ASSEMBLY INSTRUCTIONS

WM-2 QRP WATTMETER

Oak Hills Research

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Aurora, CO 80014

Introduction

Thank you for purchasing the Oak Hills Research WM-2 QRP Wattmeter kit. The WM-2 was designed specifically for the QRP operator.

The kit contains all necessary parts for assembly and installation, including a schematic diagram, large parts overlay diagram, and complete parts list.

Features

- 54 MHz to 300 KHz operating range.
- Forward and Reflected Power Measurement at QRP levels down to 5mW.
- Three Selectable Power Ranges, 100 mW, 1W, and 10W with a ±5% accuracy of the full scale.
- Selectable Power Input between the internal 9V battery or an external power jack.
- Easy to read 3" Scale.
- Low Current Drain of 1 mA, making it great for portable use.
- SO-239 Connectors.
- Easy Alignment – an RF source is *not* required for alignment.

You will need the following tools to assemble your kit: normal hand tools which include long-nose pliers; diagonal cutters; phillips head screwdriver; small bladed regular screwdriver; pliers; 20-30 watt pencil type soldering iron with a very small tip; magnifying glass; magnifying light; and a supply of *ROSIN CORE* solder. We use, recommend, and sell convenient pocket packs of Kester's "245 No-Clean" solder. A desoldering bulb and desoldering braid are also helpful to have. You should also have a piece of coarse sandpaper to remove paint on the inside of the chassis to provide a good ground connection.

Soldering is one of the most important operations you will perform while assembling your kit. About 95% of all kits returned to us for repair have problems caused by poor soldering. A good solder connection will form an electrical connection between two parts, such as a component lead

(Introduction...)

and a circuit board foil. A bad solder connection will prevent an otherwise well assembled kit from working properly. It is easy to make good solder connections if you follow a few simple rules. Use the correct type of soldering iron. A 20-30 watt pencil soldering iron with a very small tip works well. Keep the soldering iron tip clean. Wipe it often on a wet sponge or cloth, then apply solder to the tip to give the entire tip a wet look. This process is called tinning, and it will protect the tip and enable you to make good solder connections. When the solder tends to "ball" or does not stick to the tip, the tip needs to be cleaned and retinned. Always use *ROSIN CORE* radio type solder (approximately 60:40 tin-lead content) for all the soldering in this kit. The warranty will be void and we will not service any kit in which acid core solder or paste has been used.

For a good overview of kit building techniques and practices, read N1FN's comprehensive article "A to Z of Electronic Construction." It is available from OHR in hard-copy for a nominal fee, and it's free on the World Wide Web at www.MorseX.com/build/atoz.htm.

ASSEMBLY NOTES

The parts list contains a PARTS ID # and DESIGNATOR #. Use the PARTS ID # to help identify parts. The DESIGNATOR # is used on the schematic diagram and PC boards to identify individual parts. Some parts may be supplied on a tape. Carefully peel the tape layers apart, or use your cutters to cut the component leads from the tape. Never pull the components from the tape. All components are mounted on the component side of the board. All horizontally mounted components are positioned down against the board.

Printed Circuit (PC) boards can easily be damaged when you have to remove a soldered part, and the part itself will often be unusable. When you assemble the board, *be ABSOLUTELY SURE you have the CORRECT COMPONENT in the CORRECT LOCATION with the CORRECT ORIENTATION, BEFORE YOU SOLDER IT. DOUBLE CHECK YOUR WORK BEFORE SOLDERING.* If you do make a mistake and want to remove a component, follow this simple procedure. Use a desoldering bulb and/or desoldering braid to remove *ALL* solder from the connection. Make sure the component leads are loose and free in the holes before removing the component.

Use care when handling the cabinet parts, as some may have sharp edges.

You should also wear eye protection to prevent a cutoff lead clipping from flying up into your eye. An additional safeguard against this type of injury is holding the component lead as you cut it.

The WM-2 is not difficult to build. Just take your time and use common sense. Don't work too long at one time, taking frequent breaks. Take the time to read through all the steps in this booklet before beginning the kit, as this will help you become familiar with the kit and may prevent any mistakes.

Board Assembly

❒❒ 1.1 Begin by unpacking the parts bags and taking inventory. It will help to sort the components by type and value. DO NOT remove the integrated circuits from their packaging until instructed to do so, because they can easily be damaged by static electricity. As shown at the left side of the page here, two check boxes are provided to help you keep track of progress. Check off one box as you complete each step. Check off the second box when you go back to review your work.

❒❒ 1.2 All of the parts are mounted on the top side of the circuit board. Position the board in front of you with the component overlay screen up. Refer to the parts list and the parts overlay diagram to help identify parts. In the following steps, "install" means to physically install the component at the proper location on the circuit board, then turn the board over and solder the leads, and trim the leads. The printed circuit board supplied with the WM-2 QRP Wattmeter has some fine traces (tracks). BE SURE TO USE A SOLDERING IRON WITH A VERY SMALL TIP and work with plenty of light and (we suggest) a magnifying glass so that you can see your work.

❒❒ 1.3 Install a 100 Ohm (Brn-Blk-Brn) resistor at R13. *Note– all of the resistors will have a fourth, gold band, which represents the tolerance (5%) and has no bearing on the value.* As you complete the next few steps, reserve three or four trimmed resistor leads for use as jumpers later in steps 1.10 and 1.37.

❒❒ 1.4 Install the two 51 Ohm (Grn-Brn-Blk) resistors at R1 and R2.

❒❒ 1.5 Install 680 Ohm (Blu-Gry-Brn) resistor at R12.

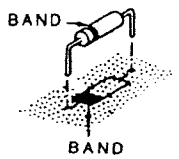
❒❒ 1.6 Install the two 2.2K Ohm (Red-Red-Red) resistors at R7 and R10.

❒❒ 1.7 Install a 12K Ohm (Brn-Red-Org) resistor at R9.

❒❒ 1.8 Install the 47K Ohm (Yel-Vio-Org) resistor at R5

❒❒ 1.9 Install the two 100K Ohm (Brn-Blk-Yel) resistors at R3 and R4.

❒❒ 1.10 Using two cutoff leads from a resistor, place a gentle arc in each wire and install at "JP1" and "TEST LOOP". Mount about 1/4" above the board.

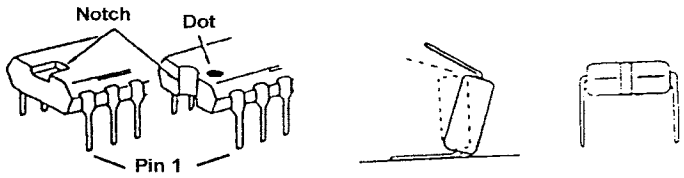


❒❒ 1.11 In the following step you will install the three 1N34A diodes. These diodes are fragile and can be easily damaged. Just put a gentle bend in each lead to match the hole spacing on the board, and be sure to match the banded end with the banded end shown on the board.

(Board Assembly...)

❒❒ 1.12 Install the three 1N34A diodes at D1, D2, and D4.

❒❒ 1.13 Before you install an integrated circuit chip (IC), lay it down on its side as shown in the drawing and very carefully roll it toward the pins to bend the lower pins into a straight line perpendicular to the body of the IC. Then turn the IC over and bend the pins on the other side in the same manner. Refer to the drawing and prepare each IC for installation as shown. IC sockets are not supplied with the WM-2 and should not be used. This means you must be especially careful to install the IC with the correct orientation. The IC will have a half-moon or rectangular notch at one end and or a dot adjacent to pin one. The end with the indentation and/or dot must match the outline shown on the circuit board. TRIPLE-check this one *before* soldering, because removing an IC that is inserted backwards is a very difficult task!



❒❒ 1.14 Install the CA3160E IC at U1 and the LM358N IC at U2. Solder all pins.

❒❒ 1.15 If the .01uF (103) mono caps are supplied on tape, cut four of them off and install at C1, C2, C3, and C5. The last .01uF mono cap will be installed later and will need longer leads– remove it from the tape by peeling the tape layers apart.

❒❒ 1.16 Install the 200 Ohm (201) trim pot at R14. It is not necessary to trim the leads on this or any of the trim pots after soldering.

❒❒ 1.17 Install the 5K Ohm (502) trim pots at R8 and R11.

❒❒ 1.18 Install the 100K Ohm (104) at R6.

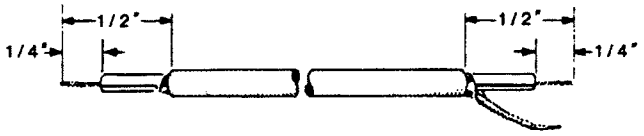
❒❒ 1.19 Locate the 6" length of large solid wire and remove all the insulation. Cut a 2" length of the now bare solid copper wire. Lay the wire down on the board at the location labeled "JUMPER" and mark the hole locations on the wire. Using your pliers, place a sharp right angle bend in the wire at each marked location to form a wide U-shaped jumper. Install the pre-bent jumper so that it is down against the board,

❒❒ 1.20 Install the 10uF electrolytic cap at C4. The long lead goes in the hole labeled "+". The negative lead is indicated with a "-" pattern on the side of the capacitor; even after soldering and trimming the leads you will be able to see that the negative side is opposite the indicate "+" on the board outline.

(Board Assembly...)

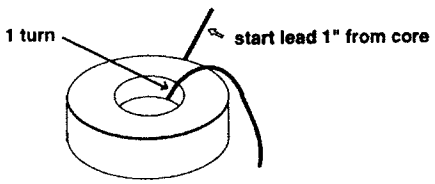
❒❒ 1.21 Locate the four small terminal pins. Notice that there is a long and short section on each side of the small flange. From the TOP side of the board, insert the *short* section of the pin into the hole labeled "TERM 1". Be sure the pin is vertical. Solder and trim the pin, being careful not to burn yourself on the hot pin (a couple thicknesses of masking tape or a bandaid on your fingertip will allow you to hold it long enough to solder it). Install the remaining terminal pins at TERM 2, TERM 3, and TERM 4.

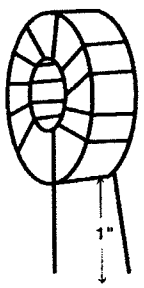
❒❒ 1.28 Locate the length of RG58/u coax cable. Cut two lengths 2 1/4" long. Remove ½" of the black outer jacket from each end of the cable. Try not to cut into the braid when removing the outer jacket. Now push the braid back to loosen it up. Comb out the braid to straighten out the stranded wires. Twist the wires together tightly to form a lead. At ONE end of each cable cut the braid off where it exits the black jacket. Now remove 1/4" of the inner conductor insulation from each end of each cable. If the inner conductor is stranded, twist the inner conductor wires together. With your soldering iron, lightly tin the exposed wires on each cable including the braid. Set the prepared cables aside for now.



❒❒ 1.29 Locate the length of red #24 wire and the two black cores. Unroll it and straighten it out without putting any kinks in it. Cut two 10 ½" lengths of this wire. Wind 12 turns of wire on each core. After winding the coils, trim both leads to 1" from the core. Completely tin each lead to the core as shown in the illustration.

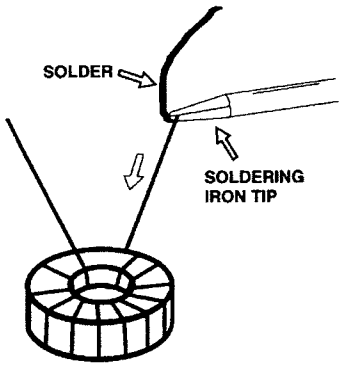
Each time the wire passes through the center of the toroid core (the "hole in the doughnut') count that as ONE TURN. Turns are always counted on the inside of the core. The turns should be reasonably tight (pull them tight by hand as you wind them) and evenly spaced around the circumference of the core.





You will note that the coil can be wound in either a clockwise or counterclockwise direction (looking at the illustration, the 1" lead marked "start" could go either under (as shown) or over the body of the toroid. In the WM-2 this does not matter but in other kits, particularly where toroids have multiple windings, it can be important. The two toroidal coils in the WM-2 are used to sample forward and reverse RF power, so they should be as nearly identical as possible. This means the same number of turns, with the same spacing and tightness.

(Board Assembly...)



To tin the lead, place the soldering iron tip on the lead near the end and feed a small amount of solder to it. A drop of solder should form, surrounding the lead, and you will see the insulating varnish bubble up through the drop of solder. Slowly move the tip of the iron down the lead toward the core, feeding solder as you go. When you are done the lead should be evenly tinned with no traces of varnish remaining. Alternatively, you can scrape the varnish from the lead with the edge of a hobby knife blade, then tin the bare copper lead as above. When the toroid leads are inserted into the holes in the circuit board, you should not be able to see any of the colored varnish insulation on the solder side of the board.

❒❒ 1.30 Insert the end of the prepared coaxial cable with the braid removed through the center of one of the prepared coils. The black outer jacket should be centered in the coil. Place this coil/cable assembly over the board at location T1. Insert the two coil leads into the holes near the center and the braid lead into the hole labeled "BRAID". From the bottom side of the board, slightly pull on the coil leads and the braid lead just enough to remove any slack. Solder and trim the coil and braid leads. On the top of the board, the ends of the coax center conductor should intersect the vertical terminal pins at TERM 1 and TERM 2. Solder these connections. Trim off any excess lead length from the coax ends. Install the other coil cable combination at T2 using this procedure.

❒❒ 1.31 At this time all components (except wires and one .01uF capacitor) should be installed and soldered on the board. Take the time now to inspect the PC board for proper solder connections and for any solder bridges. DO NOT skip this step, as it may save you some frustration later.

❒❒ 1.32 At one end of the grey 8 conductor cable, cut the outer jacket back about ½", or enough to expose the eight separate insulated wires inside. Start pulling the wires out of the jacket one or two at a time until all are removed. Discard the grey jacket.

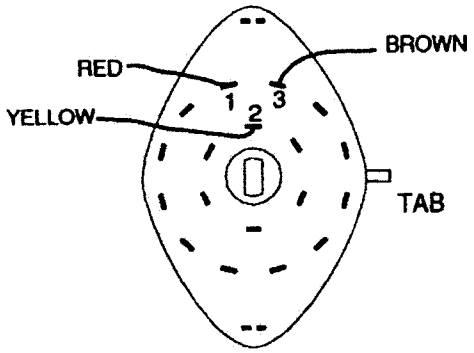
❒❒ 1.33 Cut the following wires to the indicated lengths:

❒ BLACK	3 1/2"	❒ RED	4"
❒ BLACK	3 3/4"	❒ RED	3 3/4"
❒ BLACK	4"	❒ RED	3 ½"
❒ BLACK	1 1/4"	❒ ORANGE	2"
❒ BROWN	2 3/4"	❒ YELLOW	2 1/4"
❒ BROWN	4"	❒ GREEN	1 1/2"
❒ WHITE	2 1/4"	❒ BLUE	5 ½"

(Board Assembly...)

❒❒ 1.34 In the following step you will be removing insulation from the cut wires. Be sure to use a good quality pair of wire strippers for this. DO NOT use a knife or diagonal cutters to remove the insulation, as you will constantly be repairing broken wires.

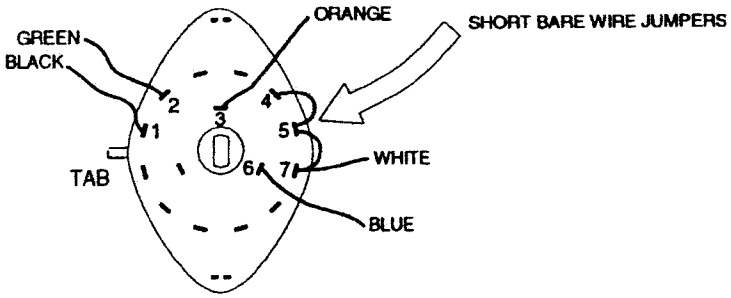
❒❒ 1.35 Remove 1/4" insulation from each end of each wire. At ***one*** end of each wire, use your soldering iron to lightly tin the exposed wires. Do not tin the exposed wire at the other end, or it will not fit into the hole on the circuit board later!



REAR VIEW
S1

❒❒ 1.36 Locate the *two-position* rotary switch. Identify it by comparing it with the S1 illustration. Note that there is an "inner" circle of terminal lugs. S1 has SIX terminal lugs in the inner circle. Position the switch with the terminal lugs facing you and the bent location tab on the front part of the switch oriented to the right, exactly as shown in the illustration. Make a small loop in the tinned end of the 2 3/4" BROWN wire, 4" RED wire, and 2 1/4" YELLOW wire. Install and solder the loop end of these wires on lugs indicated in the S1 drawing . Set the switch aside for now.

❒❒ 1.37 The other rotary switch, S2, is a *four-position* rotary switch, and it has THREE terminal lugs in the inner circle. Note that the lugs are not numbered sequentially! Position the switch so that the location tab is on the left, as shown in the drawing. Install a short jumper wire between lugs 4 and 5 and between lugs 5 and 7 as shown on the previous page.



REAR VIEW
S2

Use a cutoff lead from a resistor or cap for these jumpers. Solder the jumpers at lugs 4, and 5, but do NOT solder lug 7 yet..

❒❒ 1.38 Make a small loop in the tinned end of the 4" BLACK wire, 1 ½" GREEN wire, 2" ORANGE wire, 2 1/4" WHITE wire, and 5 ½" BLUE wire. Install and solder the loop end of the wires on switch S2 as shown.

(Board Assembly...)

❒❒ 1.39 All wires to the board are installed from the top or component side of the board. When you install the wires on the board, be sure all of the wire strands go into the hole. Also, it is best to install and solder the wires on at a time. Install the free end of the wires from switch S2 into the indicated holes in the circuit board as follows:

❒ BLACK	100mW	❒ GREEN	1W
❒ WHITE	S2A	❒ ORANGE	S2B Wip

The BLUE wire will be connected later.

❒❒ 1.40 Install the three wires from switch S1 as follows:

❒ RED	S1/2
❒ YELLOW	S1 Wip
❒ BROWN	S1/1

❒❒ 1.41 Install and solder the untinned end of the 3 3/4" RED wire and the 3 3/4" BLACK wire at the holes labeled "METER". The RED wire goes in the hole marked "+." Set the board and rotary switch assembly aside for now.

Cabinet Preparation

❒❒ 2.1 Be careful when handling the cabinet parts, as there may be sharp edges. Locate the the vinyl panel labels and the cabinet bottom (unpainted aluminum). The vinyl labels must be applied to the front and back panels of the cabinet bottom ***before any parts are installed on the panels***. And the cabinet bottom must be thoroughly cleaned before the labels are applied. The microscopic pores of the metal contain oil left over from the manufacturing process and it must be completely removed or the label will not stick permanently.

❒❒ 2.2 Clean the cabinet bottom. You can use a "soaking" cleaner specifically designed for aluminum. These usually are based on phosphoric acid and require a great deal of care in their use. Alternatively, you can use a hot water and detergent mixture (ordinary dishwashing liquid or dishwasher powder is fine) and scrub both front and back panels with a scouring pad such as Scotchbrite or Brillo. When the surface is adequately clean it will have a sheen to it and water will sheet off rather than roll off in drops. Make sure the aluminum is thoroughly dry before applying the labels.

(Cabinet Preparation...)

❒❒ 2.3 Remove the "cutouts" from the labels. The easiest way to do this is to place the label on a hard surface, press firmly on the cutout with a small blunt instrument such as the end of a pen, and lift the label upwards away from the cutout.

❒❒ 2.4 To apply the labels, remove both pieces of paper backing. The backing is split in the middle and flexing the label slightly will allow you to grab an edge and peel the backing off. Flex the label slightly so that adhesive surface is bowed out in the middle. Carefully start applying the label in the middle of the panel, lining up the holes in the label with the holes in the panel. Be very careful with this step because if the label goes on crooked it will be almost impossible to straighten. Once you have applied a label to a panel, press it down firmly and rub out any air bubbles..

Final Assembly

❒❒ 2.5 Place a #4 lockwasher on a 4-40 x 1/4" machine screw. From the bottom of the chassis, insert the screw through one of the four holes. On the inside of the chassis, place another #4 lockwasher on screw and then start a 3/8" threaded spacer on the screw. Leave the spacer finger tight. Use the same procedure to install spacers at the other three locations.

❒❒ 2.6 Install an SO-239 connector in the rear panel hole labeled "TRANSMITTER". The large square flange goes on the outside of the rear panel. Position the connector so the opening in the center pin is facing up. Insert a 4-40 x 5/16" machine screw through one of the holes in the flange. On the inside of the chassis place a #4 lockwasher and a #4 hex nut on the screw. Repeat at the other three holes. Tighten all four screw and nuts.

❒❒ 2.7 Install the remaining SO-239 connector in the hole labeled "LOAD". Use the same procedure as before *except in the upper right corner (with the front panel facing you) install a #4 solder lug instead of the #4 lockwasher.* Position the solder lug so it is pointing up. Tighten all four screws and nuts.

❒❒ 2.8 Remove the large nut and washer from both rotary switch bushings. Now replace the nut on the bushings and screw them all the way on. Back the nut off about one turn.

❒❒ 2.9 Position the board/switch assembly on the inside of the chassis and insert the switch bushings through the front panel holes. The rotary switch with just three wires attached to it goes into the front panel hole labeled "REF FWD" and the other switch goes in the remaining hole. Secure the switches with a flat washer and control nut. Position the switches so the metal tab is facing outward, toward the sides of the cabinet. Tighten the control nuts securely.

(Final Assembly...)

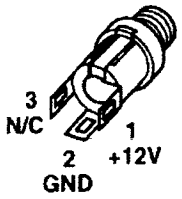
☐☐ 2.10 Position the PC board over the four spacers. Start a 4-40 x 1/4" screw with a #4 lockwasher in each of the four mounting holes. Now tighten all four screws. Turn the chassis over and tighten the four screws on the bottom.

☐☐ 2.11 Cut two 1" pieces of the large solid wire. Place the end of one of the wires in the center pin opening of the SO-239 connector near TERM 2. The other end will intersect the junction of the coax and the vertical terminal pin. Solder both connections. Trim off the excess length at TERM 2. Install the remaining 1" wire at the other SO-239 and TERM 1. Solder and trim.

☐☐ 2.12 Remove the nut and flat washer from the DC coaxial power connector. From the inside of the rear panel, insert the bushing of the connector through the hole labeled "EXT PWR". Position the connector so the center terminal is facing down. Secure with flat washer and nut.

☐☐ 2.13 From the inside of the rear panel, install the slide switch in the small rectangular hole. Secure with two small screws.

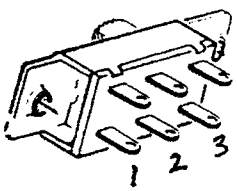
☐☐ 2.14 Connect one end of the previously prepared 1 1/4" BLK wire to terminal #2 of the coaxial power connector. Don't solder the connection yet. See drawing to identify terminal numbers on the power connector. Connect the other end to the nearby solder lug on the SO239. Don't solder the connection yet. Connect one end of the previously prepared 3 ½" BLK wire to the solder lug. Solder the connection at the solder lug.



☐☐ 2.15 Connect one end of the previously prepared 3 ½" RED wire to terminal #1 of the power connector. Don't solder the connection yet.

☐☐ 2.16 Cut both leads of the 1N4007 diode to ½". Bend both leads 90 degrees to the body of the diode. Connect the BANDED end of the diode to terminal #1 of the power connector and solder the connection. Connect the other lead to terminal #2 of the power connector and solder the connection.

☐☐ 2.17 See drawing at right to identify the numbered terminals on the slide switch. Connect and solder the free end of the RED wire coming from the power connector to terminal #3 of the slide switch. NOTE: When connecting and soldering wires to the slide switch be very careful not to cause a short circuit to the bent down tabs on the back of the switch. After all wires have been soldered to the terminals of the slide switch use your magnifying glass or light to be sure you have not created a short circuit.



WM-2 QRP Wattmeter

(Final Assembly...)

❒❒ 2.18 Connect and solder the free end of the BLUE wire coming from S2 to terminal #2.

❒❒ 2.19 Connect and solder one end of the previously prepared 4" BROWN wire to terminal #1 of the slide switch. Again, inspect the back of the slide switch to insure there are no short circuits. NOTE: The top three terminals on the slide switch are not used.

❒❒ 2.20 Position the black battery holder on the inside of the rear panel with the terminal lugs over the power connector. Insert a 4-40 x 5/16" screw through one of the holes in the battery holder and through the hole in the rear panel. Secure with a #4 hex nut. Repeat at the other mounting hole. Note that the screw *heads* are *inside* the battery holder and the nuts are on the outside of the case.

❒❒ 2.21 Connect and solder the free end of the BROWN wire to the bottom (+) terminal of the battery holder. Connect and solder the free end of the BLACK wire coming from the solder lug to the other terminal of the battery holder.

❒❒ 2.22 Use the supplied plastic cable ties to dress up the various wires coming from the PC board and the rotary switches. You MUST keep all wires away from transformers T1 and T2.

❒❒ 2.23 Install the meter in the remaining holes in the front panel. Secure with the supplied lock washers and nuts on the four mounting posts. Install a large solder lug on each of the meter terminal posts. Position the solder lugs pointing down. Secure with the supplied nuts.

❒❒ 2.24 Locate the remaining .01uF mono cap. Connect one of its leads to the (+) terminal and the other to the (-) terminal but don't solder yet. Connect the RED and BLK wires coming from the PC board. The RED wire goes to the positive terminal. Solder both connections. Bend the .01uF cap downward. NOTE: The (+) meter terminal is on the left (with rear panel facing you).

❒❒ 2.25 Turn the shafts on both front panel rotary switches full counterclockwise (left). Place a knob on the "REF FWD" shaft. Line up the notch in the knob with the REF line. Tighten the set screw. Place a knob on the other switch shaft and line up the notch with the OFF line. Tighten the set screw. If the switch has a flat space on the shaft you may need to loosen the nut and rotate the switch body slightly to get the knob to line up.

❒❒ 2.26 Turn the WM-2 over. Peel one of the cabinet feet from the backing paper and place it about ½" in from a corner. Repeat at the other three corners.

Your WM-2 is now complete and ready for alignment.

Alignment

Alignment is not difficult, but if you don't have the tools or otherwise would prefer to have OHR align it, we will do so for a nominal fee.. Details can be found on the Service Request form supplied with your kit.

❒❒ 3.1 Connect one lead of your ohmmeter to the chassis. Touch the other lead to the BLUE wire at terminal #2 of the slide switch. If there is no resistance (i.e., there is continuity) then there is a short, and the condition must be corrected *before you apply power to the WM-2.* Do the above continuity check with the slide switch in both positions.

❒❒ 3.2 Make sure that the WM-2 is turned off (the Off/range switch on the front panel is turned to the off position).

❒❒ 3.3 The WM-2 can be aligned using either a 9V battery or an external power supply (9 to 13 Volts DC). Whichever you choose, you must not change to the other during the alignment process.

❒❒ 3.4 If you are going to use a 9V battery, install it now and place the slide switch on the back of the WM-2 into the "BATT" position. Skip steps 3.5-6 and continue with step 3.7.

❒❒ 3.5 Locate the molded power cable assembly. The POSITIVE lead is connected to the center pin of the molded plug. Use your ohmmeter to identify the POSITIVE lead (it should be the lead with white printing on the insulation, but don't count on it!). Be sure this POSITIVE lead connects to the POSITIVE terminal of your power supply. If the positive terminal of your power supply is not fused, you should add an in-line fuse holder with a 1/4A fuse in the positive supply line.

❒❒ 3.6 Plug the coaxial connector on the molded power supply cable into the EXT PWR jack on the back of the WM-2. Make sure your external power supply is turned off and connect the other end of the power cable to it observing the correct polarity. Place the slide switch on the back of the WM-2 into the "EXT" position.

❒❒ 3.7 Check the position of the meter needle. If it is not resting on the zero mark, use the adjustment screw on the meter face plate to zero it.

❒❒ 3.8 Attach the BLACK lead from your digital voltmeter to chassis ground. Attach the other lead to the "TEST LOOP". You can use an alligator clip type jumper lead to connect to the test point if it is difficult to connect your probe directly to the test loop. Make sure the lead is touching only the "TEST LOOP." and is clear of any other components.

❒❒ 3.9 If you are using an external power supply, turn it on now.

(Alignment...)

❒❒ 3.10 Place the range switch on the front panel of the WM-2 to the 10W position. Adjust pot R6 for a reading of 2.310V on the voltmeter.

❒❒ 3.11 Adjust pot R8 for a full scale reading of 10W on the wattmeter.

❒❒ 3.12 Adjust pot R6 for a reading of .740V (740mV) on the voltmeter.

❒❒ 3.13 Place the range switch in the 1W position. Adjust pot R11 for a full scale reading of 1W on the wattmeter.

❒❒ 3.14 Adjust pot R6 for a reading of .225V (225mV) on the voltmeter.

❒❒ 3.15 Place the range switch in the 100mW position. Adjust pot R14 for a full scale reading of 100mW on the wattmeter.

❒❒ 3.16 Turn the WM-2 off. Very carefully cut jumper JP1. JP1 is right next to pot R6. DO NOT CUT THE TEST LOOP. Alignment is now complete.

❒❒ 3.17 Position the cover over the chassis and line up the two holes on the sides. Secure the cover with the two black 1/4" sheet screws. This completes assembly and alignment.

Troubleshooting

The four most common problems are relatively easy to identify and fix. If you are having trouble, please refer to these instructions and check your work before calling OHR for assistance! Naturally, these tips assume that you have already checked component values, orientation and soldering.

Meter can't be calibrated. Check the wiring of the Off/Range switch (S-2), the slide switch, the power connector, and the battery holder. Repeat the continuity check in step 3.1, and ensure that the diode on the power connector is installed with the banded end connected to terminal #1.

Meter reads 1/3 scale with no RF input. Make sure you have cut the jumper JP1 and have not cut the Test Loop.

Meter reads more reflected power than forward. If you calibrated your WM-2 without difficulty, but it reads more reflected power than forward when operating into a known 50 Ohm load, there is most likely a problem with the wiring of the Fwd/Rev Switch (S-1) or a problem with one of the two pickup coils T1 and T2. Double check the turns count, and the quality of the solder connection. Note that the leads should come straight down from the hole in the center of the toroid– not around underneath the bottom, which would effectively add a turn.

Operation

Always start a measurement with the WM-2 set for the 10W range and then switch to a lower range if necessary. To measure forward power, select the appropriate scale. Put the FWD/REF switch in the FWD position. To read the reflected power, simply set the switch to the REF position.

The power flowing in the line is the forward reading minus the reflected reading. The WM-2 will read ALL power flowing through it, regardless of frequency. Thus the presence of spurious signals or harmonics from your transmitter may result in a misleading measurement. Similarly, a dummy load which is not exactly 50 Ohms may result in misleading measurements.

To adjust a transmatch, put the WM-2 between the transmitter and transmatch and adjust the transmatch for the lowest reflected power.

This directional wattmeter can do anything an SWR meter can do, and much more. Because you can measure power anywhere in a system, you can user the wattmeter to find cable and transmatch losses, measure transmitter power, measure power at various points in a transmitter during the building process and much more.

The WM-2 will operate on any voltage between 9 - 13.6VDC. The meter circuit draws very little current, typically 1.2mA on standby. The input and output impedance is 50 ohms.

Turn the range switch to the off position when the meter is not in use. This will not have any effect on your transmitted signal, but will prolong battery life if you are powering the unit with a battery. The WM-2 can safely pass an RF signal of 20-25W when it is turned off. Higher power is likely to damage the WM-2, so it should be removed from the circuit when you are operating at higher power.

SWR Calculation

The primary purpose of the WM-2 is accurate measurement of forward and reflected power. Reflected power is not the same as SWR, but minimum reflected power will be measured when the SWR is lowest. If you do want to calculate the actual SWR of your antenna system, use the formula "forward power PLUS reflected power, divided by forward power MINUS reflected power." If you must change to a lower power range to read the reflected power accurately, be sure to change the range back to the higher one before measuring forward power again!

$$SWR = \frac{P_f + P_r}{P_f - P_r}$$

We hope you enjoyed building the WM-2 and that it provides you with many years of reliable service.

Oak Hills Research
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Aurora, CO 80014
(303) 752-3382

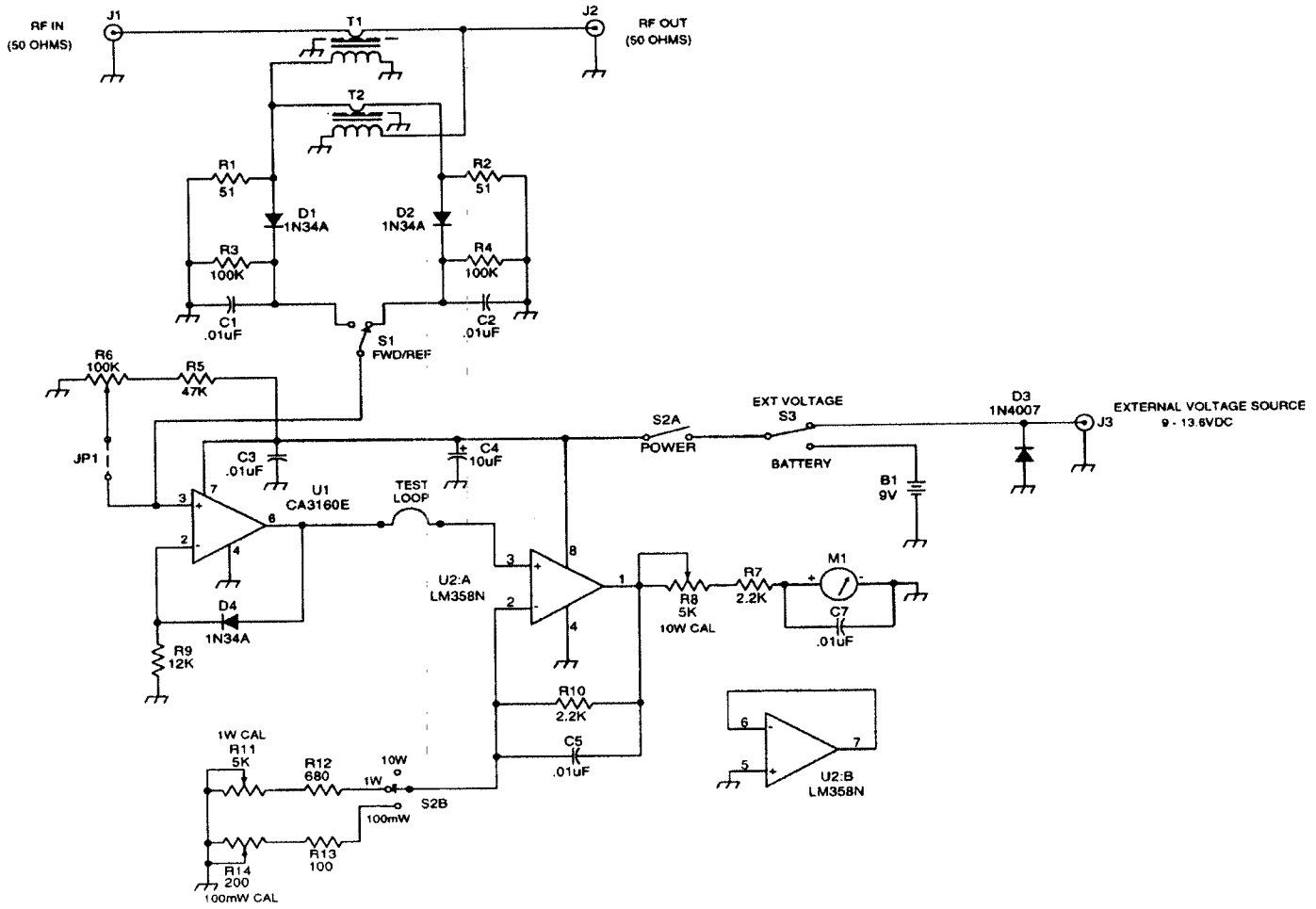
Parts List

	QTY	OHR P/N	DESCRIPTION	INSTALL AT	MARKINGS
	2	6-510-14	51 Ohm 5% 14W Resistor	R1,2	Grn-Brn-Blk-Gld
	1	6-101-14	100 Ohm 5% 14W Resistor	R13	Brn-Blk-Brn-Gld
	1	6-680-14	680 Ohm 5% 14W Resistor	R12	Blu-Gry-Brn-Gld
	2	6-222-14	2.2K Ohm 5% 14W Resistor	R7,10	Red-Red-Red-Gld
	1	6-123-14	12K Ohm 5% 14W Resistor	R9	Brn-Red-Org-Gld
	1	6-473-14	47K Ohm 5% 14W Resistor	R5	Yel-Vio-Org-Gld
	2	6-104-14	100K Ohm 5% 14W Resistor	R3,4	Brn-Blk-Yel-Gld
	1	POT2	200 Ohm PC Pot	R14	201
	2	POT6	5K Ohm PC Pot	R8,11	502
	1	POT10	100K Ohm PC Pot	R6	104
	5	MC101	.01uF Mono Cap	C1,2,3,5,7	103
	1	CE06	10uF Electrolytic Cap	C4	10uF
	3	1N34A	Germanium Diode, matched*	D1,2,4	1N34A
	1	1N4007	Silicon Diode	D3	1N4007
	1	CA3160E	Op-Amp	U1	CA3160E
	1	LM358N	Op-Amp	U2	LM358N
	2	FT50-43	Ferrite Core/ 12 T #24 Wire	T1,2	
	1	K042	3" Panel Meter	M1	
	1	K168	4 Pos Rotary Switch	S2	
	1	K167	2 Pos Rotary Switch	S1	
	1	K353	DPDT Slide Switch	S3	
	2	K092	SO-239 Coax Jack	J1,2	
	1	K293	DC Power Jack	J3	
	1	K157	Battery Holder		
	1	K348	Molded Power Cable		
	4	K355	Small Pin Terminal		
	2	K354	Small Screw		
	4	K132	Cabinet Feet		
	3	K145	Plastic Cable Tie		

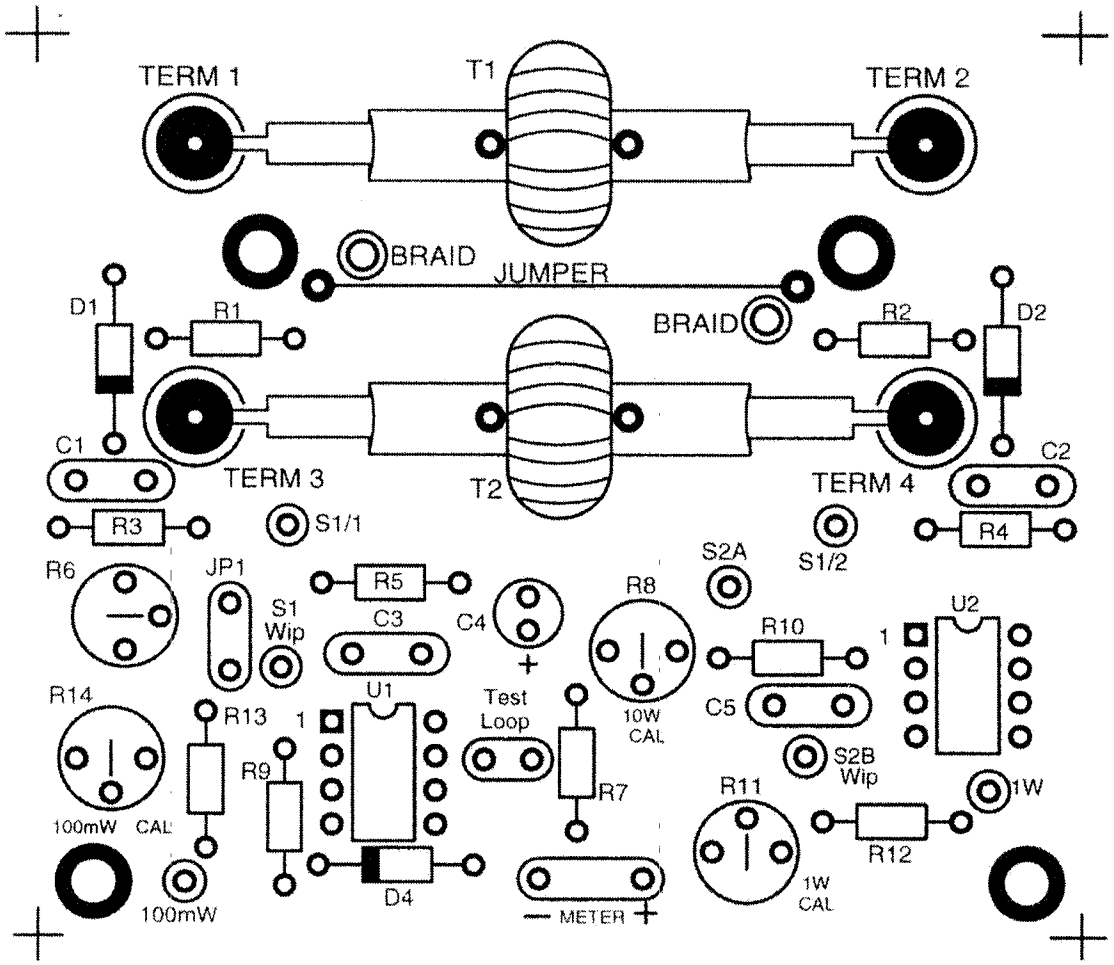
Parts List

	QTY	OHR P/N	DESCRIPTION	INSTALL AT	MARKINGS
	2	K128	Large Solder Lug for Meter		
	1	K004	Small #4 Solder Lug		
	4	K147	Round Aluminum Spacer		
	8	K162	4-40 x 1/4" Machine Screw		
	10	K056	4-40 x 5/16" Machine Screw		
	10	K059	#4 Hex Nut		
	20	K058	#4 Lockwasher		
	2	K129	#6 x 1/4" BLK Sheet Metal Screw		
	2	K012	Large Control Nut		
	2	K296	Knobs		
	4 6"		Large Solid Wire 22 AWG		
	10"	K137	RG-58/U Coax Cable		
	12"	K049	8 Conductor Cable		
	1	10-109-A	Cabinet Bottom		
	1	10-109-B	Cabinet Cover		
	1	40-205	Circuit Board		

* The 1N34A germanium diodes are *matched* for forward voltage with 10mV. This information is provided in case it is ever necessary to replace D1 or D2. D4 is not critical, but it is easier to supply three matched diodes than to keep two of them separate.



WM-2 Schematic Diagram



WM-2 Parts Overlay

1 YEAR LIMITED WARRANTY

PARTS – Replacements for defective parts will be supplied free of charge for a period of one year from the date of purchase. Replacement parts are warranted for the remaining portion of the original warranty period. If you have a defective part, you may obtain a replacement by calling us at 303-752-3382. We will pay the shipping charges on these parts.

SERVICE LABOR – For a period of one year from the date of purchase, any malfunction caused by defective parts will be corrected at no charge to you. You must deliver the unit at your expense to us. This warranty does not cover the correction of assembly errors or damage incurred during assembly of the kit.

ALIGNMENT – If you do not have the appropriate tools and equipment and wish us to align your kit for you we will do so for the fee as stated in our service request form. Complete the form and return it, with your kit, to the address shown on the form.

TECHNICAL CONSULTATION – You will receive free consultation on any problem you may encounter in the assembly or use of our product. Just send us an e-mail message at support@ohr.com or give us a call at (303) 752-3382 and we will be glad to assist you.

NOT COVERED – The correction of assembly errors, adjustments, calibration, damage due to misuse, abuse or negligence are not covered by this warranty. Use of corrosive solder will void the warranty in its entirety. This warranty does not include reimbursement for inconvenience, loss of use or customer assembly.

This warranty covers only Oak Hills Research products and is not extended to other equipment or components that a customer uses in conjunction with our products.

EFFECTIVE WARRANTY DATE – Warranty begins on the date of first consumers purchase. Please supply a copy of your invoice when you request warranty service or parts.

SHIPPING UNITS – When shipping a unit back to us for repair, use adequate packing material. Damage due to inadequate packing cannot be repaired under this warranty.

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