

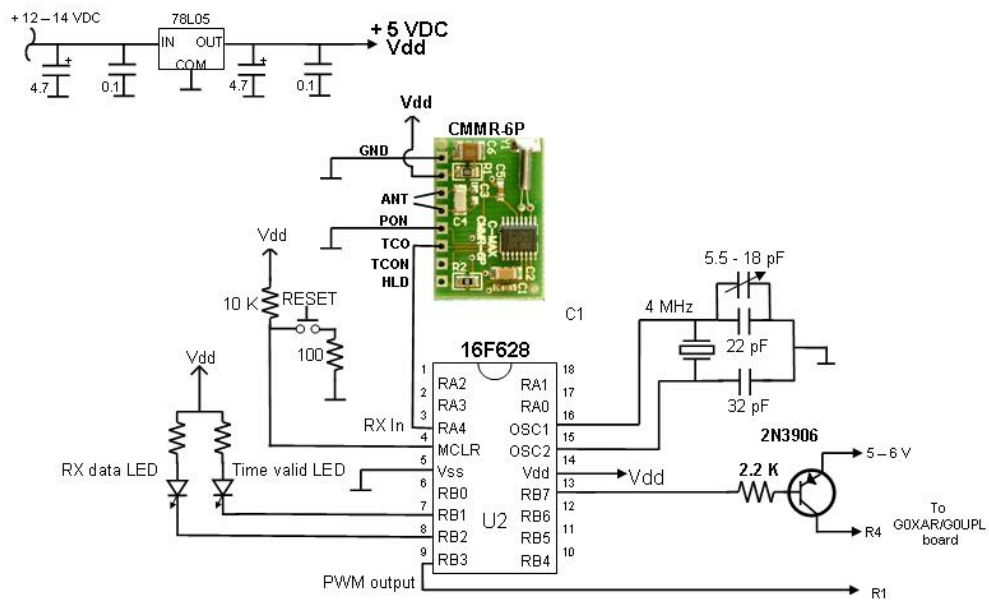
# **WWVB WSPR VCXO Controller For The G0XAR/G0UPL QRSS Transmitter Kit**

**A simple and inexpensive way to build a PC-less WSPR  
beacon.**

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26 March, 2011

**Fig. 1 WSPR Controller**

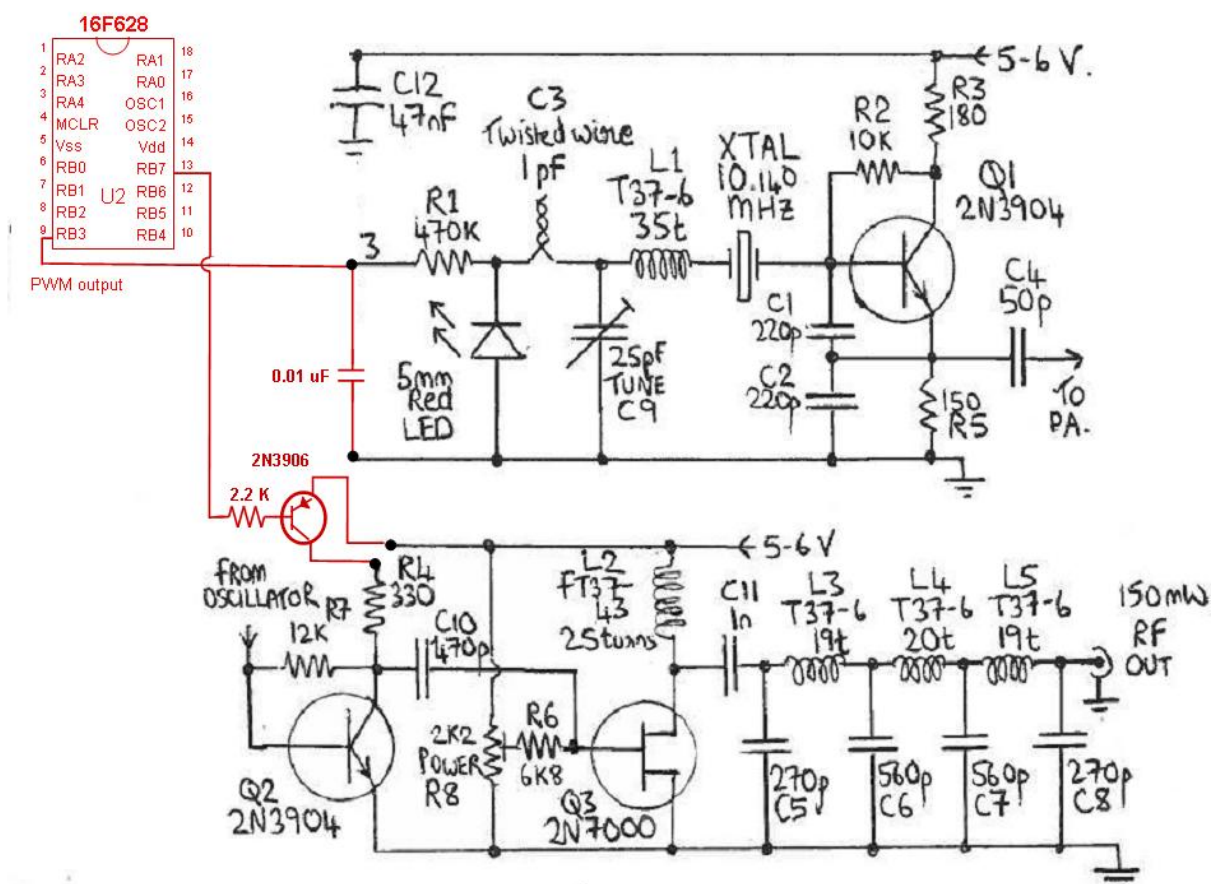
### WSPR Controller



All values of capacitors are in uF except where noted,

**W3PM**  
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**Fig. 2 G0XAR/G0UPL QRSS Transmitter Modification**



## Introduction

A C-Max CMMR-6P WWVB receiver board and the G0XAR/G0UPL QRSS transmitter kit provide an inexpensive and easy way to build a WSPR beacon. The WWVB receiver and antenna is available from Sparkfun < <http://www.sparkfun.com/products/10060>> and Digi-Key < <http://search.digikey.com/scripts/DkSearch/dksus.dll?Detail&name=561-1014-ND>> for less than \$11 US. A receiver board and antenna salvaged from an "Atomic" clock will also work. The QRSS transmitter kit is available from < <http://www.hanssummers.com/>> for about \$15 US. Pulse width modulation (PWM) provides a simple means of deriving narrow-band 4-FSK modulation from a voltage controlled crystal oscillator (VCXO). This controller provides all the necessary timing and output signals that experimenters can use as a building block in their own WSPR VCXO beacon design.

## WSPR Controller

Synchronization of WSPR transmissions is derived from an internal timer that is updated by WWVB receiver data. The internal timer operates with 20 minute segments that correspond to the WSPR "Coordinated hopping" mode in which the selected band is determined by the starting UTC minute of a Tx/Rx interval:

UTC minute	Band
00	160
02	80
04	60
06	40
08	30
10	20
12	17
14	15
16	12
18	10
20	160
22	80
... etc	

This sequence of ten possible bands repeats three times each hour. The controller provides two time slots for each 20 minute window. If the beacon is set up for 30 meter operation, the builder may want to choose the 08 and 18 minute slots resulting in 6 transmissions per hour at 8, 18, 28, 38, 48, and 58 minutes past the hour. . If both time slots are set to 08, the beacon will transmit 3 times per hour at 08, 28, and 48 minutes past the hour.

The accuracy of the microprocessor's internal timer is dependant upon the uncertainty and stability of the 4 MHz crystal reference. The prototype unit uses a 5.5–18 pF variable capacitor to adjust the clock to 4MHz. The builder may be required to use other capacitor combinations depending upon the 4MHz crystal used.

The WWVB signal strength varies by time of day and location. At my location the beacon's internal clock will reliably synchronize with WWVB in the early hours of the morning. The "RX data LED" blinks as data is received but does not necessarily indicate that the data is valid. Any noise, either atmospheric or electrical, will corrupt the data pulse. The beacon's transmitter is inhibited until a valid time update is received from WWVB. When a valid time update is received the "time valid LED" will turn on. At that point a watchdog timer is set that will inhibit the transmitter if another time update is not received within 36 hours. This ensures accurate timing of WSPR transmissions.

The pulse width modulation output (PWM) provides a simple method of modulating a VXCO. A simple integration circuit provides the varying DC voltage to drive a varactor diode (LED) to modulate the oscillator. The pre-programmed PWM values worked well with the circuit shown in figure 2. The PWM values may require modification (see below) for other VXCO circuits.

Transmitter control is provided by a keyed PNP transistor to switch the transmitter amplifier on and off.

## **Initial Set Up**

**IMPORTANT:** Before using the beacon to transmit, you must first load the WSPR message containing your station information. To generate this data, go to:  
<<http://www.g4jnt.com/beacons.htm>> and download the file: 'GENWSPR.EXE'. Follow the instructions and replace the WSPR symbol data table in the *.asm* file with your station's WSPR symbol data

The transmit time slots in the *.asm* file are preprogrammed to transmit at 8 and 18 minutes within each 20 minute timer window (ref. WSPR Controller above). The timeslots may be changed by loading the desired "timeslot" data in the setup section of the *.asm* file.

## **Calibration**

### *PIC Clock*

A small pickup loop or short length of wire connected to a modern HF receiver via a length of coaxial cable is used to set the PIC's clock. Place the loop near the 16F628 PIC and adjust the variable capacitor for 4 MHz. Although this is not a precise method of adjusting the PIC

oscillator, it is sufficient for operation with internal timing over a period of 36 hours without WWVB time re-synchronization.

### *FSK Deviation*

The pre-programmed PWM values worked well with the circuit shown in figure 2. Adjust the symbol deviation for 1.46 Hz (4.38 Hz total deviation) by carefully trimming C3 (twisted wire). The ARGO program ([www.weaksignals.com](http://www.weaksignals.com)) may also be used to ensure proper FSK keying.

The PWM software values may require modification depending upon the VXCO circuit. A PWM test program (*pwm\_test.asm*) is available for downloading. This program steps the VXCO through the four WSPR symbols. Each WSPR symbol is sent at a rate of five seconds per symbol. Use a frequency counter to verify that each symbol has a frequency delta of approximately 1.46 Hz. An error of +/- 0.1 Hz should be adequate. Each of the four PWM symbol values found in the test program (e.g. `movlw D'120'`) may be changed until the desired frequency delta is observed. The four PWM symbol values must then be transferred to the *.asm* file. The values are found in the 'Subroutine to transmit symbol data' subroutine within the corresponding symbol labels 'zero', 'one', 'two', 'three'.

### **Testing**

Off line testing is performed by connecting the transmitter to a dummy load and verifying operation using the WSPR program.

### **Acknowledgements**

Portions of this project were influenced by MJB, the stand alone PC-less MEPT\_JT beacon controller by Johan Bodin, SM6LKM.

GENWSPR.EXE by Andy Talbot, G4JNT, provides a simple method of generating the WSPR message containing your station's information.

I may be contacted at [w3pm at amsat dot org](mailto:w3pm@amsat.org) for any questions or comments.