SAW-Stabilized ASK Oscillator

Any oscillator, the output amplitude of which can be raised or lowered upon external command, can be used to transmit ASK (Amplitude-Shift-Keyed) data. The shift in power can be up or down just so long as it is consistent and of sufficient amplitude delta so as to be correctly interpreted by the processor at the link receiver output.

The amount of amplitude shift required to successfully transmit the desired data depends upon the application. Shifts of 1 dB or less can be detected under laboratory conditions, but such a data link might not be very reliable in the field. Increasing the shift makes detection easier, but very large shifts begin to incur the disadvantages of OOK (On-Off-Keyed) modulation. A reasonable compromise value of amplitude shift appears to be 6-10 dB.

One of the simplest approaches to making an ASK transmitter is to start with a known oscillator circuit and deliberately vary one or more of the quiescent parameters which results in a corresponding variation of the output RF signal power. For example, if the circuit output power is sensitive to power supply voltage variation, the supply voltage can be modulated. Similarly, if changing the oscillator current will vary the power output, the current can be modulated.

To achieve ASK, it is desirable to vary a parameter that produces only desired results. While there may be many ways to modulate the output power of an oscillator circuit, some methods will produce more undesired side effects than others. For example, there may be excessive undesired frequency shift along with the desired amplitude shift. This may well be the case if the supply voltage is chosen as the modulation variable. Since the capacitances of the active device vary with applied voltage, there is likely to be a change in circuit tuning as the supply voltage varies. However, if circuit voltages can be held constant, it is possible to change emitter current to produce the desired amplitude shift with only minimal frequency shift.

One possible implementation of this emitter-current-modulated ASK circuit begins with the standard SAW-stabilized oscillator shown in Figure 1. The quiescent operating point voltages of the circuit are fixed by the base-biasing resistor network. The emitter current (and the circuit output power) is set by choosing an appropriate emitter resistor, Re.

The base-biasing network must be carefully chosen. In low-power applications it would seem natural to make the resistor values as large as possible to avoid battery drain. However, if this circuit is to become an ASK oscillator, the resistance of the base resistor network must be low enough to provide good stability of the quiescent point voltages.

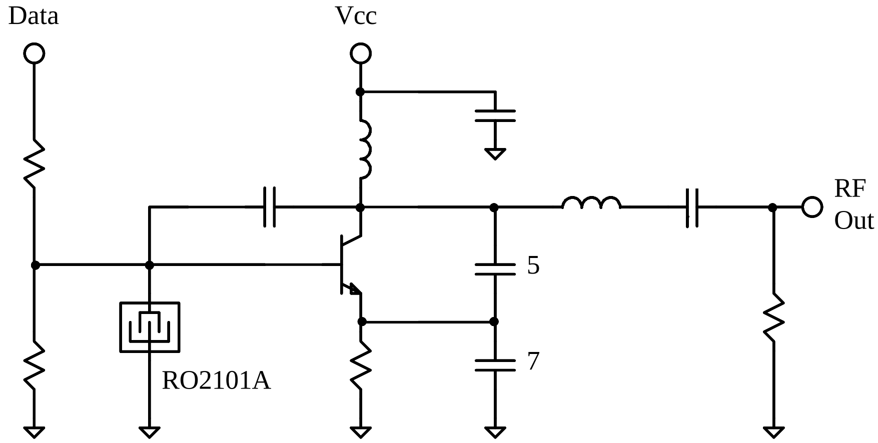

Figure 1

Next, two values of emitter resistors are chosen to provide two output power levels consistent with the system amplitude-shift requirements. As an example, assume that the desired shift is about 10 dB. After some experimentation it is determined that the two output levels should be about 0 dBm and -10 dBm. At these two levels the circuit demonstrates good start-up characteristics (with no "ghosting"; see Appendix A), and good harmonic performance while exhibiting minimal frequency shift.

In order to get the output power to shift under external control, the circuit can be modified as shown in Figure 2. The resistance value corresponding to the -10 dBm output power level is permanently installed in the circuit in the form of two resistors in series. A switching transistor is used to shunt one of the resistors, decreasing the emitter resistance to the 0 dBm value. A suitable series resistor determines the base current from the control input to the base of the transistor. A "high" on this new control pin causes the output power level to increase; a "low" yields the reduced power level.

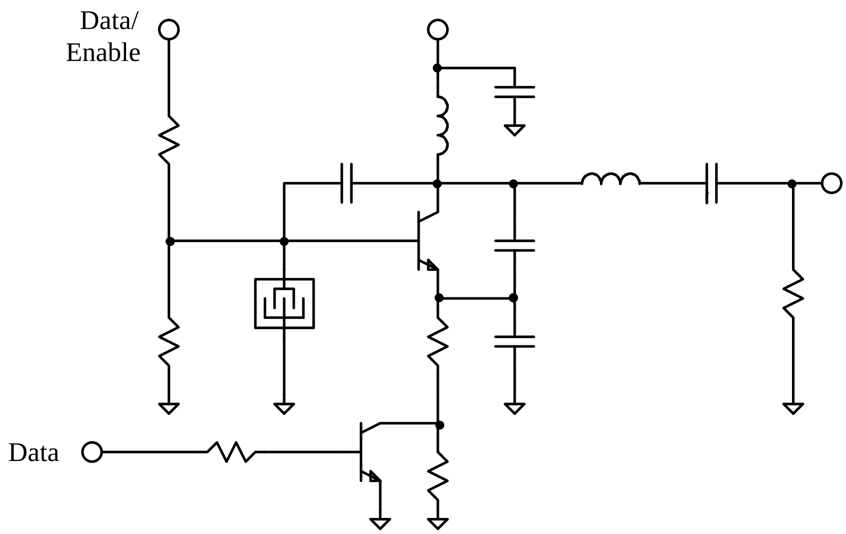

Figure 2

The circuit is now ready for operation. Besides accomplishing the original objective of constructing an ASK transmitter, there are some potential fringe benefits as well. First, the maximum data rate of this arrangement is higher than that of the circuit's OOK counterpart. The reason for this is fairly obvious: less time is required to shift the output amplitude over a 10 dB range than to shift it from totally off to on. (This fact may ultimately influence the amount of delta employed.) Second, by proper use of the two control pins the circuit can function either as an ASK or OOK transmitter.

Appendix A
Ghosting

Ghosting can appear at the RF output of an OOK (On-Off-Keyed) oscillator, the frequency of which is controlled by a high-Q resonator. This effect is so named because of its appearance on a spectrum analyzer. The ghost spectrum, which actually exists only during oscillator start-up, appears at some frequency offset from the resonator-controlled oscillator output spectrum. Because the circuit outputs this ghost energy only during the start-up interval, which is usually much shorter than the total ON portion of the duty cycle, the visual image at the ghost frequency usually appears very faint.

Ghosting is the result of an oscillator circuit's ability to oscillate at two or more frequencies. The desired oscillation frequency is that of the frequency stabilizing element (i.e., SAW resonator). An undesired oscillation frequency might be the frequency to which the active circuit itself is tuned. This natural frequency may be somewhat different from the resonator frequency due to component tolerances. For example, a SAW-stabilized oscillator fabricated from 5%-tolerance tuning components is capable of free-running oscillation anywhere within that tolerance band under the certain conditions. If the circuit meets the criteria for oscillation (loop gain >1 and 0 degrees loop phase shift), the circuit will most certainly begin to oscillate at its natural frequency when it is keyed on. As the resonator begins to function in the circuit (at some later time as determined by its Q) the output frequency will shift from that of the circuit to that of the resonator.

Ghosting can also occur at frequencies far from the predicted natural frequency of the circuit. This type of oscillation is usually parasitic in nature. Sometimes the passive components used in the circuit are the cause. For example, a capacitor may in fact look capacitive at the desired frequency of circuit operation, but inductive at some other (ghost) frequency. Inadequate attention to layout details of the circuit can also contribute to ghosting.

There are several ways to minimize or eliminate ghosting. For example, if the loop gain can be so closely controlled as to be less than one at all frequencies except that of the resonator, oscillation can only occur at the resonator frequency. Another approach would be to tightly control phase shift around the loop so that 0 degrees only occurs at the desired frequency. From a practical standpoint, designing the amplifier portion of the oscillator circuit so that it exhibits a bandpass gain characteristic is probably the most viable.

Low-loss single-port SAW resonators used in a Colpitts-type circuit constitute a special case. The capacitance of these devices can be great enough to cause the base of the transistor to be bypassed over a wide frequency range, permitting start-up oscillation of the circuit at frequencies other than that of the resonator (ghosting). An effective fix for this problem is to intentionally introduce some Miller (collector to base) capacitance. This capacitance cancels the bypassing effect of the resonator and allows the circuit to start and run only at the desired resonator frequency.