The Orion-I Beacon Waveshape Circuits

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The Orion PLL Board has been in existence for several years now and it is showing great promise as a versatile building block, capable of many features not originally designed nor intended for the project. One of these is the beacon exciter. This application allows the Orion PLL to generate a user-defined Morse code message with the ability to vary transmit power, multiplex across multiple bands, and operate as an OOK or FSK modulator. However, one of the requirements of good quality Morse code modulation is the limitation of risetime. This reduces the bandwidth (considerably), which reduces adjacent channel interference and also makes the tone more pleasant to copy. This appnote seeks to demonstrate some options for generating wave-shaped RF output that is ready to provide band best-practice RF output.

RC Based Ramp

An RC ramp is often employed to provide rise and fall-time controls for varioous applications. The Orion provides a “KEYOUT” digital logic output that can be used to control an RC circuit to provide a ramping envelope. The timing of the KEYOUT signal is critical to this process, and some of this can be controlled by a message parameter that is user defined.

Figure 1 illustrates a circuit that can be used to drive the GVA-62 buffer amplifier of the Orion PLL. This can also be adapted to control a subsequent amplifier stage if needed.

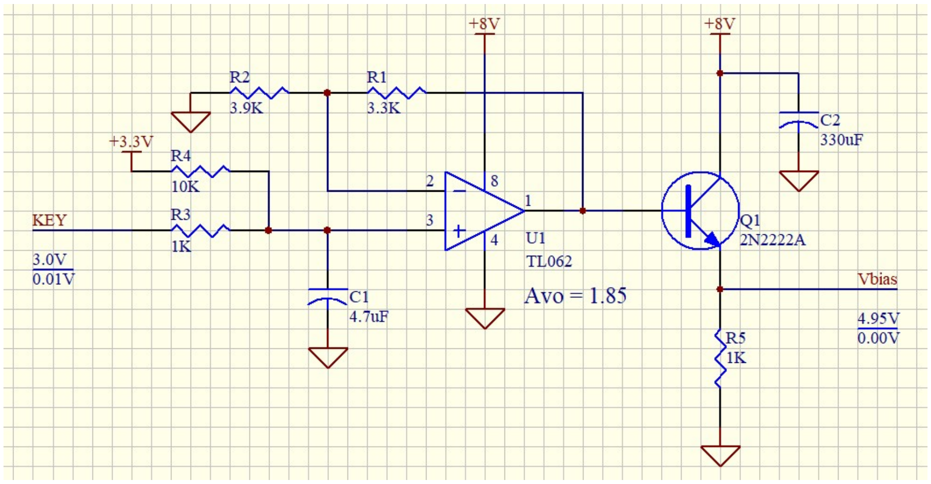


Figure 1. Amplifier power ramp wave-shaping circuit

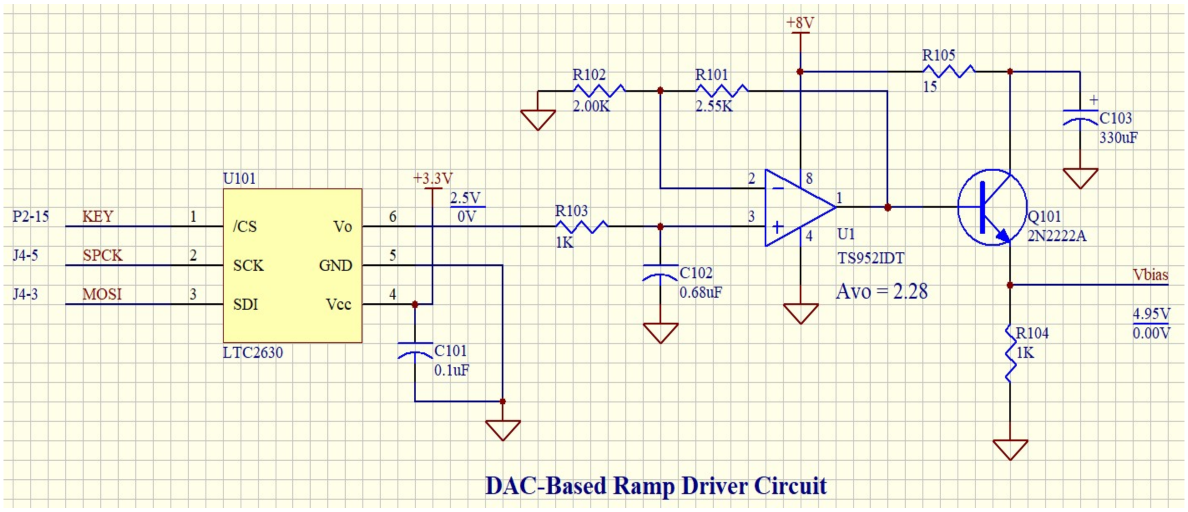
KEY is active high (approx 3.0V when RF is on). The polarity of the key output is controlled by a field in the CW message. Setting the ramp delay to 0x04 in the Morse message is recommended for best results with the above circuit. R3 and C1 form an RC network with a risetime of approximately 10 ms. This is fed to the op-amp configured as a non-inverting circuit with a gain of 1.85. R4 is needed to prevent 0V from being applied to the input of an non-rail-to-rail device. The resulting voltage varies from about 0.6V up to about 5.7Vat the base of Q1. After the inherent V_{be} diode drop of Q1, Vbias will see voltages from about 0V up to about 5V with about 4ms of rise and fall time with a current capacity of about 100mA. This is sufficient to power the GVA-62 buffer at U7 of the Orion board.

Vbias is applied to the Orion buffer amplifier (U7) by either cutting the 5V power trace that feeds FB1 (the best location for this cut is neat U3) or by removing FB1 and replacing it with a small leaded inductor (1uH range). A wire is run from the ramp circuit to the cut trace or leaded inductor.

The prototype area of the Orion makes an excellent location for the above circuit. A source of 8V power can be achieved by installing an LM317 regulator at U14 (this is described in the Orion Operation Manual). If this circuit is used to supply an external driver or PA, care should be exercised in the selection of Q1 to meet the current requirements of the RF amplifier (a heat sink is likely required for currents much above 100mA) and also make sure that the transistor has a high enough value for beta so that the OPAMP is not loaded too heavily.

DAC Based Ramp

One problem with the RC approach is that the waveshape has a discontinuous inflection point at the beginning of the ramp (whether rising or falling). This is due to the intrinsic shape of the RC charge or discharge curve. A better profile is more Gaussian in shape, where there is a gradual entry into the ramp, followed by a gradual exit. Ideally, this is accomplished without any discontinuities in the slope of the waveform.



DAC-Based Ramp Driver Circuit

Figure 2. DAC circuit to drive a buffer amplifier

Figure 2 illustrates a DAC circuit that can interface to the Orion. A small form-factor, SPI DAC (LTC2630) is used to produce a 0 - 2.5V, 8-bit analog signal that is fed to an OPAMP/emitter-follower (similar to the RC circuit of Figure 1). With this circuit, software can produce a wide variety of ramp waveforms, but the waveform shown in Figure 3 is what is included with the default spreadsheet. This waveform is incorporated into the message preamble data in the processor memory which allows it to be easily modified by the user.

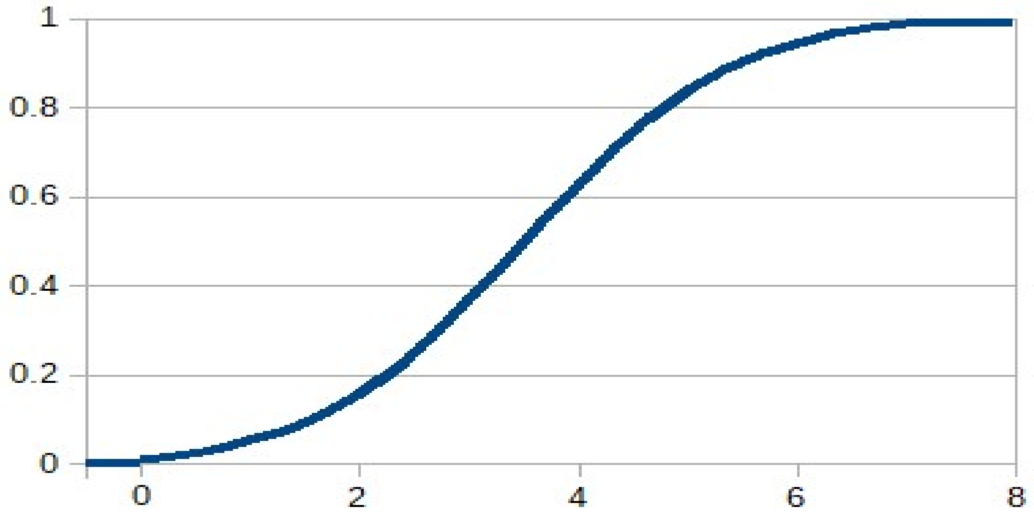


Figure 3. Plot of smoothed DAC output for semi-Gaussian ramp waveform

The waveform is produced by sending 8 different 8-bit values to the DAC at 1ms intervals. In the plot of figure 3, the first sample would be the value 0 at Y-index 0. Then, at 1ms intervals, the next value is sent until the maximum value is reached (Y-index 7). The falling ramp simply sends these values in reverse order. While the waveform has a 1KHz sample rate, it must be filtered at around 250 Hz to smooth the steps in the DAC output.

The DAC approach is not much extra effort or cost, and yields a superior and easily modified waveshape.

Some Thoughts on FSK CW

FSK CW is sometimes employed with microwave beacons. FSK is can be easier to manage and it has a reputation of not producing key-clicks. I'm not sure how the notion regarding key-clicks came about, nor do I know how wide-spread it might be but it is a reputation that I strongly contest. Key-clicks are really harmonic remnants of the step-wise transitions of a CW message. They occur when ANY aspect of the carrier is suddenly changed, be it amplitude, frequency, or phase. At the heart of this are the basic principals of modulation theory and message bandwidth.

For those who doubt this, consider the case where you can shift the frequency down from the primary carrier to accomplish a space. Start with, say, 5KHz of deviation. Now, increase the deviation to the point that it is equal to the carrier frequency (resulting in a "space" frequency of 0 Hz). This is essentially OOK which has been widely demonstrated to generate key-clicks. Logic would suggest that if one value of deviation (delta F = Fc) can create key-clicks, then other values for deviation could also create key-clicks. So even without a detailed mathematical exploration, one should suspect that FSK can create key-clicks just like OOK.

Addressing key-clicks with FSK can be difficult. There are really only two approaches: 1) Use waveshaping to turn off the carrier before shifting the frequency, then use waveshaping to turn the carrier back on at the new frequency. 2) Sweep the frequency with a particular sweep rate. Option 1 is essentially a red-herring as it requires that the

RF hardware be capable of ramping. If the hardware will support this, then the supposed advantages of FSK CW are essentially nil (IMO), and one should just implement OOK CW with waveshaping.

Option 2 is easier to manage considering that there are likely limitations keeping one from implementing amplitude-shaping. The obvious result is that the frequency is swept to the deviation frequency point at a certain rate (on the order of the typical amplitude shaping rate rise-time). Unlike the amplitude methods, accomplishing a smooth frequency shift for the case of a PLL can be difficult.

A PLL is designed to maintain the desired (set-point) frequency using a fixed reference frequency. So, the only way to shift the output frequency it is by changing the PLL set-point. This requires at least one frequency shift that leads to the deviation frequency. The rate at which the VCO frequency actually moves in response to a set-point change is controlled by the PLL loop filter response (which includes the VCO control input response which can be rather complicated for multi-band, integrated VCOs like the one used in the Orion).

Like any other control system, the PLL loop filter is critical to the stability of the frequency output. If not managed properly, the resulting CW will end up with “chirp” and/or “bounce” effects, which will generally be more of an issue than key-clicks. The gist of all this is that, while the Orion supports FSK CW, FSK ramping for the Orion has not yet been implemented. To mitigate the effects of FSK CW, the deviation should be limited to the minimum necessary to accomplish the task at hand. A value of 5x the expected receiver bandwidth is a reasonable target (for a 500Hz CW receiver, this would be 2.5KHz of deviation).

Conclusion

The Orion synthesizer can make an excellent OOK CW beacon exciter with some simple system modifications to control the rise/fall times of the OOK modulated carrier.

Abbreviations

CW	Continuous Wave (e.g., Morse Code)
DAC	Digital to Analog Converter
FSK	Frequency Shift Keying (Keyed)
IMO	In My Opinion
OOK	On/Off Keying (Keyed)
OPAMP	Operational Amplifier
PLL	Phase-Locked Loop
RC	Resistor-Capacitor
RF	Radio Frequency
SPI	Serial Peripheral Interface
V_{be}	Base-Emitter Voltage
VCO	Voltage Controlled Oscillator