Using the Ultimate 2 on 472 kHz with an external PA

As shown in Figure 1, the output from the U2 is taken from pin 7 of the DDS module via a relay which is driven by Q1 using the transmit line from the ATmega168. This arrangement ensures that when the U2 is not transmitting, the input to the PA driver is set to +5V with respect to earth.

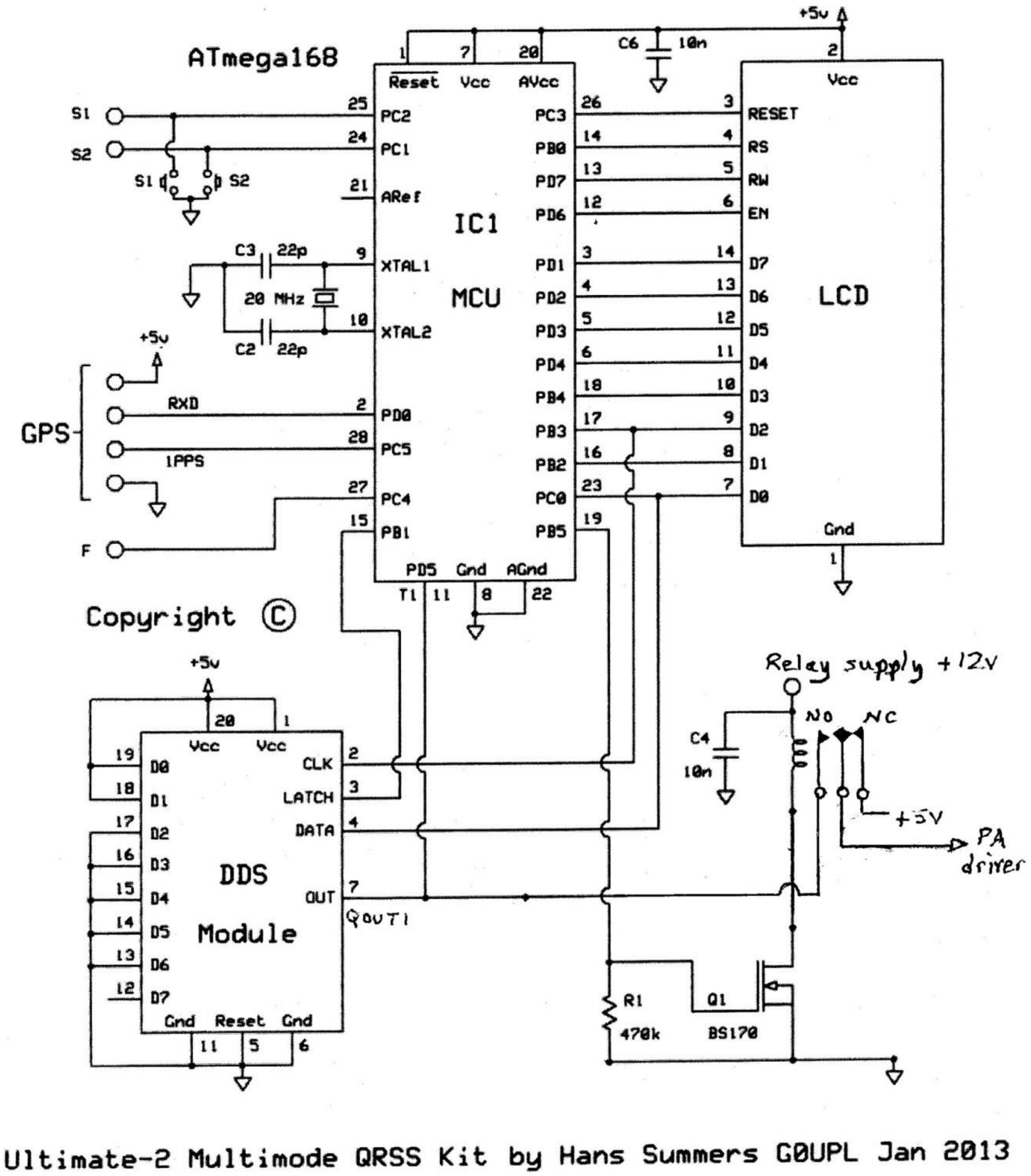

Figure 1 G8AGN's modification to original U2 circuit

Figure 2 shows the PA driver stages. The 470R resistor could probably be replaced by 1k to reduce current consumption. It may be advantageous to adjust the value of the 10k input resistor to improve the rise and fall times of the input switching waveform when measured at the IRF510 gate. Ideally, the waveform should be trapezoidal.

FB is a ferrite bead which should be threaded onto the IRF510 gate lead as close to the MOSFET as possible.

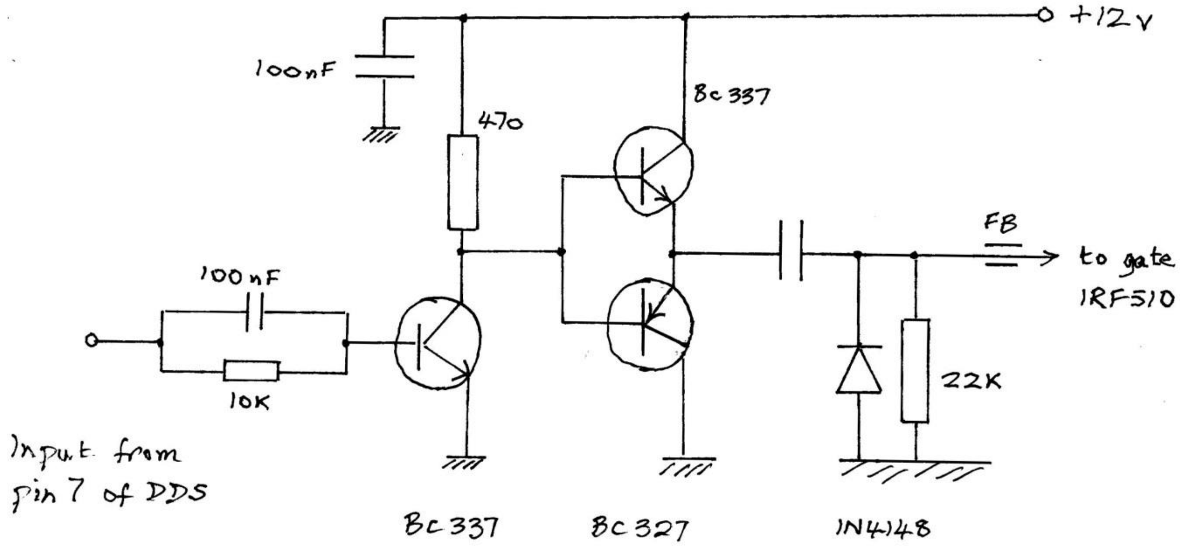

Figure 2 Driver stages for 472 kHz PA (Missing capacitor value is 100nF)

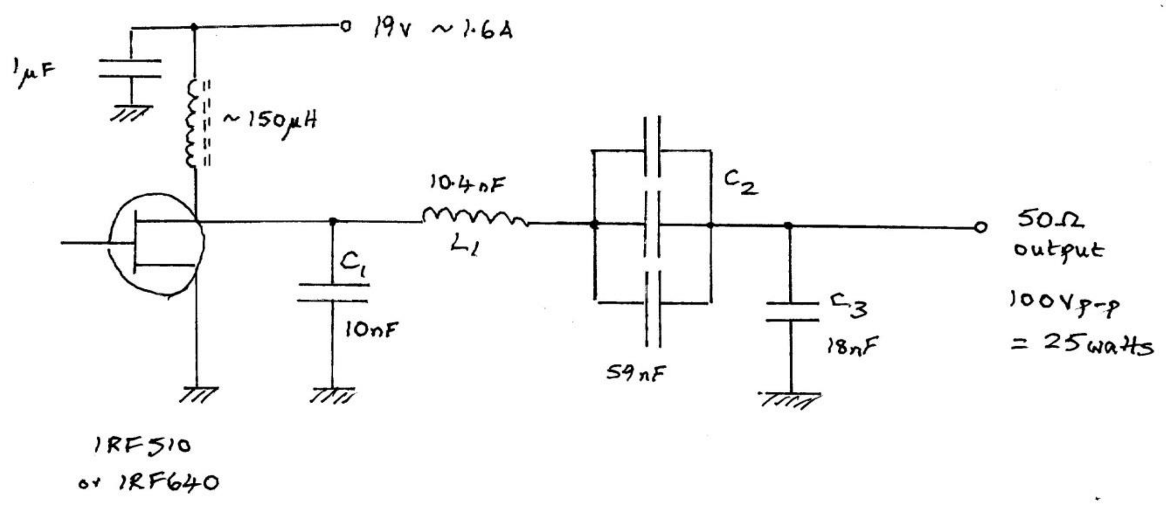

Figure 3 472 kHz PA stage

Capacitors C1, C2 and C3 should be polystyrene or polypropylene types as these have very low losses. The capacitors should be at least 100v working. C2 should be made up of several components in parallel to handle the large RF current flowing at this point.

L1 comprises approx. 30 turns of 0.9mm enamelled copper wire close wound on a 22mm white plastic tube (domestic plumbing pipe). Ideally wire of a larger diameter should be used but this will change the number of turns required.

C1 should be connected directly across the source and drain pins of the IRF510.

The exact value of the RF choke is not critical but it must be wound with thick wire to reduce losses. Suitable chokes are made by Murata for EMC suppression/SMPS applications.

NOTE that the series combination of L1 and C2 is NOT resonant at 472 kHz.

Figure 4 shows my breadboard driver and PA on soak test when driven with the U2 in WSPR mode.

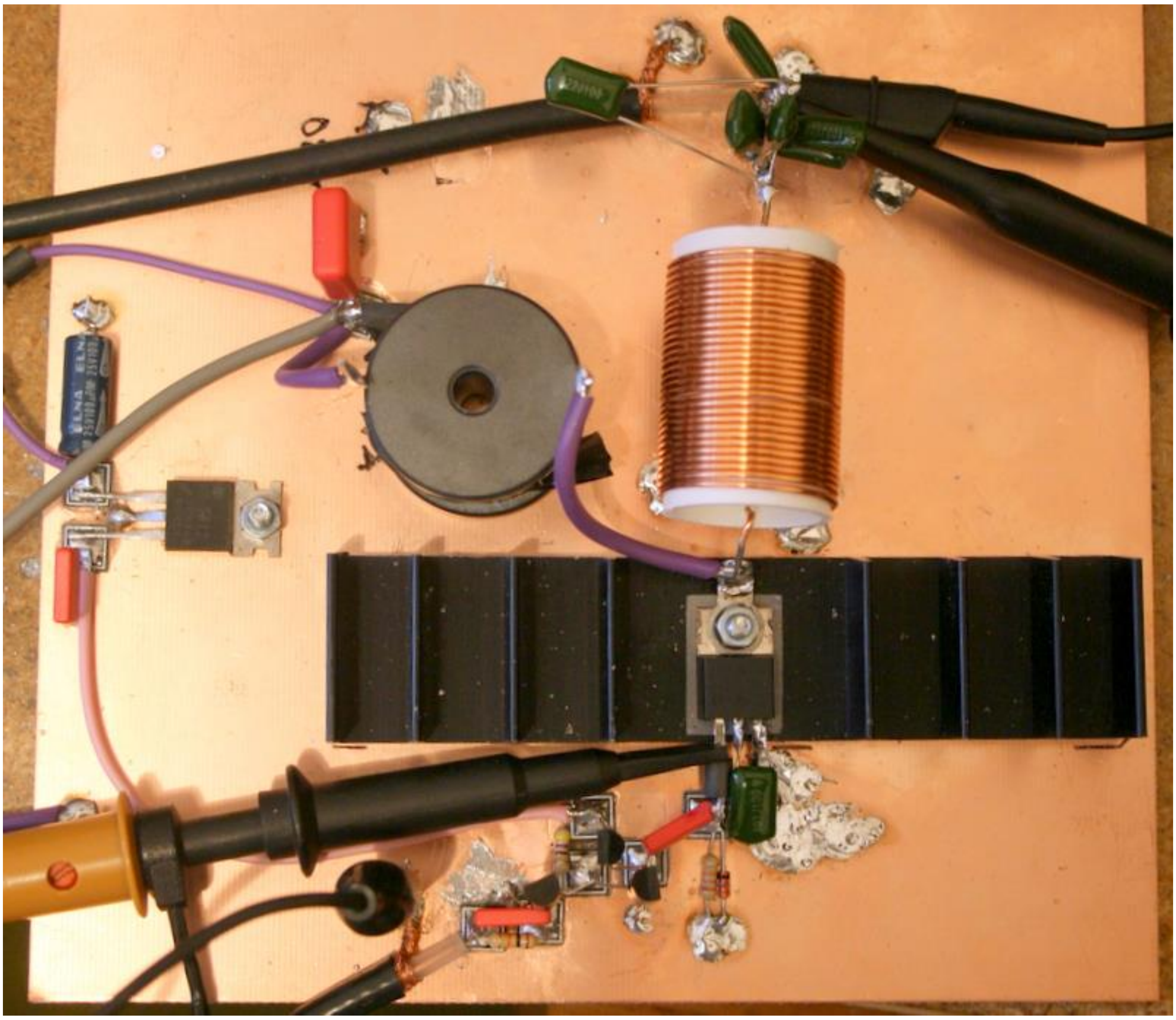

Figure 4 472k Hz driver and PA

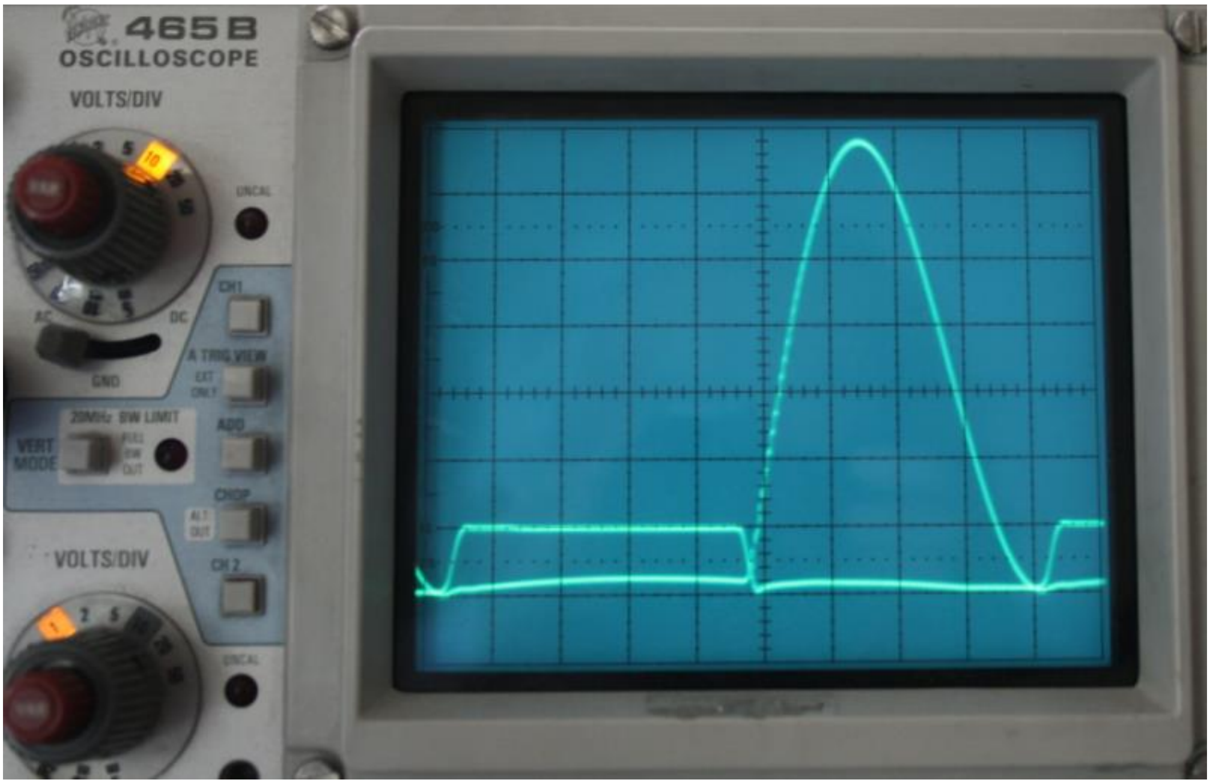

Figure 5 Gate and drain waveforms for properly adjusted class E PA (Both waveforms 10 V/div)

The most critical parts of the PA are C1 and C2. These must be adjusted to obtain a waveform at the IRF510 drain as shown in Figure 5. In this condition the IRF510 is operating in such a way that at no time does high current flow through the device at the same time as high voltage is present. Then the losses in the MOSFET are minimised and the circuit efficiency is high (at least 80%). The MOSFET should run very cool and requires only a small heat sink. A very good discussion of the C1 and C2 optimisation process is given in Ref 1 (see below).

With a 19.6V supply, my PA delivers 25 watts to a 50R load for a total current consumption of 1.6A. The easiest way to determine the output power is to measure the peak to peak voltage V across the 50R load. Then

$$Power\ (watts) = \frac{V^2}{400}$$

At 24v, the output power is increased to about 35 watts but it might be better then to replace the IRF510 with an IRF640 due to its higher breakdown voltage.

<u>Reference</u>

1. “Class E RF Power Amplifiers”, Nathan Sokal, WA1HQC, *QEX Communications Quarterly*, Jan/Feb 2001,
http://www.eel.ufsc.br/~lci/siteramo/documentos/mestres/artigos/classe.pdf