

Calibration process using the SWM-2/3 - DUAL BRIDGE INTERFACE.

The DVM calibration technique is illustrated and explained on PAGE 8

A complete FAQ for using this amazing little Wattmeter from FOX DELTA.

What is an RF watt meter anyway ?

A device that measures RF energy as voltage and displays the results on a meter or digital readout.

What makes the Fox Delta so much different ?

Outside of a simple computer interface, and the fact that is a kit, nothing is new. Actually not one thing new has come along for years. These devices are rather simple in their design and yet for many years the standard seems to remain. The benchmark is the BIRD 43. These units have been the standard for decades simply because they are accurate and dependable, but what makes them so is their selected components, rugged design and tight tolerances.

It must be understood that accuracy is dependent on the fore mentioned components. It is obvious that BIRD is the standard and that remains today. So why is the SWM-2 such a giant killer ? Well, it may not be but considerations must be allowed. First the SWM-2 is a kit and that alone changes tolerance, tolerance is the death nail of accuracy, but accuracy to the Amateur Radio Operator is acceptable at 5-10 percent anyway. If your 100W transceiver is delivering 95 watts to a dummy load on 160 and the same on 10, you are well within manufacturer's tolerance. We operate a broadband HF device that, without tuning, covers 30 MHz of radio spectrum. Your antenna can't offer the performance accuracy these broadband amplifiers can.

The SWM-2 is inexpensive to build and it does a few things that the BIRD 43 cannot. First it is one of those devices that can (and should) remain in the RF chain. If you have a BIRD 43, you should keep it in the carton and use it only for high accuracy measurements. The BIRD is a mechanical device that over time from use and the dreaded environment will lose accuracy as well. Keep it in a safe cool place till you need it. The SWM-2 is very economical when compared to a BIRD 2500 WATT slug and you can depend on the SWM-2 everyday, every transmission.

The BIRD cannot communicate with your computer. But like the BIRD, you don't have to use a computer. The BIRD is self contained but the pickup is very sensitive. If the BIRD is dropped or damaged, accuracy becomes questionable, and the expense to repair is almost un-acceptable. The BRIDGE units for the SWM-2 are simple to make and very rugged. They can be placed anywhere in the chain because they are not a self contained network (or slug).

There are many digital watt meter applications on the market, but none are less expensive to use than the SWM-2 or SWM-3 (USB). None are easier to setup and operate and none are guaranteed to be more accurate than a BIRD 43. So...if you take your time to build the FOX DELTA WATT METER, do a neat job and keep your components aligned and tight, you will have a very accurate measurement device that will keep a constant eye on

your transmission chain.

How does it work ?

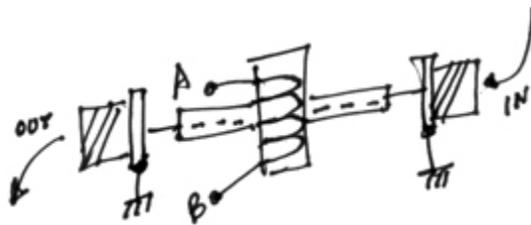
Well lets not go into technical details here but the basics are rather simple and, like the more expensive units with fancy names, the FOX DELTA works very well, especially when comparing dollars to dollars.

Most of us are familiar with transmission line transformers. We have been expanding on the HEATH KIT HM-5 for almost 5 decades now. The same basic 30:1 transformer has been used in damn near every RF pickup on the planet. Well it remains the same today. Whether you use a toroid current device or a parallel line transformer pickup, the RF is isolated and transformed as an analog output signal. This analog signal is a sample of the RF VOLTAGE/CURRENT along the transmission chain (line) at that single point on the path. The RF SIGNAL is then rectified and the resulting VOLTAGE is now applied to an analog converter where the processed digital signal levels are applied to the PIC processor for evaluation. If you have ever owned the WM-4 by Drake, you know exactly what is being done here. Difference...the analog meter has been replaced with a digital processor capable of serial communications with a software control.

That should explain the process. The DISPLAY, LED INDICATORS and BUTTONS are the human interface, just as the FORWARD and REVERSE and POWER switch was/is on the conventional SWR METER.

For the NOVICE:

Prove this on your own, take a simple toroid form and wrap some 15 to 30 turns around the core. The size of wire you choose is not really important, but #18 or smaller will work fine. Just be sure that you can pass a small piece of #12 solid wire through the center. This is your primary lead. You have just created an RF CURRENT device. On the two leads that connect the toroid secondary connect a scope probe across "A" or "B" to ground. Connect your transceiver to either end of the device and key the radio. The scope should show a decent amount of RF on the display. Now connect the probe to the other secondary lead, you should also get an RF reading, but it should not be the same...it will be more or less depending on the direction of the RF flow through the toroid. If you reverse the coax connectors you will see a reverse in the scope display. If you add a diode



at "A" and "B" you can read voltage on any DVM. If you read 10 VDC forward and 1 VOLT REVERSE. You have created an SWR indicator. The rest is simple calibration. That is the FOX DELTA SWM-2, DUAL BRIDGE technical application.

Is the kit hard to build ?

No, not at all; there are no really intense surface mount components here. A small 40 watt hand iron is all you need. While the kit is well documented, you must understand electronic basics. You should know the difference between an RF CHOKE and a RESISTOR. That information you can get on the Internet, and you are an Amateur Radio operator and should have a few of the basic skills already. But, if you do not, you can purchase these units pre-built.

Ok, I have mine ready to go, what next ??

Even if you purchased the pre-built unit, you must calibrate. You must connect it to your computer. That is easy to do with the SWM-3 (USB) unit, but the SWM-2 is a serial interface and a lot of today's computers do not have a serial interface. There are a few ways around this. You can add a serial card to the computer. One such card is the StarTech 16550 PCI interface adapter.

You can get all the details from www.startech.com or you may choose a USB to SERIAL adapter. I have tested the KEYSpan USA19HS and it works great with the SWM-2. You can contact them at www.TrippLite.com If you have a serial port on your computer (some new mother boards have a serial pin header set and Star tech also makes these header connectors as well) you are in business. All you need is a cable. The SWM-2 to SERIAL CABLE is not supplied, you must purchase or roll your own.

To roll your own it must be: DB9F to DB9M and connect straight through pins (2) to (2), Pins (3) to (3) and pins (5) to (5), with pins (9) to (9) "ring indicator" as an option. I found that the pin 9 was required when used with some USB-SERIAL adapters. So physically I would connect these 4 pins straight through with a shield to the case.

HINT: Find any old serial cable laying around cut and patch the leads above as described.

What does the computer need ?

Well if you have the cable ready and you are certain about the connection, you need software, so prepare the PC like this...First the SERIAL PORT must be configured properly.

Remember, if you have the SWM-3, all this happens "plug and play", so nothing here is worth your time...go to calibrate.

If you are a serial port user here is where we begin. You must set the serial port on your PC to the proper configuration. This is done in the operating system. Open up the control panel and select "system" – "properties" – "hardware" – "device manager" (this may already be on your desktop so go ahead and open the "system properties"). In the "device manager" look down the list and click on the (+) box next to PORTS (COM & LPT).

Now look for the serial port you chose to install and or use. You want to highlight this port and click "properties" – "port settings". The only setting you change is the BAUD

RATE (Bits Per Second), set this to 115200 and click APPLY, OK.

The configuration is done. Nothing else to see here, close the “system dialog” and move on...

Next we install the software. By now you have Version 2.0 of the firmware so we want to download the software from the FOX DELTA website. On the internet go to www.FoxDelta.com and navigate to the RF MEASUREMENT page and select your unit SWM-2 or SWM-3 from the 0-500MHz Power Measurement Index. Scroll down through the pictures and select the software you need. In this case it will be the **I2TZK PC Software for Dual Channel SWR Meter V2.01**. This is a .ZIP file. Click on the ZIP icon and download to your PC. Save it where you can retrieve it, extract the file there and prepare to execute.

USB users please note, other than a few minor differences in the look of the SWM-3 the BRIDGE units are the same and the SWM functions are identical, USB as compared to SERIAL. Please see your unit for switch settings.

What next ?

Ok execute the program software...If you have the SWM-2 you will need 12 VDC supplied to the unit. When the power is on, the initialize screen is displayed on the SWM-2 read out panel. It will display the version of the PIC16 CPU and then wait for your command. Now on the computer double click the SWR Meter Icon, a small window should pop-up and inform you that connection to the unit was found...

”**Board Found on Com(x)**”, if not found, the prompt tells you so. This could be a serial port problem, cable problem or installation problem. No matter what, the SWR meters will be displayed, at this point, so you should click SETUP on the program dialog box. In the “setup” you can look at the port settings and “force” the program to use the “com port” you have chosen. If that does not work, I suggest you check all your connections and test the COM PORT on your computer. I mentioned two manufacturers of devices that I have used for SERIAL COMMUNICATION. If you are not sure what you have, start there. The SWM-2 is a ‘simple’ communication device that uses 2 and 3 for Data Send and Receive, and pin 5 as Signal Ground. Pin 9 is “ring indicator” and is not required, simply an option. Considering everything else, I would carefully check the connections to the SWM-2 before any other adjustment is made. If you built the kit, be sure that you properly installed U3 onto the board.

Ok I see the board, now what ?

Good for you. If you have your BRIDGE UNIT in line go ahead KEY DOWN let’s see what you have. In most cases you will see some indication as long as the BRIDGE and the DISPLAY are on the same page.

You will not see an indication on “Channel B” if the BRIDGE is plugged in on “Channel A” input. So get those properly set and lets us prepare for calibration. If you want to test communication I suggest you go into setup, select “Channel A” and NAME the channel. Put your call or the radio or the antenna, anything you desire, now SAVE it and restart

the software. The connection should be made and the meters displayed on screen with the NAME you chose.

Next we prepare the dual bridge by setting the HIGH and LOW scales. Because this is a DUAL BRIDGE unit, it will measure up to 2000 WATTS ACTUAL PEAK READING. So let us set scales: Scale 1 should = “200 watts” and Scale 2 = “2000 watts”. Now save and allow the program to restart. You will notice that the ON SCREEN meter multiplier is “X20” and in this position we will remain till the BRIDGE is calibrated. Go back and be sure you have “Channel A”, Scale 1 = 200 and Scale 2 = 2KW. If this is correct, click “exit”, close the software and remove the serial cable from the SWM-2 display/interface unit. Do that now...

Where do I calibrate the reading ?

If you built your unit you will remember placing 5 separate 10 turn pots onto the board. They are indentified as RV2 - RV3 – RV4 and RV5. The pot RV1, should be rotated 10 turns counter clockwise and left at that setting. Do that now...

On the DUAL BRIDGE schematic you will see the pots located on the board and each one’s function is listed. You should refer to the schematic during calibration. Open up the DUAL BRIDGE case by removing the 4 small screws. If you are facing the DB9 connector and looking down onto the rear side of the COAX CONNECTORS, RV2-3-4 and 5 are located next to the relays and read LEFT to RIGHT respectively.

RV2 = FORWARD HIGH, RV3 = FORWARD LOW, RV4 = REFLECTED LOW and finally RV5 = REFLECTED HIGH. On the schematic, note that RL2 and RL1 are in the FORWARD LOW and REVERSE LOW positions (by default). We will talk more about this later, but you should be able to understand what happens when you select HI/LO scale settings.

Calibration:

Please be sure that the exciter is connected to the input (TX IN) on the bridge and that your DUMMY LOAD is connected to the output (ANT).

Note: You only need a 100W dummy load, you will not power up your amplifier for calibration, leave it turned off.

On the SMW2 (or 3) unit there are 2 interface buttons and a set of LED’s. The SET CMD function is the LH button. Push this momentarily, the brightness on your display should increase, up to 15 settings. I never use anything above 4, but that all depends on your eyes. Pushing this same button and hold it for 3 seconds, you will enter the SCALE MODE. Do that now and set “ChA Scale: 200W”. The right button will toggle through the scale settings between “200W”, “AUTO” and “2KW”. Set the scale to 200W. Do not worry about channel “B” at this time. When the “ChA” setting is correct, push the LEFT BUTTON again for 3 seconds, this places the SWM-2 into the WATTMETER FUNCTION. Using the RIGHT BUTTON you may toggle through the modes available. Set the SWM-2 to read: “PWR 0 SWR ---“ for channel “A”. We will calibrate in this position.

The BRIDGE should be open and component side facing up. Remember that during calibration, RF will be on the center PIN of the PL-259 connectors. Be careful not to touch the center pin, or short it to the PCB. Again I remind you, use a DUMMY LOAD. Set the exciter to 14.250 and the POWER LEVEL to 100W. If your transceiver does not have an RF POWER adjustment, you should connect a BIRD 43 behind the DUAL BRIDGE and tune up the exciter to 100 WATTS. I cannot tell you how important it is to use a DUMMY LOAD. Besides being a good fellow Ham, you will have a near perfect load for setting the REVERSE POWER levels and the SWR METER will function correctly.

Which potentiometer do I turn for FORWARD calibration?

(1F) Take note and proceed by holding the LEFT BUTTON for 3 seconds, it will enter the SCALE MODE. Do that now and set “ChA Scale: 200W”. The right button will toggle through the scale settings between “200W”, “AUTO” and “2KW”. Now you are in the FORWARD LOW POWER scale mode so you must start with the default setting, that is RV3. Adjust this pot till the SWM-2 SCALE reads 100W – [PWR 100 SWR 1.0]. This is your first adjustment.

(2F) Take note and proceed to holding the LEFT BUTTON for 3 seconds, it will enter the SCALE MODE. Do that now and set “ChA Scale: 2KW”. The right button will toggle through the scale settings between “200W”, “AUTO” and “2KW”. Set the scale to 2KW. RL2 relay has now closed and you are in the RV2 position, adjust RV2 till the SWM-2 SCALE reads 100W – [PWR 100 SWR 1.0]. This is your second DUAL BRIDGE adjustment.

(3F) Take note again and verify reading 100W on the meter in the 200W and 2KW scale settings. You use the LEFT BUTTON to enter SCALE MODE and the RIGHT BUTTON to toggle scale settings.

(4) Reverse the coax connectors. Place the DUMMY LOAD on the input (TX IN) and the EXCITER on the output side (ANT).

(5) Now using the LEFT BUTTON set the SCALE to 200W again and enter the SCALE MODE as before,

Which potentiometer do I turn for REVERSE calibration ?

(1R) Take note and proceed by holding the LEFT BUTTON for 3 seconds, it will enter the SCALE MODE. Do that now and set “ChA Scale: 200W”. The right button will toggle through the scale settings between “200W”, “AUTO” and “2KW”. You are in the REVERSE LOW POWER scale mode so you must start with the default setting, that is RV4. Adjust this pot till the SWM-2 SCALE reads 100W – [PWR 100 SWR 1.0]. This is your first (reverse) adjustment.

(2R) Take note and proceed by holding the LEFT BUTTON for 3 seconds, it will enter the SCALE MODE. Do that and set “ChA Scale: 2KW”. Toggle the RIGHT BUTTON through the scale settings between “200W”, “AUTO” and “2KW”. Set the scale to 2KW. RL1 relay has now closed and you are in the RV5 position, adjust RV5 till the SWM-2 SCALE reads 100W – [PWR 100 SWR 1.0]. This is your second DUAL BRIDGE (reverse) adjustment.

(3R) Take note again and verify reading 100W on the meter in the 200W and 2KW scale settings. You use the LEFT BUTTON to enter SCALE MODE and the RIGHT BUTTON to toggle scale settings...

If you can verify both FORWARD and REVERSE at 100W on all scales, you have completed the calibration. Place the BRIDGE back into the case and proceed to install it into your RF chain. Place the unit in front of the tuner and behind the amplifier. These connections (jumpers) should be as short as possible.

Remember that if you do not have an external antenna tuner chances are that the RED LED will light and the DISPLAY “HIG” on each transmission. This is possible because you are probably using an INTERNAL ANTENNA TUNER and the DUAL BRIDGE is now behind the tuner and in front of the antenna. This will not hurt anything and you can control the SWR METER settings in the setup panel of the software. The DEFAULT SWR setting is 3:1 but you can increase it and eliminate the “HIG” reading.

Why the relays ?

Well they are the key to using the DUAL SCALE bridge. When you are in “200W” scale the relays are NC (normally closed), in that scale range, but when you are in the “2KW” range, the relays close and place the DUAL BRIDGE in the 2000 WATT FULL SCALE range. The relays allow you to set the SWM-2 into the “AUTO” mode and the relays will be controlled by the power level. I don’t suggest this function. While it works fine you may see an occasional “off the wall” reading on your PC screen.

What if I have problems ?

Well if you anticipate them, you will...but I have built and setup several of the SWM-2 units from the V1.0 to V2.03. I have had very little problems but here are a few tips when diagnosing a problem with the DUAL bridge units.

You should understand and read the schematic carefully. The schematic may seem a bit unusual but believe me it is fine. There were some component symbols that may confuse you, but simply read the part number and do not be concerned about the symbol. I have created a set of test points that will help you determine calibration issues.

First test point is junction of D1 and R1 to D2 and R4, this should read about .2 ohms. From the junction of C7, RFC1 and D1, there should be a reading of about 12 K ohm – 13 K ohm to chassis; the same reading or close, across the junction of D2, C11 and RFC2, also chassis. This tests the LOW scale calibration circuits. If these values are too low, look for a short at C6-C7-C11 or C13. If either or both are too high (100 K ohm) then look for an open choke or poor solder connection from RVn center tap to it’s associated

connection on the D9M connector.

If the above resistance checks are acceptable, then check the 100K pot setting by reading from either side of RFC5 and RFC4 to ground. You can read this through the D9M connector also at PINS 3 or 4 to chassis. If your calibration went Ok on either side FWD or REV, you should read about 25 K ohm to ground.

OK, I get that so how do I check the HIGH SCALE ?

Remove the 4 screws that holds the PCB in place. Lift the PCB out and inspect all your RELAY solder joints under the relays. From PIN 5 on the D9M connector you should read 10 OHM to ground. This is the relay circuit. Place the board with the coax connectors facing you and D9M and RL1/RL2 on top (soldered side of board).

Checking HIGH is simple now and takes only a little logic to understand. We know the scales are correct and the output to pins 2 and 3 on the D9M connector are functioning in LOW scale. So the HIGH scale is easy to determine. We need only read RV5 and RV2 to ground through the pot that will be 100 K ohm. Through the CT we should have a reading close to 27 – 35K ohm. So, if the relays are working this will calibrate. There are 6 relay connections to test. Look at the illustration on page 8. The DVM numbers are listed on the top of the image. If these measurements are within 10% of each other, your unit should work fine. The 2 relay connections closest to the D9M connector is your fields and these should read 10 Ohms to ground.

See the reference illustration: DVM pre-calibration.

In the illustration you see the BRIDGE UNIT in the calibrate position for DVM basic settings. You should have checked your solder work by now and are confident that the readings will be accurate. Well hold on...not true. Your readings will be anything but accurate at this point. What you are about to do is adjust the 100K pots ahead of RF live calibration. This step will place the BRIDGE unit inside the ballpark and you will have little fussing to do when you calibrate LIVE.

DVM BASIC: RL1 pinouts to ground, follow the schematic as shown below.

1 = 30K, 2 = 65K, 3 = 65K (set these readings by adjusting RV3)

4 = 100K, 5 = 75K, 6 = 75K (set these reading via RV2)

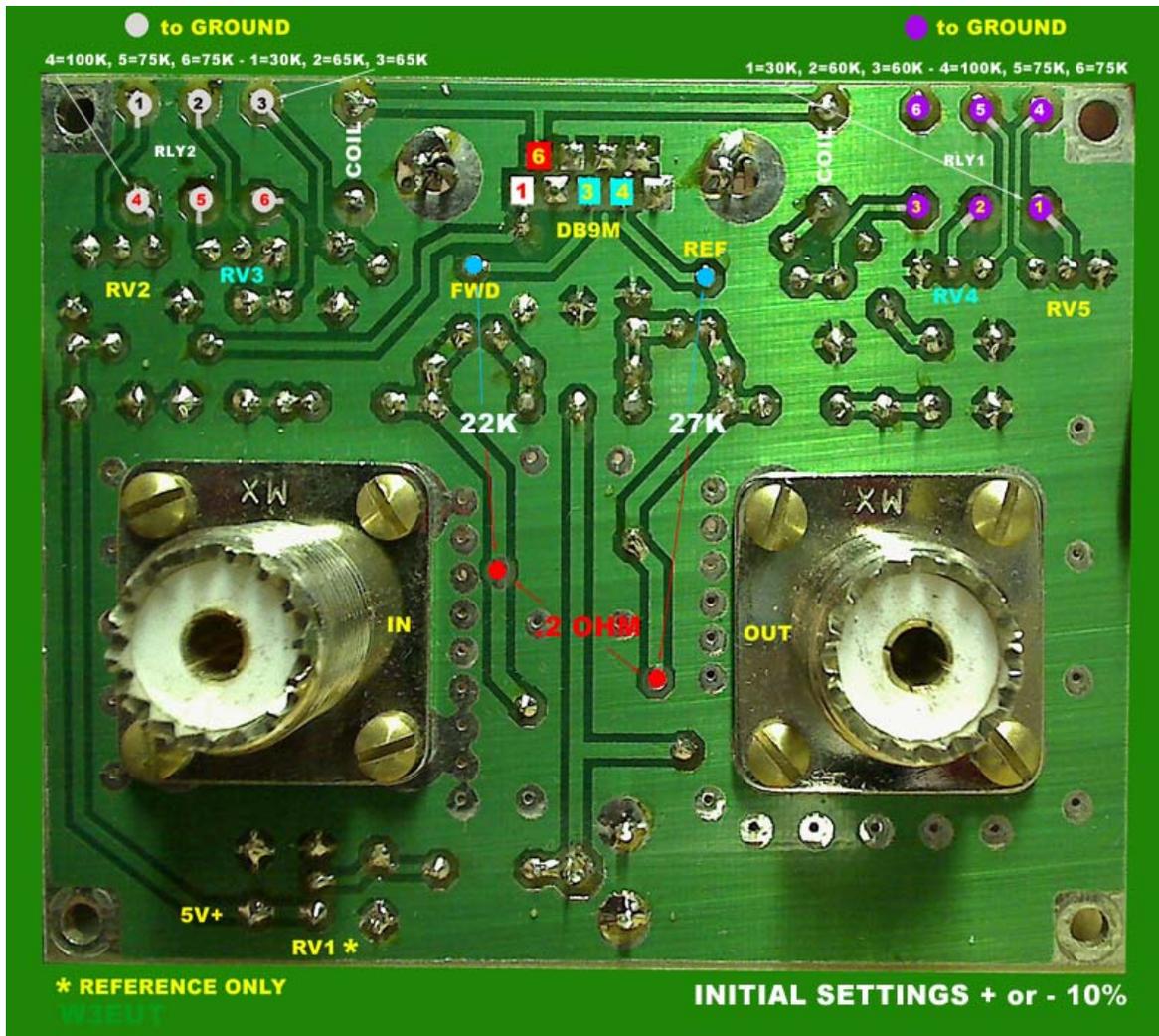
DVM BASIC: RL2 pinouts to ground, follow the schematic as shown below.

1 = 30K, 2 = 60K, 3 = 60K (set these readings by adjusting RV4)

4 = 100K, 5 = 75K, 6 = 75K (set these reading via RV5)

Because the bridge is symmetrical across the design from FWD – REV, setting these basic numbers will certainly be accurate for government work. However there are steps that should be taken to insure a more accurate reading.

Note: RV2-RV5 are 10% tolerant devices. That means any 2 adjustments could be as far off as 20%. Therefore 1% pots would be great replacements for a more accurate device.



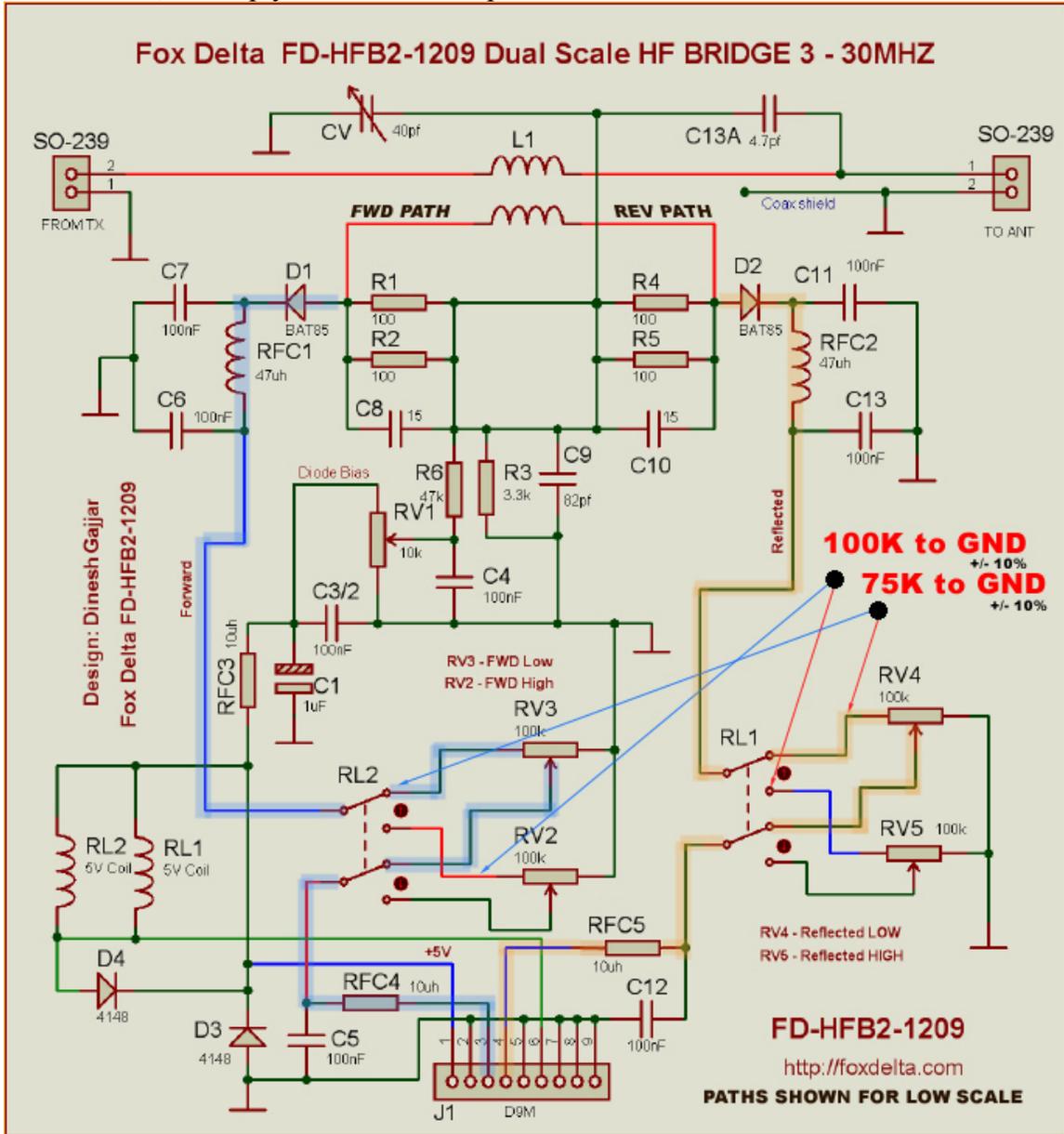
In the SCHEMATIC BELOW, you can see the basic test points that can be set while building the DUAL BRIDGE UNIT.

The RF sensor paths are shown for FWD and REV. These paths are highlighted for LOW SCALE (100 – 200W) only. However, HIGH SCALE uses the same path, by simply closes the relay applying 5VDC activated through PIN 1 of D9M, while pin 6 is common COIL. The software or the interface buttons controls the relay COMMON feed through PIN 6 to the SWM-2 wattmeter.

Setting these points to read as displayed will confirm operation and relay connections. If you install the relays first, you can test their operation by using a 3VDC signal across the coils as shown. You will hear a soft click, however you can use your DVM to confirm OPEN/CLOSE conditions.

Note that the variable capacitor CV is used to tune the L1 network. I used an oscilloscope at the junction of R1 and R4 with 10 watts of RF applied, I adjusted CV for the highest

level of RF read on the scope in the 2MS TIME BASE and CW output. This adjustment is not critical, so simply CENTER the cap as illustrated in the Fox Delta .PDF file.



It should be understood that final calibration must be done as explained in the previous text on pages 5-6. The DUMMY LOAD is very important for an accurate alignment. A simple 50 OHM non inductive resistor will do the job. You only need a dummy load for 100W range. So don't panic if you are thinking about your amplifier (do not use it for calibration). It also should be understood that placing the unit as close to the exciter as possible during calibration will help as well.

Note: If you experience a RED LED and "HIG" on your SWM-2 after reversing the coax connectors, simply use the DVM method for REVERSE and set RV4 and RV5 to match your FWD settings at RV2 and RV3.