Robust, Quiet, Stable Power Supply for Active Antenna Systems with Built-In Protection and Diagnostic Capabilities

by Sam Rankin and Steve Knoth

Introduction

The days of the simple car radio, like the Mercedes dashboard shown in Figure 1, are over, supplanted by the era of the automobile infotainment system (see Figure 2). The venerable AM/FM radio still holds a place at the infotainment table, but it now shares space with digital audio broadcasting (DAB), digital and high-definition television (HDTV), satellite radio, integrated cell phones, CD/DVD/MP3 players, global positioning system (GPS) navigation and video game systems.

Behind the dashboard, fueling this wealth of information, are active antenna systems. As infotainment centers have expanded in complexity, the number of active antennas needed to feed music and data into the infotainment center has multiplied. It is now common for an automobile to have on average, three to five active antenna systems, from a combination of AM, FM, DAB, HDTV, satellite radio, traffic alerts, cellular, WiMax and GPS—sometimes with multiple antennas per band to improve reception quality. The sensitive circuits in these active antenna systems require protection and isolation from the harsh automotive environment and a way to provide antenna status and diagnostic feedback to a host system.

The LT3050 is an innovative regulator with precision current limit and diagnostic functions. It combines the robust performance, reliability and durability common to Linear Technology linear regulators with an enhanced feature set geared towards active antenna systems, including:

- ❑ Programmable current limit
- ❑ Soft-start
- ❑ Open-circuit detection
- ❑ Output current monitor
- ❑ Open-collector fault signal

Figure 1. Old school dashboard; one passive antenna for AM/FM reception

The LT3050 is a single IC solution that replaces a complex arrangement of current sense amplifiers, operational amplifiers and discrete components and other ICs that would otherwise be needed to meet the demanding combination of protection requirements and diagnostic features required in automobile antenna systems.

The LT3050 delivers up to 100mA continuous output current with a 340mV typical dropout voltage at full load. The IC features a wide input voltage range of 2V to 45V, delivering adjustable output voltages down to 0.6V. A single capacitor provides both ultralow noise operation—only $30\mu V_{RMS}$ across a wide bandwidth of 10Hz to 100kHz—and reference soft-start functionality, eliminating large inrush currents and output voltage overshoot at turn-on. The LT3050's output voltage tolerance is highly accurate at ±2% over line, load and temperature. The LT3050's low operating quiescent current of 50µA allows it to idle continuously with

Figure 2. New school dashboard; high performance, active multi-antenna system

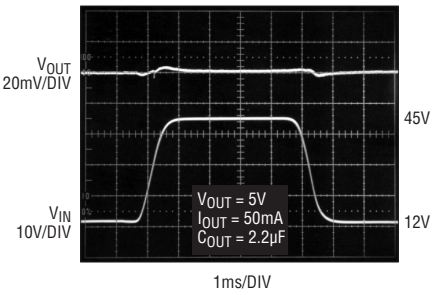

Figure 3. LT3050 transient response to load dump condition (AC coupled)

minimal battery drain and drops to <1µA in shutdown. The IC is housed in a 12-lead 2mm × 3mm DFN and 12-lead thermally enhanced MSOP packages, respectively, offering a compact footprint.

Single IC Antenna Power Supply with Protection and Diagnostic Features

The 12V car battery, the starting point for many active antenna voltage supplies, is far from the quiet, stable supply required by these systems. In addition to noise, this 12V "supply" can be subjected to reverse battery conditions or load dumps where the voltage can range or spike anywhere from –36V to 80V. The LT3050 protects both itself and the antenna in this demanding electrical environment, while providing a stable, low noise output voltage. The LT3050 also protects active antenna supply circuitry in the event of a short circuit within the antenna supply itself with an accurate and programmable current limit. Thermal conditions in automotive environments are equally challenging, requiring the supply to be stable over a –40 to 125°C temperature range with robust overtemperature protection.

In addition to these difficult protection requirements, the LT3050 simplifies the gathering of diagnostic information required to report antenna status. Programmable open circuit detection monitors the antenna supply current in case it should drop below a specified minimum operating condition. Programmable short circuit detection monitors the antenna supply current in case it should exceed a defined maximum and protects the antenna, and its supply, by limiting current flow. In addition, an analog current monitor creates a signal proportional to the antenna supply current. This is handy as a diagnostic input, or for signaling the system as to which antenna type is mounted.

Protection Features in an Accurate, Stable and Quiet Power Supply

The LT3050 generates a stable and low noise supply for active antenna systems, isolating and protecting the antenna system from the car's noisy and volatile 12V supply. The IC can withstand input voltages of ±50V and reverse battery conditions potentially generated from the 12V supply as well as output reversals to ±50V (see Figure 3).

The LT3050 provides excellent power supply noise rejection, effectively isolating the antenna supply from noise on the 12V supply line or from an intermediate step-down regulator (see Figure 4). A single capacitor provides both reference soft-start and noise bypass, enabling a programmable start-up time and ultralow noise operation.

A precision programmable current limit provides additional protection by allowing the user to set current limit as low as 110% of maximum load, without affecting load regulation during normal operation. In addition, the combination of a backup current limit, current limit fold-back, and robust thermal shutdown with hysteresis allow for indefinite output shorts from a 50V input supply without damaging the IC. The output can be pulled 50V above the input with minimal current flow into the input and without damaging the IC.

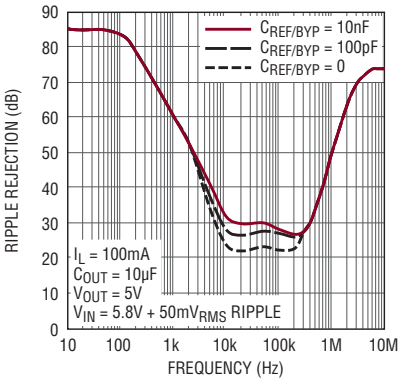

Figure 4. LT3050 ripple rejection

Diagnostic Capabilities

The LT3050 provides diagnostic information to the car's control systems. An open-collector fault indicator, capable of sinking 100µA, asserts if open-circuit or short-circuit conditions are detected, or if the IC enters thermal shutdown. The LT3050 also features an integrated current monitor that sources (via the I_{MON} pin) about 1/100 of the output current for use in antenna system monitoring and protection. See the block diagram in Figure 5. Simply connecting a resistor from I_{MON} to GND creates a ground-referenced voltage proportional to output current.

Programmable short-circuit detection and current limit is provided at the I_{MAX} pin and once set, varies less than 5% over line and temperature. The I_{MAX} pin is the collector of a specially designed current mirror device that sources about 1/200 of output current. This pin is also the input to the precision current limit amplifier. Connecting a resistor ($R_{I(MAX)}$) between I_{MAX} and GND sets the short-circuit detection and programmable current limit thresholds. The current limit amplifier circuitry performs two functions. First, it asserts the open-collector $\overline{FAULT}$ pin logic if the I_{MAX} pin voltage reaches 600mV. Second, it regulates the output drive current such that the I_{MAX} pin voltage does not exceed 600mV, thus limiting the output current to $0.6V \bullet 200/R_{I(MAX)}$.

The programmable open-circuit detection threshold is provided at the I_{MIN} pin. The I_{MIN} pin is the collector of a specially designed current mirror device that sources about 1/200 of output current. This pin is also the input to the open-circuit detection comparator, referenced to the 600mV internal reference. Connecting a resistor between I_{MIN} and GND sets the open-circuit detection threshold. If the I_{MIN} pin voltage falls below 600mV, the comparator trips and the $\overline{FAULT}$ pin asserts. The comparator uses a small amount of hysteresis to prevent $\overline{FAULT}$ pin glitches.

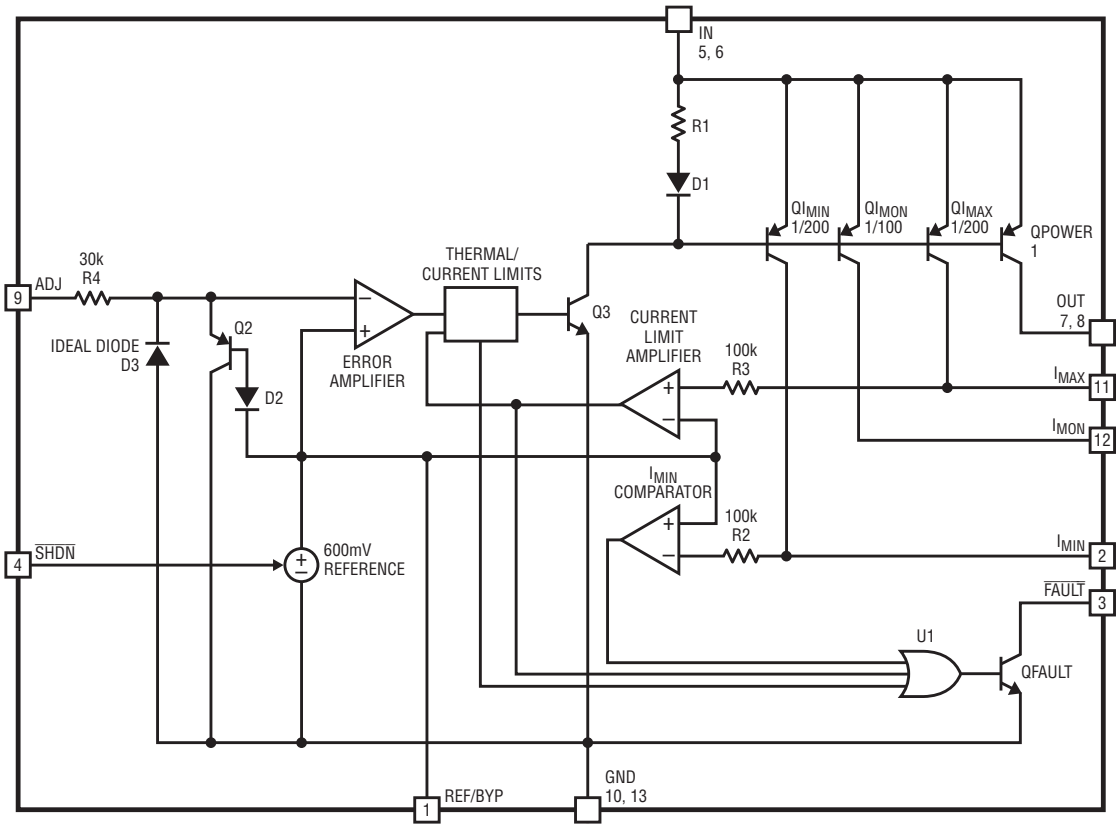

Figure 5. LT3050 block diagram

Figure 6 shows a typical LT3050 application circuit set up as an active antenna supply. Current limit, open-circuit fault threshold values, output voltage, etc. were chosen arbitrarily for illustrative purposes. In this example, the open circuit detection threshold is set by the 11.3k I_{MIN} resistor to 10mA. The 1.15k I_{MAX} resistor sets the short circuit fault threshold and current limit to 100mA (a 10nF I_{MAX} capacitor is required for current limit amplifier stability). The 3k I_{MON} resistor provides a full-scale 3V signal when output current equals 100mA. The 10nF REF/BYP capacitor provides a 5.5ms soft-start time and low noise operation.

Conclusion

As car infotainment components have grown more complex, the number of active antenna systems has grown as well. Sensitive circuitry in these active antenna systems requires protection and isolation from the harsh automotive environment as well as diagnostic feedback to report antenna status.

The LT3050 active antenna supply and diagnostics linear regulator addresses active antenna design issues with features such as programmable current limit, soft-start, open-circuit detection, output current monitor, and an open-collector fault signal. The LT3050 also features a wide input voltage range, low quiescent current, low output noise over a wide bandwidth, high output voltage accuracy, low dropout voltage and ability to withstand input and output voltage reversal.

The LT3050's stability and low noise output benefits the end user as well, with clearer and more reliable antenna transmission/receive signals to enhance the modern automotive infotainment experience.

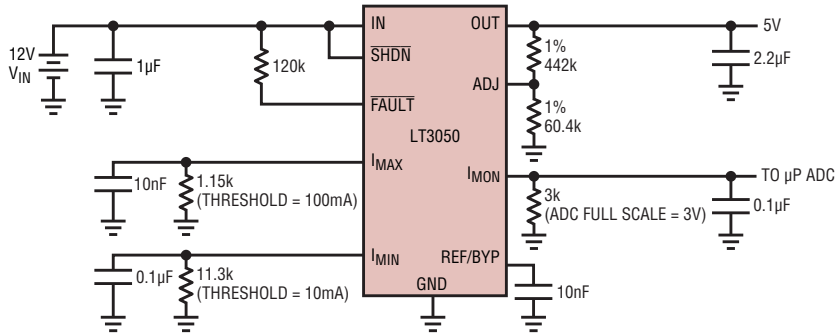

Figure 6. LT3050 active antenna supply circuit