WSPR VCXO Controller

A WSPR controller using pulse width modulation (PWM) to derive narrow-band 4-FSK modulation from a voltage controlled crystal oscillator (VCXO).

Features:

- **Internal timing or NMEA GPS timing for UTC synchronization of WSPR transmissions.**
- **On chip generation of WSPR message.**
- **'On-the-fly' GPS generation of grid square location for portable operation.**
- **Pulse width modulation output.**
- **Symbol data output.**
- **Low power consumption allowing battery operation.**

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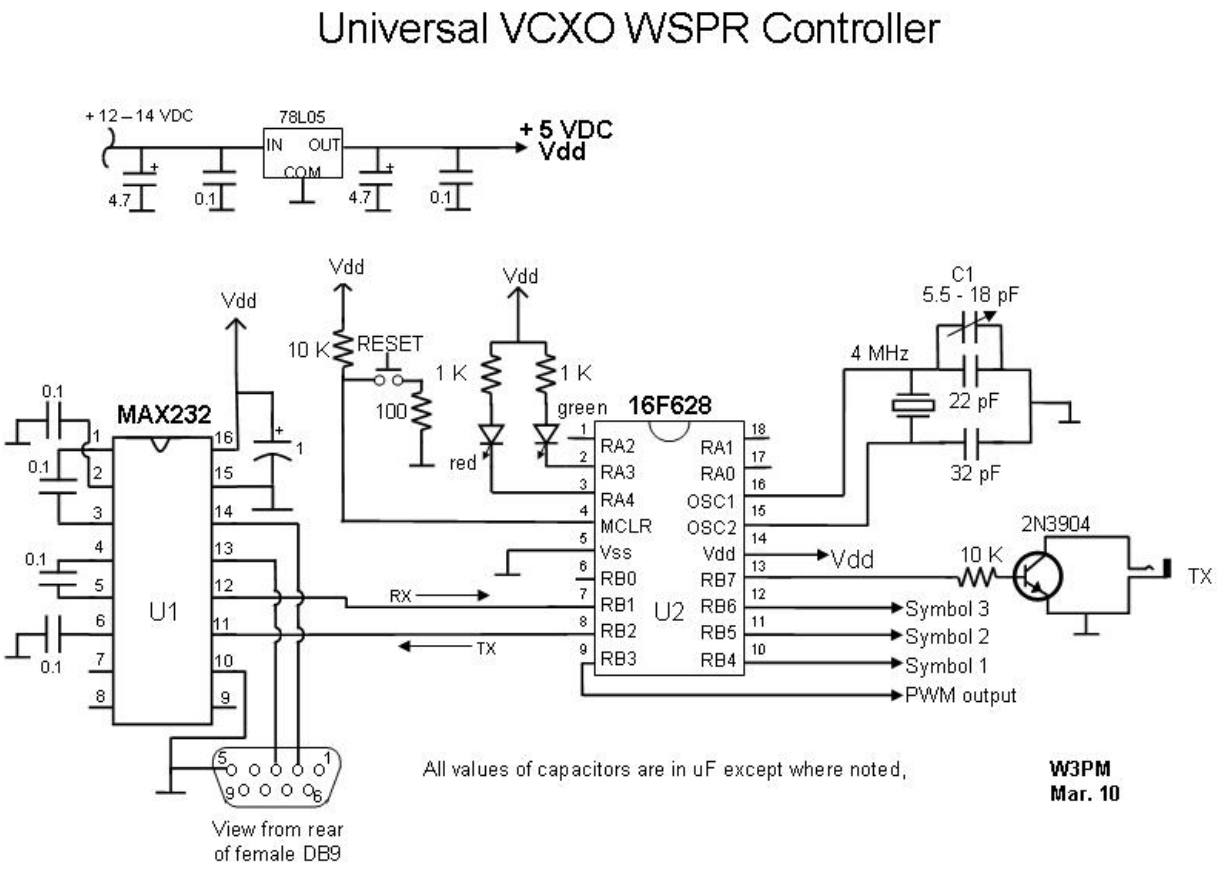

Fig. 1 WSPR Controller

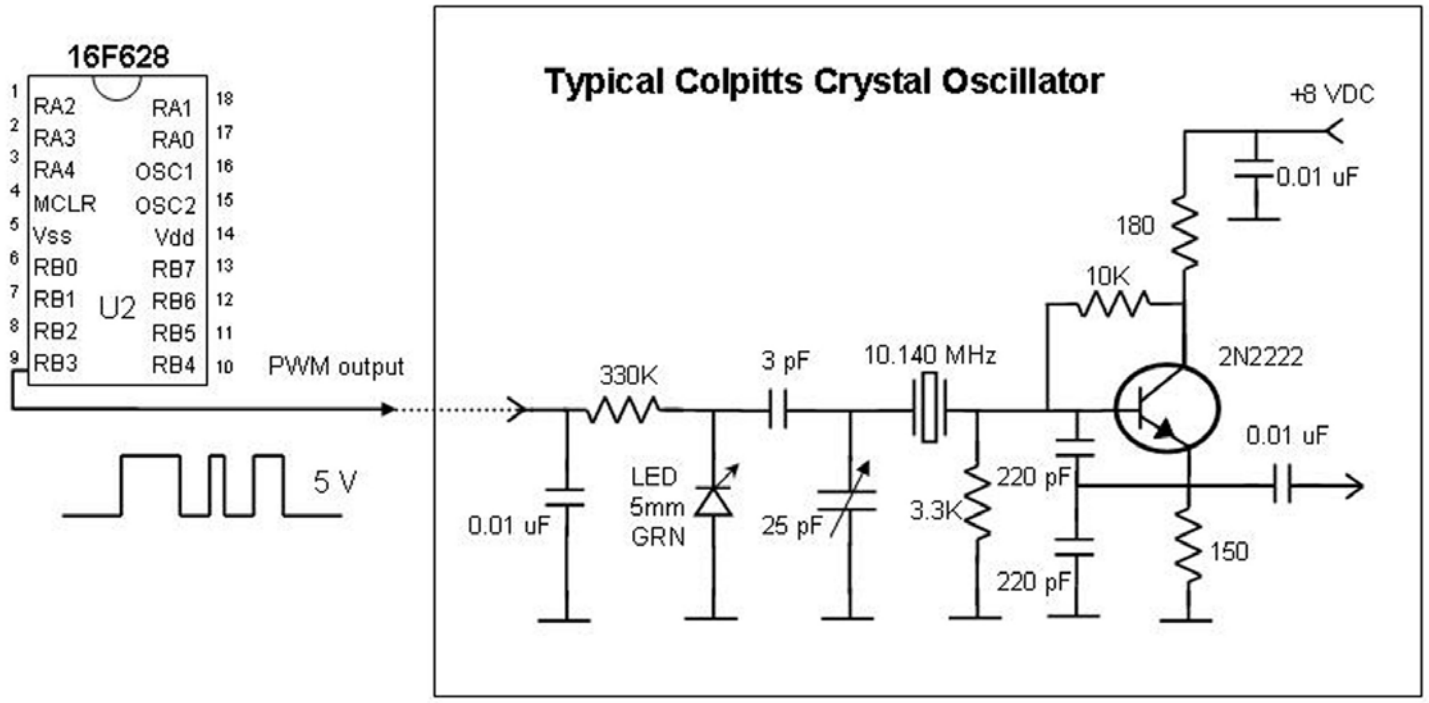

Fig. 2 Pulse Width Modulation (PWM)

Introduction

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

The WSPR controller provides the synchronized outputs necessary to modulate an oscillator with the station specific WSPR message. The WSPR message is generated on-chip. The RS232 interface allows the user to enter their specific callsign, grid square, and location via a connected PC. The unique WSPR message is stored in the PIC's EEPRPOM in a compressed format and may be changed at any time via the PC interface.

Synchronization of WSPR transmissions is derived from either an internal timer, or via a 4800 baud RS232 NMEA GPS data stream. Connecting the unit to a 4800 baud RS232 GPS NMEA data source will override the internal oscillator and allow the unit to default to GPS timing. When using GPS timing the current grid square location is automatically updated in software. The unit defaults to the pre-programmed grid square location if internal timing is used.

The short and long term accuracy of the internal timer is dependant upon the uncertainty and stability of the microprocessor's 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 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.

Three keyed outputs are also provided for use with other methods of VCXO modulation. Each output corresponds to the four channel symbols used in the WSPR protocol. Symbol 0 is the baseline unmodulated signal, therefore it is not provided as an output.

Transmitter control is provided by a keyed NPN transistor to switch an amplifier or relay on or off.

Initial Set Up

The station callsign, grid location, and decibel power must first be loaded into the PIC controller. The communication format to load this data is plain ASCII, 4800 baud, 8 data bits, no parity, 1 stop bit, no echo. Flow control is not used.

Note: Callsigns up to 6 characters may be entered. Special characters such as "/" cannot be used. Grid square data consists of 4 characters. (e.g. EM64)

Perform the following to load the message:

- Depress the RESET pushbutton

- Enter four consecutive + characters "++++" within a six second window

- Station data is entered after the following prompts:

CALL?

GRID?

POWER?

The callsign and grid square data are not case sensitive, but decibel power must be entered as two characters, i.e. '07' for 5 mW.

- Upon successful transfer, the channel symbol data will appear on your screen for verification

- Depress the RESET pushbutton to start

The message file is now stored into EEPROM. It will only require reload upon change of station callsign, location, or power.

If GPS NMEA timing used, the system will automatically update the grid square data. This will allow portable operation without requiring manual grid square updating. The data stored in EEPROM is NOT changed. The system will revert to the original grid square data loaded into EEPROM if internal timing is used.

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 two or three days without the need for time re-synchronization.

PWM Software Values

The pre-programmed PWM values worked well with the circuit shown in figure 2. 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 *PM_vcxo.asm* program. The values are found in the '*Subroutine to transmit symbol* data' subroutine within the corresponding symbol labels '*zero*', '*one*', '*two*', '*three*'.

The proper frequency delta between symbols probably could be set by varying the hardware values of the oscillator's PWM input. I have not tried this method.

Testing

Off line testing is performed by connecting the VXCO to a dummy load and verifying operation using the WSPR program. The ARGO program (www.weaksignals.com) may also be used to ensure proper FSK keying.

Operation

After the controller is first turned on, initial synchronization begins by depressing the reset pushbutton at the beginning of an even minute. The unit will begin a WSPR transmission ten minutes after the reset pushbutton is depressed and will repeat the transmission every 10 minutes.

If GPS NMEA timing is required, simply connect a 4800 baud RS-232 GPS NMEA output to the DB-9 connector. The GPS NMEA timing will override the internal oscillator and allow the unit to default to GPS timing. If GPS timing is disconnected, depress reset pushbutton at the beginning of an even minute to resume operation with internal timing.

Two LED indicators are used to monitor proper operation. The red LED is lit during transmitting periods. The green LED will flash at a one second rate to indicate internal timing. If GPS timing is used, the LED will flash at a two second rate.

Acknowledgements

The on chip generation of the WSPR message algorithm would not have been possible without the help of Andy Talbot, G4JNT. His excellent paper ‘The WSPR Coding Process’ provided a simple description of the encoding protocol.

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

I may be contacted at w3pm at amsat dot org for any questions or comments.