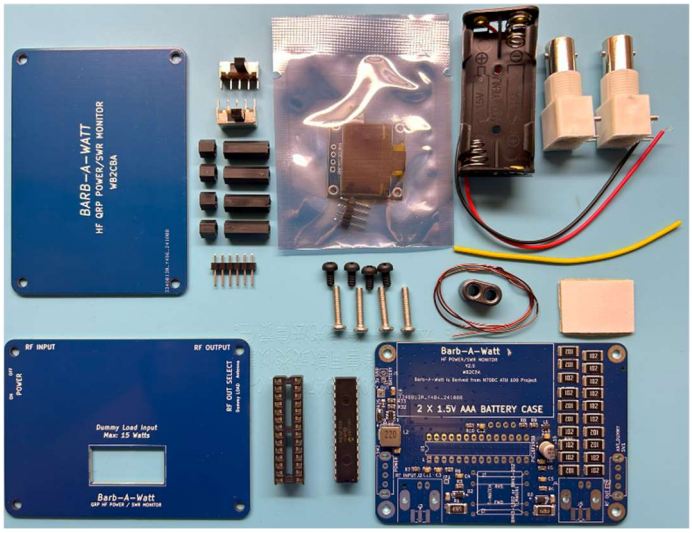
The SWR meter uses a tandem match consisting of two 5 turn coils on each side of a BN43-1502 binocular core. A forward and reverse line is passing the RF signal to the output and the PIC processor measures power and the return loss as SWR. These values are then displayed on the 128 x 64 OLED display for easy readability.

The Barb-A-Watt is powered by 2 x standard 1.5v AAA batteries and draws approx. 15-25mA during operation depending on the delivered battery voltage. With the batteries self-contained within the unit, it's ideal for portable operation. AAA Alkaline batteries should have an 850mAHr capacity and deliver up to 40 hours of continuous operation.

There are two slide switches. Looking from the top, the left side slide switch is the power ON and OFF switch. The right-hand side slide switch is for directing the RF output to either the internal dummy load or the RF output (Antenna) socket.

Bill of Materials

List of Parts included in the kit:



1 x SMD populated PCB

1 x Top face panel

1 x Bottom face panel

1 x 28pin IC Socket

1 x PIC16F1938 Microprocessor (Pre Programmed)

2 x slide switches

1 x 128x64 OLED Display and 4 Pin Male Header

1 x BN43-1502 (or BN43-202) Binocular Toroid

2 x BNC Connectors

1 x Battery Holder (2 x AAA)

12" (300mm) - AWG 24 (0.5 mm) enamel copper wire

3" (~75mm) of insulated solid core copper wire

4 x 6 mm (or 5mm) standoff

4 x 15mm standoffs

8 x M3 screws (typically 4 x M3 14mm machine screw, 4 x M3 6mm plastic screws – actual supplied may vary slightly depending upon stock)

1 x Strip of double-sided tape to fix battery holder to the bottom panel

Tools Required

You will need the following tools to build the Barb-A-Watt:

- Soldering Iron and Solder (An ESD Protected soldering iron is recommended to prevent potential static discharge damage to the PIC Controller)
- Wire Cutters
- Philips Head #1 Screwdriver
- Modeling knife (for scraping enamel off the magnet wire)
- Wire strippers

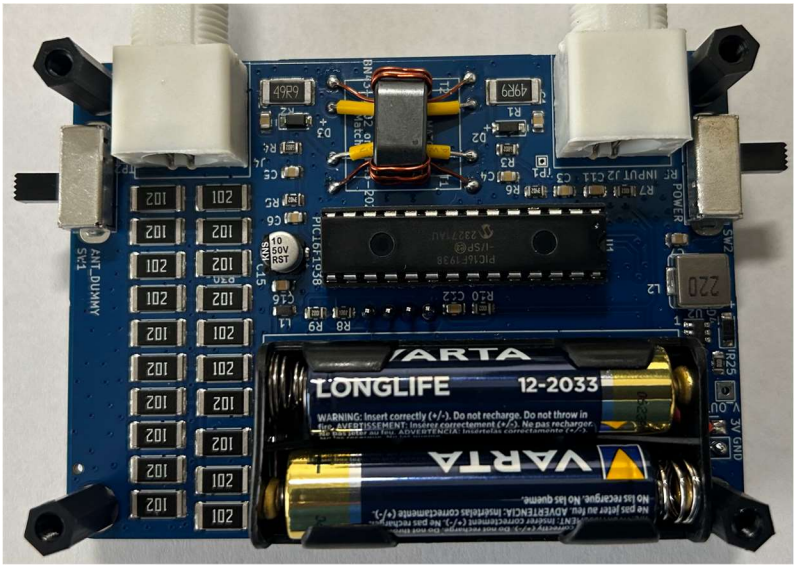
Construction Overview

The use of pre-mounted SMD components simplifies the construction process. Kit construction requires the following activity and is listed in the recommended assembly order:

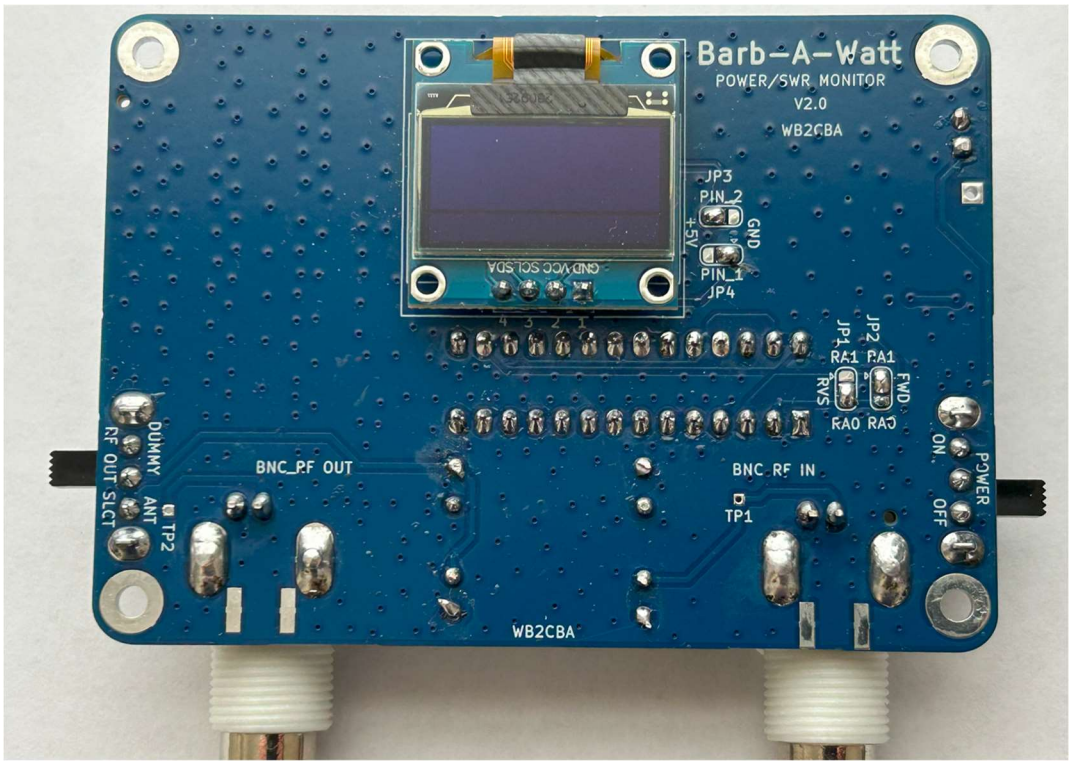
- Winding the BN43-1502 binocular core used for SWR sensing and soldering it with the sensing wires to the main PCB.
- Soldering and attaching components to the main board:
  - 2 x Micro Switches
  - 2 x BNC Connectors
  - 1 x 28 pin IC Socket
  - 1 x 128 x 64 OLED Screen using the 4-pin header
  - Soldering 4 jumper connectors for the OLED power supply and the SWR Sensing direction
  - Attaching the battery holder and soldering the connector leads to the main board and
  - Inserting the PIC Microcontroller into the IC Socket
- Testing the correct operation of the Barb-A-Watt
- Assembly of the main PCB, top and bottom covers with the supplied standoffs and screws.

This is an easy to build kit and can be accomplished by a novice kit construction with basic soldering skills, although winding the toroid can be a little tricky so follow the toroid winding instructions carefully. As a guide an intermediate kit builder should easily build this kit in approx. one hour.

The completed component side of the BAW is shown below:



The completed ‘Screen Side’ of the board is shown below:



The fully assembled Barb-A-Watt is shown below:

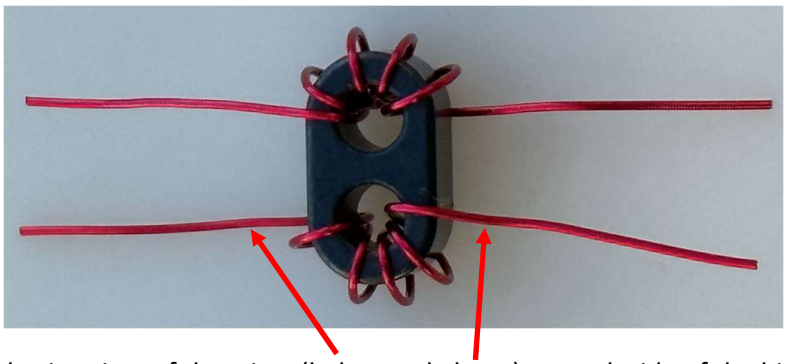
Building The Barb-A-Watt:

When building the Barb-A-Watt **it is recommended that construction be undertaken in stages according to the following sequence:**

1. Wind and install the binocular toroid.
2. Solder the slider switches, BNC connectors, OLED Pin Headers and the 28 pin IC Socket.
3. Attach the battery holder and solder the battery connection leads to the main board
4. Solder the jumper connections for the OLED power supply and the FWD/RVS test points
5. Install the OLED display
6. Insert the PIC Controller
7. Insert the batteries and test the Barb-A-Watt Operation
8. Assemble the Barb-A-Watt.

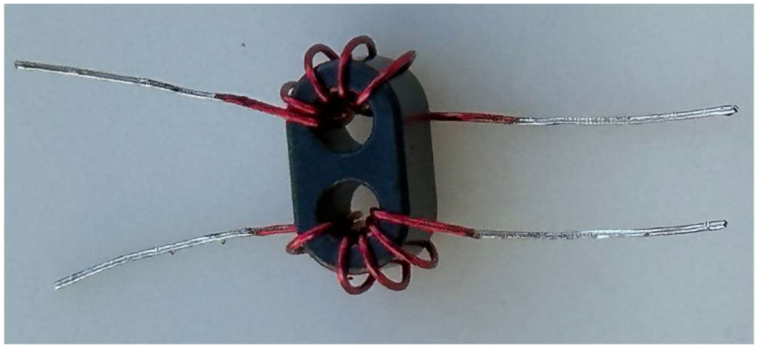
Stage 1: Wind and Install the Binocular Toroid

To wind the BN43-1502 inductor core start at one side of the core and feed the enamel copper wire 5 times through the hole. Every time the enamel copper wire goes through the hole counts as one turn. After completing 5 turns in the first hole, wind 5 turns in the second hole on the opposite side of the binocular core. When winding the toroid, try and keep the wire as close as practical to the toroid. When you finish it should look like the example in the photo below:

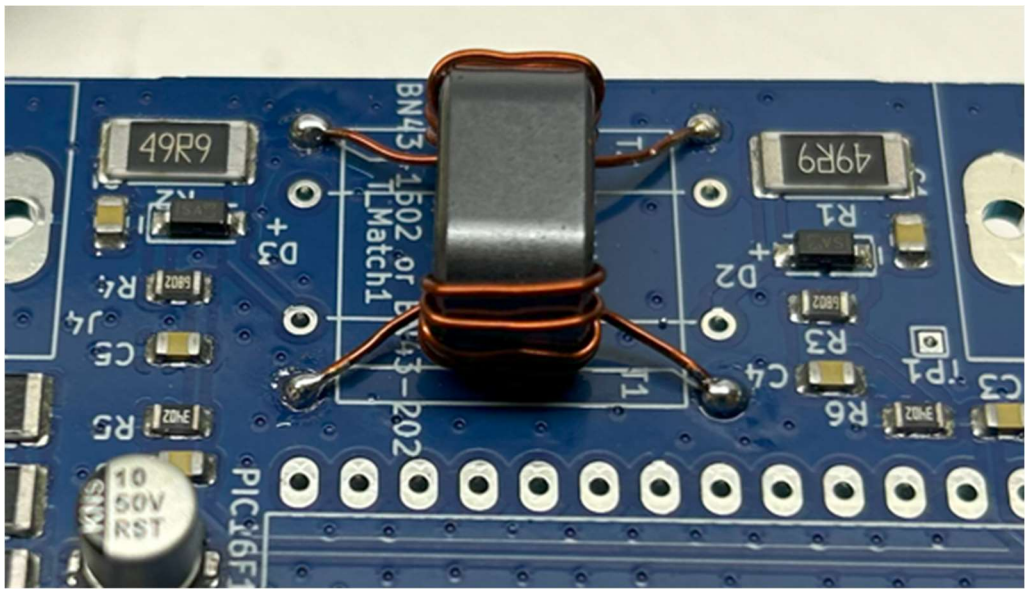


NOTE: the entry and exit points of the wires (below and above) on each side of the binocular toroid. Wind your binocular toroid in the same manner. Ensure that the windings do not overlap and are evenly spaced.

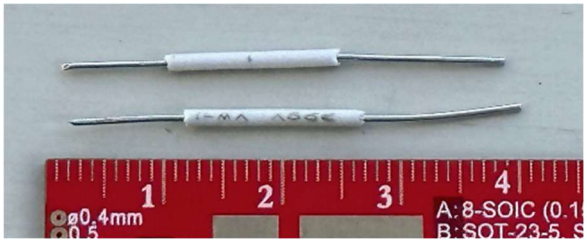
Remove the enamel coating from the wires by either sanding or scraping with a sharp modeling knife and tin the wires with solder as shown below (Don't apply too much solder as you may have difficulty passing the wire through the hole in the PCB):

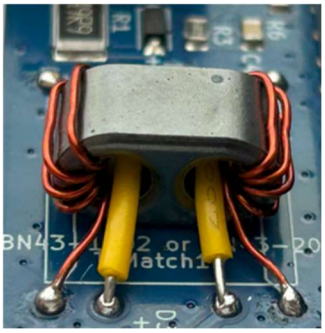


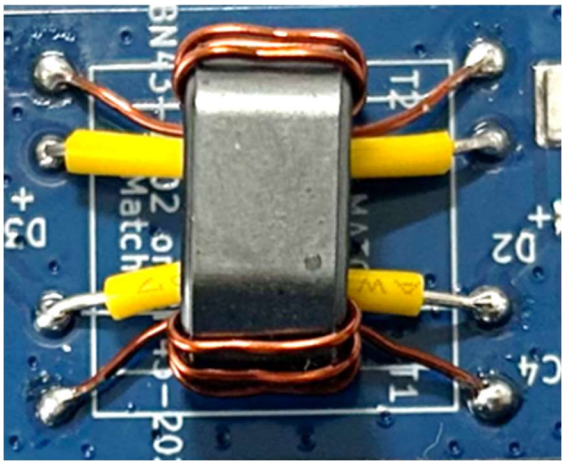
Solder the binocular core and its windings to the PCB as shown below. Keep the windings tight against the binocular core and ensure that the windings do not overlap.

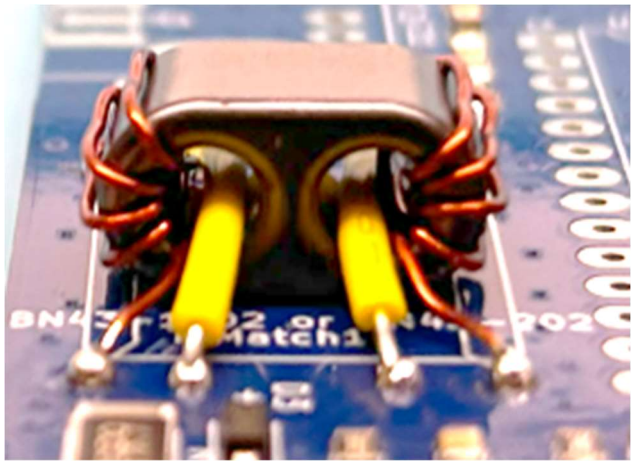


Next cut two 1.5” (~35mm) lengths of insulated solid core electrical wire. These wires will be fed through the holes of each binocular core (white or yellow wires in the photo) and soldered to the PCB as shown below:









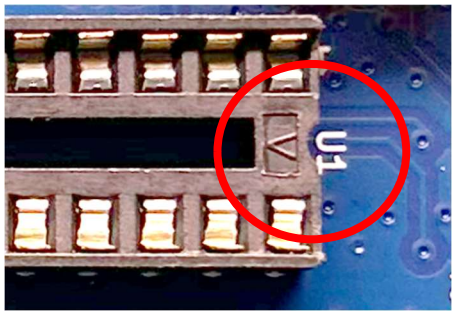
Adjust the length of the insulated through wires as needed take your time to ensure a neat and uniform installation. **Hint:** Bend the ‘through’ wires at right angles at each end to fit into the PCB hole and cut off any excess length before inserting into the toroid and soldering. This makes fitting the wire and then rotating it to fit into the PCB hole a lot easier.

Stage 2: Solder Slider Switches, BNC Connectors, OLED Pin Headers and 28 pin IC Socket

Solder the components to the main board in the following order:

- Slider Switches,
- BNC Connectors,
- OLED Pin Headers; and
- 28 Pin IC socket

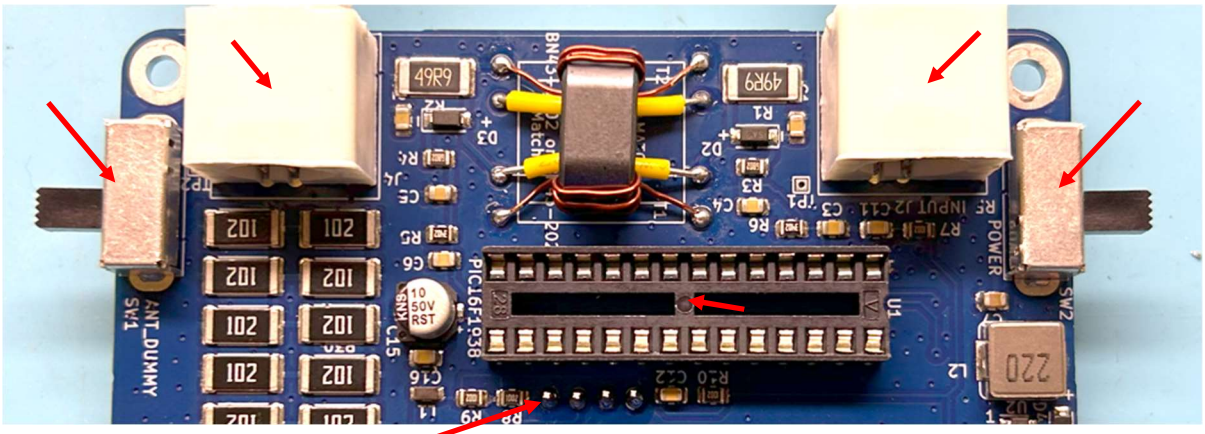
You may need to straighten some of the IC Socket pins before inserting them into the board. Note the alignment of the notch in the end of the socket, with U1 printed on the PCB as highlighted in the photograph below.



When installing the **28 Pin DIP socket** – solder two pins diagonally opposite at each end, confirm the socket is flush with the PCB, adjust if necessary and then spread the thermal load by soldering every second pin, returning to pick up the remaining pins.

Ensure that the **OLED 4-pin header** is soldered perpendicular to the main board. The best way to do this is to place the header and solder a single pin to the PCB. Check that the board is aligned and if not, apply heat to the solder joint with one hand and with the other move the header into the correct alignment, remove the heat and hold the header in position until the solder solidifies. Once you are happy that it is seated flush on the PCB and at right angles to the board, proceed to solder the remaining pins.

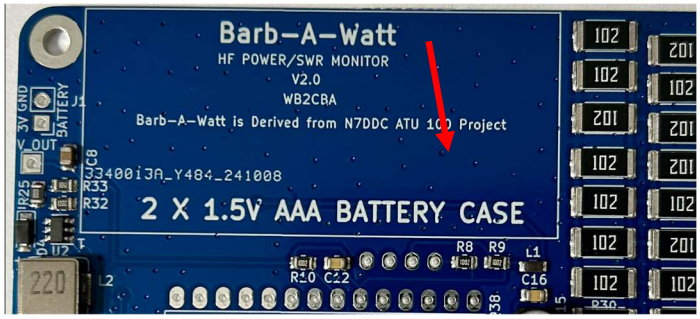
Don't use excessive heat when soldering so as not to melt or damage the components. These components are installed into the positions shown on the completed board below:

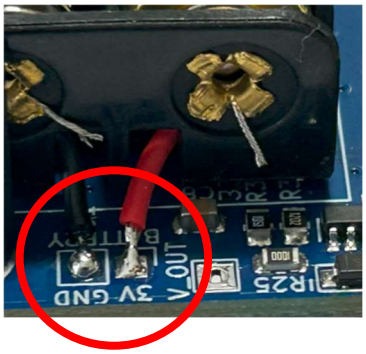


NOTE: The long ends of the 4 pin OLED header are soldered to the component side of the PCB with the black plastic spacers positioned on the other side of the board from that show above – see OLED installation Step 5 for further details.

Stage 3: Attach the Battery Holder and Solder the Power Supply Leads to the PCB.

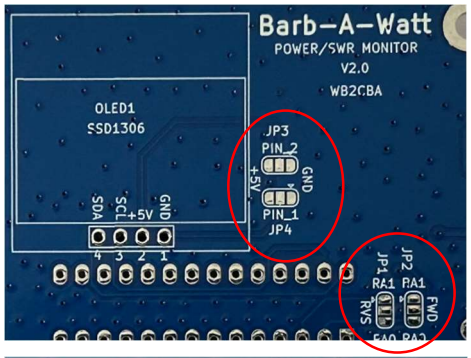
Using a piece of double-sided tape, attach the battery holder to the PCB carefully aligning it with the position shown on the PCB screen print. Cut and solder the power leads to the PCB observing the correct polarity as shown below. Be aware that the conductor in the power lead wire is thin so take care not to strip any wire off with the insulation.

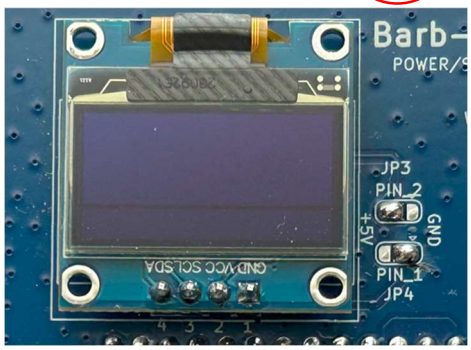




Stage 4: Solder the Jumper Connections for OLED and FWD/RVS Test Points

Turn the board over and identify the JP1, JP2, JP3 and JP4 jumper connections.



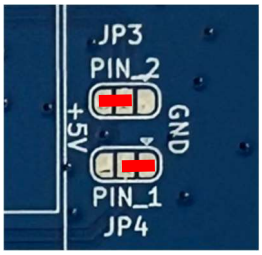


JP1 and JP2 are used for testing. JP3 and JP4 ensure that the power supply connections to the OLED screen match the power requirements of the OLED screen to be used. (Some manufacturers have the GND and +5v pins reversed).

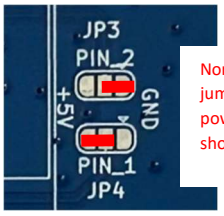
Perform a check to ensure that your OLED screen matches the pin configuration shown on the silk screen on the PCB eg:

Pin 1: GND
Pin 2: +5v (V_{cc})
Pin 3: SCL
Pin 4: SDA

If this is the case – solder the jumpers so that they match the jumper setting shown in the left and right photographs. The jumper is formed by soldering a bridge between the two pads on the PCB.

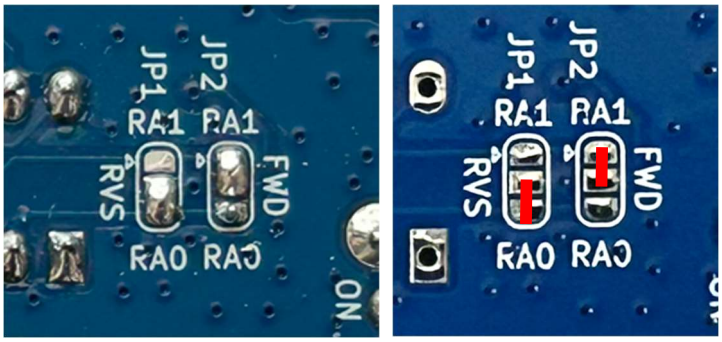


The OLED's supplied with the kit meet the above specification, should you subsequently replace the OLED and your OLED has Pin 1 as V_{cc} and Pin 2 as GND then these jumper settings would be reversed as shown below:



Non-Standard only use these jumber settings only if your OLED power pins are reversed from those shown on the PCB screen print.

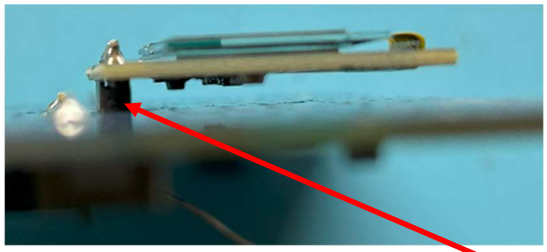
Solder JP1 and JP2 as shown below:



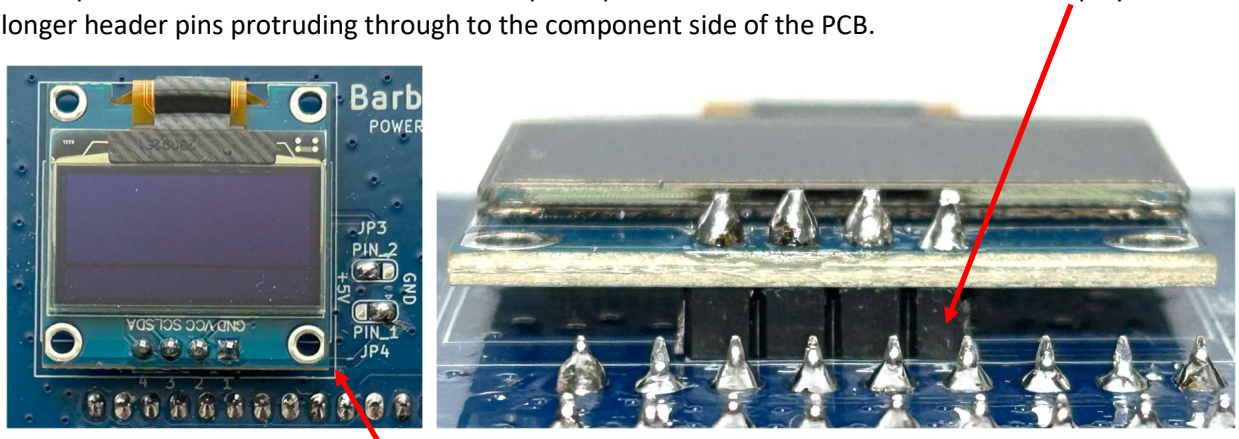
Stage 5: Install the OLED Display

The OLED display is installed onto the **solder side of the PCB** using the 4-pin header. It is good practice to use a tiny strip of double-sided tape stuck to OLED display's component side for two purposes: It ensures that the OLED display is correctly aligned with the viewing window on the Top Cover and provides an electrical isulator to prevent any short circuit with the PCB and components on the underside of the OLED display. *(If you take care and solder the OLED parallel to the PCB on the horizontal plane the OLED will not touch the PCB due to the spacers on the header pins, but a strip of insulating tape underneath the OLED would add an (optional) extra level of protection).*

Take care to ensure that the OLED display is soldered parallel to the main PCB and **don't overheat the pin headers** during soldering to avoid melting the plastic spacers.



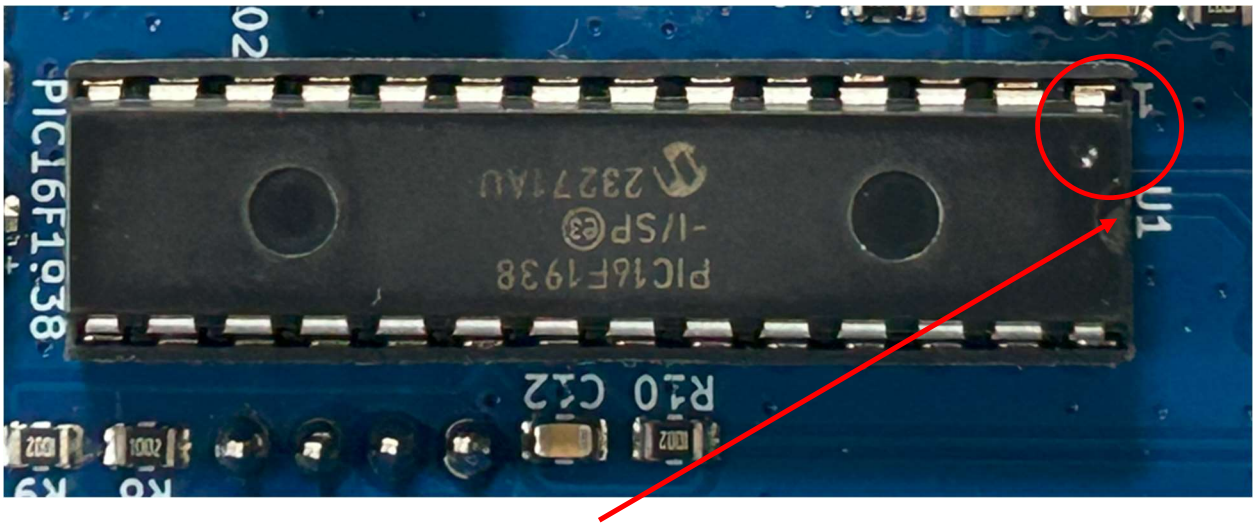
The 4-pin header is installed with the black spacer positioned between the PCB and the display with the longer header pins protruding through to the component side of the PCB.



Correct alignment of the OLED display can be assured by lining it up with the outline printed on the PCB. The ground and VCC pins on the OLED display align with the '1' and '2' identifiers on the PCB.

Stage 6: Insert the PIC Controller

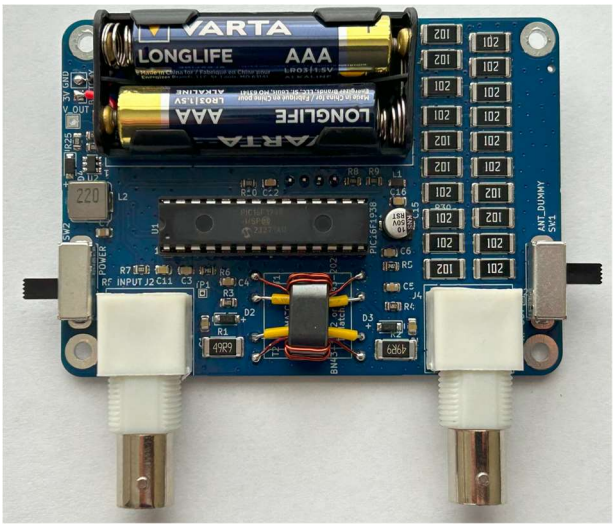
The new IC chips come with their pins angled out a little from the vertical and they will need some manipulation to push the IC into the socket. Carefully hold the chip with both hands on a flat surface (eg: table top) and rotate the IC so that the pins bend inward – do this to both sides so that the IC pins are now vertical (right angle to the chip) and will align with the IC socket. Don't bend the pins one by one. It's best to align both strips of pins to be vertical and then insert the IC into the socket. If you have an IC insertion tool that's even better, but most don't have one on hand.

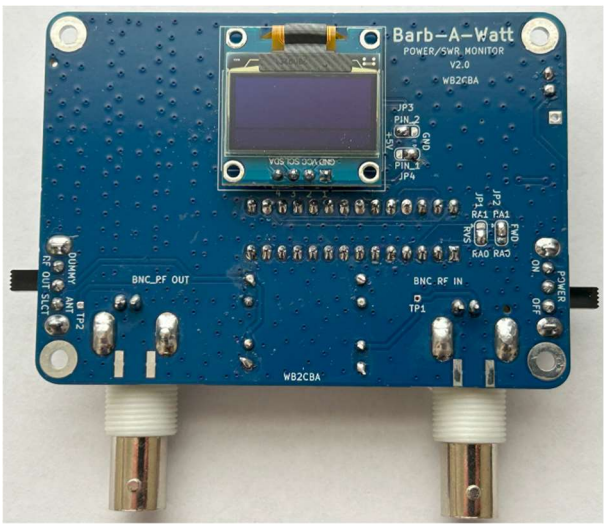


NOTE: the correct orientation of the pins on the IC. The notch on the IC should be aligned with the U1 identifier on the PCB. The 'dot indent' on the IC aligns with the pin 1 identifier on the PCB.

When handling the PIC controller take precautions to ensure that you do not damage the controller with any static discharges.

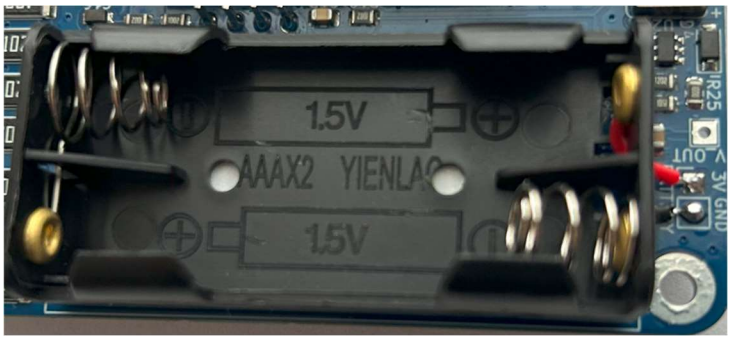
This completes the construction process. The finished main board should look something like this after installation of the batteries:





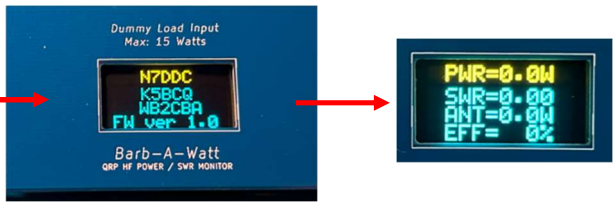
Stage 5: Inserting the Batteries and Testing Operation

With the construction of the main board complete, insert two AAA batteries into the battery holder observing the correct orientation shown on the bottom of the battery holder.



There are no user configurable settings, so you may wish to check that all is well before proceeding to assembly the Barb-A-Watt.

When the power switch is switched to the ON position (with the batteries installed), after a delay of approx. 2 seconds you are greeted with a splash screen as shown. After a further 2 seconds the flash screen is replaced with the measurement screen as shown to the right of the flash screen.



If you do not see these screens, go back over the instructions and undertake any necessary fault finding.

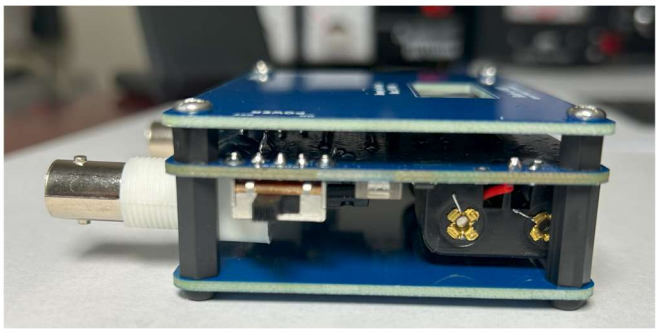
Step 8: Assemble the Barb-A-Watt

To assemble the Barb-A-Watt use the provided screws and spacers to enclose the top and bottom boards around the main PCB such that the finished product looks something like that shown below.

The suggested final assembly method is as follows:

- Start with the top cover and screw the 14mm M3 screws through the cover and into the 5mm spacers.
- Sit the main board onto the inverted top cover, aligning the OLED display with the top cover display window and then attach the 15mm spacers as shown below:

- Attach the bottom cover by screwing the 5mm plastic screws into the 15mm spacers. This will result in 'plastic feet' on the bottom of the Barb-A-Watt which will not scratch any tabletop etc.

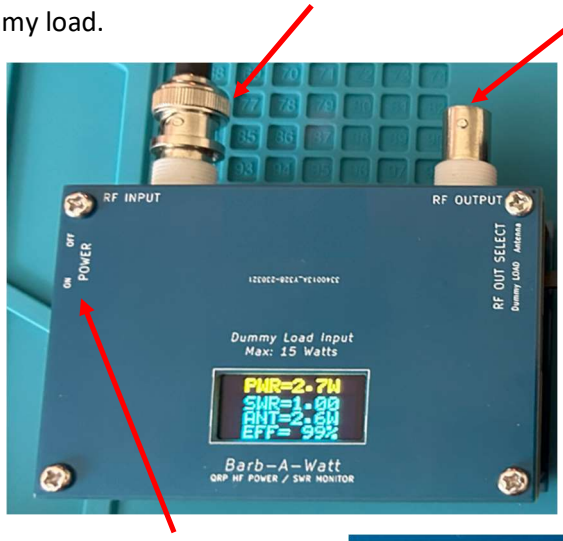


The Barb-A-Watt construction and assembly is now complete 😊 .

Using The Barb-A-Watt:

Using the Barb-A-Watt is the same as using any regular Power/SWR meter.

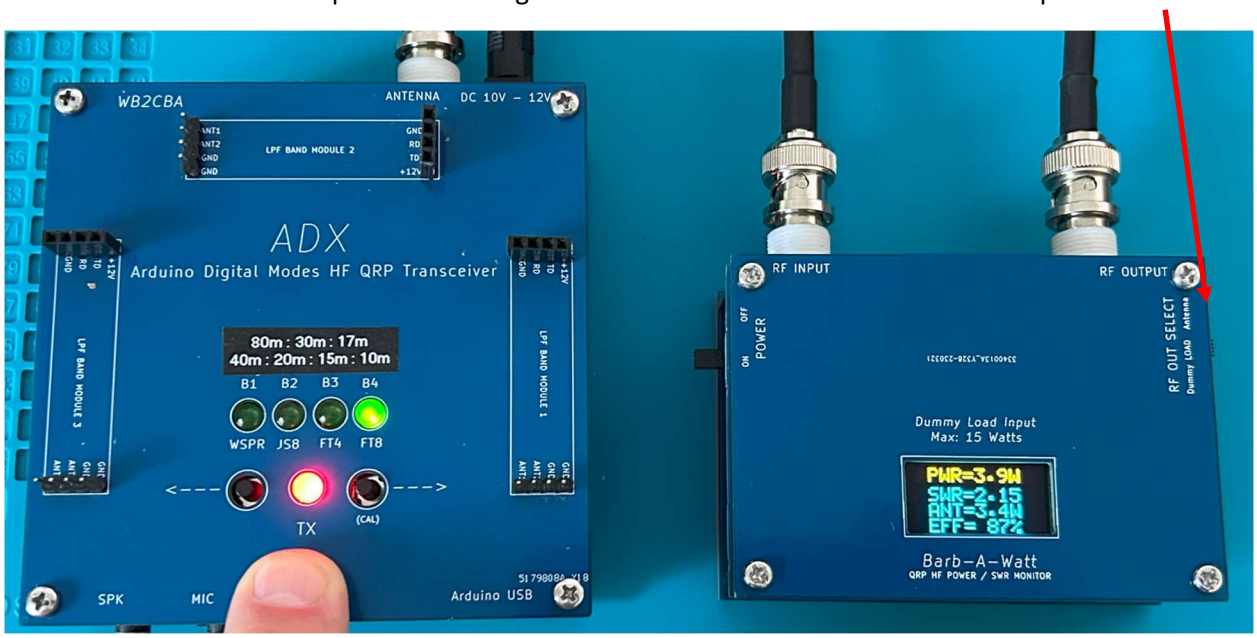
The **transceiver antenna output** is connected to the RF Input and Barb-A-Watt RF output is connected to the antenna or external dummy load.



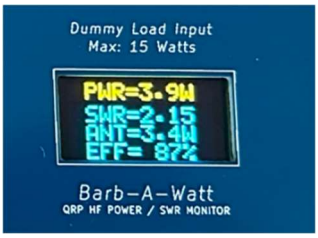
When the power switch is switched to the ON position (with the batteries installed), after a delay of approx. 2 seconds you are greeted with a splash screen as shown. After a further 2 seconds the flash screen is replaced with the measurement screen as shown to the right of the flash screen.

The RF input power can be switched between the internal dummy load (Max. 15W) or the external RF output port (Max. 20W). In this example the Barb-A-Watt is measuring output power from a QRP transmitter using the internal dummy load, after switching the output switch the Dummy Load position:

In this example the Barb-A-Watt is measuring the SWR of an external antenna after connecting the antenna to the RF OUTPUT port and moving the RF OUT SELECT Switch to the Antenna position.



The measurement screen shows four measured values:



- RF **Power** input from the Tx (Max 20W or 15W to dummy load)
- SWR
- Actual RF power output to the **Ant**enna (or dummy load)
- Actual RF output **Eff**iciency in %.

The power meter calibration is hard coded in software, there is no user adjustable parameter to calibrate the power meter.

In summary the Barb-A-Watt can be used in two different scenarios:

- As a **classic RF power meter with an internal dummy load** by sliding right slide switch to the Dummy Load position. This is ideal for use during construction and/or testing of QRP radios.

CAUTION: DO NOT EXCEED 15 WATTS RF POWER WITH THE INTERNAL DUMMY LOAD

- As an **RF POWER and SWR meter** when connecting to an antenna (or external dummy load), after switching the RF OUT SELECTOR switch to the Antenna position. In this mode the Barb-A-Watt is a good companion for real time QRP QSO Antenna and RF power monitoring in the shack and/or portable operation. To conserve the battery the power can be switched off and the Barb-A-Watt left in circuit during normal operation and switched on when you want to check the power and SWR periodically.

CAUTION: DO NOT EXCEED 20 WATTS RF POWER WHEN USING WITH AN EXTERNAL ANTENNA

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Barb, WB2CBA
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