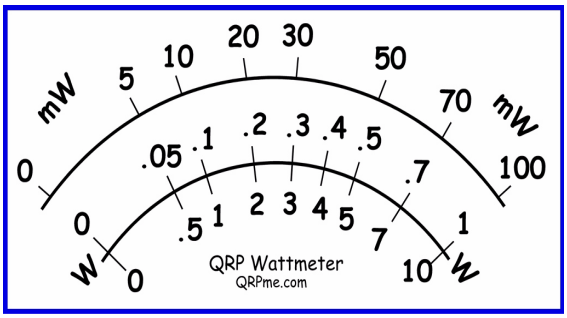
QRP-DWM

Directional-Coupler Watt Meter

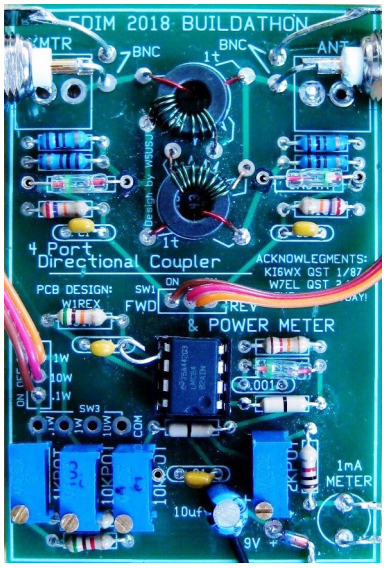
Assembly and User Guide

Preliminary

By: W5USJ CyM-Tech Documentation Services



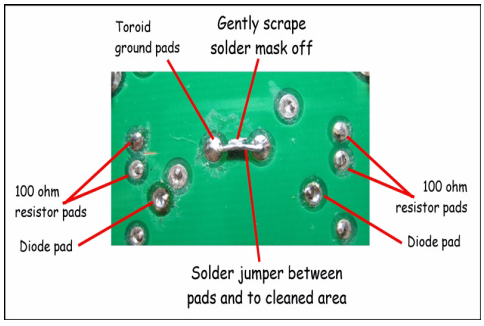
Enhancing Your QRP Operating Enjoyment



PCB Assembly Top View

Addendum:

Correct missing toroid ground after installing toroids. Refer to pg 4.



The QRP-DWM Directional-Coupler Watt Meter is a kit developed by W1REX and W5USJ with PCB design and artwork by Rex Harper, W1REX; QRPme.com in Limerick, Me.

The kit is produced and supplied by QRPme.com.

The 4-port directional coupler used is similar in function to the WM-2, W1FB, NoGaWatt, GQRP, KD1JV and others. QRPme first used the 4-port coupler for a Kit of the Month (KotM) club project.

The 4-port coupler design has it's origin based on a 1969 patent. See manual page 9.

Insertion Loss: Less than 1dB
Return Loss: Greater Than 26 dB, greater than 30 dB mid range.

Table of Contents

Please study the entire guide before starting assembly.

List of Materials (LoM)

PCB

[_] 1 – Rectangular green, Requires modifications

Note: Some parts labeled on the PCB have changed – refer to text
The kit may contain extra parts, set those aside.

Capacitors

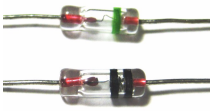
Qty Value Marking
[_] 4 – 0.1 uF 104
[_] 0 – 0.01 uF 103 (use 0.1 uF)
[_] 0 – 0.001 uF (not used)
[_] 1 – 10 uF electrolytic (polarized)

Resistors 1/4 Watt, 5% / Gold Tolerance Band

[_] 2 – 0 ohm blk band
[_] 4 – 100 ohm brn, blk, brn 5%, alt blu bdy, brn, blk, blk, blk brn 1%
[_] 2 – 27 k red, vio, orn
[_] 1 – 51 k grn, brn, orn
[_] 1 – 12 k brn, red, orn
[_] 1 – 1 k brn, blk, red 5%, alt blu bdy, brn, blk, blk, brn, brn 1%
[_] 1 – 18 k brn, gry, orn
[_] 1 – 5.1 k grn, brn, red
[_] 1 – 10 k 20 t potentiometer (Sens)
[_] 1 – 10 k 20 t potentiometer (1 W adjust)
[_] 1 – 2 k 20 t potentiometer (0.1 W adjust)
[_] 1 – 2 k 20 t potentiometer (10 W adjust)

Semi-conductors

Diodes (polarized)
[_] 3 – 1N34A Point Contact Diode
[_] 1 – 1N5818 or Blue Band Diode
Integrated Circuit
[_] 1 – TLV-272 Op amplifier



1N34A
or
1N60

Point Contact Diodes.

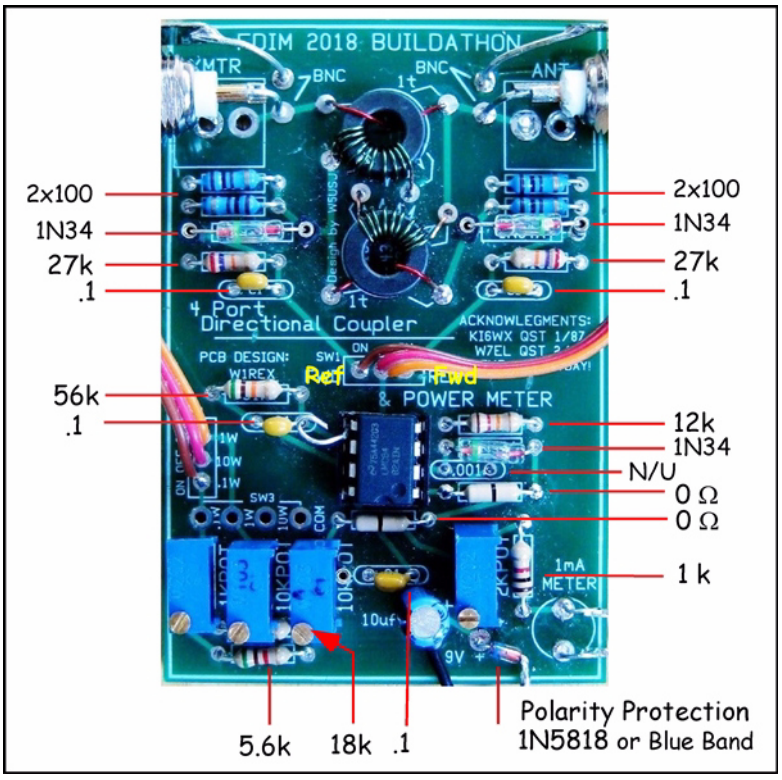
This is a Schottky silicon junction diode: Alternate use for reverse polarity protection.

Miscellaneous

[_] 2 – FT37-43 Toroids
[_] 2 – Switch SPDT
[_] 1 – Switch SPDT Center Off
[_] 1 – 9 volt Battery Snap
[_] 2 – BNC Jacks
[_] 1 – 8-pin DIP Socket
[_] 1 – Roll Magnet Wire
[_] 1 – Hook-up Wire and 22 ga buss wire

Circuit Board Assembly

[_] Install 4ea 100 ohm resistor as shown in the illustration below

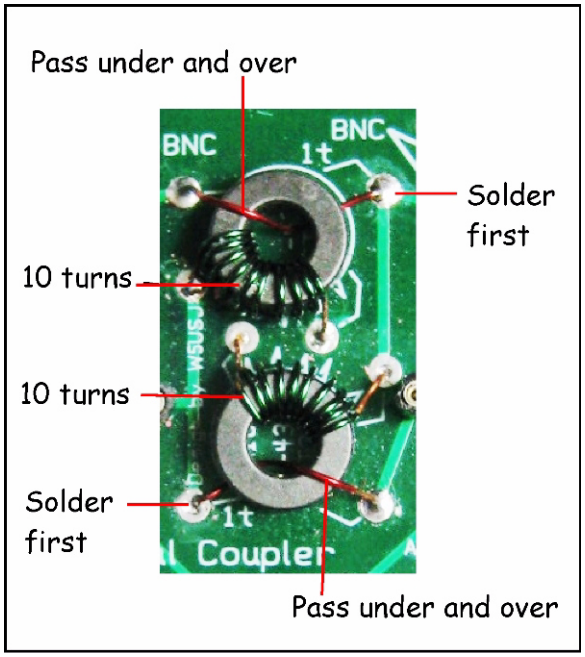


[_] Bend leads slightly, as they are inserted, to hold parts in place.
[_] Ensure that the parts are seated against the board,...
[_] ...solder the leads and trim them off close to the board.
Continue in this manner with the remainder of the parts
[_] Install 3 ea 1N34 diodes
Note: Diode next to op amp has closer spacing. Bend leads carefully to prevent glass breakage. Make sure the banded ends of the diodes matches the silkscreen outline on the PCB.
[_] Install 2 ea 27 k ohm resistors
[_] Install 4 ea 0.1 ceramic capacitors
Note: Two capacitors are marked .01, use .1 instead
[_] Install 56 k and 12 k ohm resistors
[_] Install 2 ea 0 ohm resistors (single black band)
One in place of labeled 1 k resistor
[_] Install 1 k, 18 k and 5.6 k ohm resistors

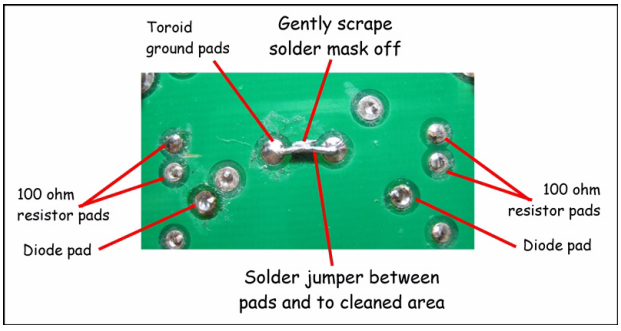
Toroids

[_] Cut two 10-inch lengths of magnet wire
[_] Carefully wind 10 close-spaced turns on each of two FT37-43 toroids. Leave 1/2 inch of lead at each end. Strip the insulation from these leads close to the cores. Ensure that both are wound in the same direction, CW or CCW.

Note: There are on-line tutorials about winding toroids



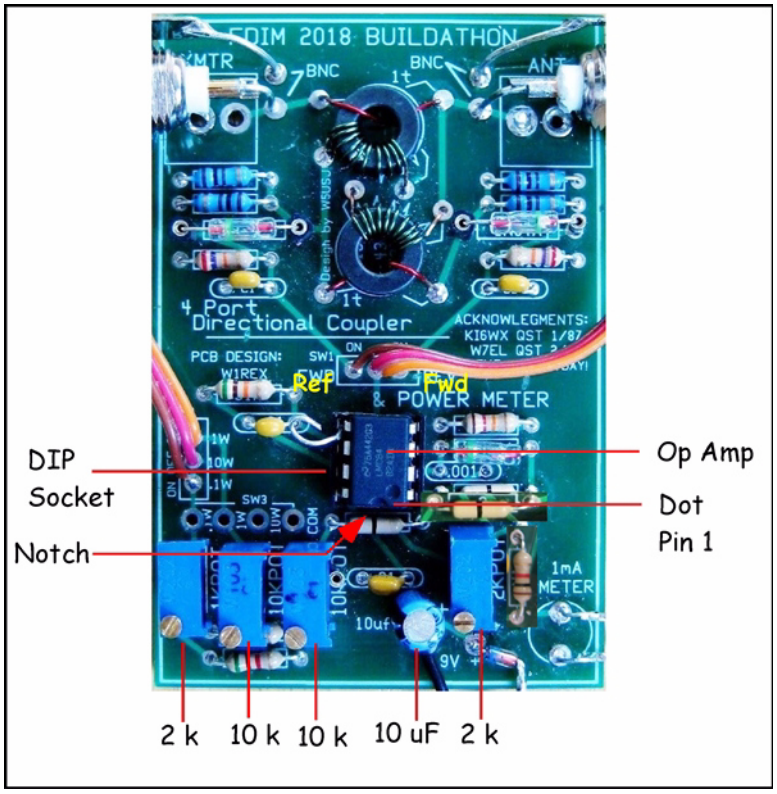
[_] Insert the wire ends into the pads on the PCB. Align the core with the silk screen. Hold the cores in place and solder the wires. Trim excess length
[_] Cut two 1-inch lengths of magnet wire. Strip insulation about 1/4 inch from each end.
[_] Solder one end into the PCB as shown in the illustration. Pass the wire under and up through the toroid and then down into the other pad.
[_] Solder the wire and trim excess length.



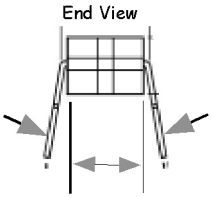
Fix missing ground connections

Large Parts

[_] Install 2ea 2 k 20t pots, 2ea 10 k 20t pots and 10 uF capacitor. Observe capacitor polarity.



[_] As shown in the previous examples, bend leads slightly as they are inserted to hold parts in place.
[_] Ensure that the parts are seated against the board,...
[_] ...solder the leads and trim them off close to the board.
[_] Install the DIP socket. The notch should be positioned relative to the silk screen image. Hold the socket against the board and solder the pins.
[_] On a flat surface, form by bending the leads on both sides of the Op Amp such that they are parallel to each other.
[_] Carefully insert the Op Amp into the socket without bending or kinking the leads. Observe that the dot in the corner of the op amp is at the notch-end of the socket.

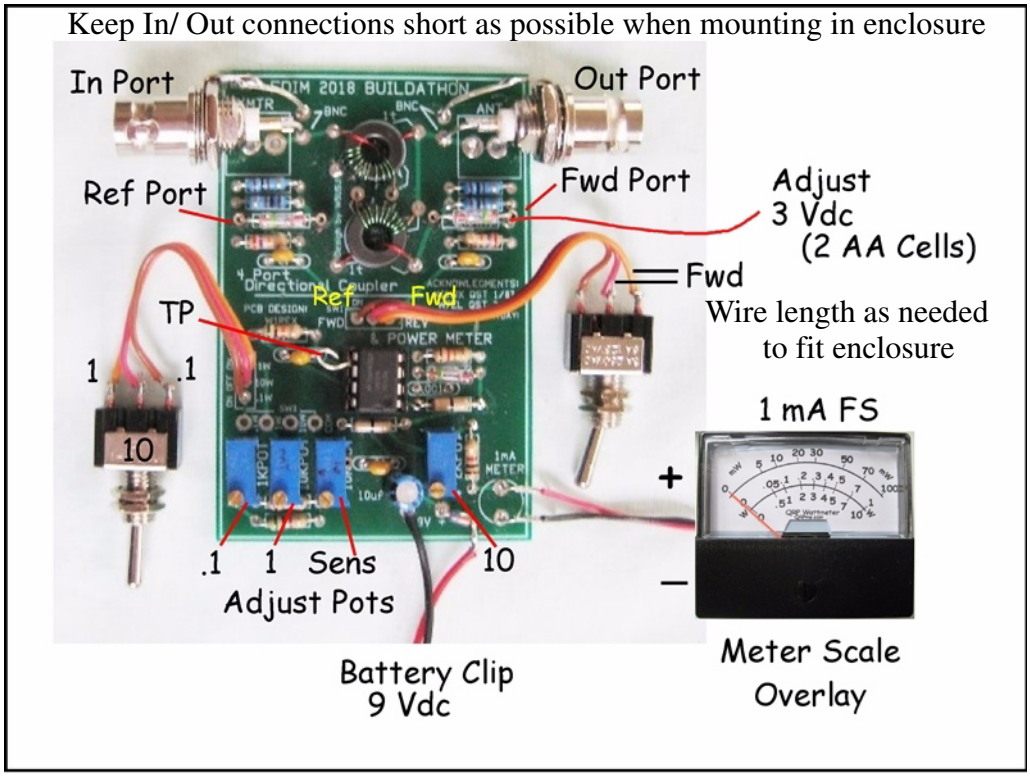


Op Amp

Final Assembly will describe the procedures for connecting the peripheral components and mounting in an enclosure.

Note: The 4-port coupler design has it's origin based on a 1969 patent. A high-power version is in recent ARRL Handbooks.

Final Assembly



Final assembly, with connections to panel-mounted components, will need to consider lengths of interconnect wiring to fit as needed.

See the Appendix, page 10, for a suggested enclosure.

Power connections can be to a 9 Vdc battery with on/off switch along with a polarity protection diode. Review the schematic in the Appendix. Alternately, the power connections can be an external 13.8 Vdc supply with 9 volt regulator and / or a switch-selected 9 volt battery

Wire colors have typically had meaning: Black and Green for ground, Red and Orange for power. Brown, Red and Orange for the switches, the color codes for 1, 2 and 3 respectively, help to identify which switch terminal is connected to which pad on the PCB.

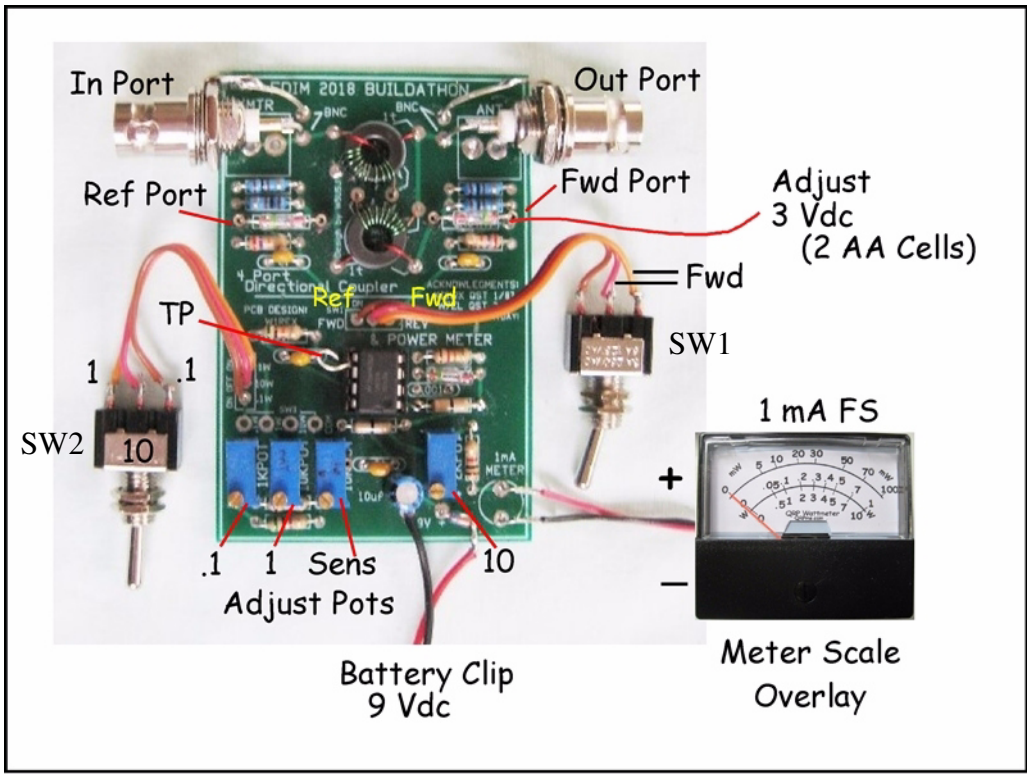
22 ga buss wire is used to wire and support the PCB to BNC connections. Place a small hook and loop pad center bottom to support that end.

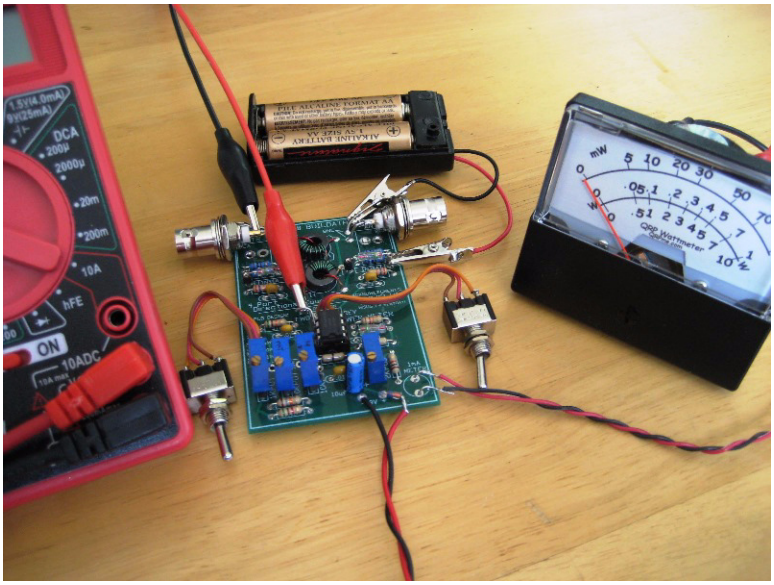
Use other colors to indicate specific functions between the PCB and the peripheral components.

Adjustment and Testing

Refer to the Adjustment setup drawing at the top of page 8.

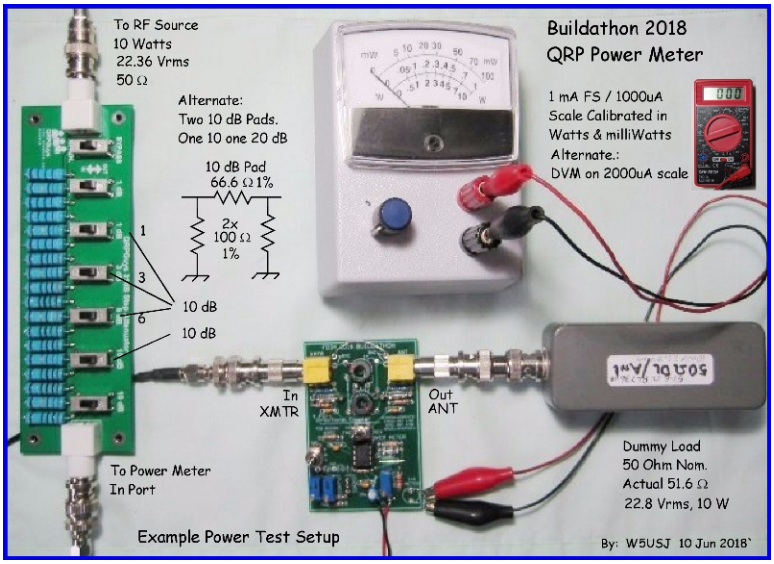
[1] Connect 9V to DUT (battery snap)
[2] Connect 1mA meter to meter pads
[3] Connect jumper from 3 Vdc to Fwd port
[4] Set SW2 to 10W position
[5] Set Sens Pot for 2.6 V at pin 5
[6] Adjust meter pot for 1mA FS
[8] Set Sens Pot to 0.8 V at pin 5
[7] Set SW2 to 1W position
[9] Adjust 1W pot for 1mA FS
[10] Set Sens Pot to 0.26 V at pin 5
[11] Set SW2 to 0.1W position
[12] Adjust 0.1 W pot for 1mA FS
[13] Set SW2 to 10W position
[14]: Return Sens pot to top of range
[15] Remove all setup hookups but meter





Power Measurements

[1] Source of accurately measured 10W, 31.7 Vpk**, 50 Ohms
[2] Accurate 50 Ohm Dummy Load, or accurately measured resistor load.
[3] Accurate 10 dB and 20 dB attenuator or 2ea 10 dB
[4] SW2 to 10W position, Input, 10 W observe meter
[5] Insert 10 dB SW2 to 1 W position observe meter,
[6] Add 10 dB, SW2 to 0.1 W pos, observe meter
If you're sure of accurate power levels, tweak the adjustments a little for full scale readings.
**Adjust Vpk as needed for other than 50 Ohms.



Theory and Applications

Some History

Excerpt from the NoGaWatt directional coupler manual:

"We have been calling this the Stockton (GM4ZNX from W1FB[1] info and G4ZNQ from Sprat) bridge because he is the one who introduced it to QRPers. However if you were to open your 1996 copy of the ARRL handbook you will see this same "Directional Coupler" (P22.36) that has a US patent in 1969 by Sontheimer and Fredrick[2]."

1-W1FB's Design Notebook, Page pg 173
2-Patent No. 3,426,298 Feb 4 1969

From W1FB:
"An SWR bridge circuit appeared in the winter 1989/1990 edition of SPRAT, the ham journal of the GQRP club. It was designed by D. Stockton, G4ZNQ. I experimented with the circuit and found the performance to be excellent. The circuit is simple and bridge balance is easily achieved without the usual balancing trimmers found in the classic Bruene bridge. The circuit yields good accuracy, has low insertion loss and is not frequency sensitive."

Measuring VSWR

The QRP-DWM can be used to sample a transmitter's forward voltage and reflected voltage output. The voltages measured can be used to calculate VSWR.** Also, the forward power port can be connected to an oscilloscope for display of the transmit envelope.

**VSWR = 1 + sqr (Vref / Vfwd) / 1 – sqr (Vref / Vfwd)

Example: Vref = 0.0025, Vfwd = 2.5 VSWR = 1.07:1

Note: See page 11, sample Small Basic program for calculating VSWR

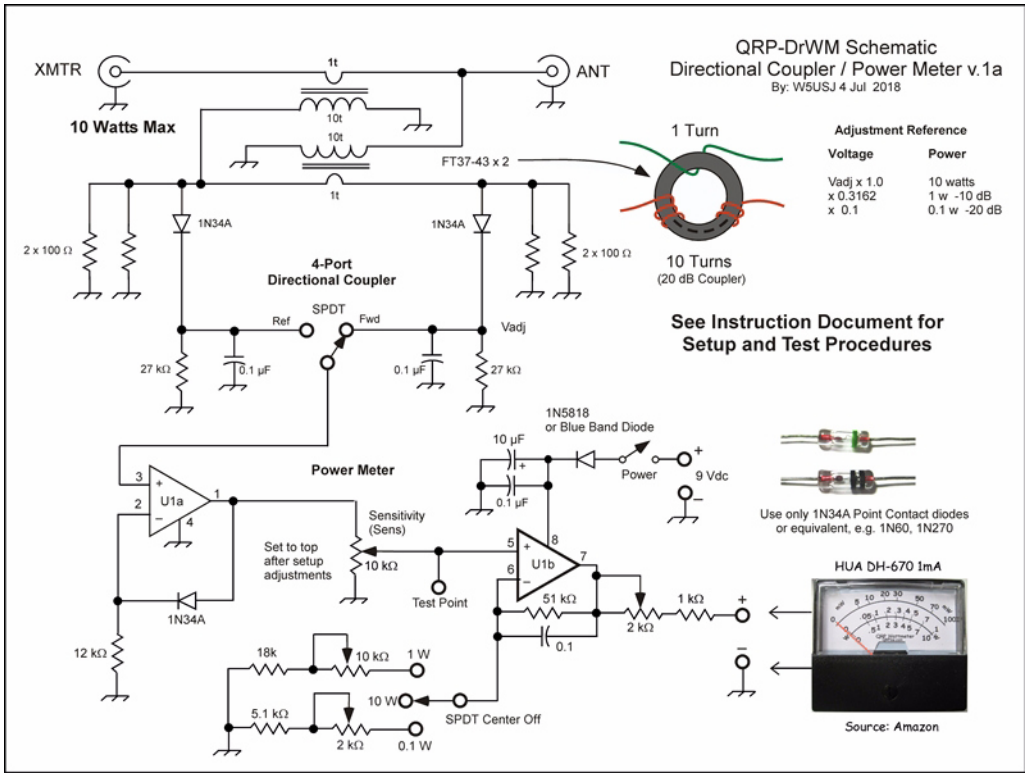
Transmitter Tuning

Connect the QRP-DWM between a QRP transmitter, with or without a tuner. Tune for minimum meter indication at the reflected, Ref, port.

Without a tuner, adjust the antenna length and or the feedline length to achieve a matched condition indicated by minimum reflected voltage.

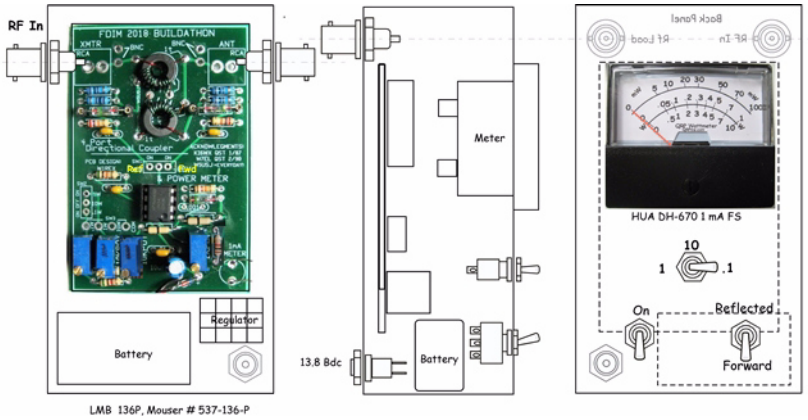
Appendix

Schematic



QRP-DWM Schematic

Enclosure



Example installation of the QRP-DWM in LMB 136P enclosure
Left drawing with BNCs on the side, middle and right with BNCs on the back.
The HUA meter requires a 2 in clearance hole for mounting.

Small Basic Program

Calculate VSWR

```
' By: Chuck Carpenter, W5USJ, 6 Mar 2018
' Utility to calculate VSWR from measured power or power converted to voltage.

' SWR = 1 + sqr ( Pref/Pfwd) / 1 - sqr ( Pref/Pfwd)  [Power in Watts or as Volts
'measured with a Peak Detector or RF Probe.]
Calc:
TextWindow.Clear ()
'Calculations
TextWindow.WriteLine ("Enter Forward Power or Volts, Fwd ")
  Pfwd = TextWindow.ReadNumber ()
TextWindow.WriteLine ("Enter Reflected Power or Volts, Ref ")
  Pref = TextWindow.ReadNumber ()
  Div1 = Math.SquareRoot(Pref / Pfwd)
  Div2 = ( 1 + Div1 ) / ( 1 - Div1 )
  SWR = ( .01 * Math.Round (100 *Div2))
TextWindow.WriteLine (" SWR, P or V = " + SWR )
Agn: 'Go to Calc Start
          TextWindow.WriteLine ("")
            TextWindow.WriteLine ("Enter C to Continue, 'enter' to End")
              Agn = TextWindow.Read ()
              If (Agn =  "C" or Agn = "c") then
                goto Calc
              Else
                goto end
              endif
end:
```