My QRSS TX is powered off +5v, which is fed from +12 or +13.8v, and I suspect many others do this.

Some stations are running their TX off +9v (excluding the ATtiny13 which is +5v), and getting power around 220mW. The currents quoted have been in excess of 100 mA, with the 2N7000 PA device being rather too hot to touch. Some stations are using heatsinks. Maximum power dissipation for the 2N7000 is 400mW in free air at 25C.

When the 30m TX is fed off +5v, around 100mW is obtained at 85- 90 mA overall current. Around 25 mA for the ATtiny13, the oscillator and driver stage, leaving around 60 mA for the PA device.

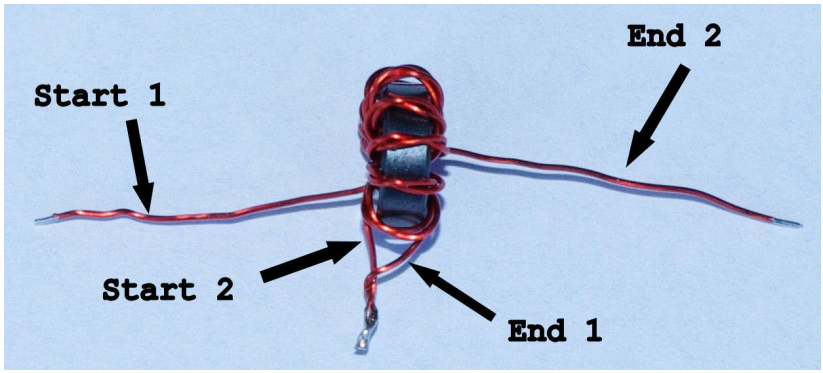
I thought about driving the PA to ~60mA, directly off a +12v PSU. This is 720 mW, and with efficiency of ~50%, then ~360 mW could be available.

The formula for matching PA collectors/drains to optimum load is R load ~ $V^2/2Pout$.
Using 12v and Pout of 0.36 W, then R load is 200 ohms.

I looked at the existing value of inductance for the PA drain coil, and considered it too high in value. Typically about 4 to 10 x the load is used for the reactance. The design used about 220uH or 200 x 50 ohm (~ 10k reactance at 40m).

So I thought ~ 10x 200 ohms load or ~2000 ohms.
At 40m this is ~ 50uH (6 turns of bifilar wound wire)
At 30m the same 50uH could be used.

At 80m, at whom another amateur is building the QRSS TX, 113uH was selected and this is 9 turns of bifilar wound wire.



The above example is of an 80m bifilar choke with 9 turns of the twisted wire. The wire was cut to twice the required length, folded and then twisted with a battery drill (on slow speed!) with the other end anchored. Twists/cm I reckon ~ 3

To determine the length of wire http://toroids.info/ has a good calculator and works well in practice. I have calculated the information for the 3 bands

80m Coil	Core Details	No of turns	Inductance	Length of wire
L1	T37-6 (ylw)	27t	2.2 uH	40 cm
L2 (5v)	FT37-43 (blk)	25t	220 uH	37 cm
L3 & L5	T37-2 (red)	25t	2.5 uH	37 cm
L4	T37-2 (red)	27t	3 uH	40cm
L2 (12v)	FT37-43 (blk)	9t (bifilar)	113 uH	32cm

40m Coil	Core Details	No of turns	Inductance	Length of wire
L1	T37-6 (ylw)	27t	2.2 uH	40cm
L2 (5v)	FT37-43 (blk)	25t	220 uH	37cm
L3 & L5	T37-6 (ylw)	19t	1.1 uH	30cm
L4	T37-6 (ylw)	21t	1.3 uH	32cm
L2 (12v)	FT37-43 (blk)	6t (bifilar)	50 uH	25cm

30m Coil	Core details	No of turns	Inductance	Length of wire
L1	T37-6 (ylw)	27t	2.2 uH	40cm
L2 (5v)	FT37-43 (blk)	25t	220 uH	37 cm
L3 & L5	T37-6 (ylw)	19t	1.1 uH	30cm
L4	T37-6 (ylw)	20t	1.2 uH	31cm
L2 (12v)	FT37-43 (blk)	6t (bifilar)	50 uH	25cm

The Bifilar wire lengths are longer to allow for length shrinkage while twisting.

Now the winding details out the way, next are modifications to the PCB. First a seperate +5v regulator is required and this may already be constructed either on a separate PCB/VeroPCB or a ratsnest. Remember to use adequate bypass capacitors. Typically 100nF to 10uF

Overview

The PA supply needs isolating from the +5v side
Extra bypass capacitor
Fitting resistors to pins 5,6 an 7 of the Attiny13
Fitting of bifilar Inductor

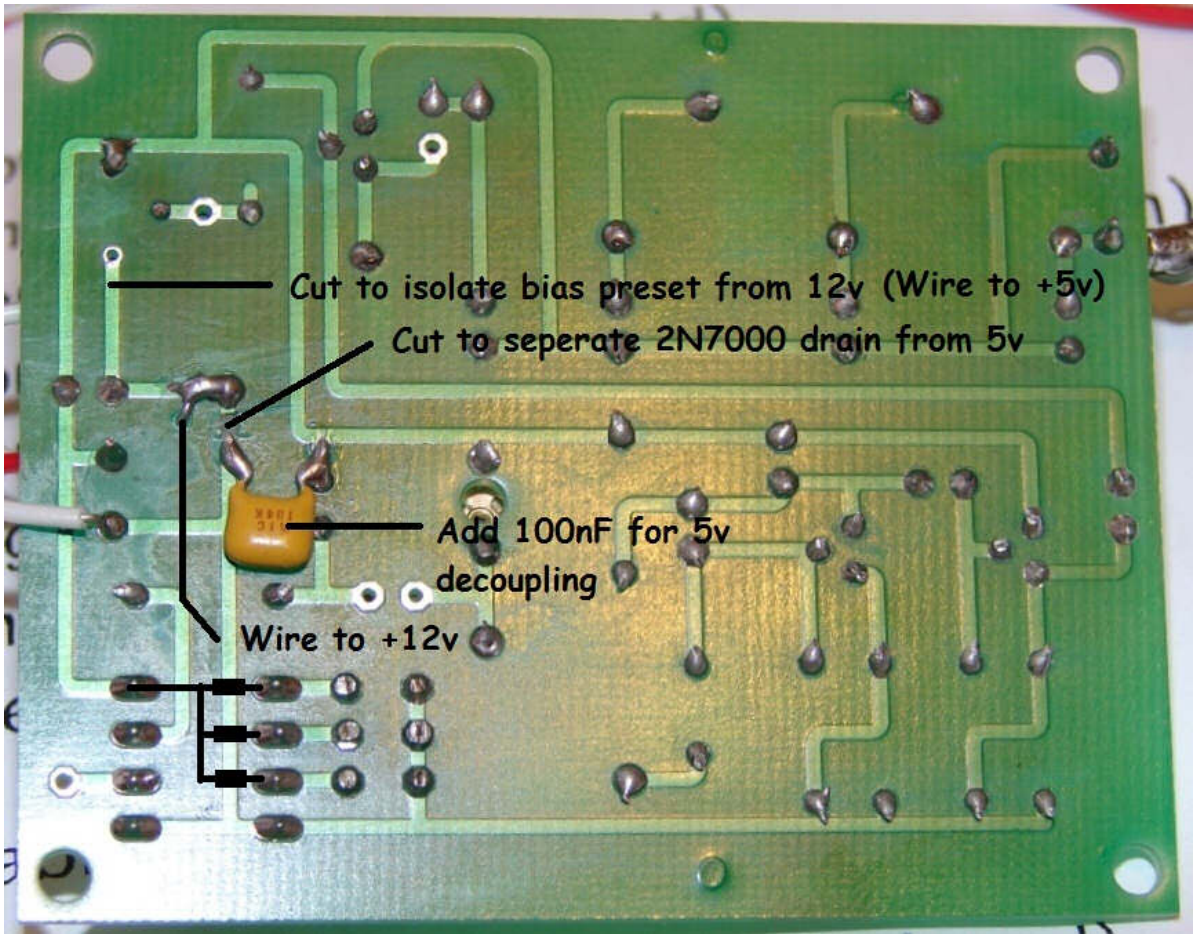
The following image shows the track cut to isolate the top of the drain choke from +5v. Just to the left of the cut on the track a small hole has been drilled so an external wire can be connected to +12v

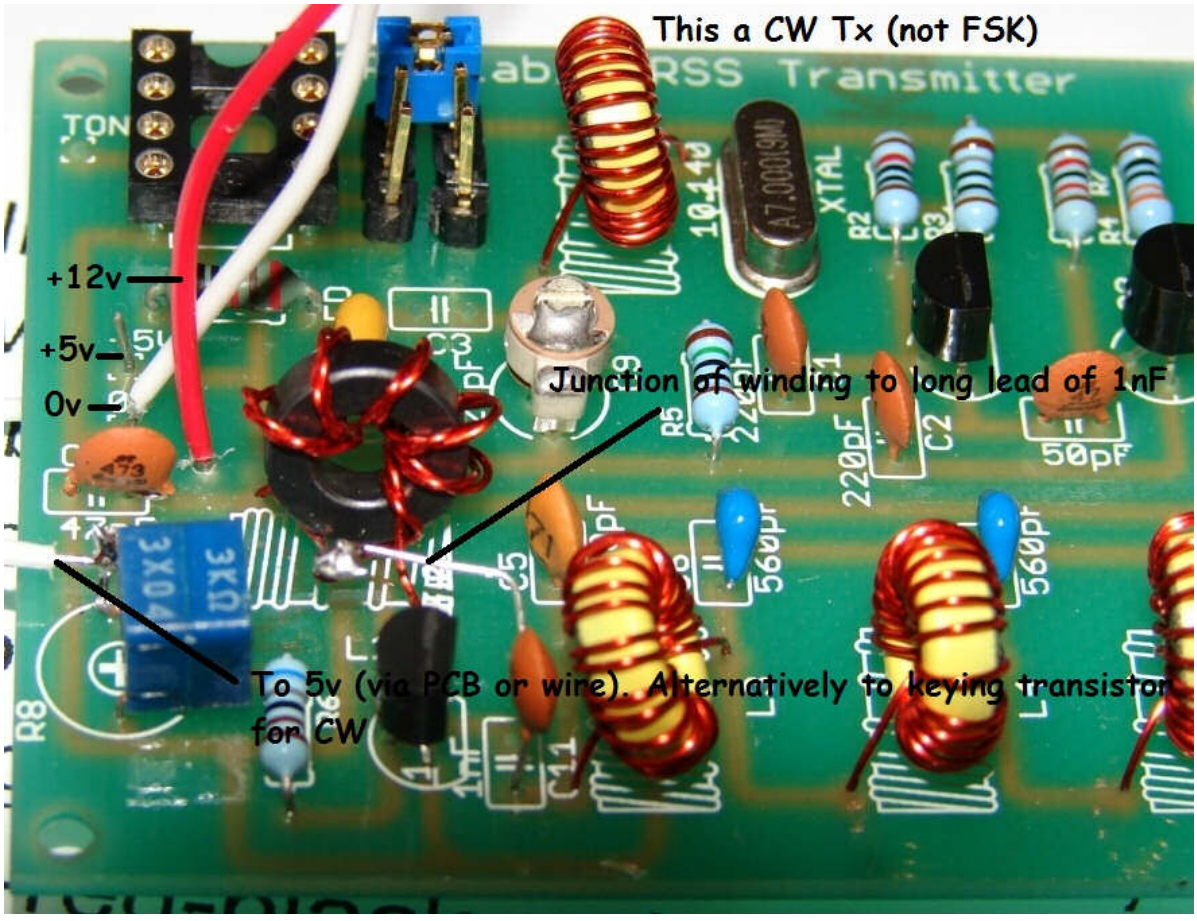
An additional track cut is made to isolate the top of the bias preset from the 12v.
Connect the bias preset either to +5v
or to the CW keying line as documented at
http://www.hanssummers.com/qrsskit/qrsskitmod1.html
Since the +5v should be a regulated supply it will minimise operating point drift of the PA device. Whereas the +12v could be a unregulated source such as a battery. Some people have noted that over-adjustment of the bias preset can lead to excess current. It could be worth adding an additional resistor between the +5v (or the keying line). A 1k8 might be a good place to start

There is only one supply bypass capacitor fitted to the whole unit, and after the track is cut, it is on the +12v side. An additional 47nF to 100nF is fitted as shown to act as a supply bypass for the +5v line

Pins 5, 6 and 7 of the ATtiny13 can float up and down and give incorrect keying. These should be pulled down to ground via 10k to 100k resistors. Pin 4 of the ATtiny13 is ground. The resistors could be SMD resistors or small leaded resistors wired to the selection pins and run adjacent to the IC pins. (It may pay to insulate the tracks underneath the IC if soldering SMD resistors there. (On a small sample of 3 units, I have seen this problem, so would think it is common)

The 2nd image shows the top of the PCB. The bifilar choke is fitted. One of the two single wires is connected to the +12v supply and the other to the drain of the FET. The common connection is connected to the free end of 1 nF capacitor. The other end of the capacitor is going to the low pass filter. (There are components missing on the 2nd image as they are removed for completion of the CW part of the unit.)


Cut to isolate bias preset from 12v (Wire to +5v)
Cut to seperate 2N7000 drain from 5v
Add 100nF for 5v decoupling
Wire to +12v


This a CW Tx (not FSK)
RSS Transmitter
+12v
+5v
0v
Junction of winding to long lead of 1nF
To 5v (via PCB or wire). Alternatively to keying transistor for CW

Settings.
Set bias pot to minimum so resistance on lead of 6k8 near preset is close to 0 ohms when measured to ground. Plug output of TX, either into a low level power meter (able to read 1 watt or less easily), or into known 50 ohm load able to dissapate 1 watt.

Insert current meter into + 12v supply. Note if the +12v supply also feeds the +5v, then the readings will be the overall current value (Red value on graph.)

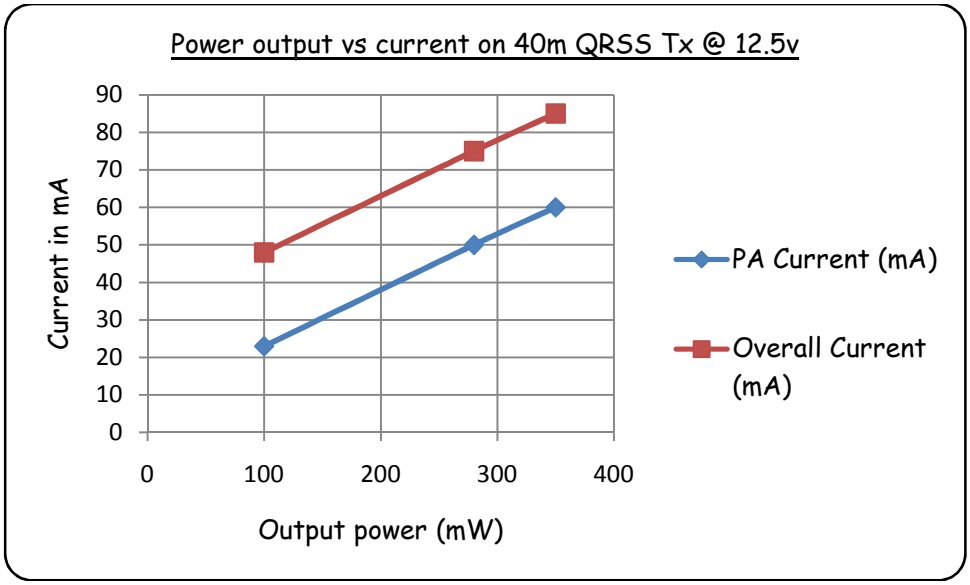
Note the current reading on switch on. If it is wildly excessive investigate for fault. It should be about 25 mA if the 12v also feeds the 5v regulator. If one is monitoring PA current only it should be close to 0 mA

Carefully adjust the bias preset for the required output power, and the current should be close to those values seen. (or vice versa... Adjust current should give required output power.

If running CW (not FSKCW) then monitor keying cycle. I use a LED and 470 - 1 k ohm resistor on keying line to show key up/key down on the outside of enclosure anyway. One could adjust the preset, when off and not see anything, then when it puts the PA on TX, it lets the smoke out. ☹
If one is going to run the TX off 13.8v then keep PA current around 52 mA maximum (77 mA overall). This should keep the 2N7000 dissapation under 400mW. This could be pushed further if the 2N7000 has some sort of heatsink. The thermal resistance of the 2N7000 is ~ 312 degrees/watt (junction to ambient) If one runs 0.4 watt through the device at 25C ambient the internal junction is 125C + 25C or 150C (!!)
Test Results on 40m version

PA Current (mA)	Overall current (mA)	Power out (mW)
23 mA	48 mA	100 mW
50 mA	75 mA	280 mW
60 mA	85 mA	350 mW

Backwave when used in CW mode (not FSKCW) better than 30 dB



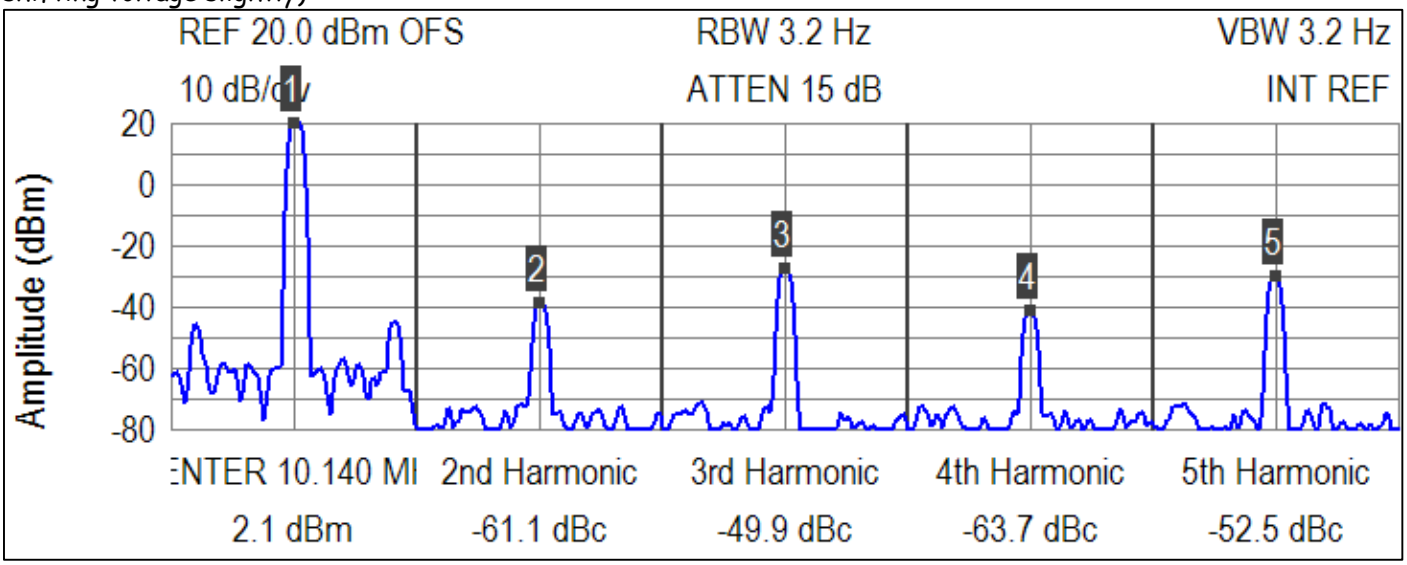
Additional suggestions
Use insulation over the crystal such as cotton wool or expanded polystyrene, and this will reduce the changes in air temperature affecting the crystal frequency. Keep enclosure out of direct sunlight.

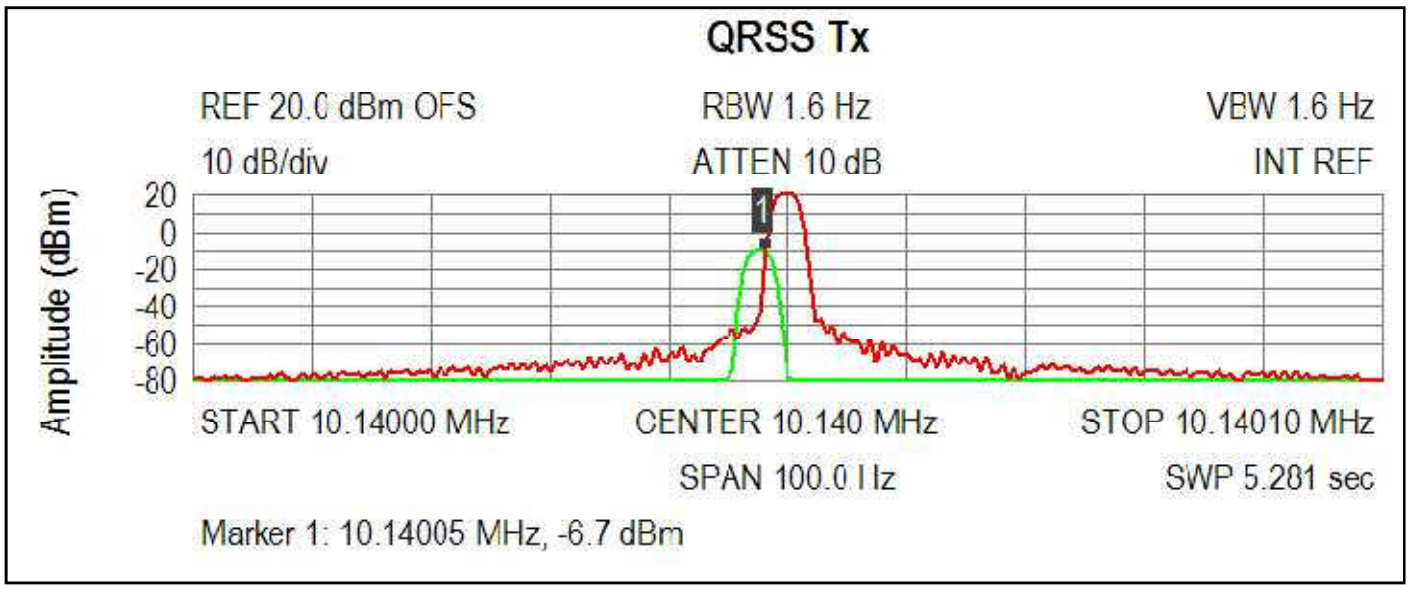
A useful accessory is a resistive VSWR bridge that can be fitted inside the unit, since most commercial SWR meters are far too insensitive
http://www.qqrp.com/resistive_swr_bridge.pdf is a good example. This can be fitted between the TX, any matching unit (if required) and the aerial. The 0A91 diode is pretty long in the tooth now and an alternative is the schottky diode 1N5711. An additional use for the resistive bridge is as a 6 dB attenuator. (when antenna is matched)

One can also construct a simple 1 watt RF power meter using a 1 watt 47- 56 ohm resistor (not wirewound) with one side to ground. The RF goes to the top of the resistor. The top side goes off to a 1N5711 diode (anode to the resistor). The other side of the diode goes to a rf decoupling capacitor such as a 10 nF. The other side of the capacitor goes to ground. All built with short leads, perhaps even connectorised and in a box. The DC output across the capacitor can be fed to a analog meter or DVM. A chart can be made using the formula
P in W = $(Vdc+0.3)^2/(2 \times 50)$
Example:- If one measures ~ 5.2v DC then P is = $5.5^2/100$ or ~ 0.3 watt or 300 mW

A suggestion by Colin ZL2CMC was to add a Tune function (applicable to CW version not FSKCW) by adding a SPDT switch & one resistor. Refer to the schematic http://www.hanssummers.com/qrsskit/qrsskitmod1.html The switch common goes to the base of the added switching transistor. One side of switch the goes to the added 22k/100nF combination (normal position). The other side of the switch goes to a 10k - 22k resistor, with the other end of the resistor connected to +5v (added tune position). Useful for setting power, frequency and also adjustment of an ATU (Note an added 10nF across the B-E junction of that added switching transistor will help stop stray RF from activating that circuit.)

Additional tests performed on my 30m QRSS Tx (CW not FSKCW)
Below are plots of my 30m QRSS TX taken with Signalhound USB Spectrum Analyser (with CW modifications as per Hans Summers website) used at 5v with no +12v PA modifications.
Harmonics are typically -50 dB down or better
There is 2 - 3 Hz frequency due to oscillator pulling between CW on/off keying. (This could be the +5v PSU shifting voltage slightly)





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