Spectral-mask shaping for a Class 1 Gen 2 PR-ASK RFID I/Q modulator

By Doug Stuetzle

An integrated I/Q modulator such as the LT5568-2 can generate the 900 MHz transmit signal for a Class 1 Gen 2 UHF RFID reader. While there are less-expensive alternatives—for example directly modulating a VCO—an I/Q modulator offers more flexibility to generate multiprotocol signals to meet RFID standards. For example, a Class 1 Gen 2 reader can send information to one or more tags by several different modulation formats. The RF carrier may be modulated by double-sideband amplitude shift keying (DSB-ASK), single-sideband amplitude shift keying (SSB-ASK), or phase-reversed amplitude shift keying (PR-ASK) using a pulse-interval encoding format.

To implement SSB-ASK modulation, the I and Q inputs of a balanced modulator are driven with in-phase and quadrature signals; the quadrature signal is the Hilbert transform of the in-phase signal. The resulting modulator output is a LO-suppressed, single-sideband RF signal. Alternatively, to generate a double-sideband RFID signal, the circuit required to drive such a modulator is simple. Only the I (or Q) port of the modulator need be driven with the baseband signal. The unused port is left unconnected or not driven. Thus, a single digital-to-analog converter (DAC) can be used to drive its dc output current of 10.4 mA into the modulator's 50 Ω internal input resistance (Figure 1).

A 0.5 V dc bias current output DAC should be chosen, which matches the common-mode dc voltage at the baseband pins of the LT5568-2. The waveforms generated by the DAC should be equal and opposite such that their average value satisfies the 0.52 V dc bias requirement of the LT5568-2.

The interface circuit includes a 10 MHz Butterworth low-pass filter to attenuate the sampling images from the DAC. This is a reconstruction filter, so its corner frequency will depend upon the sampling frequency of DAC.

Besides this filter, some pulse shaping is necessary in order to control the filter sidelobes such that the shaped waveform will meet the RF spectral mask requirements of this class of RFID reader equipment.

The EPC Global specification does not include spectral mask requirements, except for dense-reader mode operation. The reader emissions are constrained by the requirements set forth in FCC part 15.247 (for U.S. applications), or ETSI EN302208 section 8.4.3 (for European applications).

The ETSI mask is more demanding than the FCC requirements, so it is used in the design example here. This mask includes a channel that is 200 kHz wide. The ETSI mask requires the adjacent carrier power at ±300 kHz from the main carrier shall not exceed –36 dBm. In the Class 1 Gen 2 RFID specification the '0' symbol duration is denoted "TARI," or Type A Reference Interval. The symbol is a simple pulse, with a 'low' time of 1/2*TARI, and a 'high' time of 1/2*TARI. The '1' symbol duration can be between 1.5*TARI and 2*TARI, with a 'low' time of 1/2*TARI. To meet this mask with a PR-ASK signal, choose TARI equal to 12.5 µs. The average symbol duration is then 15.625 µs, yielding a data rate of 64 kbps. The central lobe of the signal will then be ~200 kHz just wide enough to fit within the mask.

To meet the requirements of the mask outside the channel, some pulse shaping is added to the symbols. This can be done digitally with a FIR filter. In this case, a 118 kHz raised cosine filter with 39 taps and an alpha of 0.8 was used. This can be implemented in the baseband DSP that drives the DAC. The resulting shaped pulses appear in Figure 2.

The effect of this pulse shaping is to reduce the sidelobes of the PR-ASK signal. Figure 3 shows the unshaped and shaped pulse spectra and their relation to the ETSI spectral mask. This mask assumes the RFID transmit power is +33 dBm. The FIR filter is designed to reduce the spectral width of the signal without slowing the symbol transitions excessively. This is critical because there is also a time domain mask that shaped pulses must meet, per section 6.3.1.2.5 of the EPC Global

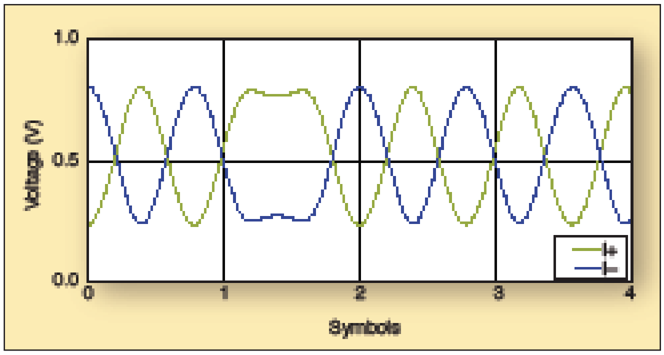
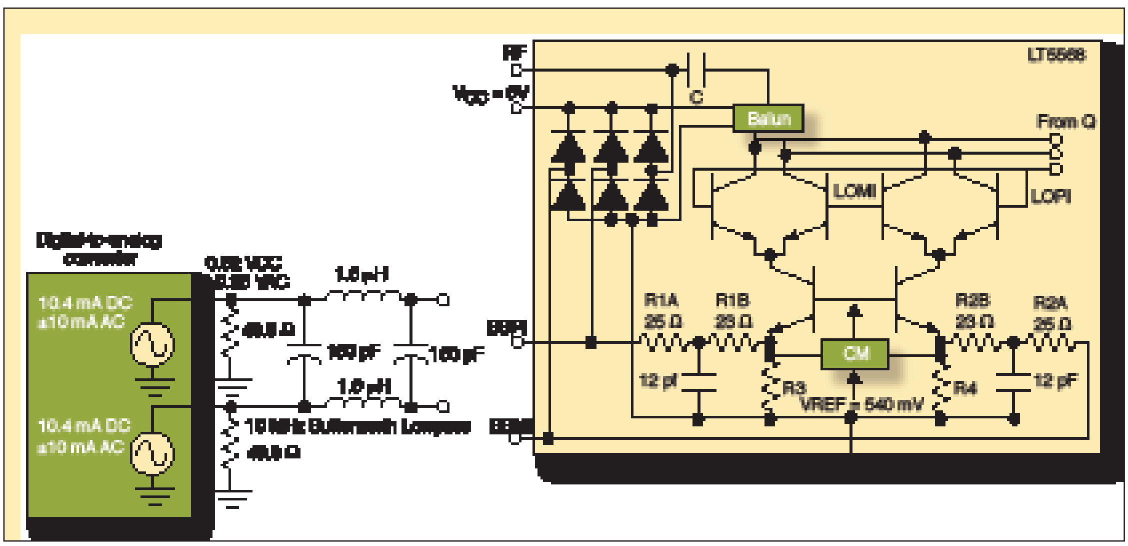


Figure 2. Baseband PR-ASK pulses at 64 kbps data rate.

Figure 1. LT5568 baseband interface circuit.



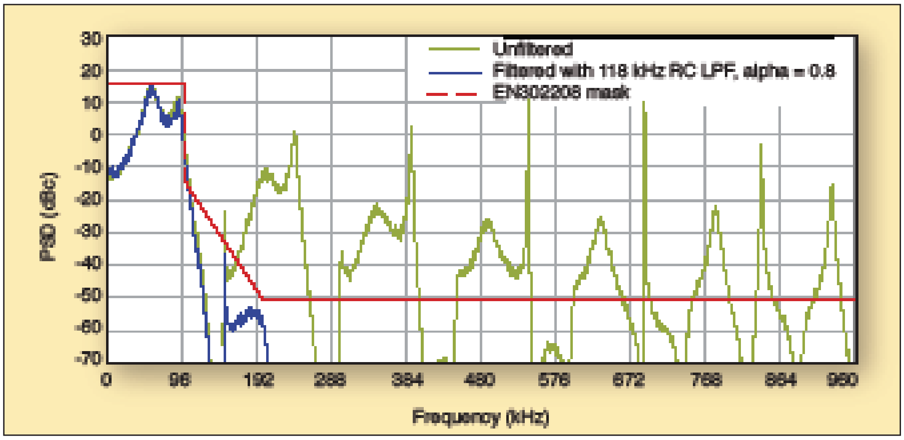


Figure 3. Baseband PR-ASK pulse spectra.

specification.

An advantage of this LT5568-2 modulator in an RFID transmitter application is its high output dynamic range. Its output noise floor is exceptionally low and it adds negligible distortion to the RF output signal. Its output third-order intercept point (OIP3) of +22.9 dBm preserves the baseband pulse shaping as well as minimizing spectral regrowth. Note that the LT5568-2 works equally well at the ETSI 865 MHz to 868 MHz band. The result is excellent transmit spectra purity. Additionally, its low output noise floor of –159 dBm/Hz helps to minimize the noise leakage from the RFID transmitter output to its receiver input. This is especially critical in single antenna designs having limited isolation in the circulator between the transmitter output and the receiver input. Thus, a reduced RF noise leakage has the beneficial effect of improving the receiver sensitivity, and consequently boosting the RFID reader's useful range.

ABOUT THE AUTHOR

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