

Part 3 - CW Transmitter

Build Sequence 5

Transmit Driver Amplifier

Circuit Description

The transmit driver amplifier takes the approximately +9 dBm CW signal from the VFO and linearly amplifies it to a level of approximately +25 dBm (about 330 mW). This is the amount of drive needed to fully power the transmit power amplifier for a 5 W output.

Trimmer R74 acts as a voltage divider to provide a fully adjustable level of VFO energy to the amplifier. Q22 is voltage-divider biased by R75 and R76 to ensure that the amplifier operates in class-A mode. Q22's emitter is RF bypassed to a 12 Ω resistor (R79) through C71. A bifilar broadband transformer (T8) is used to transform the expected 50 Ω output load to a 200 Ω collector load. Note that this amplifier is powered from the +12v T line, which means that it is only turned on during key-down.

- ❑ **Step 1 – Install R74**
- ❑ **Step 2 – Install C70**
- ❑ **Step 3 – Install Q22**
- ❑ **Step 4 – Install T8**

Refer to the Construction Methods to wind T8, a bifilar broadband transformer.

- ❑ **Step 5 – Install R75, R76, R77, R78, R79**
- ❑ **Step 6 – Install C71, C72, C73**
- ❑ **Step 7 – Sanity Check**

Connect a temporary test lead (an alligator clip lead is probably best for this test) to the +12v rail for use in keying the transmit driver amplifier. Terminate the amplifier output (C73) with a 50 Ω dummy load. Connect the VFO to the mainboard (coax from VFO output to hybrid splitter, +12v to VFO feedthrough capacitor). Set R74 to fully clockwise to get the maximum amount of VFO drive signal into the amplifier input. Connect the +12v rail to a power supply, and turn on power.

Connect the temporary +12v test lead to the +12v T node on R78. Measure the power output at the dummy load using an oscilloscope, RF probe, or milliwatt meter (if using a milliwatt meter, it may have a built-in 50 Ω termination). You should measure approximately 10 to 11 V_{pp} using the oscilloscope. Also note that the waveform is not very clean (due to the impedance mismatch of R74

and the hybrid splitter). If using the RF probe, you should measure approximately 2.5 to 2.8 V on your voltmeter. If your output is connected to a milliwatt meter, you should read approximately 250 to 330 mW of output power.

While monitoring the output power, adjust R74 counterclockwise and note that the output smoothly adjusts down to nearly zero. Turn R74 back to fully clockwise and check that the power smoothly ramps back up to the value measured previously.

Transmit Power Amplifier

Circuit Description

During periods of key-down, the transmit driver amplifier generates a CW signal of approximately +25 dBm (330 mW), which is then amplified by the class-C transmit power amplifier to a level of about +37 dBm (5 W).

Transformer T9 provides a 4:1 impedance transformation to match the 50 Ω output of the transmit driver amplifier to an impedance of 12.5 Ω, which is needed to drive the base of Q23 properly. In order to get a power output of 5 W, the collector needs to see a load of :

$$R_L = \frac{V_{CC}^2}{2P_O}$$

Since we desire a 5 W power output:

$$R_L = \frac{12^2}{2(5)}$$

$$R_L = 14.4 \Omega$$

We can come close to this by using a 1:4 broadband transformer (T10) to transform the standard 50 Ω output impedance to a 12.5 Ω load for Q23's collector.

- ❑ **Step 8 – Wind and install T9**

Refer to the Construction Methods to wind T9, a bifilar broadband transformer.

- ❑ **Step 9 – Install C74**
- ❑ **Step 10 – Install R80**
- ❑ **Step 11 – Install Q23**

Secure Q23 to the copper clad substrate using a 4-40 bolt (approximately 1/4 inch) and nut.

- ❑ **Step 12 – Wind and install T10**

Refer to the Construction Methods to wind T10, a bifilar broadband transformer wound on a binocular core (BN43-302).

- ❑ **Step 13 – Install C75, C76, C78**
- ❑ **Step 14 – Wire T10 to R71 (+12v)**

Transmit Low-Pass Filter

Circuit Description

This low-pass filter is a standardized three-pole, half-wave design taken directly from the W1FB QRP Notebook. Since the Transmit Power Amplifier operates in class-C mode, the output waveform will be heavily distorted and have much harmonic content. The purpose of this filter is to greatly reduce the harmonics of the signal, which will result in a clean sine wave output at the antenna port when operating into a 50 Ω resistive load.

- ❑ **Step 15 – Install C79**
- ❑ **Step 16 – Wind and install L12**

L12 is a 738 nH inductor wound on a T37-6 ferrite core. Cut a 9 inch length of 26 ga. magnet wire and wind 16 turns on the core. Prepare the leads as specified in the Construction Methods.

- ❑ **Step 17 – Install C80**
- ❑ **Step 18 – Wind and install L13**

L13 is a 866 nH inductor wound on a T37-6 ferrite core. Cut a 10 inch length of 26 ga. magnet wire and wind 17 turns on the core. Prepare the leads as specified in the Construction Methods.

- ❑ **Step 19 – Install C81**
- ❑ **Step 20 – Wind and install L14**

L14 is a 738 nH inductor wound on a T37-6 ferrite core. Cut a 9 inch length of 26 ga. magnet wire and wind 16 turns on the core. Prepare the leads as specified in the Construction Methods.

- ❑ **Step 21 – Install C82**
- ❑ **Step 22 – Install antenna connector J2 to C82**

This is a user-supplied connector. Use your own preferred antenna jack (BNC, UHF, etc.) using a small piece of RG-174 coaxial cable.

T/R Switch

Circuit Description

This circuit is not so much a switch as it is a filter. L11 and C77 form a 14 MHz series-resonant LC circuit. During periods of receiving, the incoming RF is picked off after the 14 MHz low-pass filter. It passes through the T/R switch circuitry with very little attenuation, since the L11/C77 is resonant at this frequency range. From there it is fed into the front end of the receiver.

During periods of transmit, the 14 MHz component of the output of the PA (remember that there are also lots of harmonics present at this point) can pass through L11/C77. However, because this is such a large signal, the waveform will be clipped by D13-D16. This will only allow a maximum signal level of about 2.4 Vpp to pass to the receiver front end, which is low enough to protect it from damage. Since the audio chain is also muted during transmit, your ears are protected from the very large audio signal this would generate.

- ❑ **Step 23 – Install C77**
- ❑ **Step 24 – Install D13, D14, D15, D16**
- ❑ **Step 25 – Wind and install L11**

L11 is a 5.68 μH inductor wound on a T50-2 ferrite core. Cut a 22 inch length of 26 ga. magnet wire and wind 34 turns on the core. Prepare the leads as specified in the Construction Methods.

Alignment and Performance Verification

- ❑ **Step 26 – Verify Power Output**

Connect a temporary test lead to +12v for keying (as described in Step 7). Connect a 50 Ω dummy load to the antenna jack J2 (If you have a power meter with a built-in load, connect this to J2). Connect the +12v rail to a power supply, and turn on power. Make sure that your headphones are not connected to J1 during this test.

Apply the +12v test lead to the +12v T node of R78 in order to key the transmitter (be careful to key down for only enough time to make a measurement). Measure the power output at the dummy load using an oscilloscope or power meter. You cannot use the RF probe for this measurement because the 5 W output power nearly exceeds the PIV rating of a 1N34A diode. If using an oscilloscope, you should measure a signal of approximately 50 Vpp with a very clean sine waveform. If using a power meter, you should measure approximately 5 W of output power.

While keying the transmitter, adjust R74 counterclockwise and observe that the power

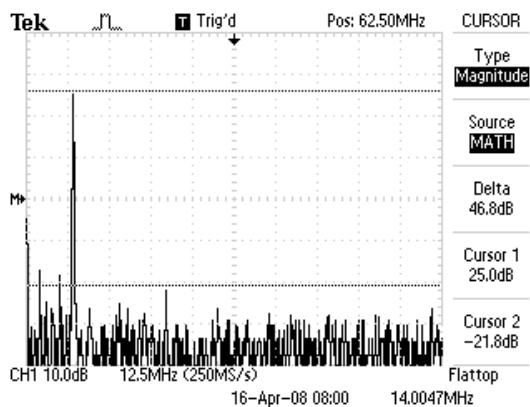
output is continuously adjustable down to nearly 0 W. Readjust R74 back to fully clockwise, and observe that the power output smoothly adjusts back up to the maximum output of approximately 5 W.

□ **Step 27 – Verify Signal Purity (Optional)**

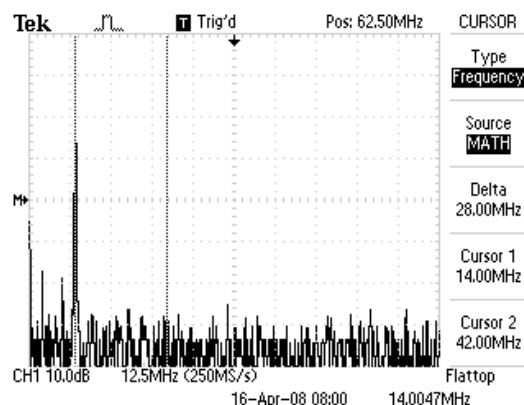
If you are fortunate enough to own an oscilloscope with a FFT function or a spectrum analyzer, use it to measure the spurious output of the transmitter into a 50 Ω resistive load. If your oscilloscope does not have a FFT function, you can still roughly verify signal purity by observing that the output waveform is very close to a perfect sine wave.

Due to the wide variations in instruments, I cannot provide detailed instructions on how to setup your particular test equipment for this measurement. Please consult your product manual for this information.

To illustrate an example, I tested the beta rig using a Tektronix TDS1012 DSO, which has a FFT function. The following illustration is a screen shot of the FFT display, showing that there are no spurious products greater than -43 dBc (decibels below the carrier). This meets the FCC specifications for spurious emissions (§97.307), which states that the maximum spurious level allowed in a HF transmitter is -43 dBc.



The next illustration is the same FFT measurement, but with the frequency cursors turned on. This shows that the carrier is at 14.00 MHz and that the large spur present above the carrier is the 3rd harmonic at 42.00 MHz.



A spectrum analyzer display should be fairly similar to this, but should provide even better accuracy and measurement capabilities.