The LT1684 Solves the Global Ringing Problem

by Dale Eagar

Ring generators are sine wave output, high voltage inverters for the express purpose of ringing telephone bells. In decades past, the phone company generated ring tones with motor generator sets, with the capacity to ring many phones simultaneously. The most common frequency used to ring telephones is 20Hz, while 16Hz and 24Hz are also widely used. The output voltage is about 90V with less than 10mA-per-bell output current capability. Since the power supplied is low, one would think that the task is minimal. However, there are several things that complicate matters:

- ❏ The output needs to be DC coupled to make detection of the off-hook condition possible.
- ❏ If the ring signal has to go out over any significant length of wire, there is potential for crosstalk and EMI if the ring signal is not low distortion and free of digital noise.
- ❏ The output needs to be current limited.
- ❏ The output needs to be robust, because lightning, static discharge and line faults impose ugly transients on a ring generator's output.
- ❏ If the output is to drive a FAX machine or modem, it needs to have sufficient peak voltage to trip the ring-detect circuit on the most conservative unit (a 35V square wave will ring just about any phone but hardly any modems).
- ❏ All but the simplest systems need isolation of the ring generator output from the digital logic initiating the ring.
- ❏ In designs where Caller ID is required, output noise can become an issue.

What is needed for most systems is a high voltage, robust, clean, isolated DAC that has output smoothing for harmonic suppression.

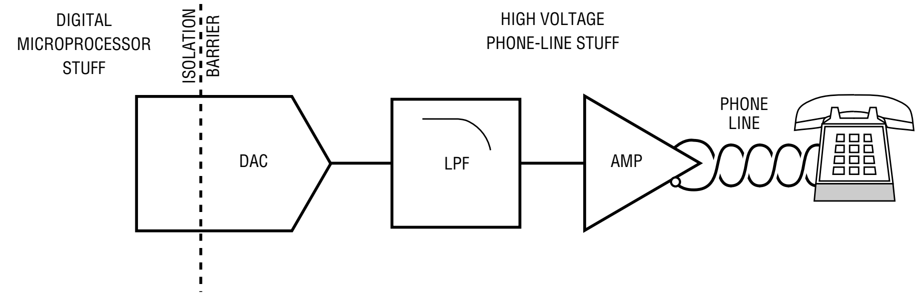

Figure 1. The LT1684 incorporates all of the functions required to go from bits to bells.

Introducing the LT1684

The LT1684 is an isolated, pulse width modulated (PWM) DAC with internal reference, output filtering and amplification (see Figure 1). Utilizing the robustness and voltage handling capability of two external MOSFETs, the LT1684 provides the precision voltage and current control required to fill the gap between microprocessor and phone line.

Ring frequency, amplitude, cadence and starting and stopping voltage points are controlled by the digital controller connected to the LT1684's input. In addition to providing the correct frequency and voltage to ring phones in systems all around the globe, this approach allows implementation of Caller ID, cadencing and the simultaneous ringing of multiple phone lines.

The Circuit Guts

The LT1684 uses several novel circuit concepts to perform its seemingly magic task. While providing precision control of the ring-signal voltage and current, the LT1684 IC doesn't need to actually handle the enormous voltages involved (Figure 2). The digital input is isolated by coupling the pulse width modulated signal differentially through RC networks (R1 and R2 and C1 and C2 in Figure 2). The input characteristics of the differential receiver allow fault-free digital isolation even while sustaining large common mode voltages across the isolation barrier.

With the input resistors and capacitors, the LT1684's digital inputs are well protected against kilovolts of static discharge. Although normally

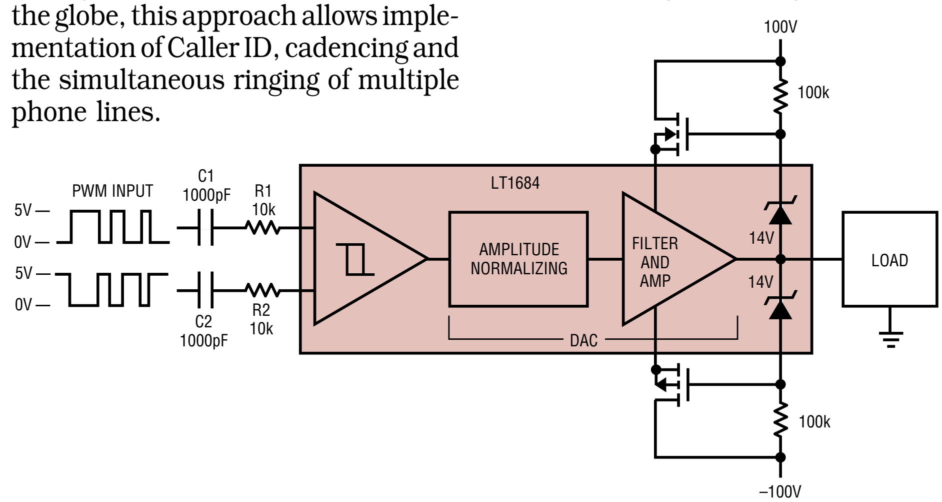

Figure 2. The LT1684 controls its output over hundreds of volts while operating in a ±12V window.

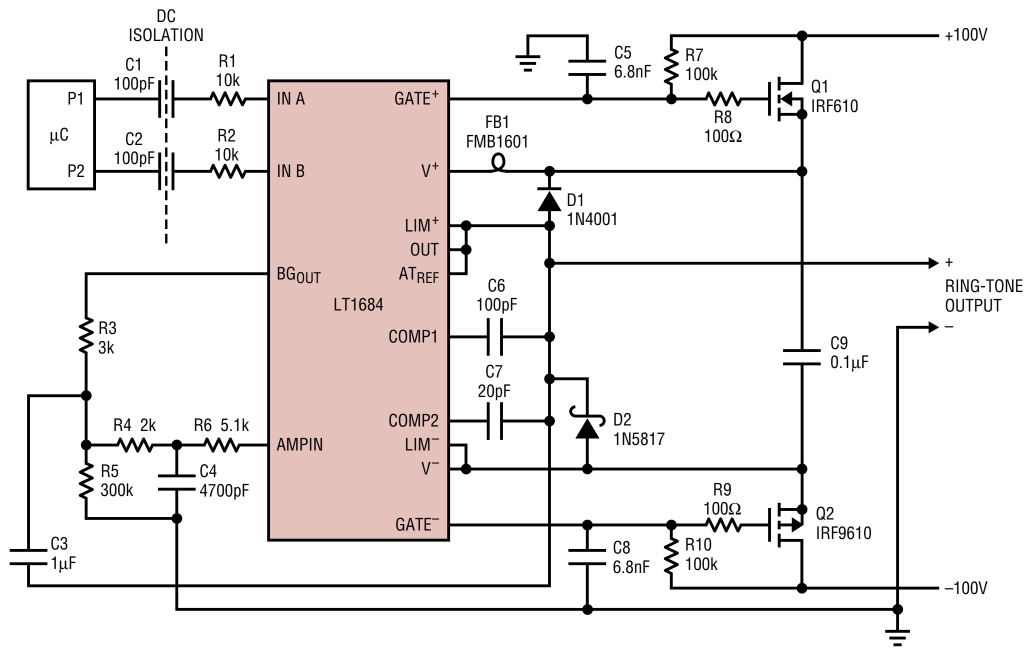

Figure 3. LT1684 typical application

driven by CMOS inverter outputs, this circuit can be driven from a distance by an RS422/RS485 differential line driver such as the LT1785, with only a 2-wire connection.

The filter/amplifier in the LT1684 is a 2nd order multiple feedback (MFB) lowpass filter. This topology was derived from a unique inside-out circuit transformation of the standard textbook MFB filter. More details of this transformation can be found on the LT1684 data sheet and in *Linear Technology* VI:2 (May 1996).

The DAC in Figure 2 is implemented by a novel bidirectional bandgap reference that outputs either 1.25V or –1.25V depending on the state of the output of the differential receiver. This bandgap output is referenced to the output pin of the LT1684 and is available on the BG_{OUT} pin. Referring to Figure 3, the bidirectional bandgap output is applied to the input of the 2nd order MFB lowpass filter/amplifier through R3. R3–R5 and C3–C4 set up the gain and corner frequency of the filter/amplifier. C5–C8 are compensation capacitors for the amplifier. R6, D1 and D2 are for protection from lightning. R8 and R9 subdue the high frequency MOSFET demons in Q1 and Q2.

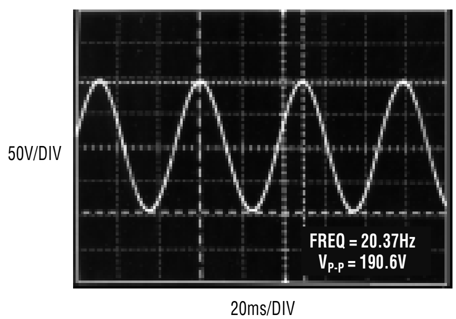

Figure 4. Ring signal from Figure 3's circuit

This circuit has the output current limit set at ±200mA, more than enough to ring ten phones. For current limits less than 200mA, two current limit resistors can be added in the Lim^+ and Lim^- leads, allowing the current limit to be set anywhere from 20mA to 200mA.

If additional output current is required, the LT1684 can be paired up with the LT1166 automatic bias control to provide any amount of current that is required.

Conclusion

By enabling direct software control of frequency, amplitude and cadence, the LT1684 allows a single design to be used in phone systems globally.