

Autek Research

WM1 SWR/WATT METER



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INSTRUCTIONS

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Your new WM1 SWR wattmeter has been thoroughly tested twice before shipment. Please read the instructions carefully for best results, and save them for future reference.

POWER

The WM1 needs +9 to +18vdc (**coax power jack-center is NEGATIVE***) at approximately 15ma (one manual says 100-200 with meter lights). Be sure adaptor meets this range with a light load. One listed as 9vdc, actually produced 21vdc without the meter lights, and still 16.5 with them. The better alternative would be a regulated 10-15vdc adaptor with an in-line fuse (250ma or so). Plug the 115 vac adaptor into the jack at the left rear. Note you might need to adjust the SWR infinity setting if you use a supply different than you have in the past (Calibration procedure, step 4).

The WM1 may also be powered from a battery. A 9 volt battery is marginal, but usable. The first effect of reduced voltage is that the SWR reading cannot reach infinity, but will still be accurate at lower readings. The meter will typically read SWR to 3:1 with B+ as low as 8 volts, and accurately indicate power as low as 7 volts. In 220 volt countries obtain an AC adaptor locally as we do not carry them. If using small batteries you may want to clip one lead to the Power LED (does not void warranty) since the LED consumes about 2/3 of the power (only applies to WM1 without meter lights).

RF HOOKUP

Connect the transmitter to the coax connector so marked. Connect the antenna coax or antenna tuner to the output connector. (If these are reversed, the meter reads reflected, not forward, power and the SWR reading will be off scale).

OPERATION

Select the lowest range scale for power in use. Then select AV (Average) or PEAK (PEP). PEP stands for “peak-envelope-power” and shows the peak output power, even if this peak lasts only a few milliseconds. PEP is measured by electronic circuitry which responds much faster than the meter. (The meter takes a fraction of a second to move to the internal electronic true PEP power). Note that SWR is computed automatically and displayed directly, unlike virtually all other meters on the market. There is no need to do a full scale adjustment or compute SWR with a nomograph. Any variation of SWR reading with power level is due to a small voltage drop in the diodes in the RF head. (The small box). This phenomena occurs with virtually all meters in the under \$500 class.

The indicated SWR will drop noticeably at 1/10 full scale, and at even higher scale readings on the 20 watt scale. However, the meter is usable for nulling antenna tuners and checking general antenna condition at powers as low as ½ Watt or lower.

USE THE LOWEST RANGE SCALE THAT DOES NOT PEG THE POWER METER FOR MOST ACCURATE READINGS.

When using “PEP” you may be surprised to find that PEP reading on SSB is not much different than the PEP or AV reading with “key-down”; THIS IS NORMAL. Modern SSB transmitters with compression and/or ALC are peak-power limited on SSB and CW.

When sending a string of dots, you will probably notice an increase in PEP (vs. key down). This is due to a slightly smaller drop in transmitter power supply voltage, yielding increased peak power.

PEP is generally used on SSB, and AV is used for Tune-up. Switching to AV on SSB produces a noisy, low SSB power and SWR reading. The PEP feature also allows you to comply with latest FCC rules allowing 1500 Watts PEP OUTPUT on many bands and for most classes of licensees.

The SWR reading in the PEP position will be accurate for reasonably continuous speech, but is designed to decay much faster than the PEP power reading. This allows almost instant response to antenna tuner adjustments when talking on SSB. Incidentally, try this: transmit a continuous carrier on CW (key down); note the power reading in the AV position, then switch the WM1 to PEP.

You’ll probably notice a slight increase in PEP. No, the PEP detector isn’t wrong: you’re measuring the increase in PEP power caused by the tiny ripple on your power supply voltage.

Occasionally, you may want the meters to decay faster when switching to a lower range scale. Simply switch momentarily to AV, which will discharge the PEP circuit.

CALBRATION

Your WM1 is calibrated using an air-cooled 1 KW 50 Ohm +/- ohm “drift less” load and a special technique to measure power which is accurate to less than ½ percent. It is unlikely you have equipment of this accuracy. (Two 5% instruments can disagree by as much as 10%). For example, dummy loads commonly used by hams can vary from 38 to 63 ohms in our experience, even though specified as accurate to 5%. Worse yet, most drift 10 or more ohms when heated: The complete calibration procedure is shown below. (Note: steps 1, 3 and 4 may be done without fear of degrading factory accuracy. Step 1, in particular, may have to be performed occasionally).

Calibration Procedure

1. With DC power applied to the WM1 (LED lit), but your transmitter off, mechanically zero both meters with the front-panel meter screws using a screwdriver.
2. Connect the remote head to your transmitter and to a load known to be 50 ohms resistive at the frequency transmitted (a 40 ohm load, for example, which is off by 20%, would cause power calibration to be off by 20% at 50 ohms, and SWR would not read correctly). You should preferably transmit on 40 meters (7 MHz).
 - While transmitting a carrier, adjust the trimmer capacitor in the remote RF head (C1 in older version of head, C6 in newer version) until the SWR reads 1:1 or as close as possible. Use 20-200 watts if possible.
3. Reverse coax connections to the RF head, so that your transmitter is connected to the output and the load is connected to the input. Disconnect one wire going to the SWR meter to avoid pegging this meter.
 - You're now reading reflected power, which is much more sensitive than SWR. Touch up the trimmer to yield lowest power reading.
4. Reverse coax connections to the RF head again so that the transmitter is connected normally to the input. Reconnect the wire to the SWR meter. Disconnect the load from the RF head output, leaving NOTHING connected to the RF head output coax connector, not even a short length of coax.
 - Transmit less than 200 Watts CW (no linear) and adjust the SWR trim pot on the circuit board (see drawing) so that the SWR meter reads infinity (full scale). Do this on 40 meters if possible, for best accuracy.
5. Connect your accurate 50 ohm load as in step 2. With a power meter of known accuracy in series with the WM1, adjust the PWR trim pot on the circuit board (see drawing) until the WM1 reading agrees with the reference power meter. Be sure SWR is 1:1.

OPERATING CAUTIONS

Never run the WM1 at an SWR greater than 4:1 with power greater than 300 watts. This could possibly burn out the RF head, which is not covered by warranty. These limits are quite conservative. Your linear is likely to arc-over before the WM1 is damaged. However, to be safe, check SWR before switching on your linear. Never short the WM1 RF head output; this could melt the RF wire in the head.

IN CASE OF TROUBLE

- *METER DAMAGED*

This is extremely rare. Damage is not always evident by looking at the unopened box. All shipments are insured. Keep the original box and packing material and report damage to the shipper (usually UPS). Once you do this, you will not have any problems collecting. We do this for you, and will ship a replacement upon receipt of the damaged equipment.

- *METER DEAD. POWER OR SWR READING TOO LOW*

Check power source. Be sure meter has a DC supply attached as in section A, and that the voltage is proper. Note: AC adaptors are tested by the manufacturer, not by us. Should you receive a bad AC adaptor, write or call and we'll get you out a good one immediately.

Examine the RF head. If you've shorted the head output the wire through the toroid may have overheated. Simply replace the wire.

If you've subjected the head to high SWR at high power, the white portion of the trimmer capacitor may be cracked or singed. We can send you a replacement for \$5 ppd USA.

If you've shorted any RF head board component to either coax connector, say while adjusting the trimmer, you've probably blown both diodes. Replace these with any GERMANIUM diode, available at Radio Shack. 1N34, 1N270, and others are suitable.

Damage to the RF head, especially the trimmer capacitor, can also be caused by lightning. A direct strike is not necessary. This is also not covered by warranty. Again, note that simply replacing the damaged component and a minor recalibration is sufficient (unless the toroid or 33 ohm resistors are damaged).

- *SWR READING TOO HIGH/POWER TOO HIGH*

- 1) Be sure input and output on RF head are not reversed.
- 2) If this occurs only at high power and is more apparent in PEP position, it could be arcing (spark) in your transmitter, linear, or antenna.
- 3) RFI. See below; could also cause low readings.

- *ERRATIC READING WHEN TOUCHING CASE. READING VARIES WHEN WM1 IS MOVED TO A DIFFERENT POSITION ON THE TABLE.*

This may indicate RF flowing in cables or the power connected to the main meter box, or direct RF pickup.

The WM1 is extensively tested in a high power RF environment. However, extreme or unusual conditions might exist in some shacks which could cause a problem (we test at 1 KW with the antenna only 15 feet away with no problem).

Be sure the meter is not near unshielded feed lines or coils carrying power. The top of the antenna tuner or linear may not be the best location. If readings vary as the main meter cabinet is moved around, the problem is probably direct radiation into the unit. Find a good location or reduce the radiation from the source.

More likely it is a ground loop. If the meter reading does not vary when moved several feet, suspect ground loops.

Transmitted power can be picked up by the house wiring and flow from the AC adaptor through the WM1 chassis and back to the remote RF head. (Using a small battery would eliminate this possibility). Unplug the AC adaptor from the wall socket. The WM1 will continue to operate for a second or two. If the reading instantly changes when unplugged, you probably have a ground loop.

Try:

- 1) Plug the AC adaptor into an outlet away from the transmitter.
- 2) Connect a good earth ground to your transmitter or linear.
- 3) Move the WM1 to a different location.

Note that sending the unit back to “checkout” is useless, since we will find nothing wrong with it. If you experience persistent RF pickup with any Autek equipment, send a 9” + wide SASE for a more detailed discussion. We realize it can be quite frustrating at first if you have this problem, but fortunately, this is rare, and we know of no one who has not been able to solve it.

- *METER “STICKS” AT ONE READING OR CANNOT GO BEYOND A CERTAIN READING*

This could be caused by low B+ or battery voltage. See POWER section.

On at least one occasion, a microscopic piece of the meter plastic molding has broken off and lodged itself in the meter movement. The solution is simple: turn the WM1 upside down and shake the obstruction out of the movement. If problem reoccurs, remove the two screws which hold the front panel of the meter, remove the clear front panel, and shake the obstruction out.

We believe this problem is eliminated and would appreciate a postcard if you experience it so we can tighten quality control further.

- *OTHER PROBLEMS*

See our ongoing “late notes” for reports of common problems, if any, as well as tips from owners.

THEORY OF OPERATION

See schematic/block diagram. The RF head operates as follows:

Capacitors C1 and C5 form a voltage divider for RF voltage at the head output. Toroid L1 measures the current flowing into the load and impresses a voltage across the 33 ohm resistors proportional to this current. Voltage at the left of R1 is proportional to voltage across the load plus current into the load. Voltage at the right of R2 is proportional to voltage across the load minus current into the load. (Voltages at opposite ends of the toroid are 180 degrees out of phase, as with all transformers). These RF voltages are rectified by the diodes and converted to DC values. With a 50 ohm load, C1 (C6 in later version) is adjusted to null out the voltage between D2 and the 5V reference—this voltage is proportional to the Square root of “reflected power.” Similarly the voltage between D1 and the 5 V reference is proportional to “forward+ reflected” power, theoretically. With any load other than 50 ohms resistive, the reflected power is non-zero and SWR is above 1:1. Note that all voltages in the RF head are referenced to a regulated 5 volts from the main circuit board, not ground. The drawing shows a block diagram of the main circuit board. Forward and reverse voltages are scaled for the power range selected and peak detected by active peak detectors, not just diodes.

The peak detectors have negligible error (less than 0.1%). The forward and reverse voltages are then divided in a wide range electronic divider circuit accurate to 0.2% or better, and drift-free due to the precision resistors and voltage regulator used. Autek Research has supplied complete schematics on all other products. If you’ve purchased our products before, you’ve noticed they have significant technology advantages, and are usually less expensive than similar devices as well. As a result, our engineering has been at least partially copied with a similar design. Often this “copy” is so poor that it not only costs us sales, but raises doubts about the quality of our product by inference. (“I tried aactive filter and it didn’t work very well, so no need to try Auteks”, etc).

As a result, we’re sorry we can’t supply a complete schematic of the proprietary circuitry in the WM1. However, service is available at a very reasonable cost.

TYPICAL PERFORMANCE

- Impedance: 50 ohms
- Insertion VSWR: Less than 1.1:1
- Accuracy: 5% FS (8% worst case) 10% of reading to 0.2 FS
- Insertion loss: Negligible
- SWR Computation: Less than 10% drop at 3:1 at 10 watts
 - (20 watt range scale) usable to ½ Watt or less.
 - PEP charge time (internal): 20 ms or less.
- Frequency range: 1.5 to 30MHz.

WARRANTY

We back our products better than most companies—not just 90 days, but on full year.

LIMITED ONE YEAR WARRANTY: Autek Research warrants to the original consumer purchaser that its products shall be free of defects in workmanship and materials from one year from the date of purchase.

WARRANTY LIMITATIONS: Any components of the RF head which could be burned out operating at high SWR and Power are not warranted. This includes, but is not limited to, the trimmer capacitor. This limited warranty does not cover, and we are not Responsible for, any product which has been modified by the owner, except as provided for in the instruction or any malfunction or failure resulting from improper use, improper voltage, lightning, improper service or repair by the owner or his agent, or from abuse, neglect accident, fire, use contrary to instructions, or other causes beyond the control of Autek Research. This warranty is made to the original consumer purchaser only, and is effective only upon presentation of documented evidence of provable date of purchase. This warranty covers only Autek products used for purposes as advertise. We are not responsible for Incidental or consequential damages. Some states do not allow exclusion or limitation of incidental or consequential damage, so the above limitation or exclusion may not apply to you. This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

SERVICE AND RETURNS

To obtain service, FOLLOW THE CHECKLIST BELOW, then mail to Autek Research, Box 302, Odessa, Fla. 33556. Our records show your order, by date of order, if you wish to claim warranty service, you must do so with the return. You must tell us your purchase date WITHIN 10 DAYS, or enclose a copy of check or charge statement. (Simply stating "I bought the unit a few months ago" is not sufficient to find your order, and service charges automatically apply). Our minimum service charge is \$17 in U.S.A. Enclose an additional \$15 outside US, except an additional \$5 in Canada. We fix 75% of failures for the minimum, and will proceed to \$28 without your permission. Any additional charges will be COD. Please, use no charge cards on repairs, as this causes a delay.

CHECKLIST WHEN RETURNING A UNIT

1. Do not send correspondence, check, etc. separately. PUT EVERYTHING INSIDE THE PACKAGE WITH THE WM1. Enclose a check or M.O. inside the package.
2. Enclose a detailed description of problem inside the package.
3. Do NOT send separate correspondence explaining that you are returning the unit, or asking permission to return it. This is not necessary.
4. Allow 1-3 weeks for repair plus up to 2 weeks shipping times. Exception: if you just got the unit we'll normally ship a replacement after confirming improper operation or damage. (Only 1 in 4000 packages are ever lost. If repair takes longer, be patient. It's not lost, we're working on it!).

IF WRITING:

1. Always give approximate purchase date. We may have made a change in design since.
2. Give full details of problem. Be sure to tell us your transmitter, linear, feed line type, antenna and antenna height. We want to help you, but most letters are too vague. We have no idea of the condition of your rig, your ability to follow instructions, your technical knowledge, and what you've tried to solve any problem, and no desire to carry on extensive correspondence. Include all details in the first letter.
3. We cannot comment on ANY modifications to our equipment as inventive hams would make this a fulltime job.
4. Enclose an 8 1/2" wide SASE for a speedier reply (OK to fold envelope).

LATE NOTES

None to date. ojm

Schematics & Layouts

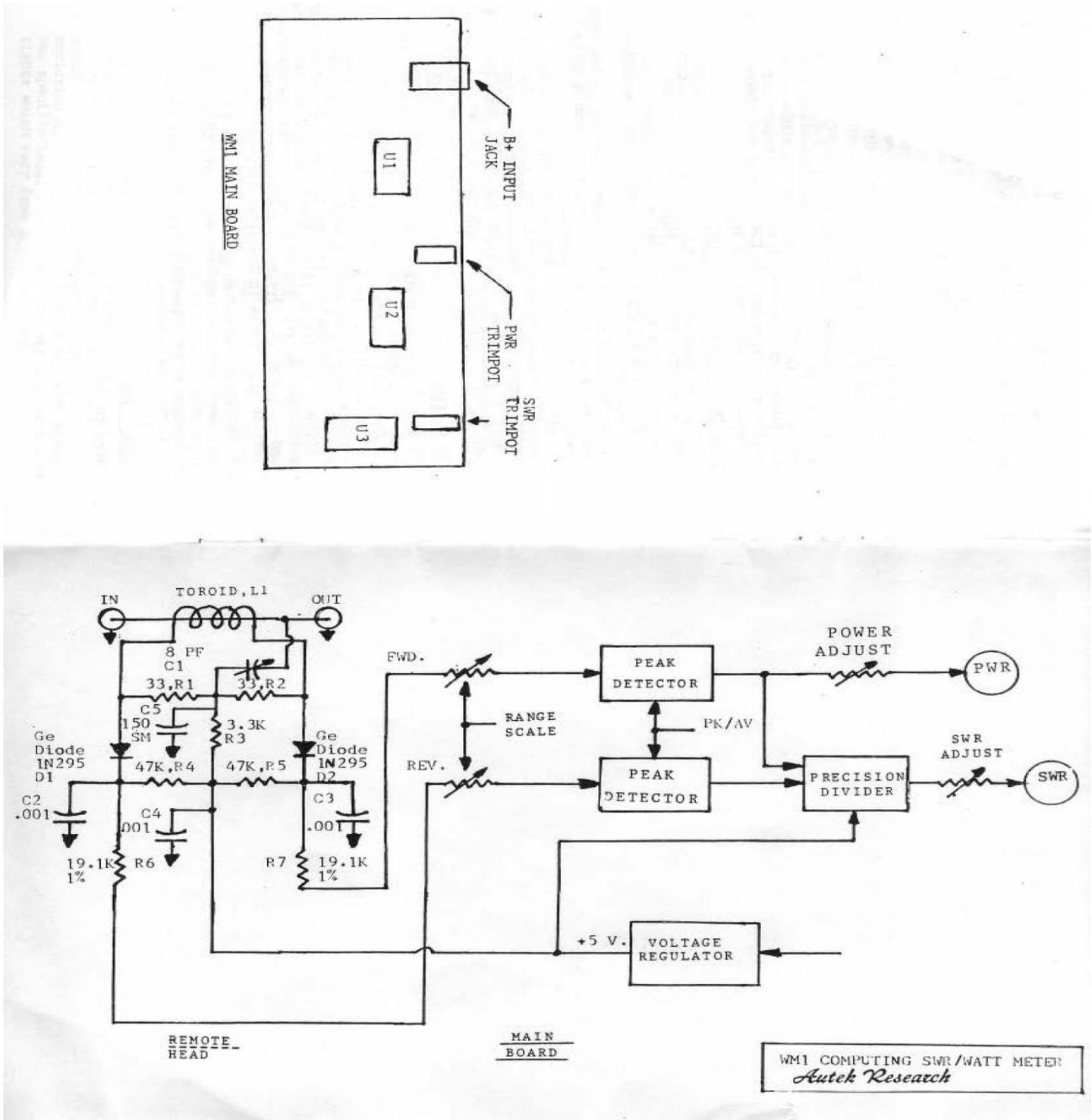


Fig 1 - Older version of Head schematic and Block Diagram from printed manual.

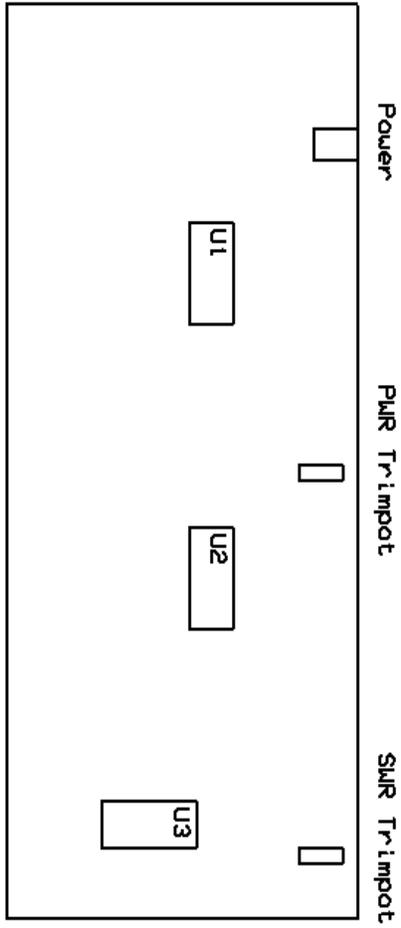
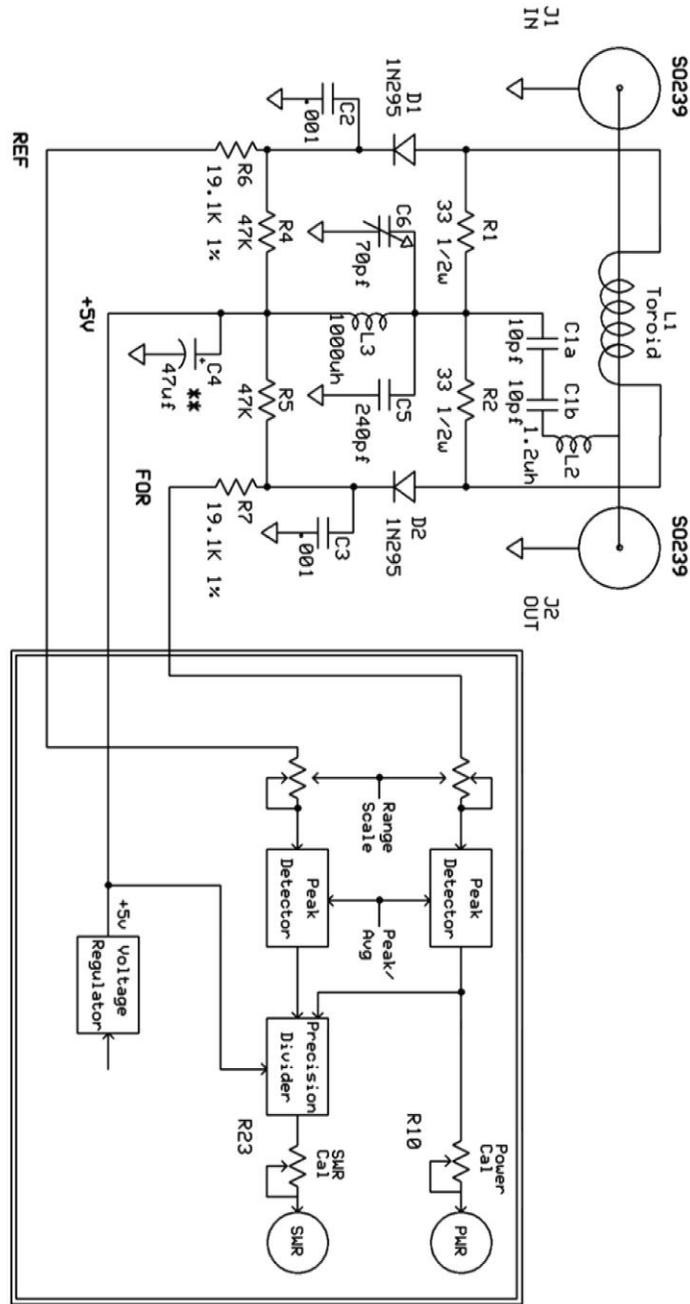


Fig 2 - WM1 Main Board

WM1 Remote Head



Main Board Functional Diagram

Fig 3 - WM1 - Newer version of Head and Block Diagram – Redrawn. See schematic for notes on Remote Head differences.

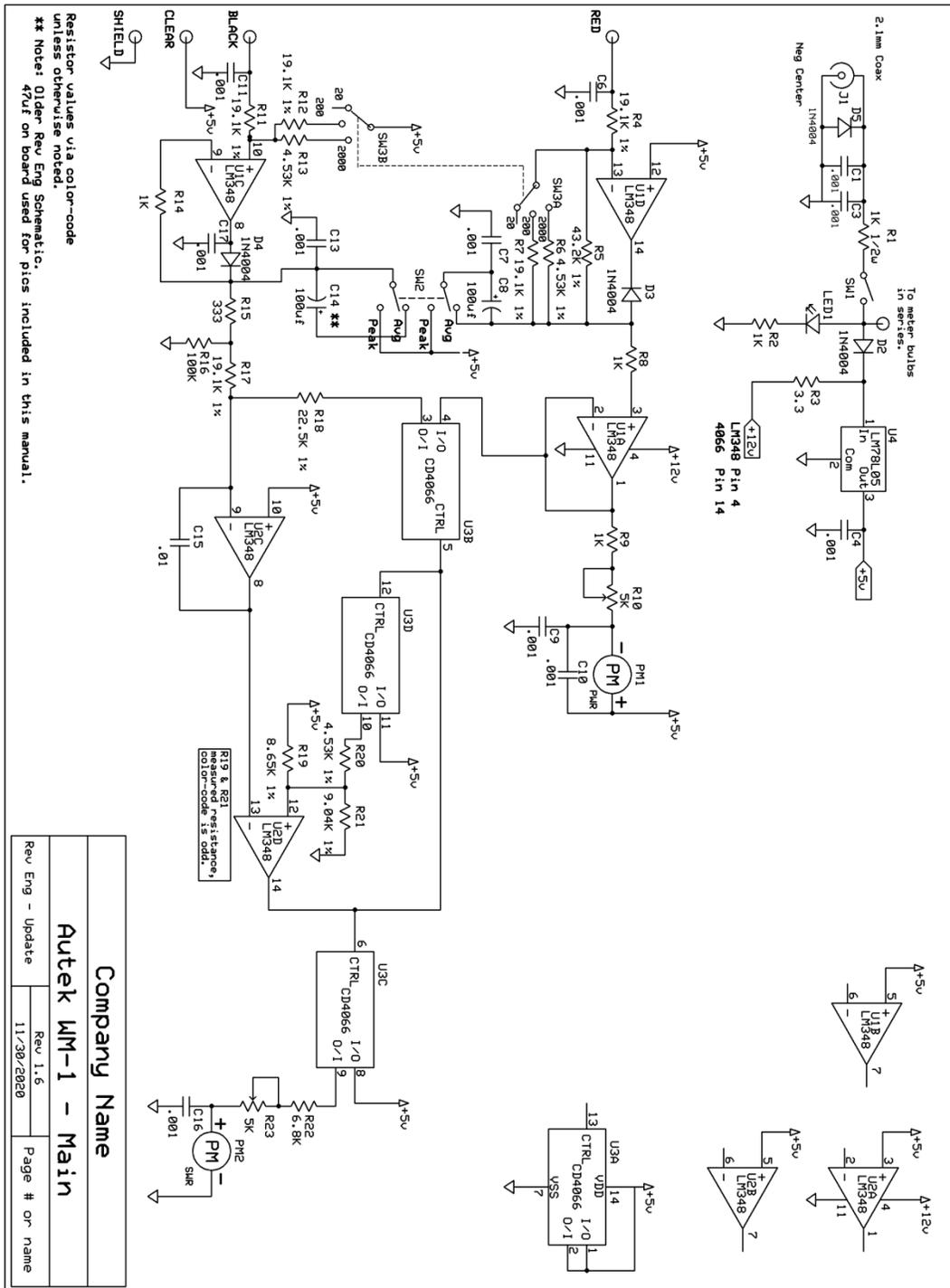


Fig 4 - WM1 Main Board Schematic (updated from earlier Rev Eng version). Resistor values based on color-code. See parts list for more details.

Note: With the exception of U1, U2 and U3, part designations are not Auttek's original; they have been assigned. Gaps in a series indicate an alternative may have existed, it's not accidental. Each meter has a .001uF cap across the terminals as well as the ones on the Main Board (indicated on the schematic).

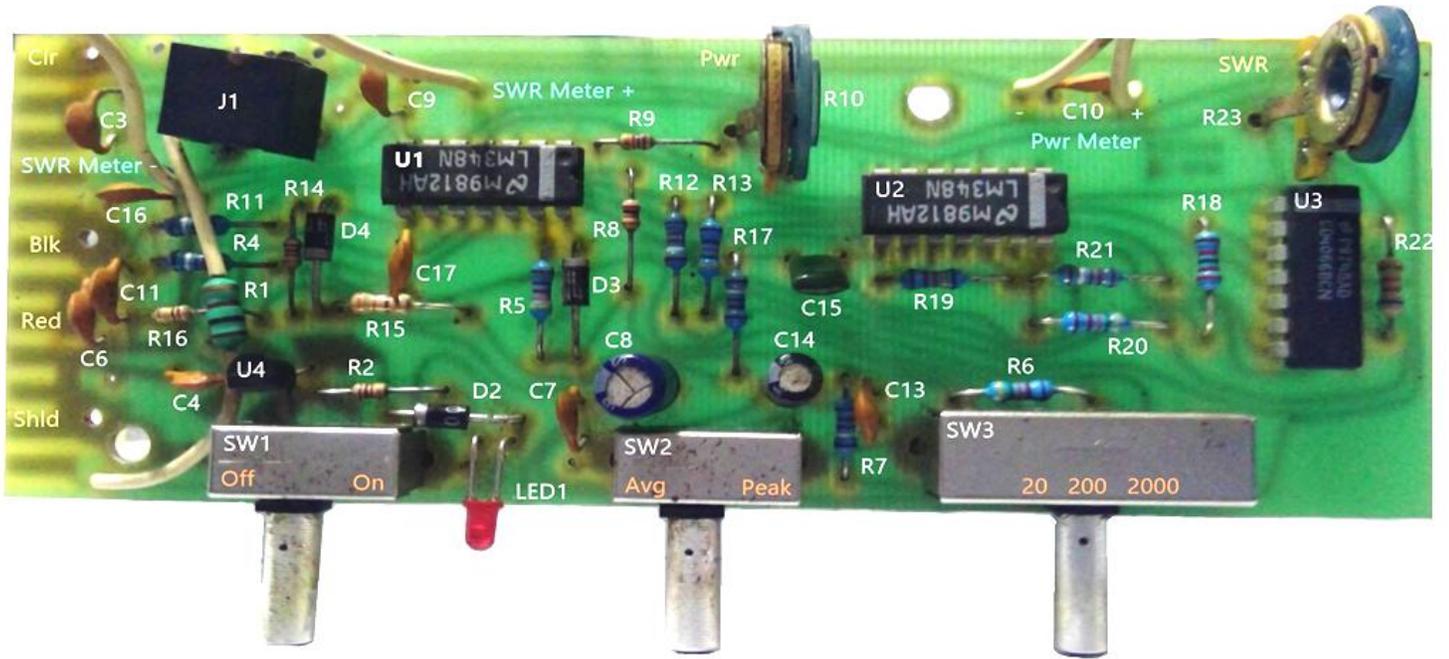


Fig 6 - WM1 Main Board – Top View

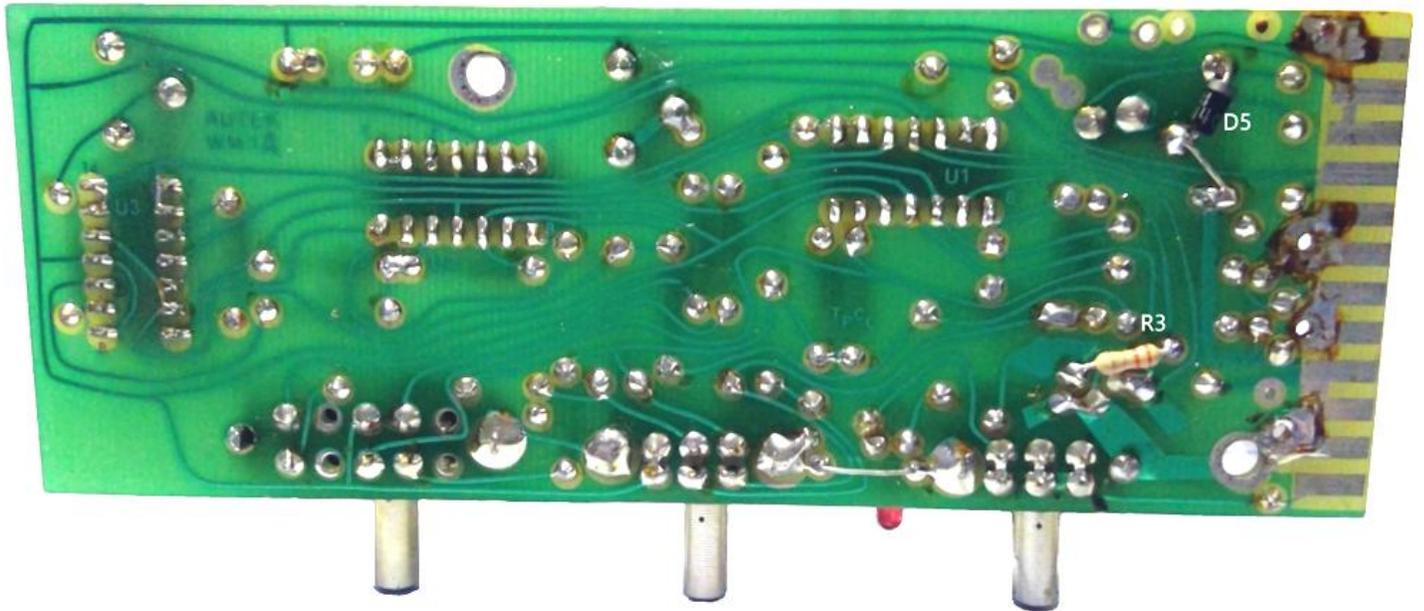


Fig 7 - WM1 Main Board – Bottom View

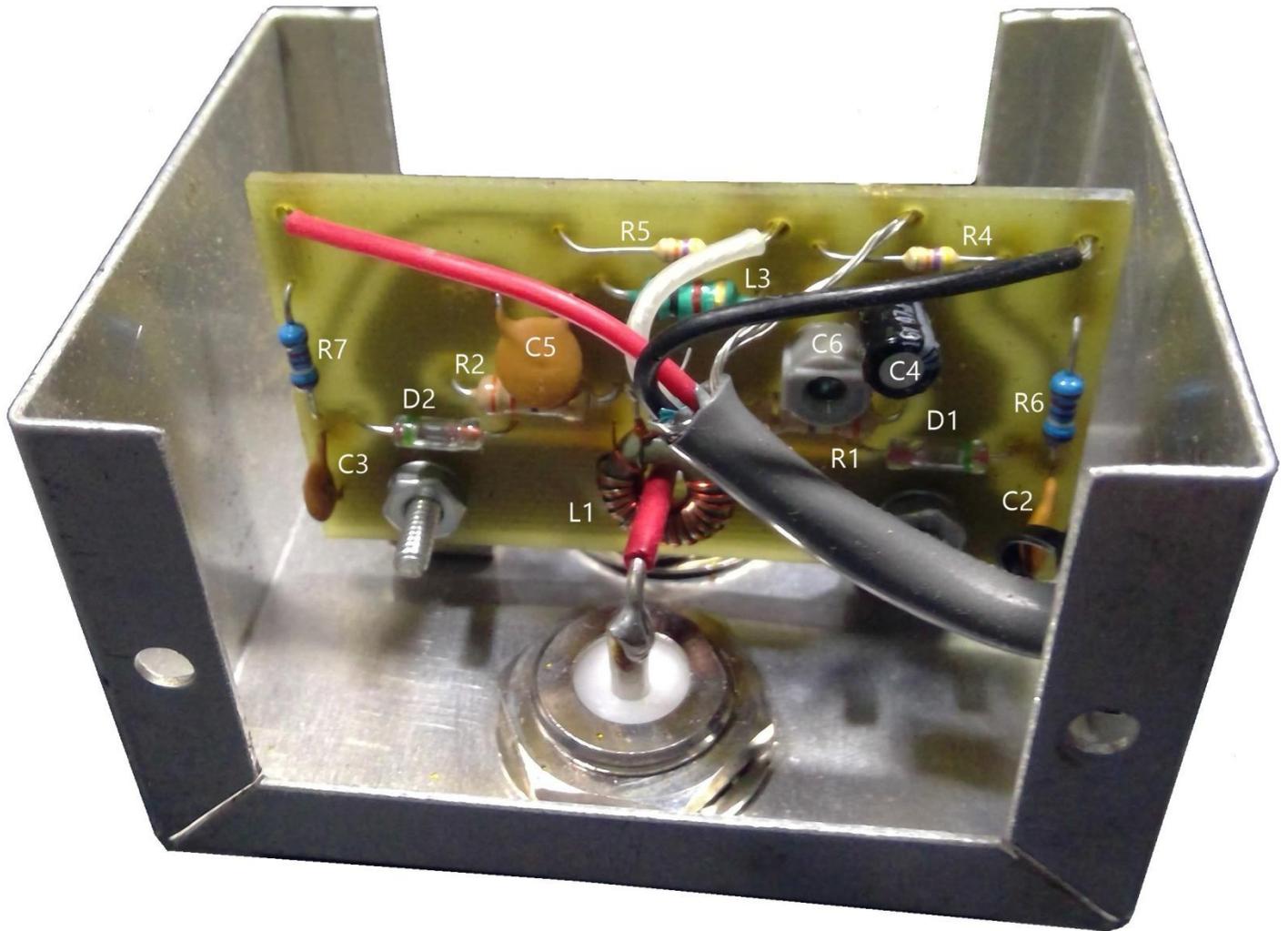


Fig 8 - WM1 Remote Head – Top View

Tests showed this to be very consistent 160-10 meters, so board was not removed from enclosure to preserve physical state.

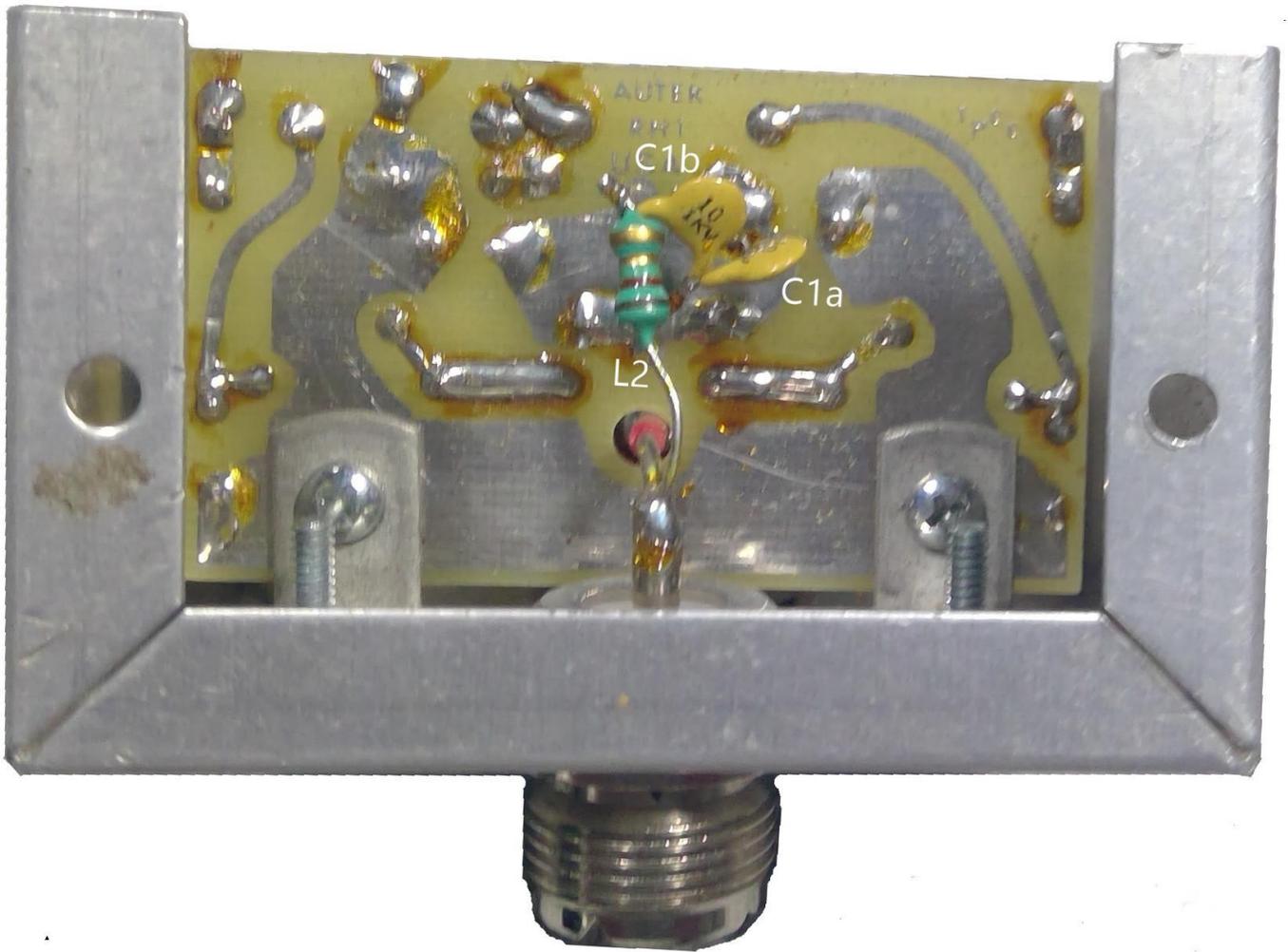


Fig 9 - WM1 Remote Head – Bottom View

Tests showed this to be very consistent 160-10 meters, so board was not removed from enclosure to preserve physical state.

Parts List

WM1 Main Board

Part	Value	Description	Notes	Measured 1% (Fluke 77)	2008 Schem
C1	0.001uf	Disc Cap, Radial			
C2	0.001uf	Disc Cap, Radial			
C3	0.001uf	Disc Cap, Radial			
C4	0.001uf	Disc Cap, Radial			
C5	Not Used				
C6	0.001uf	Disc Cap, Radial			
C7	0.001uf	Disc Cap, Radial			
C8	100uf (47uf)	Electrolytic, Radial			
C9	0.001uf	Disc Cap, Radial			
C10	0.001uf	Disc Cap, Radial			
C11	0.001uf	Disc Cap, Radial			
C12	Not Used				
C13	0.001uf	Disc Cap, Radial			
C14	100uf	Electrolytic, Radial			
C15	0.01uf	Polyester, Radial			
C16	0.001uf	Disc Cap, Radial			
C17	0.001uf	Disc Cap, Radial			
R1	1K 1/2w	Resistor, Axial			
R2	1K 1/8w	Resistor, Axial			
R3	3.3	Resistor, Axial			
R4	19.1K 1%	Resistor, Axial		19.2K	19.2K
R5	43.2K 1%	Resistor, Axial		43.08K	42.2K
R6	4.53K 1%	Resistor, Axial		Not Measured	4.53K
R7	19.1K 1%	Resistor, Axial		19.07K	19.2K
R8	1K 1/8w	Resistor, Axial			
R9	1K 1/8w	Resistor, Axial			
R10	5K	Resistor, Axial			
R11	19.1K 1%	Resistor, Axial		19.2K	19.2K
R12	19.1K 1%	Resistor, Axial		19.2K	19.2K
R13	4.53K 1%	Resistor, Axial		4.522K	4.53K
R14	1K 1/8w	Resistor, Axial			
R15	333	Resistor, Axial			
R16	100K 1/8w	Resistor, Axial			
R17	19.1K	Resistor, Axial			
R18	22.5K 1%	Resistor, Axial		21.54K	21.54K
R19	8.6K 1%	Resistor, Axial		8.65K	8.6K

Part	Value	Description	Notes	Measured 1% (Fluke 77)	2008 Schem
R20	4.53K 1%	Resistor, Axial		4.54K	4.52K
R21	9K 1%	Resistor, Axial		9.04K	9K
R22	6.8K	Resistor, Axial			
R23	5K	Resistor, Axial			
J1	2.1mm Coax	DC Power Socket			
PM1	500ua, 200ohm	Panel Meter	Power		
PM2	500ua, 200ohm	Panel Meter	SWR		
LED1	Red Led	3mm			
D1	Not Used				
D2	1N4004	Silicon Rectifier, Axial			
D3	1N4004	Silicon Rectifier, Axial			
D4	1N4004	Silicon Rectifier, Axial			
D5	1N4004	Silicon Rectifier, Axial			
SW1		SPST Slide Switch	On - Off		
SW2		DPDT Slide Switch	AV - PEAK		
SW3		3PDT Slide Switch	20-200-2000w		
U4	LM78L05	5 Volt Regulator, TO-92			
U1	LM348	Op Amp, 14 pin			
U2	LM348	Op Amp, 14 pin			
U3	CD4066	Quad Bi-lateral switch, 14 pin			

Remote Head

Part	Value	Description	Notes
R1	33 1/2w	Resistor, Radial	
R2	33 1/2w	Resistor, Radial	
R4	47K 1/8w	Resistor, Radial	
R5	47K 1/8w	Resistor, Radial	
R6	19.1K 1%	Resistor, Axial	
R7	19.1K 1%	Resistor, Axial	
C1a	10pf	Disc Cap 1kv, Radial	Older version C1 was 8pf trimmer
C1b	10pf	Disc Cap 1kv, Radial	
C2	0.001	Disc Cap, Radial	Larger (500v?)
C3	0.001	Disc Cap, Radial	Larger (500v?)
C4	47uf	Electrolytic, Radial	Older schematics show .001uf, error or changed later? Regulator would prob osc with .001.
C5	240pf	Disc Cap, Radial	Older version C5 was 150pf SM
C6	70pf	Trimmer Cap	Was not in older version
D1	1N295	Germanium Diode	
D2	1N295	Germanium Diode	
J1	SO-239	Single Hole Mount	
J2	SO-239	Single Hole Mount	
L1	Toroid		
L2	1.2uh 5%	RF Choke, Axial	Epoxy form (looks like 1/4w resistor)
L3	1000uh 5%	RF Choke, Axial	Epoxy form (looks like 1/4w resistor)

Notes

From the parts list, it can be observed that several of the 1% resistor values (2008 version) seem to have measured values (rather than based on the color code). As a matter of fact, there are a few that have identically measured values (or nearly so), between the WM1 used for the 2008 Rev Eng schematic and the one used to create the layout pics and parts list for this update. This suggests that these resistors, (set gain values for the power ranges and are part of the precision voltage divider in the SWR section), were hand selected (either by the developer or his supplier). This makes sense, because there is only one calibration control for power and one for SWR. The actual gain for each position is set in the precision diode sections. For each range to 'track', the values would have to be carefully selected. The schematic with the 2008 values has been included for reference.

The point here, is that if one of these resistors needs to be replaced, it would be a good idea to use the measured value as a starting point (esp where the values match between the two meters), and get several; might take several tries to get the appropriate value.