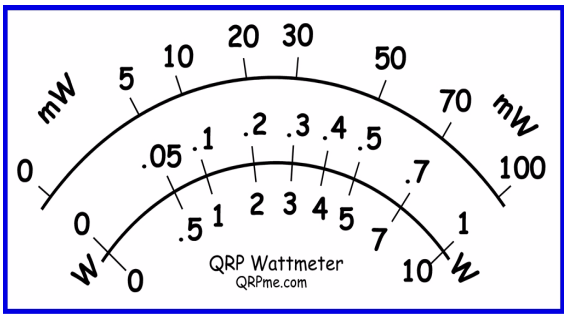
QRP-DPM

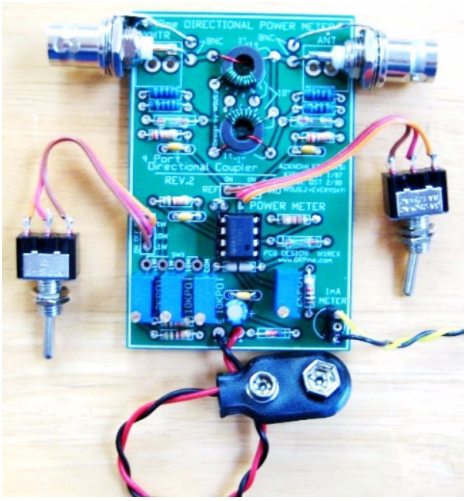
Directional-Coupler Power Meter

Assembly and User Guide

By: W5USJ CyM-Tech Documentation Services



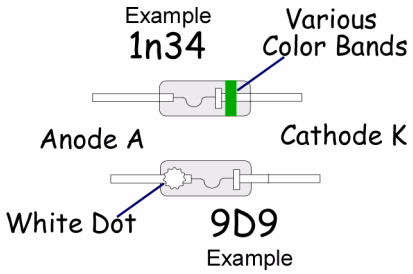
Enhancing Your QRP Operating Enjoyment

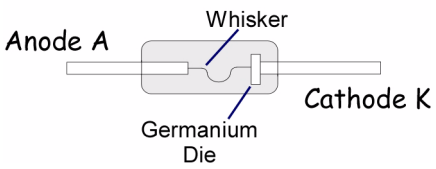


PCB Assembly Top View

Addendum:

Added 9D9 diode marking illustration





Match marked end of diode to PCB silk screen image anode and cathode.

The QRP-DPM Directional-Coupler Power 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, 160 through 10 meters: greater than 30 dB mid range.

26 dB RL = 1.11 VSWR
30 dB RL = 1.07 VSWR

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Document Created with FrameMaker

Please study the entire guide before starting assembly.

List of Materials (LoM)

PCB

[ ] 1 – Rectangular green labeled Directional Power Meter

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

Capacitors

Qty	Value	Marking
[ ] 4	– 0.1 uF	104
[ ] 1	– 10 uF electrolytic (polarized)	

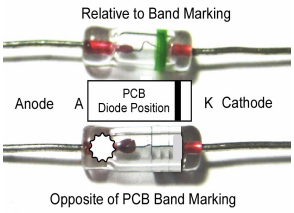
Resistors 1/4 Watt, 5% / Gold Tolerance Band

[ ] 1 – 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

Note: Orientation
1N34 Cathode band
9D9 Anode white dot

Diodes (polarized)
[ ] 3 – 1N34A Point Contact Diode
Alternate: 9D9 White anode dot
[ ] 1 – 1N5818 or Schottky Diode
Integrated Circuit
[ ] 1 – TLV-272 Op amplifier



Point Contact Diodes.

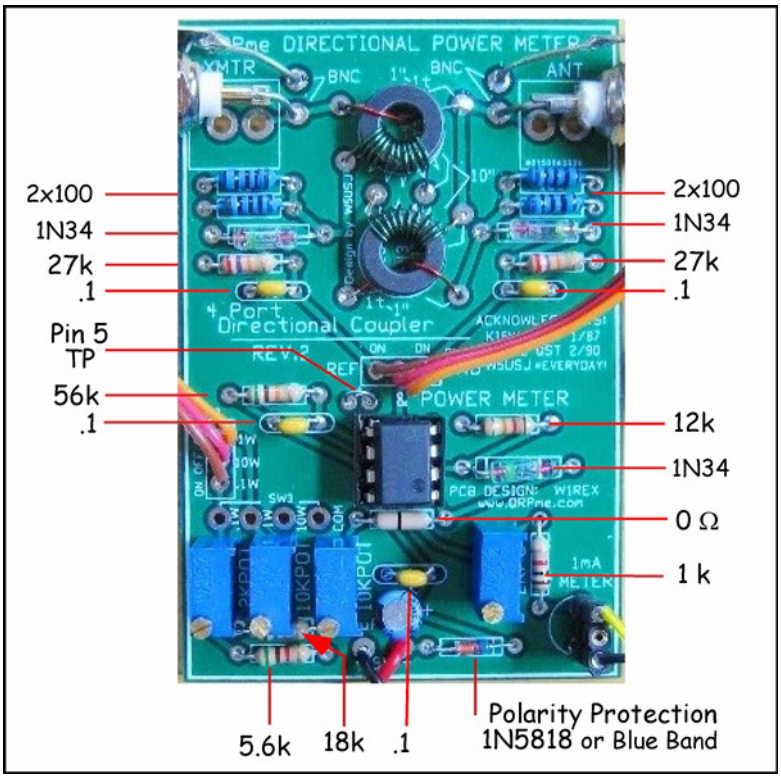
This is a Schottky silicon junction diode: Alternate use for reverse polarity protection.

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 20 ga buss wire

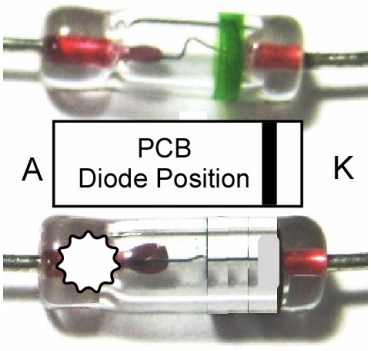
Circuit Board Assembly

[ ] 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; Alternately, 3 ea 9D9 diodes.

1N34 Color Band



9D9 White Dot

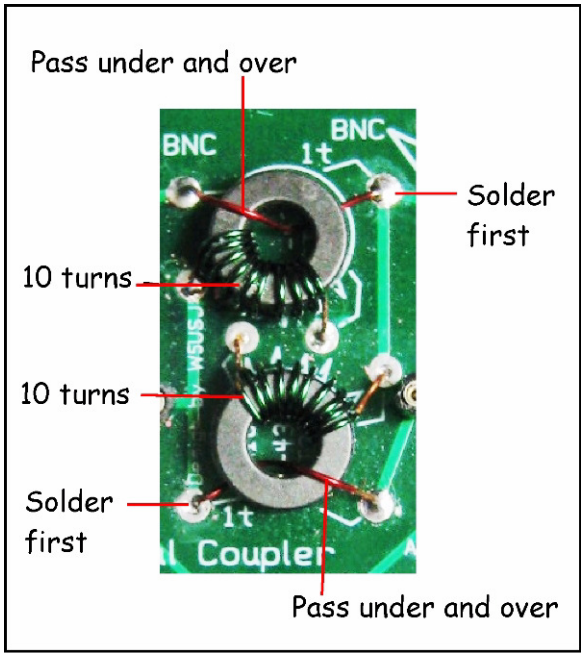
Note: Bend leads carefully to prevent glass breakage. Make sure the marked ends of the diodes matches the silkscreen outline on the PCB.

[ ] Install 2 ea 27 k ohm resistors
[ ] Install 4 ea 0.1 ceramic capacitors
[ ] Install 56 k and 12 k ohm resistors
[ ] Install 1 0-ohm resistors (single black band)
[ ] Install 1 k, 18 k and 5.6 k ohm resistors
[ ] For a test point (TP) at U1-pin5 form, using a clipped component lead, a U- shaped loop with spacing of 0.1 inch. Insert the loop into the two pads at the corner of U1-pin5. Space the loop about 3/16 in above the PCB and solder in place. See illustration Pin 5 TP above.

Toroids

[ ] Cut two 7-inch lengths of magnet wire
[ ] Carefully wind 10 close-spaced turns on each of two FT37-43 toroids: About 37 uH. 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.

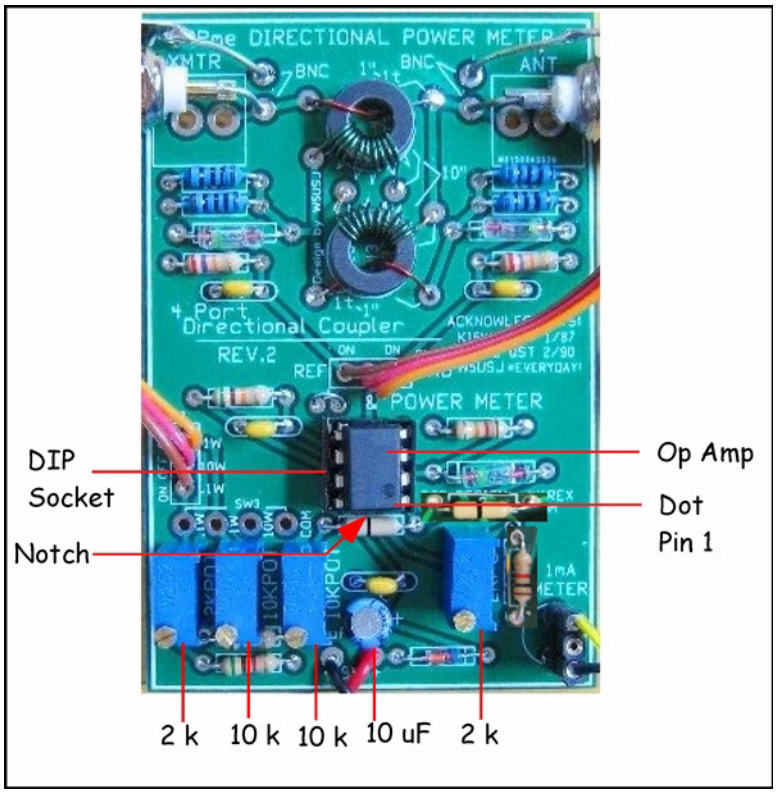
Note: There are on-line tutorials about winding toroids



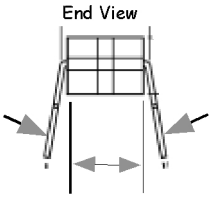
[ ] Insert the wire ends into the pads on the PCB. Align the core with the silk screen. Hold the cores in place and solder the wires. Trim excess length
[ ] Cut two 1-inch lengths of magnet wire. Strip insulation about 1/4 inch from each end.
[ ] Solder one end into the PCB as shown in the illustration.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

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 notch/dot in the corner of the op amp is at the notch-end of the socket.

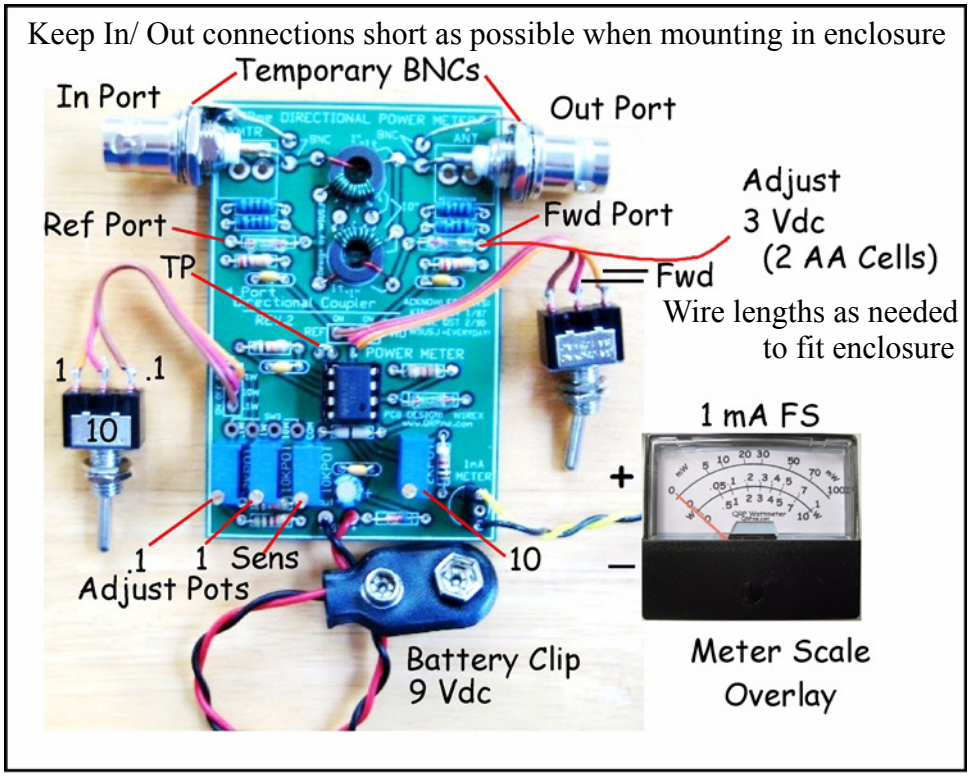


Op Amp

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

Assembly for testing prior to mounting in final enclosure.



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

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 a DPDT center-off switch to select battery or regulated external supply.

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.

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

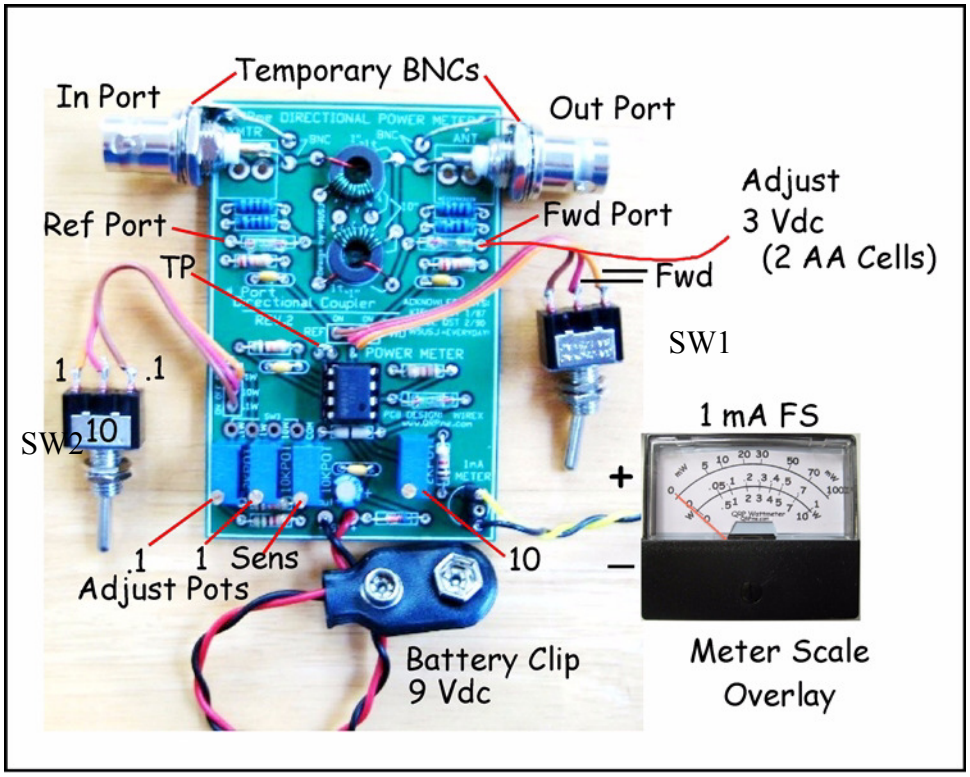
[ ] Insert the lead for the meter ground connection (–) through the pad and across the bared PCB spot. Solder the lead to both the pad and the PCB.

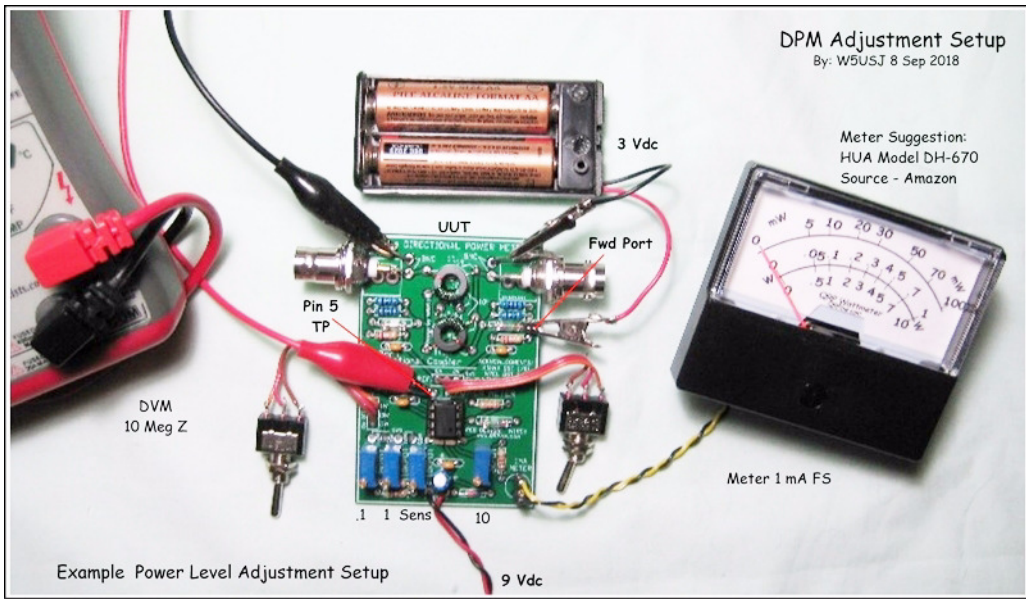
See the Appendix, page 11, for a suggested enclosure.

Adjustment and Testing

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

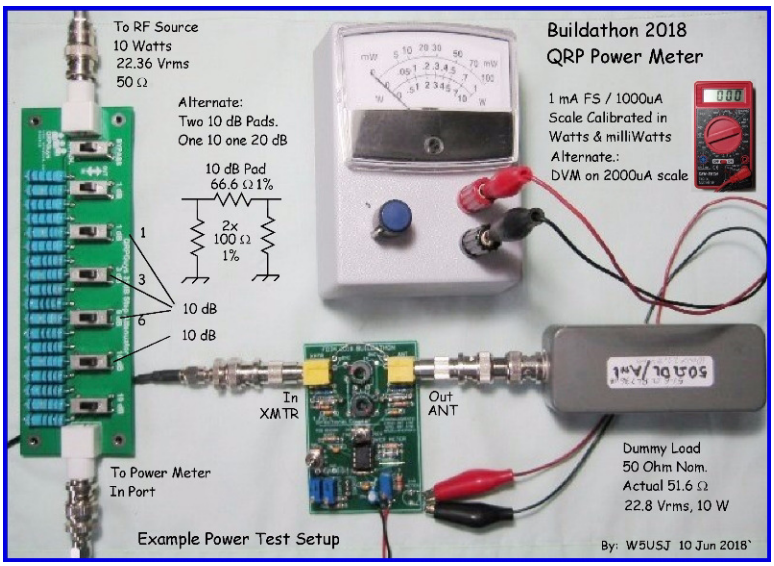
[1] Connect 9V to DUT (battery snap)
[2] Connect 1mA meter to meter pads
[3] Connect DVM to pin 5 test point
[4] Connect jumper from 3 Vdc to Fwd port
[5] Set SW2 to 10W position
[6] Adjust Sens Pot to 2.6 V at pin 5
[7] Adjust meter pot for 1mA FS
[8] Set Sens Pot to 0.8 V at pin 5
[9] Set SW2 to 1W position
[10] Adjust 1W pot for 1mA FS
[11] Set Sens Pot to 0.26 V at pin 5
[12] Set SW2 to 0.1W position
[13] Adjust 0.1 W pot for 1mA FS
[14] Set SW2 to 10W position
[15]: Return Sens pot to top of range
[16] 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
Adjust the setting pots as needed for each power level.
**Adjust Vpk as needed for other than 50 Ohms, e.g., 22.75 Vrms (32.168 Vpk) for 51.6 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-DPM 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 12, example Small Basic program for calculating VSWR

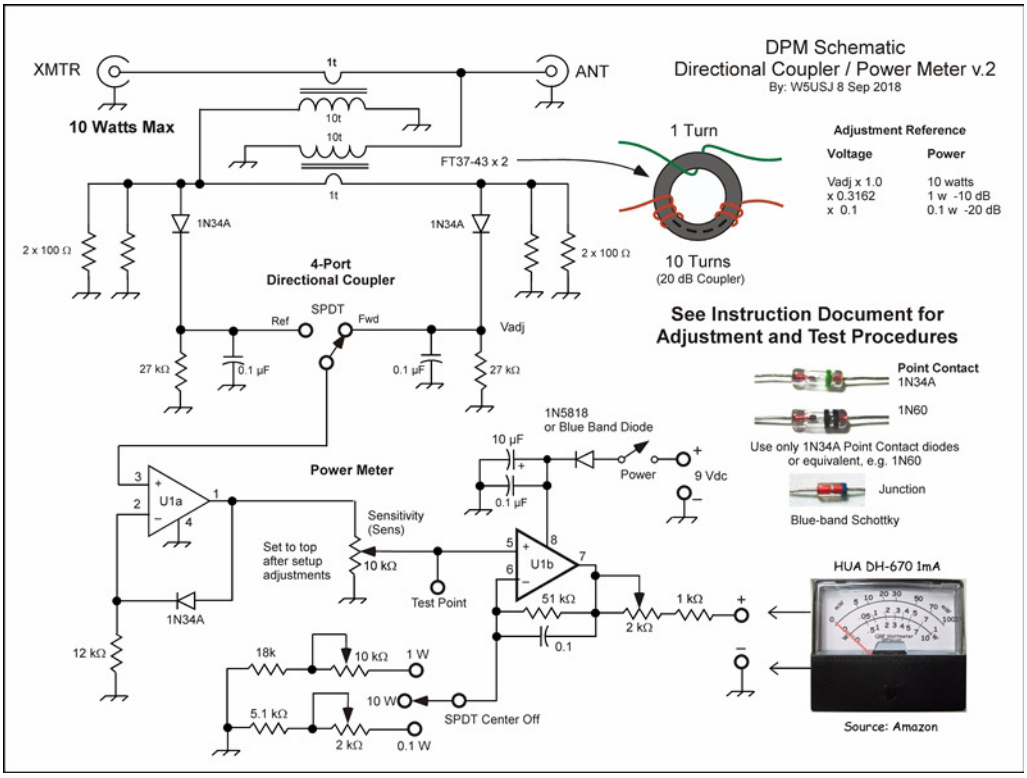
Transmitter Tuning

Connect the QRP-DPM between a QRP transmitter, with a tuner, to an antenna or 50 ohm dummy load.
Adjust for minimum meter indication at the reflected, Ref (Vref), port.

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

Appendix

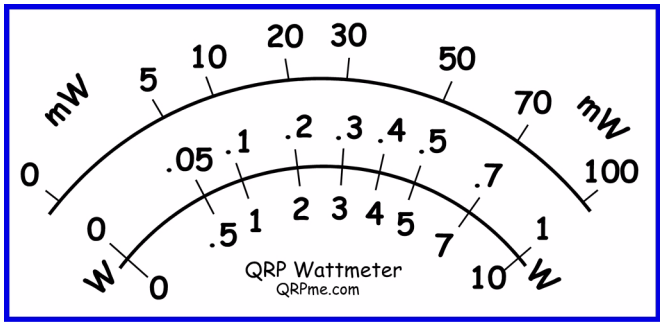
Schematic



QRP-DPM Schematic

Meter Scale

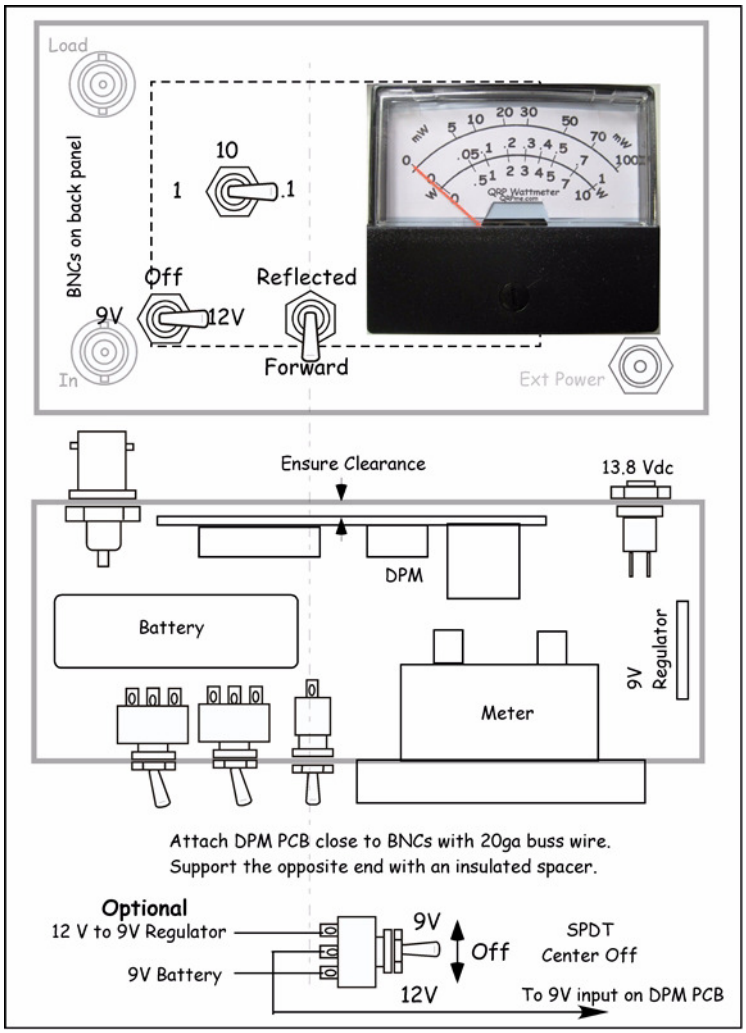
Suggested logathrimic power scales for replacing linear numbered meter scales.



Adjust the dimension across the mW scale arc to fit the meter being used. Be careful to change dimensions uniformally both vertical and horizontal.

The dimension from 0 to 100 where it crosses the arc for the HUA meter is 2 inches.

Enclosure (suggested)



Example installation sketch of the QRP-DPM in an LMB 136P enclosure, Mouser part number: Mouser # 537-136-P

[ ] Note power switch wiring if both internal and external power sources are used.

[ ] 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:
```

Power Equations:

Po = Vpk squared divided by 100 — using peak detector/50 Ohm Rload
Po = Vrms squared divided by Rload — using RF probe
Po = ((Vpk x 0.707) + 0.3) divided by Rload — measured Rload

Rload = accurately measured (or assumed) 50 Ohms
Rload = accurately measured, e.g., 51.6 Ohms measured with 0.8% DMM
Subject to component and measurement accuracy...
can be affected using assumed Rload values. A 51 Ohm 5% resistor can measure from 48.45 to 53.55 Ohms. With a scope-measured 20 Vpk, calculated power would be about 3.72 W to 4.12 W. With an assumed 50 Ohms Rload, calculated power would be about 4 W.