


# designideas

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## Hardened Ethernet cable goes underground

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 An application required the extension of Ethernet (IEEE 802.3u-1995) service from a home to a garage, a distance of approximately 300 ft. Wireless communication using IEEE 802.11a/b/g equipment had proved unreliable due to the buildings' construction, which comprises stucco over embedded wire mesh. In effect, the buildings' walls form Faraday cages that attenuate radiated signals. Straight-line aerial deployment of the Ethernet cable between buildings would have required installation of support poles, and simply laying the cable on the surface of the ground would expose the cable to damage from automobiles, hungry pets, and inquisitive children. At first glance, burial of the cable appeared impractical due to the presence of a large concrete surface between the buildings. However, an alternate route through an adjacent garden would avoid tunneling beneath the concrete slab but would expose the cable to environmental hazards, such as spade work and burrowing animals.

This Design Idea describes how to environmentally "harden" a Category 5 UTP (unshielded-twisted-pair) cable conforming to EIA/TIA 568B and ISO/IEC 11801:1995 that's terminated with RJ-45 connectors (ISO 8877). Without adding repeaters, a Category 5 Ethernet cable can extend to 100m, or a little more than 300 ft. In this application, the cable run comprises 100 ft of exposed cable, 100 ft of "garden-grade" protected cable, and 100 ft more of exposed cable. To apply the idea, you have to find a way to protect and handle the exposed 200 ft of cable.

Depending on your installation's requirements, you will need various numbers and lengths of the following parts: a 100-ft-long garden hose whose fittings conform to the ANSI/ASME B1.20.7-1991.75-11.5 NH thread-form standard; a 4-Gbyte SCSI disk drive, which need not be functional; a continuous, 300-ft-long Category 5 Ethernet cable terminated in RJ-45 connectors; a 120-ft-long, nylon twine; a 5-in.-long, electrical-grade, adhesive-backed tape; a 2-in.-steel, socket-head-cap, 1/4-20-thread machine screw (ANSI/ASME B1.1-1989); and two bricks.

To construct the design, uncoil and stretch the garden hose as straight as possible, perhaps using a driveway as a work surface. Place a brick on each end of the hose to prevent it from curling. If you use only one length of garden hose, cut off and discard the hose fittings. Using Torx or Philips screwdrivers as appropriate, dismantle the 4-Gbyte SCSI disk drive by removing all of the screws that retain the drive's cover. If the cover resists removal, look for screws beneath labels. Remove the drive's head-positioning magnets, which can exert a strong pull on nearby ferrous objects. Use caution to avoid pinching your fingers between the magnets and the steel surfaces. Discard the remainder of the SCSI drive.

Securely tie the nylon twine to the 1/4-20 steel machine screw and insert the screw into one end of the hose. Apply the magnet to the hose's exterior to attract the machine screw. Slide the magnet along the hose to pull the nylon twine through the hose. When the screw reaches the

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hose's far end, untie the twine and save the screw for future use. To ease manipulation of the Category 5 cable, deploy it from either its original dispenser box or a spool mounted on a suitable axle so that the cable can easily unwind. Securely attach the twine to one end of the Category 5 cable. Walk to the far end of the hose and gently pull the cable through the hose. If you encounter excessive resistance, investigate the cause and remove any cable kinks or feeder-end snags.

When the cable appears at the pulling end, stop for a moment. Go to the other end of the hose and wrap an inch or two of electrical tape around the cable where it's just about to enter the hose. Return to the far end of the hose and continue pulling the cable through the hose. Stop pulling when you see the electrical-tape marker. You now have a 300-ft-long Category 5 cable whose central 100 feet the garden hose protects. If you decide to protect more of the cable, repeat the process by feeding the twine through a second length of hose. Use the hoses' couplings to make a watertight joint between lengths. If you take this approach, make sure that you properly orient the hose segments before you spend too much time threading the twine through the hose. **EDN**

# Shunt regulator improves power amplifier's current-limit accuracy

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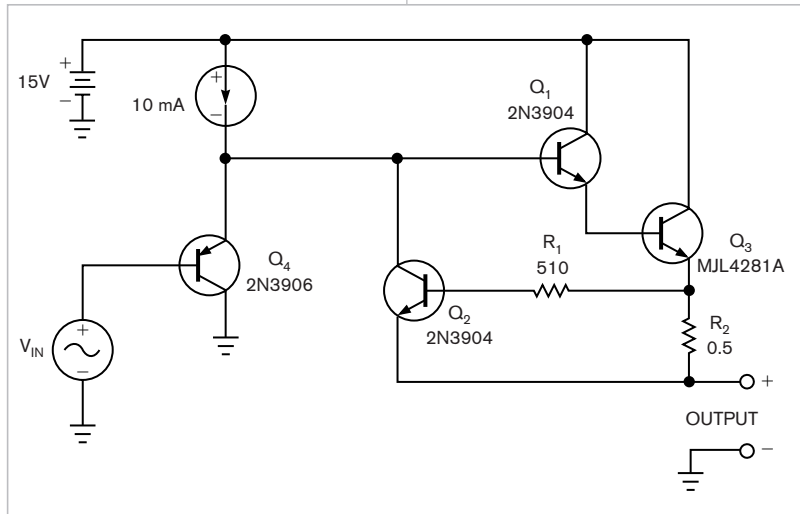
Adding current-limiting circuitry to a power amplifier's or a linear voltage regulator's emitter-follower output stage protects both the output transistor and the downstream circuitry from excessive-current dam-

age. **Figure 1** shows the classic current-limiter circuit: Transistor  $Q_2$  senses the output-current-induced voltage drop across ballast resistor  $R_2$  and diverts base current from Darlington-connected transistors  $Q_1$  and  $Q_3$ . Transis-

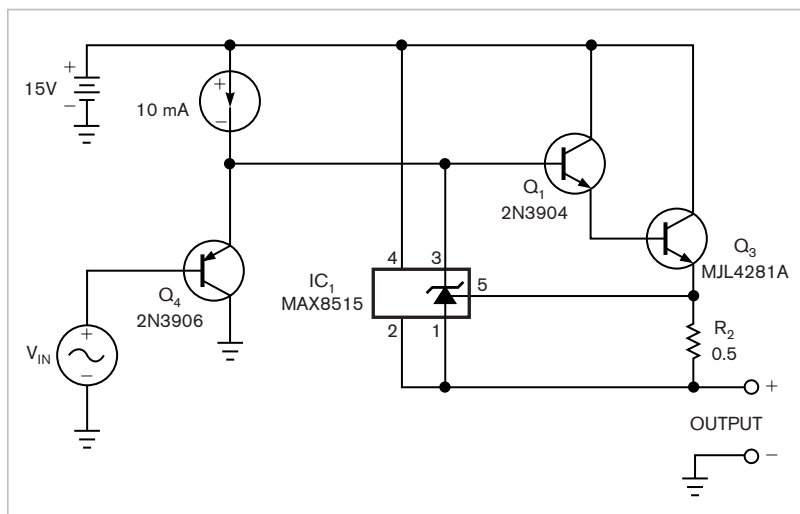
tor  $Q_2$ 's base-emitter voltage,  $V_{BE}$ , sets the circuit's current-limit threshold. Unfortunately, a small-signal transistor's  $V_{BE}$  exhibits a temperature coefficient of  $-2\text{ mV}/^\circ\text{C}$ , which causes a substantial variation in the current-limiting threshold over the circuit's operating-temperature range.

You can improve the circuit's performance by replacing  $Q_2$  with  $IC_1$ , an adjustable shunt regulator (**Figure 2**). With an input threshold voltage of 0.6V, the MAX8515 allows use of a lower value for current-sense resistor  $R_2$  and thus helps minimize  $R_2$ 's power and thermal losses. Alternative commonly available shunt regulators present input voltages of 1.25 to 2.5V. In addition, a separate power-supply input connection allows the MAX8515 to maintain accuracy when its internal output transistor approaches saturation.

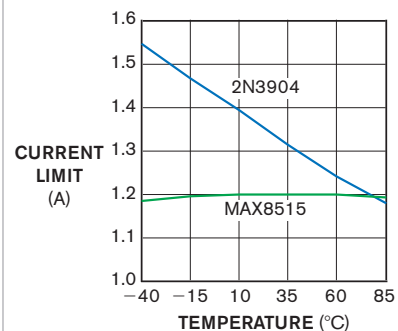
**Figure 3** compares current-limit accuracy for the circuits of **Figure 1** and **Figure 2** over an operating-temperature range of  $-40$  to  $+85^\circ\text{C}$ . Neglecting the temperature coefficient of sense resistor  $R_2$ , the shunt-regulator version maintains its output current to an accuracy of better than 2%, and the small-signal-transistor version exhibits a 25% current variation over the operating-temperature range. **EDN**



**Figure 1** A small-signal transistor,  $Q_2$ , provides an output-current limit for this emitter-follower power amplifier.



**Figure 2** Substituting a shunt regulator,  $IC_1$ , for  $Q_2$  in **Figure 1** improves the output-current-limit accuracy.



**Figure 3** Output-current-versus-temperature plots for the circuits of figures 1 and 2 show improved accuracy for the shunt-regulated circuit (bottom trace) over the discrete-transistor version (top trace).

# Low-power, super-regenerative receiver targets 433-MHz ISM band

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Designers often choose a super-regenerative receiver—despite its frequency instability and poor selectivity—for battery-powered, short-range, wireless applications in which power consumption is a major issue. Examples include remote-keyless-access systems, automobile alarms, biomedical monitors, sensor networks, and computer peripherals (Reference 1). A super-regenerative detector can also demodulate frequency-modulated signals through slope detection. Tune the detector so that the signal falls on the slope of the detector circuit's selectivity curve. This Design Idea presents a super-regenerative receiver that consumes less than 1 mW and operates in the license-free, 433-MHz ISM (industrial/scientific/medical) band.

In its simplest form, a super-regenerative receiver comprises an RF oscillator that a “quench signal,” or lower frequency waveform, periodically switches on and off. When the quench signal switches on the oscillator, oscillations start to build up with an exponentially growing envelope. Applying an external signal at the oscillator's nominal frequency speeds the growth of the envelope of these oscillations. Thus, the duty cycle of the quenched oscillator's amplitude changes in proportion to the amplitude of the applied RF signal (Figure 1).

A super-regenerative detector can receive AM signals and is well-suited

for detecting OOK (on/off-keyed) data signals. The super-regenerative detector constitutes a sampled-data system; that is, each quench period samples and amplifies the RF signal. To accurately reconstruct the original modulation, the quench generator must operate at a frequency a few times higher than the

## IN ITS SIMPLEST FORM, A SUPER-REGENERATIVE RECEIVER COMPRISES AN RF OSCILLATOR THAT A “QUENCH SIGNAL,” OR LOWER FREQUENCY WAVEFORM, PERIODICALLY SWITCHES ON AND OFF.

highest frequency in the original modulating signal. Adding an envelope detector followed by a lowpass filter improves AM demodulation (Reference 2).

Figure 2 is a block diagram of the super-regenerative receiver circuit in Figure 3. The heart of the receiver comprises an ordinary Colpitts-configured LC oscillator operating at a frequency that the series resonance of  $L_1$ ,  $L_2$ ,  $C_1$ ,  $C_2$ , and  $C_3$  determines. Switching off transistor  $Q_1$ 's bias current quenches the

oscillator. (Note that increasing  $C_1$  and  $C_2$  improves the oscillator's frequency stability at the expense of increased power consumption.) Cascode-connected transistors  $Q_2$  and  $Q_3$  form an antenna amplifier that improves the receiver's noise figure and provides some RF isolation between the oscillator and the antenna. To conserve power, the amplifier operates only during oscillation growth.

Based on a Schmitt-trigger circuit, the quench generator switches the oscillator and RF-amplifier stage. To improve sensitivity, the triangular waveform across  $C_5$  quenches the oscillator, and the square wave at the output of  $IC_1$  switches the RF amplifier. The quench generator's two outputs are phased in quadrature so that the RF amplifier has received power when the detector's oscillations start to grow. The quench frequency of this circuit is 100 kHz to allow data transfers at rates as high as 20 kbps.

The envelope detector comprises a common-source amplifier that's nominally biased to operate in Class B mode. To increase this stage's gain, you apply a small amount of bias current to make it operate in Class AB mode. To reduce the load on the oscillator's LC tank circuit,  $C_{10}$  connects to a tap on inductor  $L_1$ , as inductor  $L_2$  shows.

The first stage in the data-recovery circuit comprises buffer  $IC_{2A}$ ; amplifier  $IC_{2B}$ ; and a third-order, lowpass filter for suppressing quench-frequency components in the envelope detector's output. A dc-coupled Schmitt-trigger circuit,  $IC_3$ , extracts the transmitted data from the demodulated signal. A lowpass filter comprising  $C_{12}$  and  $R_{16}$  extracts the demodulated signal's dc

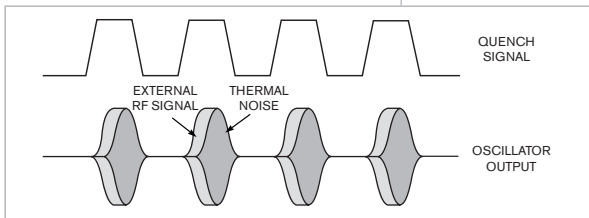


Figure 1 In a super-regenerative detector, the arrival of a signal starts RF oscillations sooner than under noise conditions.

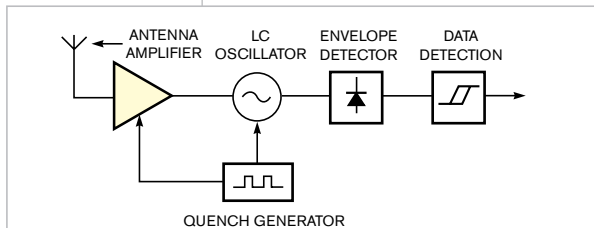


Figure 2 The super-regenerative receiver is considerably simpler than a superheterodyne circuit.

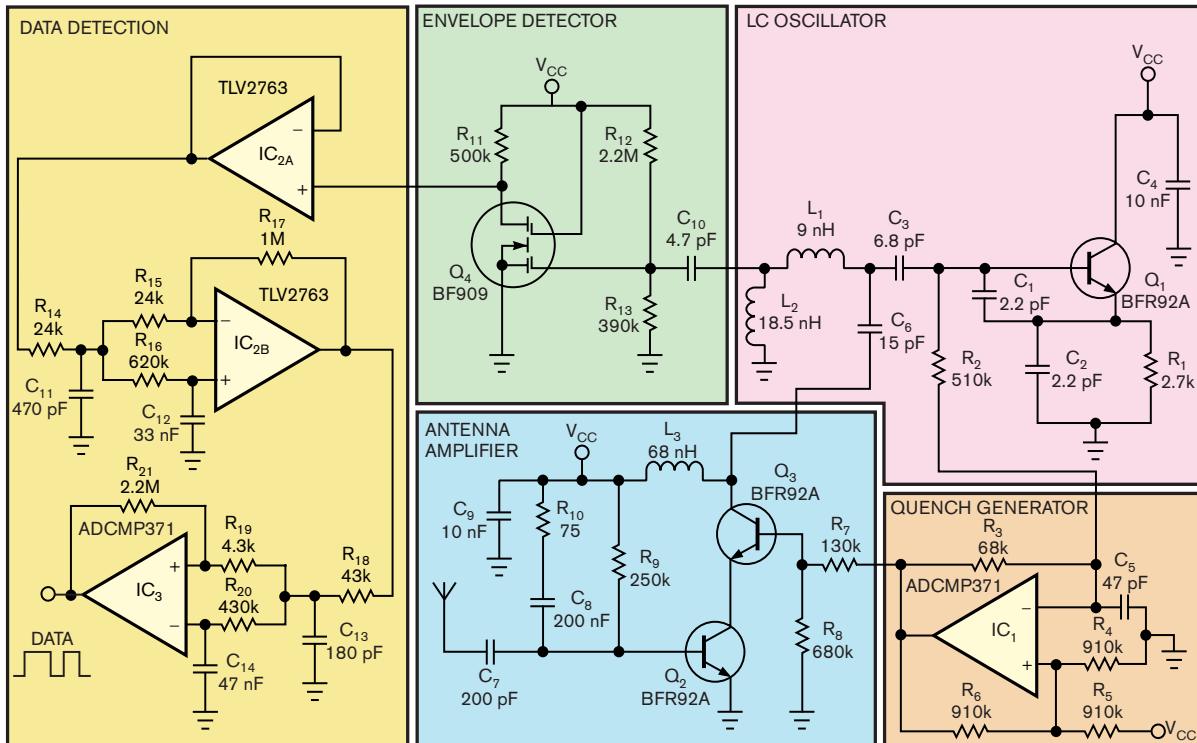


Figure 3 The super-regenerative receiver features relatively few components.

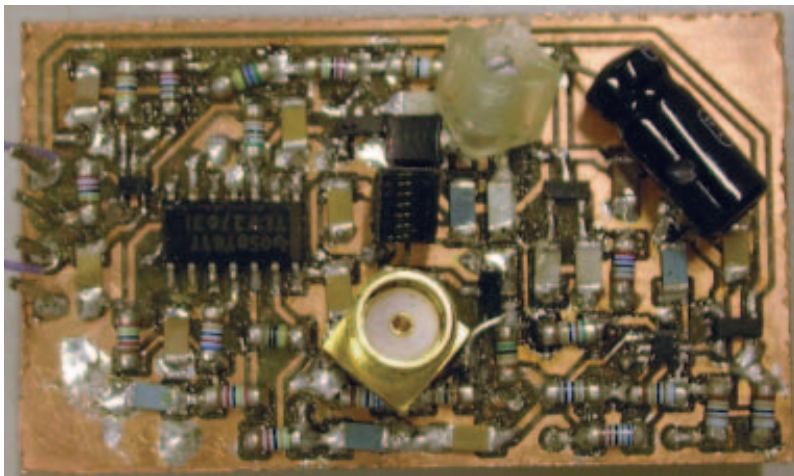


Figure 4 A prototype version of a super-regenerative receiver uses mostly surface-mount components. The large, black, leaded component in the upper right corner is a power-supply-decoupling capacitor. Note the RF-input connector in the center of the pc board.

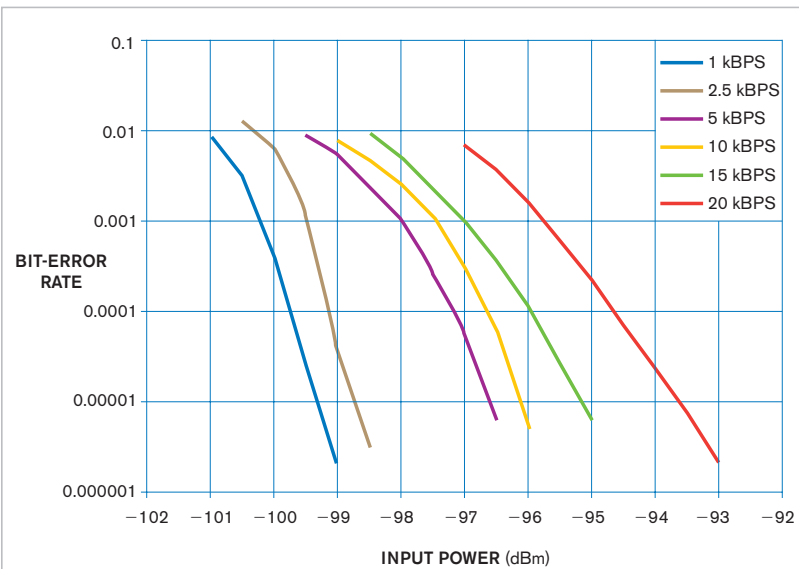
component and sets the Schmitt trigger's decision threshold. As a consequence, the data transmitter must use a dc-balanced coding scheme, such as Manchester coding, for modulation. On the receiving end, no additional active components are necessary for extracting the data-recovery circuit's decision threshold, which helps minimize the receiver's power consumption.

The prototype occupies a compact pc board measuring approximately 5×3 cm (Figure 4). Using a simple, home-made PRBS (pseudorandom-binary-sequence) generator that uses Manchester coding with a 28-to-1-bit sequence (Reference 3), BER (bit-error-rate) measurements yield the results in Figure 5. These results demonstrate a sensitivity of less than -100 dBm for a 10-to-4 BER at 1 kbps. The receiver consumes 270 μA at 3V for a power consumption of 810 μW. As a further

enhancement to the design, it includes a transmitter circuit based on Maxim's MAX1472, creating a simple, compact, low-cost, and low-power transceiver for the 433-MHz ISM band. You can easily adapt the receiver circuit for recovery of AM audio or other analog signals by replacing the Schmitt trigger, IC<sub>3</sub>, with a conventional audio-output amplifier. Retune the RF oscillator to cover the frequency range of interest.**EDN**

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- 3 Mélange, Cedric, Johan Bauwelinck, Jo Pletinckx, and Jan Vandewege, "Low-cost BER tester measures errors in low-data-rate applications," *EDN*, Dec 5, 2005, pg 123, [www.edn.com/article/CA6288033.html](http://www.edn.com/article/CA6288033.html).



**Figure 5** Measurements of bit-error rate versus input RF power highlight the prototype receiver's sensitivity. The frequency is 433.92 MHz.