Down East Microwave Inc.

Design Note

From: DEMI R & D Dept.

DN#: 020

Date: April 24, 2006

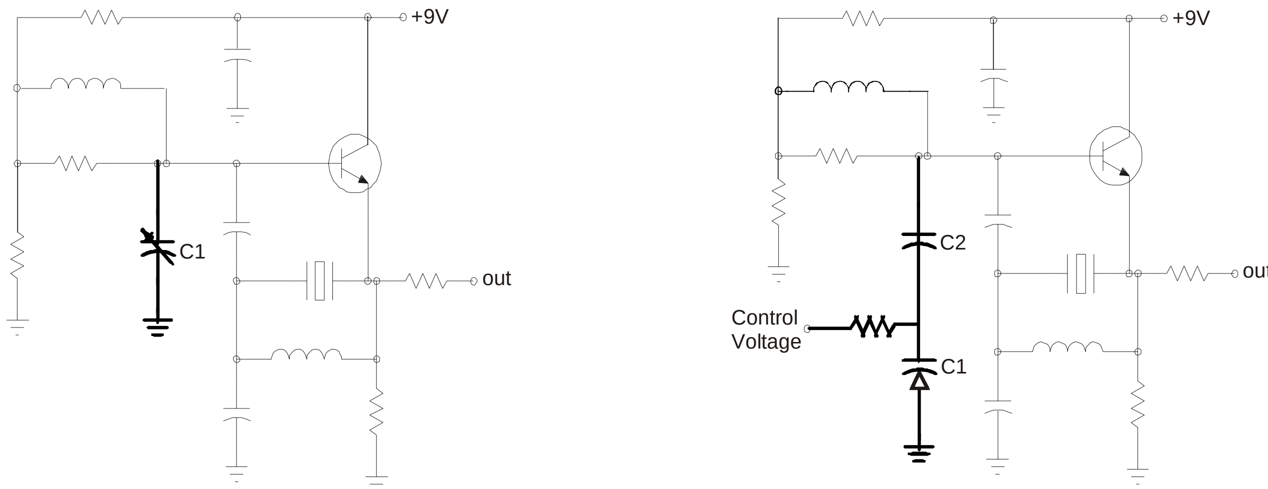
Re: VCXO circuitry for MICRO LO

PREFACE: With the growing popularity of the various "Referenced Locked" circuits, we have been asked to provide a description and our recommendations in modifying any DEMI local oscillator circuit into a **V**oltage **C**ontrolled Xtal **O**scillator (**VCXO)**. This design note will provide the basics for producing a usable circuit and discuss possible problems and pitfalls in applying the modifications.

BASIC CIRCUITS: The basic requirement of this conversion is to provide a means of adjusting the frequency with a variable voltage. This variable voltage or voltage "Swing" will be provided and pre-determined by the referenced locked circuit device. The next additional circuit requirement is to close the loop by providing a frequency feed back from the Local Oscillator to the reference lock circuit. This RF signal may need a specific level and may have a frequency maximum. Other important items to consider are regulated voltage supply and shielding from noise.

VARIABLE VOLTAGE CONTROL: All referenced locked circuits will have a minimum and maximum source voltage to control a VCXO circuit called the Control Voltage. This control voltage will vary from 0 to +5 VDC in most cases. Once the control voltage range is determined, the oscillator of choice needs to be modified to accept this voltage to adjust or "Steer" the oscillator's frequency. The most common way of implementing this is to replace the variable capacitor in the LO with a varactor diode. A varactor diode is a diode that changes its value of capacitance from high to low as DC voltage (starting at Zero) is applied to its Anode.

The type of varactor utilized will depend on its capacitance range and value to voltage ratio. The ideal varactor circuit will have the same capacitance range or a bit less as the original variable capacitor, utilizing the Steering voltage supplied by the reference lock circuit. Another key factor would be to have a smooth adjustment range as possible. Some tricks may be designed into the circuit to help with the capacitance value, range and linearity. Varactors that have very large ranges and values, but have excellent linearity, can be coupled into the circuit with a smaller fixed value capacitor that is required for DC blocking. This in turn will reduce the total capacitance of the circuit. The schematics in Figure 1 show both original and modified to depict the modification simplicity.



Standard

Modified

FIGURE 1.

The value of the total capacitance may be calculated using the formula below. In this case, the varactor diode is C1 and the coupling capacitor is C2. Then, the total series capacitance of the two values equals:

$$C1 \times C2 / C1 + C2$$

To achieve accurate results, be sure to obtain a data sheet of the chosen varactor and have a clear understanding of it's range and value with the applied minimum and maximum steering voltage before selecting the fixed value capacitor. Then, plug in the values, min and max to calculate the total capacitance swing.

An example would be a varactor that varies from 12 pf @ 0.0 VDC to 2 pf @ 5.0 VDC in series with a 12 pf capacitor. This would produce a total capacitance swing of 6 pf maximum to a minimum of approximately 1.7 pf. The min/max values and range can be adjusted with different combinations of the two values. The important factors are that the minimum and maximums values do not exceed the oscillators requirements for its optimum performance. If the range, high or low, can be adjusted to stop the oscillator from operating, the there will not be any feedback to the reference lock circuit. This, in turn, will cause the control voltage to rail, high or low, not allowing the oscillator to start again. The circuit needs to be designed so it will remain oscillating at both minimum and maximum voltages that the reference lock circuit will source.

The next design desire will be the linearity of the swing. Although not as important, a smooth rate of frequency change per volt will make the circuit more reliable and have better frequency stability over temperature change. This is difficult to calculate but may be minimized by reducing the capacitance change per steering voltage swing. Now minimizing this swing to far may not allow the oscillator to start when cold, but if it is always used at a constant temperature or has some sort of "heater circuit", the oscillator will start and lock when it is within the" temperature window". The swing range may also be adjusted by designing a voltage divider on the control voltage line to minimize the voltage swing.

RF SAMPLED FEEDBACK CIRCUIT:

All reference lock circuits require a RF feedback to close the loop. In most cases, this RF signal will need to be less than 300 MHz. With all DEMI local oscillators, there will be a point in the circuit where a signal of less than 300 MHz can be coupled out. Coupling out should be done with a small value capacitor such as 1 pf. The smaller the value used, the less the amount of energy is removed from the multiplier circuit supplied to the rest of the local oscillator and the less of a chance of upsetting the load on the output of the main oscillator. After coupling, it will be necessary to amplify the level of this signal to the reference lock circuit requirements. This may be done with a MMIC and attenuator circuit to fine tune the level. Some circuits have critical level requirements. Be sure of and measure the final power level. A sample circuit is shown below depicting the coupling point and what is required to achieve the correct level.

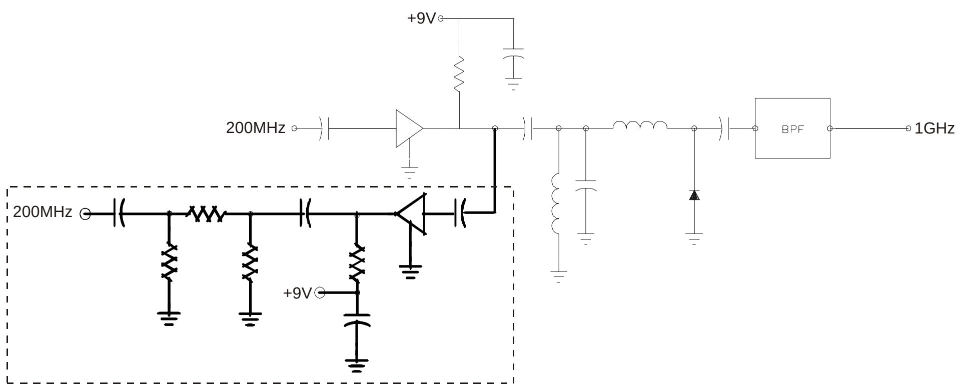


Figure 2.

OTHER IMPORTANT POINTS:

After modifying the LO circuit with the additional amplifier, be sure to use the same regulated supply voltage that the original LO board was operating from. Recheck the final output power level of the LO to verify it will be suitable to use with the transverter of choice. Vary the control line manually to verify the output level will not change over the frequency tune range.

If assembling the LO circuit in the same enclosure as the reference lock circuit, be prepared to deal with additional noise on all interfacing connections. Do not supply both circuit with the output of the same voltage regulator. In some instances, additional by-passing may be required. Please note that additional capacitive loading on the control voltage line may interfere with the circuits performance.

If your plans are to modify more than one circuit for use, because of the different schemes that the reference lock circuits provide, the frequency of the noise generated will vary. Treat every new referenced locked oscillator as an individual circuit and check for "extra" noise riding on all conductors. You may also consider a complete shielded enclosure for either circuit within the original enclosure.

CONCLUSION:

There is no hard fast method of reference locking any DEMI local oscillator circuit. Component types and values will vary from circuit to circuit. The quality of the original Crystal will vary enough to make standard values impossible. Yes, every DEMI LO can be referenced locked but it will require experimenting and patience to achieve the desired results. The above methods are suggestions only and do not guarantee results.