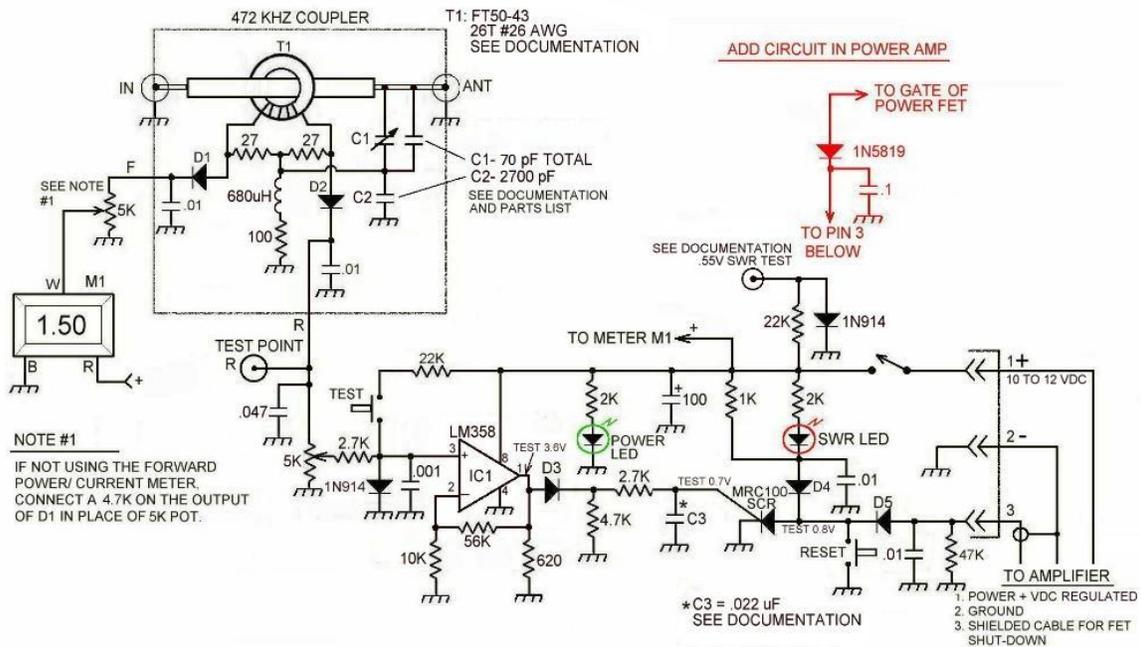


3/02/2026...Added a new (limited components circuit) that can be used for amplifiers 200 watts and above. See last page.

6/16/2019...Change in this revision. The coupler was redesigned with a new T1 core (FT50-43) that allows for high power and low power amplifiers, and the circuit now uses a LM358 op-amp in the place of the FET. This circuit is much improved with better SWR detection. It also has a .55V set point for SWR adjustment.

### 472 kHz SWR SHUT-DOWN CIRCUIT



06-03-2019

There is a large print schematic at the end of this document, but first some background on the MOSFET shutdown circuit.

After hearing about flakey antennas causing MOSFETS to fail, I decided to build a shutdown circuit to protect my amplifiers. The goal was to kill the drive to the FET before the FET had time to destroy itself. I decided that 100us shutdown after high SWR was well below the avalanche breakdown time. I did my testing on the IFRP250 but doing research on other devices like the IFR540 the 100us should be good.

At the set point (the point where the SWR trips) the delay is 200us. One watt above the set point is 100us, 3 watts is 60us, and 5 watts is 40us. With a high SWR spike the delay will be less than 40us.

With current, voltage, and temperature of the MOSFET all being a factor, MOSFET failure can be a complicated issue.

### **From the Toshiba MOSFET Avalanche Ruggedness Application Notes.**

Avalanche breakdown occurs when a voltage exceeding the breakdown voltage BVDSS is applied to a MOSFET. This is due to a back-EMF voltage induced by a circuit's stray inductances. Reducing stray inductances is the most important measure for protection against avalanche breakdown. If stray inductances cannot be reduced sufficiently, it is necessary to consider drive conditions to prevent voltage surge or add a surge-absorbing circuit.

<https://toshiba.semicon-storage.com/info/docget.jsp?did=59466>

So when we are using the Power MOSFET for RF amplification you can't always control what happens on the antenna system with changing conditions and stray inductances, so the SWR shutdown should take care of that by killing the drive to the MOSFET before the avalanche threshold is exceeded.

I have tested the shutdown circuit up to 300 watts, and 400+ watts should not be a problem.

## **Construction**

Start by building the directional coupler. I made the design simple to build with only 26 turns no center tap on the transformer. Wind 26 turns #26 wire on a FT50-43 core. I used the inter conductor from RG6U coax for the primary winding through the transformer. Note how the wires exit the core; I taped them to the RG6 foam insulation. *See pictures.* The two 27 ohm resistors should be matched to balance the circuit. I tried 1% metal film, and 5% carbon film both worked well. **Use ½ watt resistors.** **Note** 26 turns is the wire going through the center of the core 26 times. I used two capacitors for C1, one fixed and a trimmer. This improves the fine-adjustment when you zero the voltage.

## **Testing the coupler**

Connect a transmitter to the input of the coupler, and the output to a 50-ohm load. Connect a 4.7K resistor to D1-F and ground, and a 4.7K resistor to D2-R and ground. These resistors will simulate the shutdown circuit while testing. Connect a voltmeter to the R output and ground.

Apply RF power to the coupler and adjust the C1 trimmer for a dip in the voltage. Be careful not to short out the circuit; use an insulated tuning tool to adjust the trimmer capacitor. The voltage should be as low as possible, less than 5mv at 100 watts in. Now check the voltage on the output of D1-F. It should read around 3 volts at 100 watts. I was only able to test the coupler with 2 watts drive at 135 kHz. I don't have a 135 kHz amplifier, so some changes may be needed if trying to use it on 2200M. Check the parts list for the C1-C2 values I used at 135kHz.

## **Observations and Suggestions.**

**D3.** It's very important to use a fast recovery switching diode like a 1N914 or 1N4937. This insures the trigger timing is consistent on the gate of the SCR. Do not use a Schottky diode, the .6 volt drop across the diode is a part of the circuit.

**Input voltage.** I recommend placing a 10 or 12 volt regulator inside the amplifier to supply the regulated voltage. Wire the regulator so that its continuous not switched.

**Forward current meter.** The digital volt meter works well for reading forward RF current and takes up very little space on the project box. The current meter is optional so if you choose not to add it, you still need the 5k pot or a 4.7k resistor connected to (F) forward power output of the coupler. An analog meter with a power scale will work also.

### **Wiring to the amplifier.**

For the ground and power leads I used # 24 gauges stranded wire. For the control cable I used a small shielded audio cable. Small coax like RG-174 would work well too. On the amplifier I mounted a 3 conductor plug so I could move the control box from one amp to another.

### **Boxes for the coupler and shutdown circuit.**

I used two separate boxes for the coupler and shutdown circuit, but there is no reason not to build both in the same box. I just had the two boxes lying around so I built and tested the coupler first then moved on to the shutdown circuit in a separate box.

### **Amplifier control Circuit.**

Add the Schottky diode circuit to the gate of the MOSFET final. If using two finals add two circuits one to each FET, and tie the two cathodes of the 1N5819 to pin 3 of the shutdown circuit. These added circuits have no effect on the drive to the FET finals unless there switched to ground by the SCR.

### **C3 Timing**

A .022uf will trigger the SCR at around 100us. I did my entire bench testing with the .022 and tried to damage the FET by removing the load shorting the output making a loose or bad coax connections and I was not able to damage the FET. All the testing was done using an IFRP250 running 100 watts out. FYI changing C3 to a .01 will lower the trigger time 50%, but I don't think it's necessary. I'm running the shutdown circuit on my amplifiers with the .022uf.

### **Adjusting the circuit.**

First press the test switch and the circuit should trip and the red SWR LED should come on steady. Press the reset and the LED should clear.

Verify that C1 is still nulled with the shutdown circuit attached. Apply RF power to the coupler and adjust C1 for a dip in the voltage (less than 5 mv at 100 watts) on the R-test point while connected to a 50-ohm load.

There is a .55 VDC test point on the circuit. Connect a jumper from this point to the R test point. Adjust the 5K reflected pot until the SWR LED comes on. This is equal to 5 watts reflected. This is a good setting for SWR protection, but you could adjust the circuit for any other power level you prefer. You could also adjust the reflected trip level by moving the transmitter frequency until the SWR is at the desired level you want to circuit to trip. This is a good test to verify everything is working correctly under operating conditions.

### **Adjusting the forward power meter.**

If you have added the current meter adjust F-5K pot to read 1.50 with a 100 watts in, or .7 at 25 watts in. The output should be terminated into a 50 ohm load.

### **Final Test**

With the circuit connected to the amplifier and with output power press the test switch and the output should drop to zero. This is also a good test to do regularly to verify all is working well.

If you have problems, check the idle voltage on IC1 and the SCR. When you press and hold the test switch the voltage should change to, (IC1 out 3.6v), (SCR gate .7v), (SCR Anode .8v).

**One final note.** If you're building a new amplifier you could add this circuit inside chassis. Remember the shutdown circuit does not protect the jumper coming from the amplifier to the directional coupler. Make sure you use a good jumper!

I hope this will save a few FET's. Email me with any questions.

Tom WB4JWM

## Parts list.

Parts available at Mouser Electronics or <https://www.taydaelectronics.com/>

D1, D2 BAT46.

D3 1N914, or 1N4937, fast recovery Diode.

D4, D5 1N5819

IC1 LM358

L1 680uh choke Tayda Electronics A-475

SCR MCR100 or equivalent

M1 EBay DC 0-30V LED panel voltmeter 3 wire.

5k Use a multi turn trimmer for the shutdown adjustment, (Cermet 25 turn)

BOX for shutdown circuit 60 X 112 MM 1590B

BOX for directional coupler 38 X 92 MM 1590A

27 ohm resistors in coupler. Use 1% or 5% ½ watt.

T1 FT50-43... <http://www.kitsandparts.com/toroids.php>

C2 2700 pf (.0027uf) capacitor. I used a Polyester Film Box Type Capacitor. Tayda A-700

C1 5-35 PF Trimmer capacitor rated 250v or above.

C1 30pf Fixed. This gives you around 50 totals when the Trimmer is adjusted for a null.

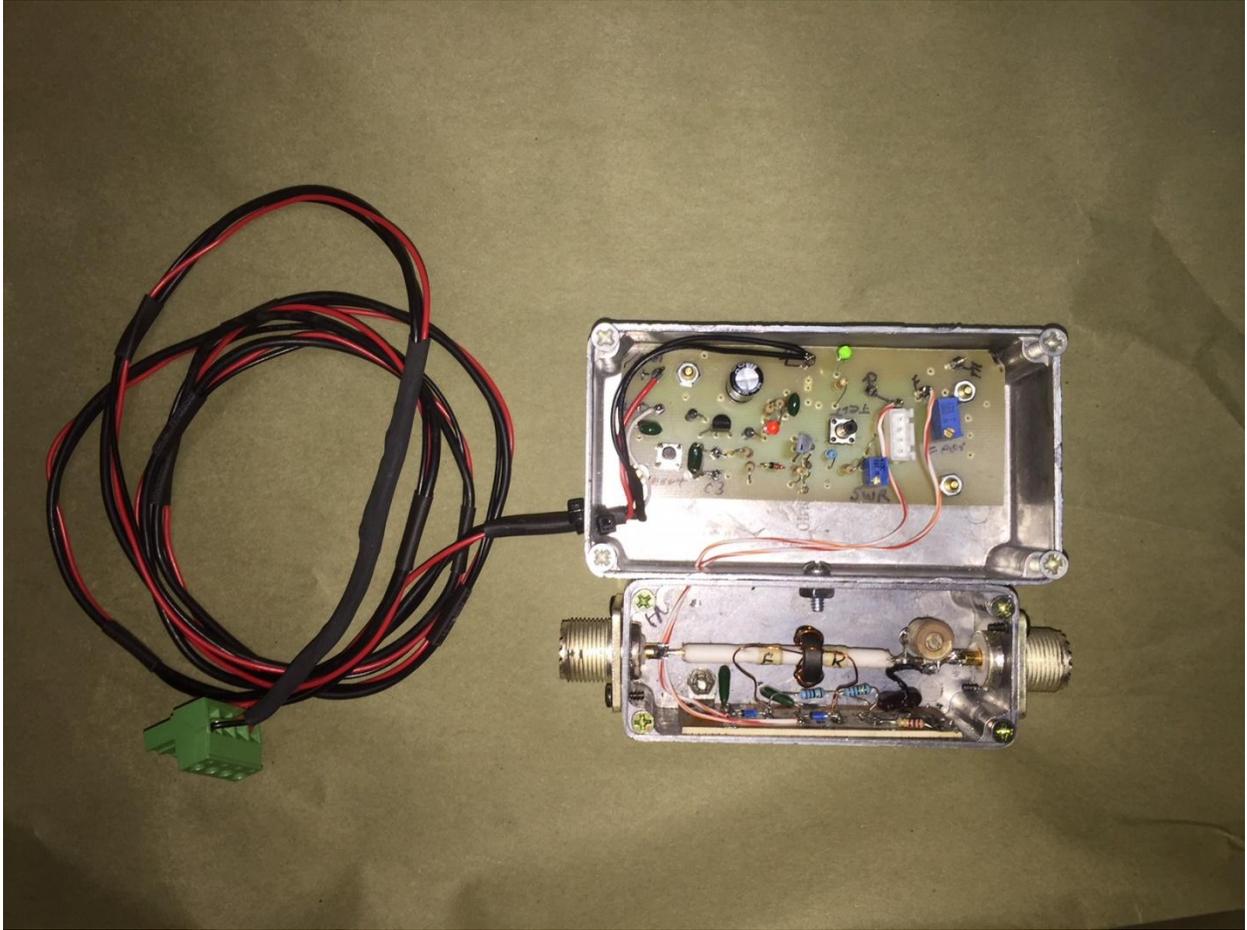
4-34 pf 250V found here. <https://www.jameco.com/> • **Jameco Part no.: 32839**

**If using the coupler on 135 kHz, three components changed.**

C2 .0082uf

C1 10-70 pf Trimmer Capacitor, or something that covers the 50 pf range.

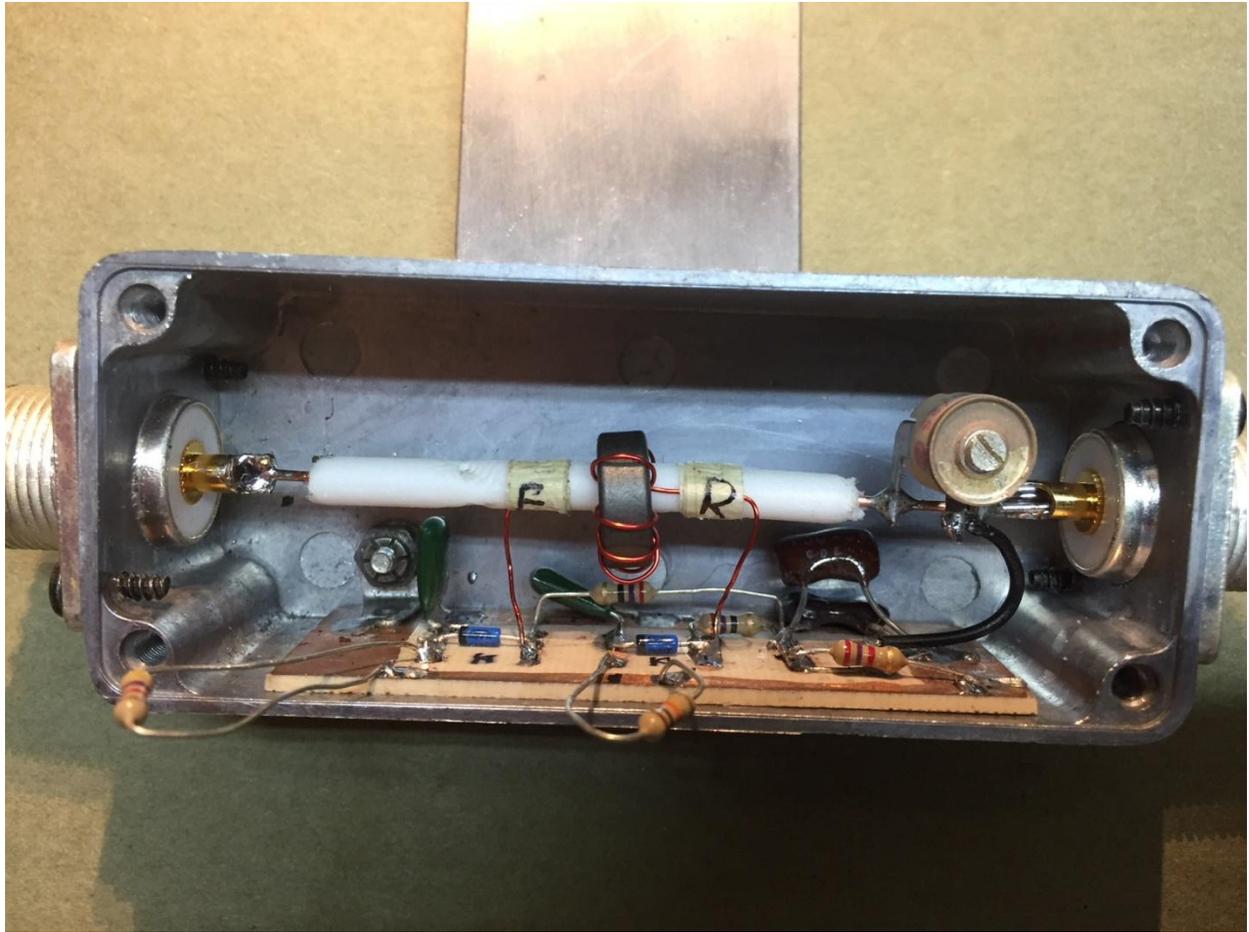
C1 Fixed value is a 100pf.



**This is the second one I built and it is not the same as the next picture showing one in operation. The coupler position is reversed. This is the original circuit using the FET so the IC is not shown in this picture.**

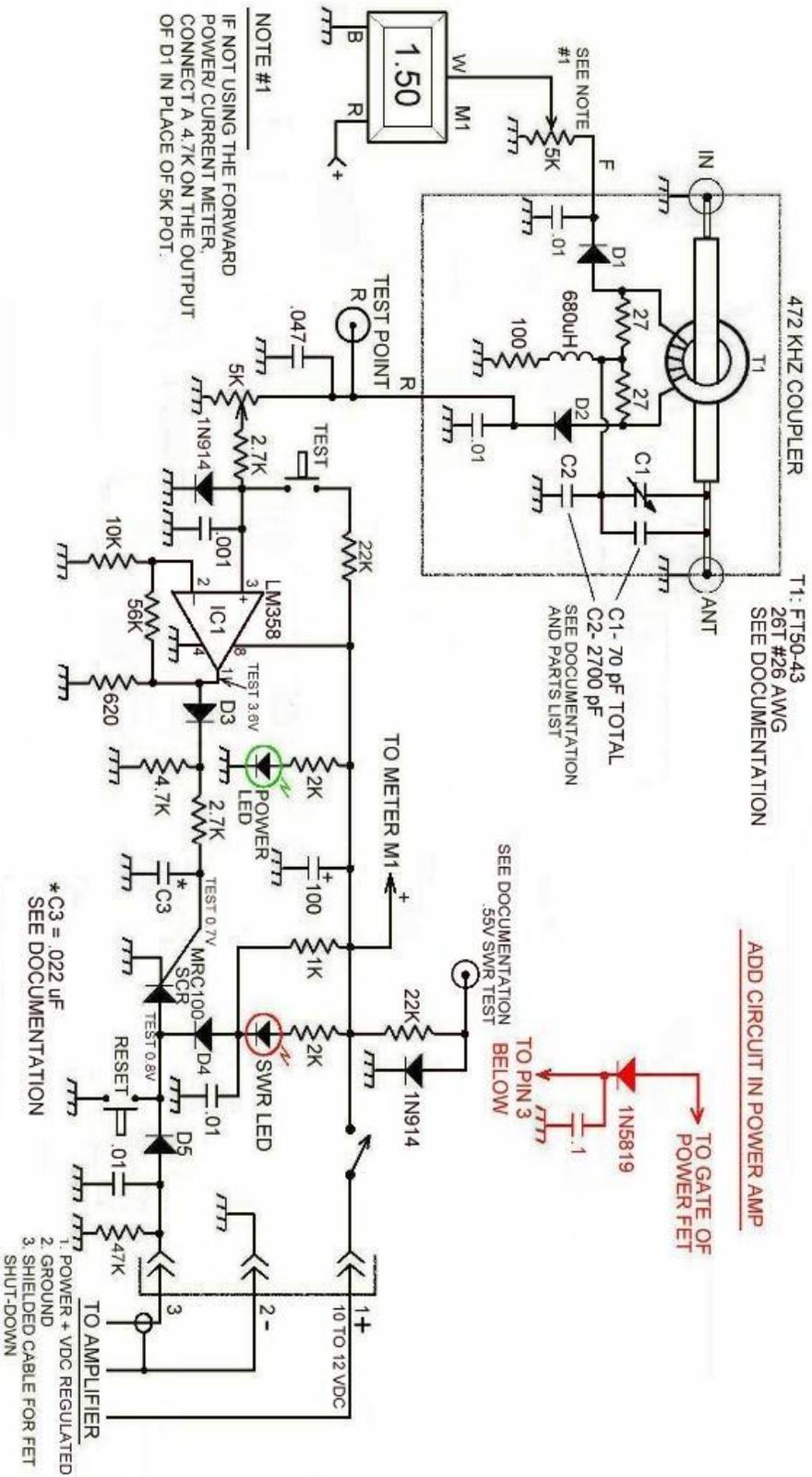


Shutdown unit under operating conditions, transmitter just above 200 watts.



Coupler shown with the test resistors connected. Notice how the wires exit the T1 core. Reflected wire exits to the right, forward current wire exits to the left. Left SO-239 is amplifier in; Right SO-239 is antenna connection.

# 472 KHZ SWR SHUT-DOWN CIRCUIT



# 472 KHZ SWR SHUT-DOWN CIRCUIT

## SIMPLE CIRCUIT USED FOR AMPS OVER 200W

