Norcal Power/SWR Meter
Assembly & Operating Manual

Revision 1A
6/9/2008

Copyright 2008
NorCal QRP Club

Contents

CONTENTS **2**
INTRODUCTION **3**
SPECIFICATIONS **3**
ASSEMBLY **4**
OPERATING GUIDE **16**
CIRCUIT DESCRIPTION **19**
PARTS LIST **20**

INTRODUCTION

The NorCal power/SWR meter is an in-line power meter, designed to measure from 0.1 watt to 9.9 watts at HF. A Stockton bridge is incorporated to measure the forward and reflected power, and SWR is calculated from the measurement. The power levels and SWR are displayed on LCD. The power/SWR meter also incorporates analog meter, which is connected to the reflected power. The fast and smooth response of analog meter is ideal for match box adjustment.

The power/SWR meter incorporates PIC 16F690 and power level can be displayed in multiple ways. The mode button cycles through four modes of display. Mode one is basic forward power, reflected power and SWR. Mode two displays the forward and reflected power in bar-graph. Mode three is peak envelope power for sideband. Mode four sends the forward power and SWR in Morse code for the visually challenged hams.

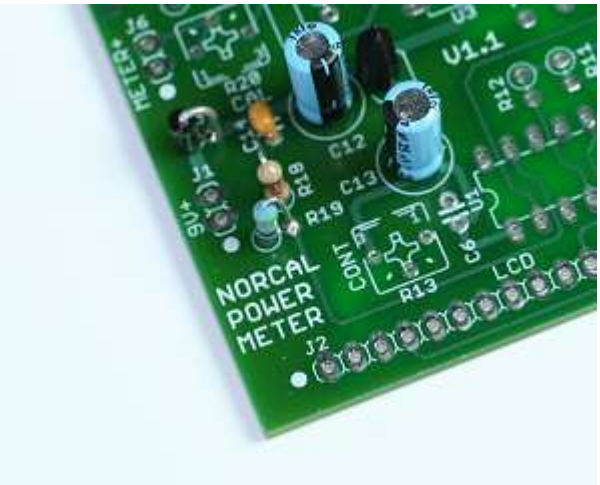
The kit is made of through-hole parts and comes complete.

SPECIFICATIONS

Frequency range	160m to 10m (useful to 6m with reduced accuracy)
Power level	0.1 watt to 9.9 watts
Accuracy	within +/- 10% for 0.5 watt to 9.9 watt
Insertion loss	0.1dB typical
Power	9V battery, less than 20mA
Dimensions	3” x 4 1/4” x 4 1/8” (HWD)
Connectors	BNC

ASSEMBLY

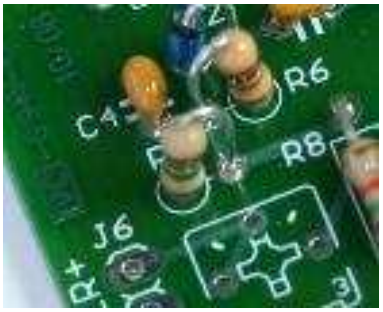
Insert the following components –
❑ D5 (1N5817) Bend the lead on D5, and observe the orientation
❑ C14 (0.1uF)
❑ C12 (10uF) Observe the orientation on C12
❑ U2 (LM78L05)
❑ Insert C13 (1uF) Observe the orientation on C13
❑ R18 (10K, 1% - brn blk blk red brn)
❑ R19 (4.99K, 1% - yel wht wht brn brn)
❑ Solder and trim the leads.



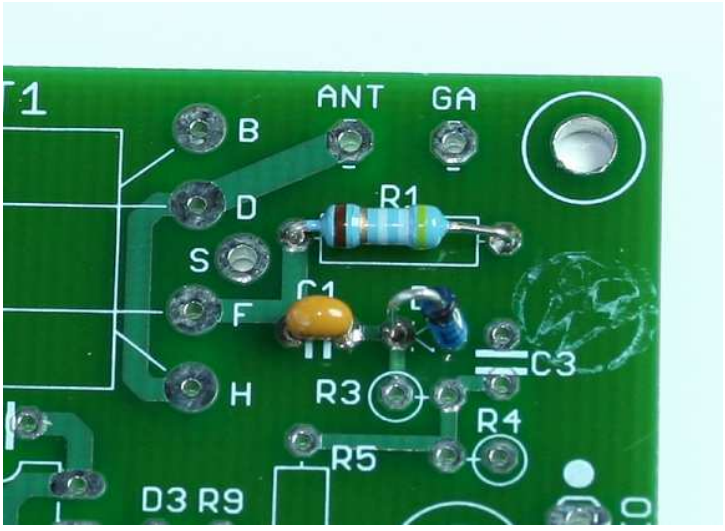
Test the voltage regulator by applying 9V to J1. Check the voltage at U1 pin 1. It should be +4.9 to +5.1V. 9V battery clip can be tack soldered temporarily at J1. Remove battery after test.

❑ Insert R2 (49.9ohm, 1%) – yel wht wht god brn
❑ C2 (0.01uF)
❑ D2 (1N5711). Observe orientation on D2
❑ Solder and trim the leads.
❑ Insert R1 (49.9ohm, 1% - yel wht wht gld brn)
❑ C1 (0.01uF)
❑ D1 (1N5711). Observe orientation on D1
❑ Solder and trim the leads

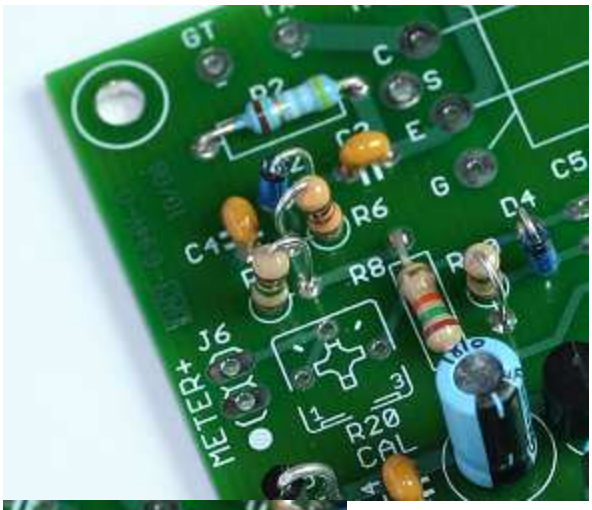
❑ Insert R6 (1K – brn blk red gld)
❑ C4 (0.01uF)
❑ R7 (1M – brn blk grn gld).
❑ Solder and trim the leads



❑ Insert R3 (1K – brn blk red gld)
❑ C3 (0.01uF)
❑ R4 (1M – brn blk grn gld)
❑ Solder and trim the leads

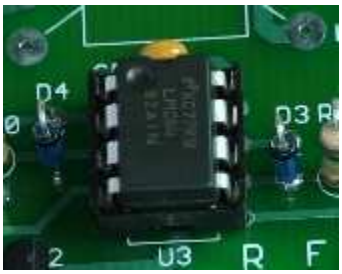


❑ Insert R8 (15K – brn grn org gld)
❑ R10 (150K – brn grn yel gld)
❑ D4 (1N5711). Observe orientation on D4
❑ Solder and trim the leads.



❑ R5 (15K – brn grn org gld)
❑ R9 (150K – brn grn yel gld)
❑ D3 (1N5711). Observe orientation on D3.
❑ Solder and trim the leads.

❑ C5 (0.01uF) Just in front of U3
❑ U3 (LMC6482A). Observe orientation on U3. Builder may elect to use socket for U3.
❑ Solder and trim the leads.



❑ R20 (20K trimpot) Bend R7 away if it obstructs.
❑ solder and trim the leads.
❑ Set the pot to mid range.

❑ R15 (1K – brn blk red gld)
❑ C8 (0.01uF)
❑ R14 (10K – brn blk org gld)
❑ R11 (10K – brn blk org gld)
❑ R12 (10K – brn blk org gld)
❑ Solder and trim the leads.

❑ R13 (5K trimpot)
❑ C6 (0.01uF)
❑ U1 socket. Observe orientation on socket.
❑ Solder and trim the leads.

❑ C7 (10uF electrolytic) Observe orientation
❑ C10 (0.1uF)
❑ C11 (0.1uF)
❑ R17 (1K – brn blk red gld)
❑ R16 (1K – brn blk red gld)
❑ C9 (10uF). Observe orientation on C9.
❑ Solder and trim the leads.

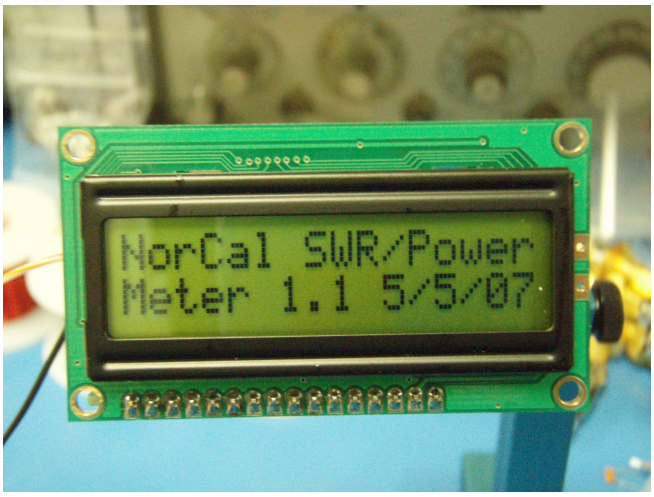
❑ Insert J2 socket and solder. Keep the connector parallel to the board. Trim the leads.

❑ Locate J8 header. It has 17 pins.
❑ Trim off one pin carefully.
❑ Insert the long end of pins to the LCD display.
❑ Solder on top side as shown below.

Here is the bottom side of the LCD display.

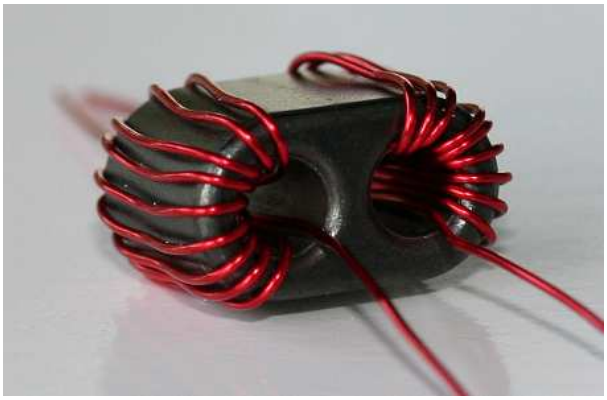
❑ Gently push the LCD display to J2 on the main board. It will be tight the first time.

❑ Locate U1 (16F690) and insert to the U1 socket. The leads will need to be bent in slightly to insert into the socket.
❑ Ensure all the pins are properly in the socket.
❑ Apply 9V to J1.
❑ Adjust R13 contrast for clear display on the LCD. Remove the protective cover from the LCD.



Congratulations! So far, so good. Remove the battery and **remove the leads from J1**.

We will now proceed to winding the Stockton bridge, T1.



❑ Follow each step slowly

❑ With the 22 ga red wire hold the core looking through the holes start the first turn by inserting the long end into the right hand core hole and bringing it out the back.

❑ Continue winding turns in a counter clock wise fashion until you have 10 turns of wire through the core. Keep the winding tight and ensure the wires do not overlap inside the core.

(**note: picture shows red wire for both windings, both red and green wire is provided in the kit**)

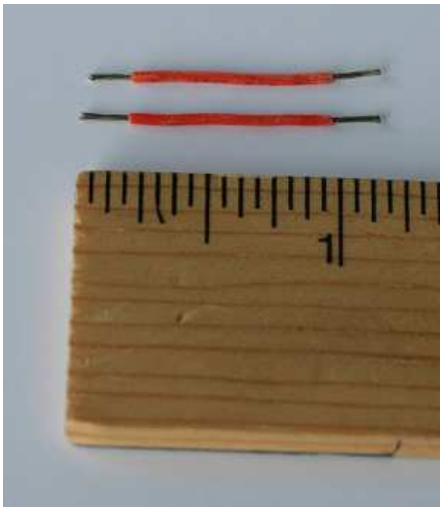
❑ With the 22 ga green wire hold the core looking through the holes start the other winding by inserting the long end of the wire into the left hand hole and bringing it out the back.

❑ Continue winding turns in a clock wise fashion until you have 10 turns of wire through the core. Keep the winding tight and ensure the wires do not overlap inside the core.

❑ Trim and tin the two leads on both sides.

❑ Insert the wires into ‘B’ and ‘H’ as shown.
❑ Solder and trim the leads.
❑ On the other side insert the wires into “A” and “G”
❑ Solder and trim the leads.

❑ Cut two insulated wire, each 1.1” long. Remove ¼” insulation.



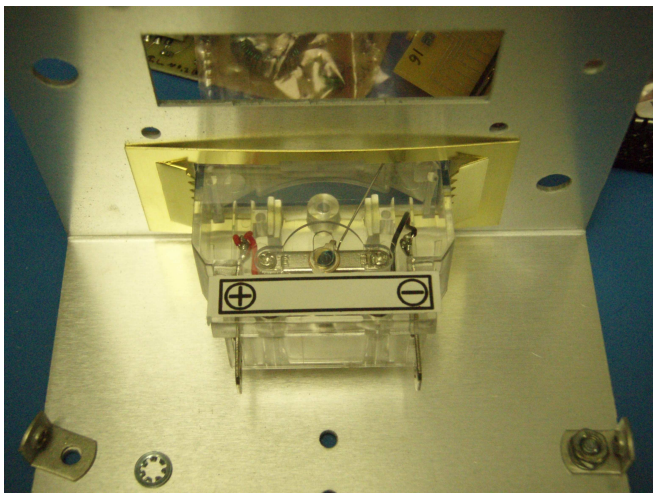
❑ Insert the two insulated wires into the core and to ‘F’ and ‘D’
❑ Solder and trim the leads. The antenna side is complete.

❑ Insert the insulated wire into ‘C’ and ‘E’.
❑ Solder and trim the leads. This is TX side.

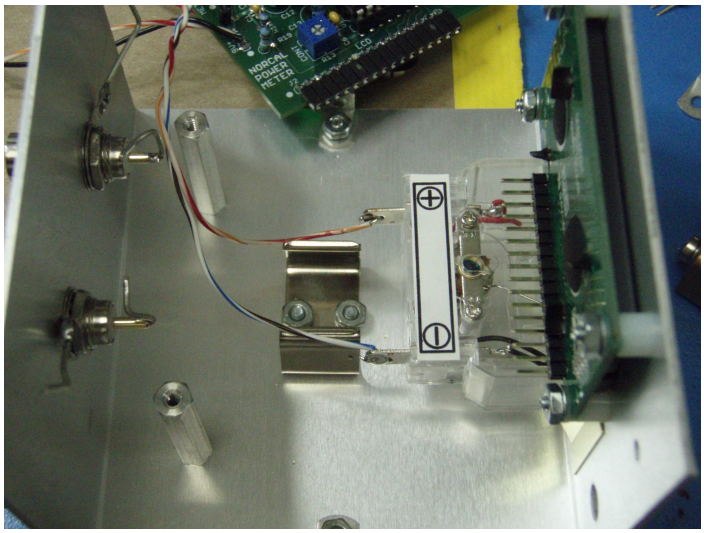
The bridge is now complete. This is what the core should look like soldered to the board.

We will proceed with the enclosure.

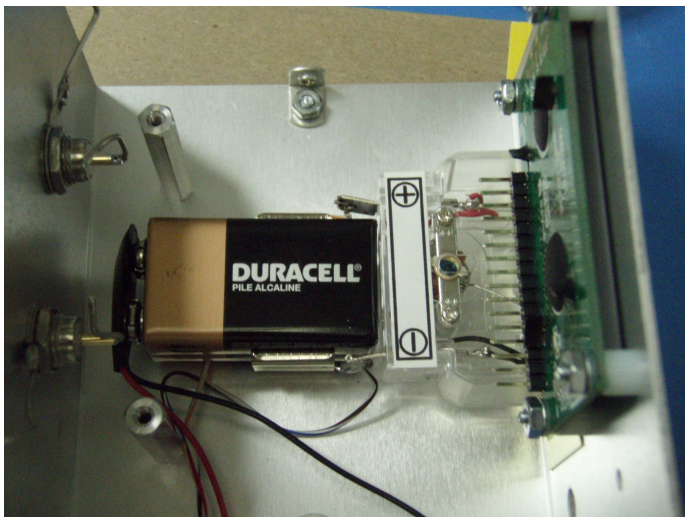
❑ Solder 7” wires to the meter terminals and mount the analog meter to the case. Mount the two enclosure brackets using short screws and lock washer. Use the non-tapped holes for the bottom. Solder the meter wires to J6. Make sure the positive terminal goes to ‘+’ on J6.



❑ Mount the LCD display using the long screws and spacer. Use nylon washer (to prevent scratching the board) and lock washer. It is easier to install lower two screws first; then install the top two screws.
Mount the battery clip, two metal spacers and BNC jacks. The battery clip holes are too small for the screw. Use 1/8” bit to enlarge the holes prior to installation. The bus wires can be soldered to the BNC now but it will be easier to solder them later.



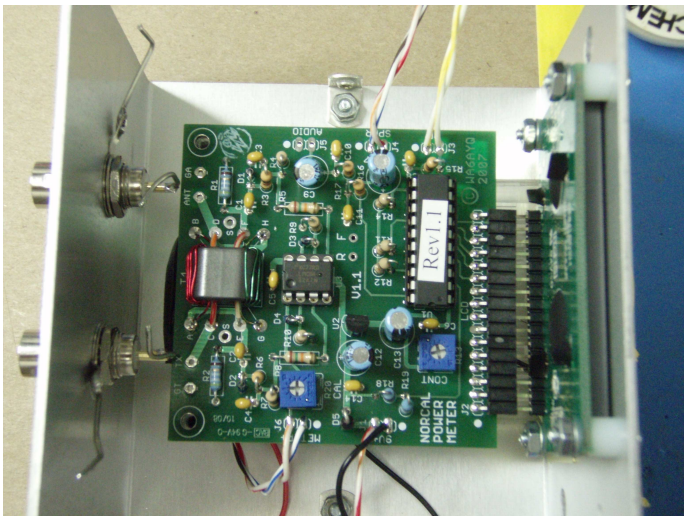
❑ Install the battery to the holder. Ensure the battery does not touch the analog meter terminals. They can be bent out slightly to prevent shorting.



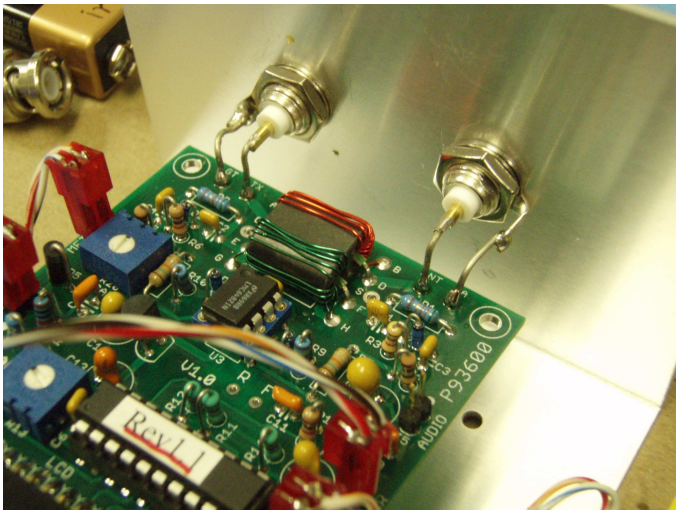
❑ Solder 3” wires to J3.
Solder 4” wires to J4.
Solder the negative lead (black) of battery to J1 with dot. Solder single 4” wire to J1, positive side.

Gently install the J2 header jack into LCD header pins. Ensure all the pins are installed.

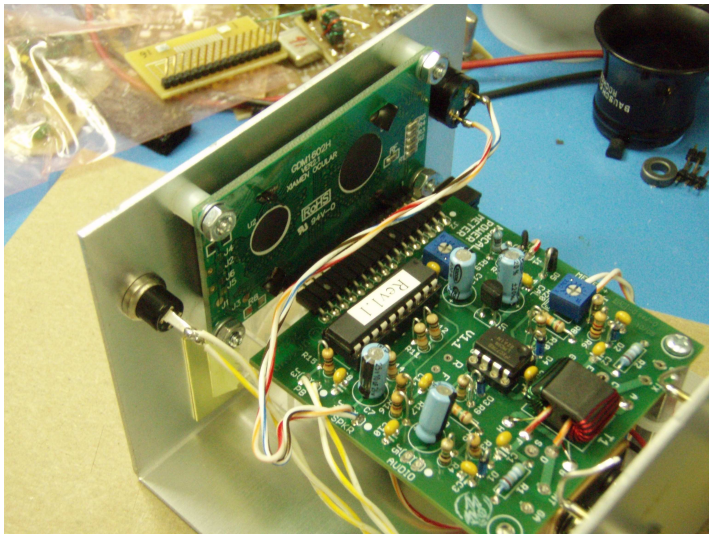
Install two short screws to the metal spacers.



❑ Solder the bus wires from BNC jacks to the board. The wires can be soldered to the top side pads. Trim the leads and inspect the solder joint!



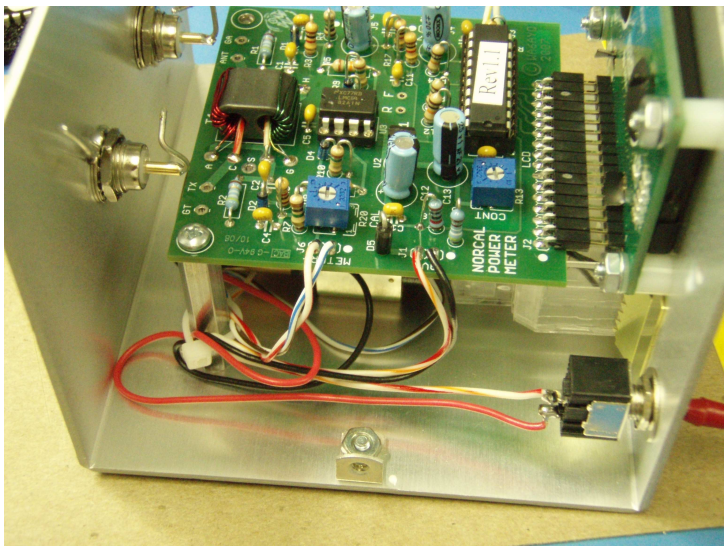
❑ Mount the push-button switch (left side on the picture) and speaker. I used Superglue on the speaker.
❑ Solder the wires from J3 ‘PB’ to the push-button switch. There is no polarity.
❑ Solder the leads from J4 ‘SPKR’ to the speaker. Note that ‘dot’ on J4 is negative.



❑ Mount the toggle switch as shown. Solder the positive lead (red) of battery to the switch terminal. Solder the wire from J1 ‘+’ to the other terminal on the switch. The wires can be bundled with tie-wrap, if desired.

Turn on the power meter and press the mode button. There should be two-tone beep.

Install four rubber feet at the bottom. Install the cover using two short screws.

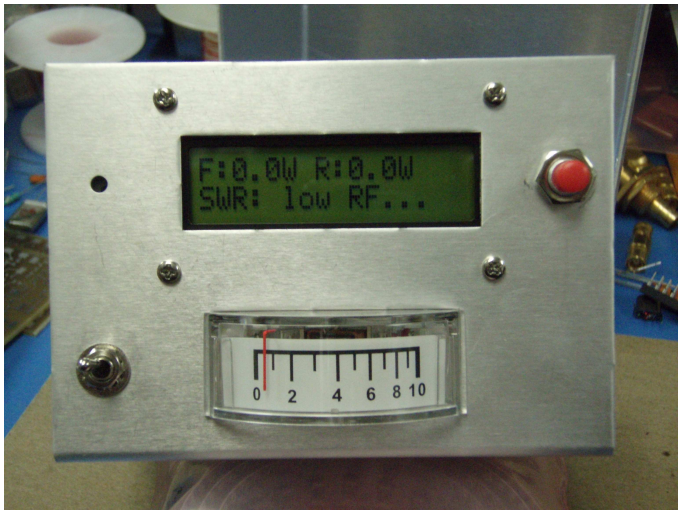


OPERATING GUIDE

The NorCal power/SWR meter displays the version and date at power up. It then displays the battery voltage and status. ‘Battery OK’ is displayed for higher than 7.9V. ‘Check Battery’ is displayed for lower voltage. The meter can operate down to 7.5V on the battery.

The NorCal power/SWR meter has four modes of display. It powers up at the last mode selected. Push button switches from one mode to next.

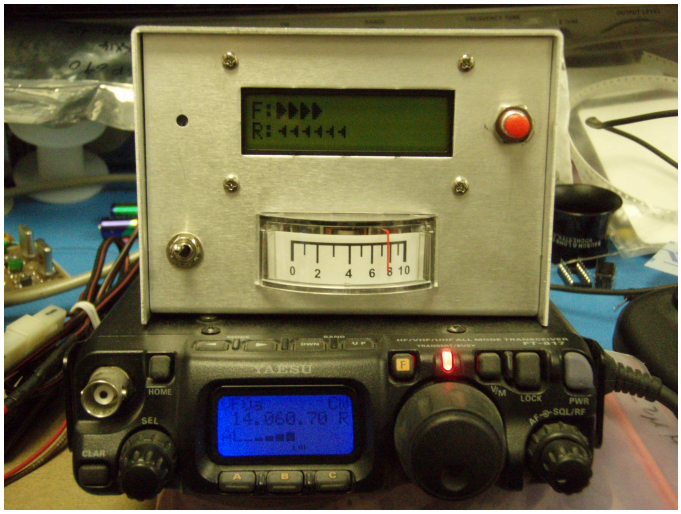
The first mode displays forward power, reflected power and SWR.



When the power is below 0.1W, SWR states ‘low RF…’ There is no warning for power higher than 9.9W. It is not recommended to exceed 9.9W.

Next display mode is bar-graph of forward power and reflected power. Depressing the push-button enables the mode. There is large right pointed triangle and small right pointed triangle. Each large triangle represents 1W of power and each small triangle represents 0.1W of power for forward power.
The reflected power is same but triangles are left pointed.

The example below shows 4W forward power and 0.6W reflected power. The test was achieved by 100ohm load at the output.



Depressing the push-button enables the next display mode, SSB peak power:

The peak detection is performed by software. 30 samples are taken at 200uS interval and the highest amplitude over sample is display on the top line. It is continuously updated. The bottom line is ‘hold’ function, displaying the highest amplitude over all the samples. The normal voice modulation will be far below the specified power level of the rig. Whistle into the microphone to obtain the maximum output level.
The ‘hold’ value resets to zero once you move to next display mode.

The last display mode outputs the forward power and SWR in Morse code.

When you enable this mode, ‘OK’ is sent in Morse code. The forward power is sent first in following sequence: ‘P’ ‘4’ ‘period’ ‘9’ from above example. Then SWR is sent in following sequence: ‘S’ ‘1’ ‘period’ ‘1’. It repeats the power and SWR until you exit this mode. Hold the push-button to exit. The entire Morse code sequence must be completed prior to exiting.
The code speed is set to approximately 10WPM.

CIRCUIT DESCRIPTION

A Stockton bridge is used to sample the forward and reflected power. The coupling is determined by the number of primary to secondary turns. It is 1:10 ratio and 20dB coupling is achieved. 1W of power will produce 0.01W at the output of the bridge.

49.9ohm, 1%, resistor provide termination to the bridge. The RF power level is converted to DC voltage using compensated detector consisting of D1, D3, U3B and associated components. The DC voltage is read by PIC 16F690, which has analog to digital converter.

The reflected detector is exact duplicate of forward detector. The SWR is calculated by the PIC using the two voltages. An analog meter is attached to the reflected detector. It has smooth fast response compare to the digital display. It is ideal for match box tuning. Adjust the match box for dip in the meter for lowest SWR.

The movement of meter will depend on the power level and SWR. I set R20 so that meter reads '10' with 5W of power and 3:1 SWR. R20 is close to middle position for this condition.

D5 is reverse battery protection. U2 is +5V regulator. R18 and R19 is a 3:1 voltage divider. It is connected to the PIC and ADC. The voltage is read at power up and displays the battery status.

A push-button is connected to pin#11 on the PIC via the de-bounce circuit, R15, C8 and R14. There is software de-bounce function as well.

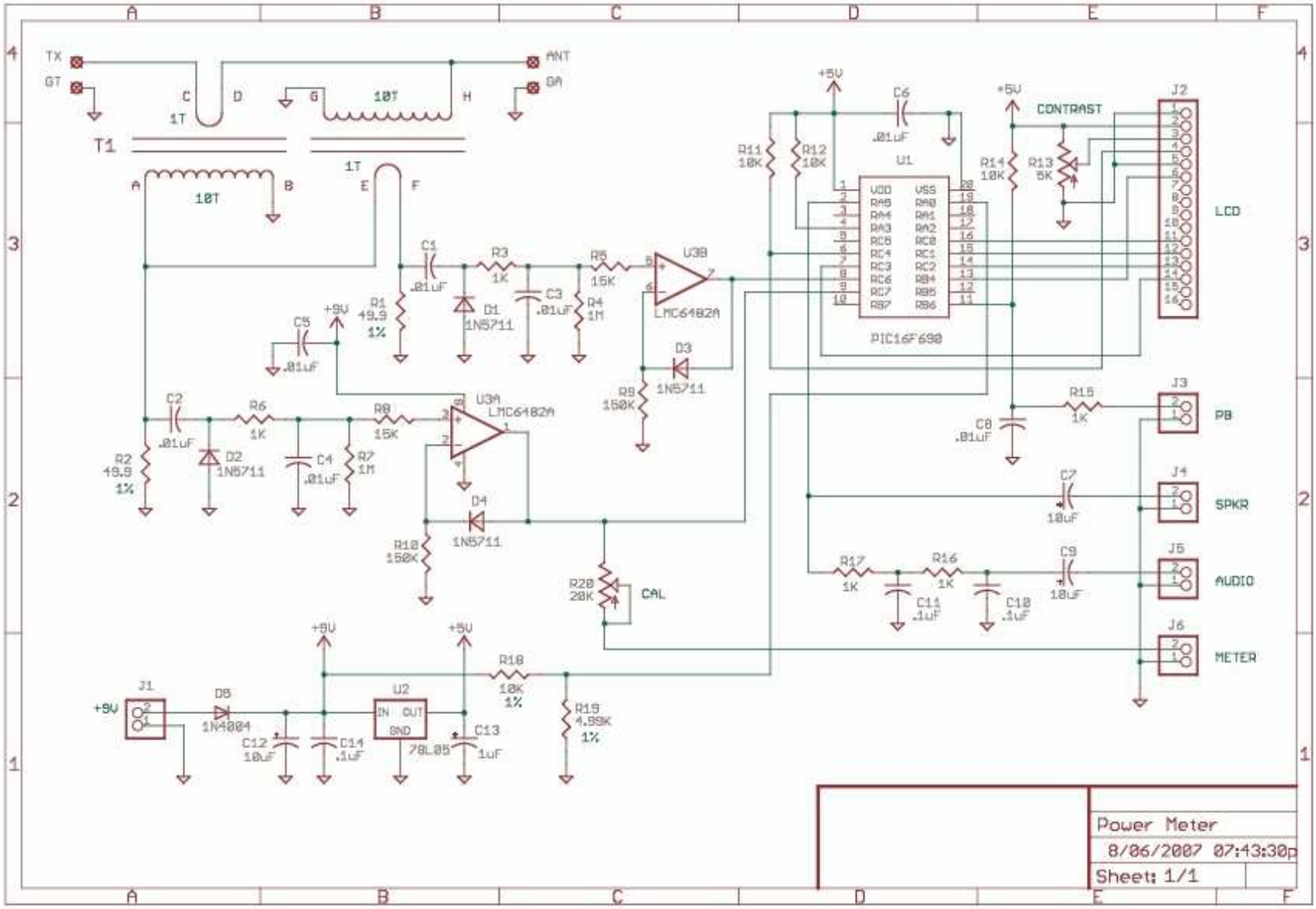
The speaker is connected to pin#2 on the PIC via C7. The output is square wave and provides the Morse code tone. R17, C11, R16 and C10 is low pass filter set to approximately 1KHz. The audio output, J5, can be connected to audio amplifier for larger volume. There is ample space to add larger speaker and amplifier (such as LM386) in the enclosure.

16F690 PIC was selected for large program memory (4K), 12 channel 10bit ADC, internal oscillator (8MHz), and 256 bytes of EEPROM.
The software was developed using PIC Basic pro compiler.
The PIC was programmed using PICKIT2 from Microchip.

Parts List

Reference designator	Value	Marking
C1, C2, C3, C4, C5, C6, C8	0.01uF	0.01 or 103
C7, C9, C12	10uF electrolytic	10 or 106
C13	1uF electrolytic	1 or 105
C10, C11, C14	0.1uF	0.1 or 104
D1, D2, D3, D4	1N5711	1N5711
D5	1N5817	1N5817
J6, J7	BNC jack	
J8	17 pin header	
J2	16 pin right angle socket	
M1	100uA meter	
R1, R2	49.9ohm 1%	yellow, white, white, gold, brown
R3, R6, R15, R16, R17	1K 1/4W 5%	brown, black, red, gold
R4, R7	1M 1/4W 5%	brown, black, green, gold
R5, R8	15K 1/4W 5%	brown, green, orange, gold
R9, R10	150K 1/4W 5%	brown, green, yellow, gold
R11, R12, R14	10K 1/4W 5%	brown, black, orange, gold
R20	20K trim pot	20K or 203
R13	5K trim pot	5K or 502
R18	10K 1%	brown, black, black, red, brown
R19	4.99K 1%	yellow, white, white, brown, brown
SP1	piezo speaker	
SW1	SPST switch	
SW2	push button momentary switch, normally open	
T1	BN-43-302, binocular core	
U1	16F690 PIC	
U4	LCD display	
U2	78L05 voltage regulator	
U3	LMC6482A dual op amp	
N/A	20 pin socket for U1	
9V battery clip		
PCB		
Case	2 mounting brackets included	
3/16" nylon standoff	Qty 4 for LCD display	
4-40 x 0.5" screws	Qty 4 for LCD display	
#4 nylon washer	Qty 4 for LCD display	
4-40 nuts	Qty 6, 4 for LCD display, 2 for battery clip	
4-40 x 0.25" screws	Qty 6, 4 for case mount, 2 for PCB mount	
4-40 x 1.25" threaded standoffs	Qty 2	
#4 lock washer	Qty 6, 4 for LCD display, 2 for PCB mount	
rubber feet	Qty 4	
9V battery holder	Qty 1	

26 ga enamel wire	12" each of red and green
22 ga insulated strand wire	24" each two colors
insulated stranded wire	two colors, 20 ga, 24" each
bus wire, 20 ga	12"


TX
GT
ANT
GA
T1
1T
10T
C1
.01uF
R3
1K
R5
15K
U3B
LMC6482A
R1
49.9
1%
D1
1N5711
C3
.01uF
R4
1M
C5
.01uF
+9V
D3
1N5711
R9
150K
C2
.01uF
R6
1K
R8
15K
U3A
LMC6482A
R2
49.9
1%
D2
1N5711
C4
.01uF
R7
1M
D4
1N5711
R10
150K
R20
20K
CAL
+5V
C6
.01uF
U1
PIC16F690
R11
10K
R12
10K
R14
10K
R13
5K
CONTRAST
J2
LCD
R15
1K
C8
.01uF
J3
PB
C7
10uF
J4
SPKR
R17
1K
R16
1K
C11
.1uF
C10
.1uF
C9
10uF
J5
AUDIO
J6
METER
J1
D5
1N4004
U2
78L05
C12
10uF
C14
.1uF
C13
1uF
R18
10K
1%
R19
4.99K
1%
Power Meter
8/06/2007 07:43:30p
Sheet: 1/1