design ideas

Edited by Bill Travis

IR distance ranger covers 1 to 20 cm

Paul Florian, McKinney, TX

COMMERCIALLY AVAILABLE IR distance rangers typically handle a 3- to 30-in. detection distance. Many times, it is necessary to determine smaller distances. The circuit in **Figure 1** is useful for measuring small distances to reflective surfaces. Its measurement range is from less than 1 cm to approximately 20 cm for a flat, white surface. The output of the circuit is an active-high pulse at connector P_1. A 12-msec pulse corresponds to the minimum measurable distance; the output frequency is approximately 25 Hz. If the circuit detects no reflection, then the output at connector P_1 remains high. IC_{1A} is a 0.1-mA current source. The source charges C_1 and produces a linear voltage ramp. Every 40 msec, the output of IC_2 switches low and discharges C_1 through D_1. IC_{1B} and Q_1 buffer the voltage on C_1. Q_1 ramps the current through the IR LED from 0 to 60 mA. IC_3 is a synchronous-detection photo IC. IC_3's output switches low when the IC detects a reflection from D_2.

When the reflection distance is small, not much current through the IR LED is

Figure 1
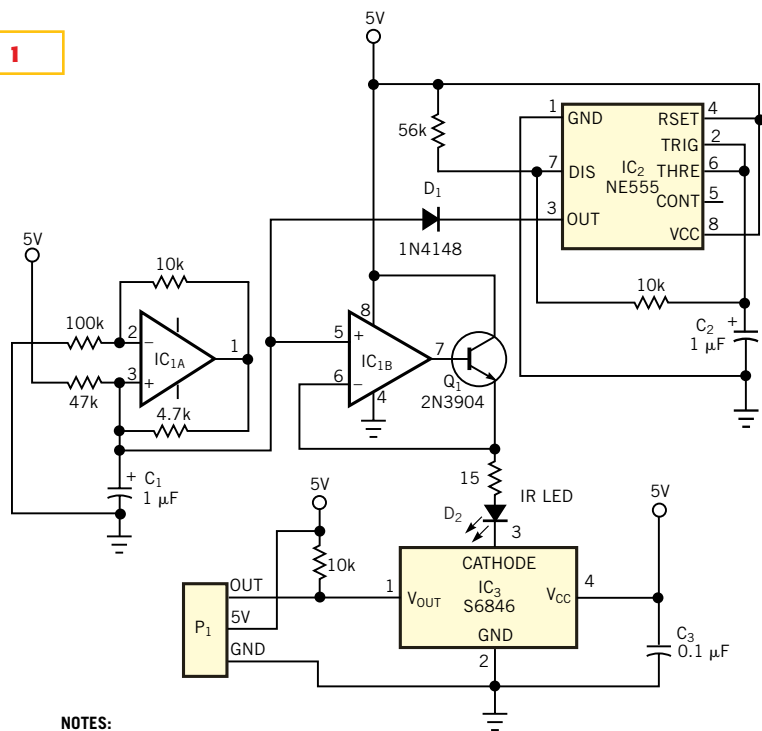
NOTES:
IC_1: TEXAS INSTRUMENTS TLV2252IP.
IC_2: NATIONAL SEMICONDUCTOR LM555CN.
IC_3: HAMMAMATSU S6846.
D_2: LUMEX OED-EL-1L2.

This circuit detects distances considerably lower than commercial IR rangers.

Publish your Design Idea in *EDN*. See the What's Up section at www.ednmag.com.

necessary to trigger the photo IC, and the pulse-width output is short. When the reflection distance is greater, it takes more current through D_2 to trigger IC_3, and the pulse-width output is greater. The maximum pulse width is always less than 40 msec. The duration of the output pulse also depends on the color of the reflecting surface and the alignment of D_2 and IC_3. D_2 and IC_3 are spaced 0.5 in. apart. A piece of heat-shrink tubing shields the sides of D_2. To align the circuit, leave some extra lead length when you mount

D_2 and IC_3. Next, make small bends in the positions of these components while monitoring the output pulse width to achieve the minimum pulse width for a given distance to a reflective surface. With careful adjustment, a detection range of 20 cm is possible to a flat, white surface. The detection distances for nonwhite surfaces are lower.

Is this the best Design Idea in this issue? Select at www.ednmag.com.

Digital volume control has log taper

Doug Farrar, Los Altos, CA

DIGITAL POTENTIOMETERS provide a compact and convenient way to attenuate audio-amplifier signals. However, most such potentiometers suffer from at least one flaw: a nonlogarithmic step increment. To avoid this problem, a user must usually step the potentiometer in a nonlinear sequence to simulate a logarithmic taper. For this reason, the potentiometer needs many taps, and you need software help to complete the design. The circuit in **Figure 1** is a low-cost, digitally attenuated audio amplifier that does not use a digital potentiometer. The circuit attenuates the signal in logarithmic steps, by using an inexpensive 8-to-1 analog switch as its "potentiometer." The resistor string, R_1 through
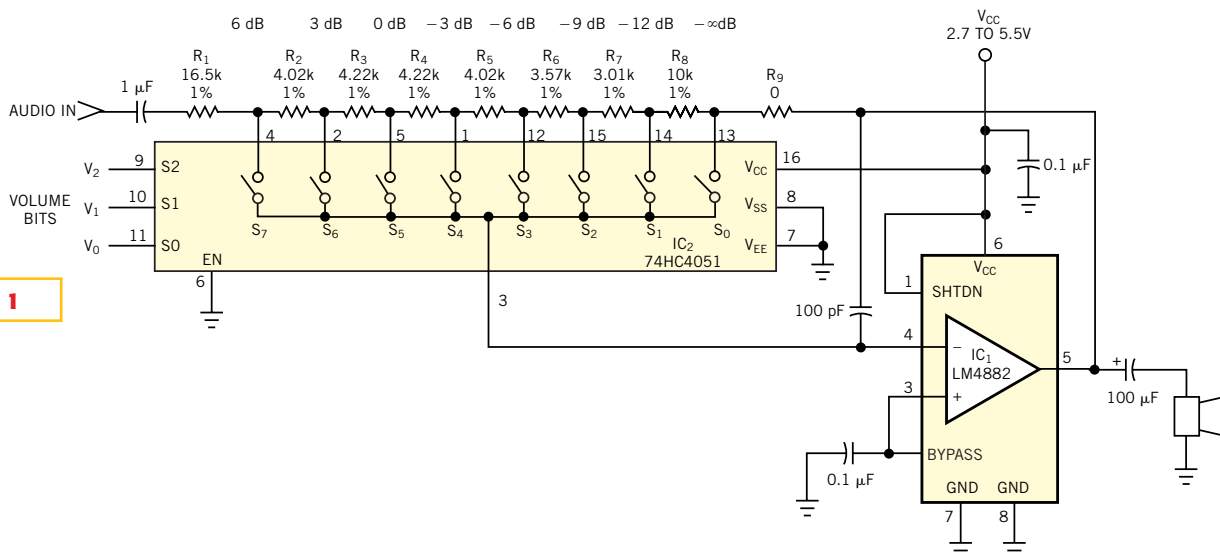
Figure 1

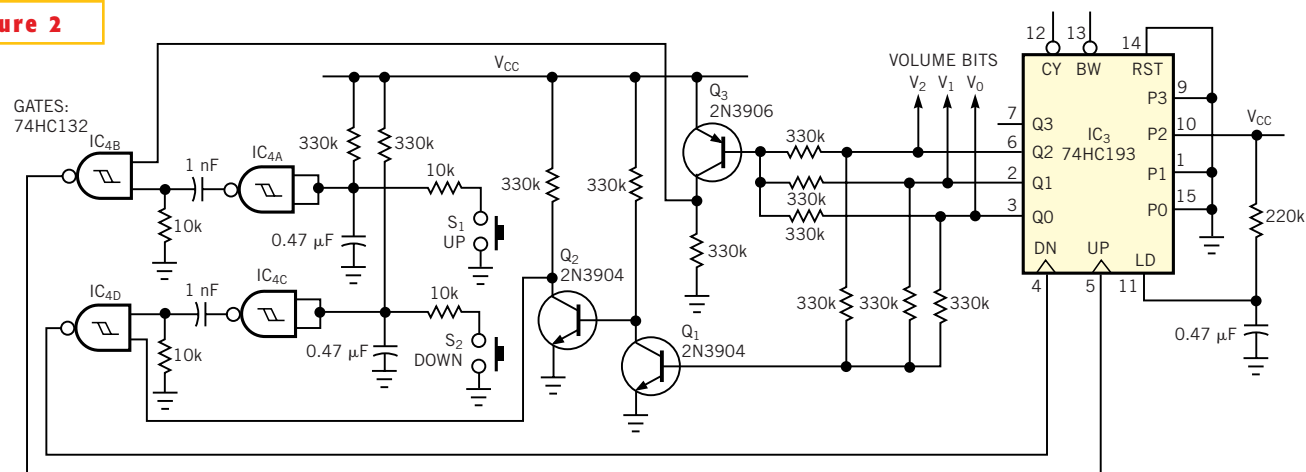This circuit sets audio gain logarithmically in 3-dB steps.

Figure 2

Up/down pushbutton switches step the gain in the circuit of Figure 1.

R_8, sets the gain of power amplifier IC_1. Analog multiplexer IC_2 selects one of the eight tap voltages and applies it to IC_1's inverting feedback node. Because only one bias current flows through the non-linear switches, the topology introduces no measurable distortion.

The amplifier changes gain in 3-dB steps, starting from a high of 6 dB, then decreasing to 3 dB, 0 dB,...-12 dB, and finally $-\infty$ dB (in other words, "mute" or "off") as you step the volume bits V_2 to V_0 from 7 to 0. If you don't want to turn off the amplifier at the minimum-volume setting, you could change resistor R_9 to a finite value for whatever end-atten-

uation level you desire. The assumption in **Figure 1** is that your system has a way to generate the 3-bit volume codes. For those applications that do not have these bits available, you can use the circuit in **Figure 2** to generate them. Pushing switches S_1 and S_2 clocks up/down counter IC_3 up and down, respectively. Transistors Q_1 and Q_2 decode the counter's zero state and disable the down clock when the count reaches zero. In this fashion, the circuit limits the counter to a value of 0 to 7. Once you attain a maximum or minimum volume, further pushes on the up and down switches, respectively, have no effect on the volume setting un-

til you go in the opposite volume direction. Standby-current consumption of the logic is almost entirely a function of the resistors you use for Q_1 to Q_3, because the logic chips use almost no power. You can set a nonzero power-up volume by using IC_3's load (LD) pin when you first apply power. In **Figure 2**, the counter powers up at a "4" volume, rather than "0" (muted). 74HCXX logic operates over 2 to 7V, but the power amplifier, IC_1, uses 2.7 to 5.5V. Therefore, IC_1 sets the operating-voltage range.

Is this the best Design Idea in this issue? Select at www.ednmag.com.

Tricks improve on Excel LCD initialization

Aubrey Kagan, Weidmüller Ltd, Markham, ON, Canada

A PREVIOUS DESIGN IDEA on using Excel for LCD initialization relies on the user for cutting and pasting from Excel into an editor (**Reference 1**). It appears that it would take a minimum of six keystrokes or mouse strokes from one character to a new character to perform this operation. This procedure does not allow for the addition of comments, which would be advantageous in the maintenance of the character set. Over a set of 64 characters, a user would take nearly 400 actions. The use of macros would allow for the reduction of these keystrokes or mouse strokes and would probably improve the previous idea.

In using such macros, rather than copy the numbers associated with characters into the text editor, as the previous Design Idea suggests, you append each sequence of numbers to a text file. When the character set is complete, you can open the text file, massage it with find-and-replace techniques, and then paste
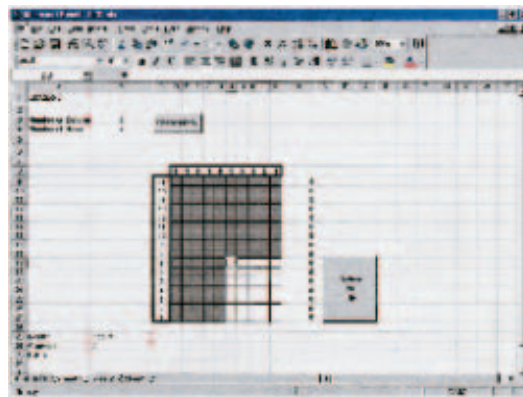

Figure 1

This Excel configuration simplifies LCD-matrix initialization.

it as a whole into a target file. An added benefit is that each sequence appears on a single line rather than having a line for every row of the display. You can maintain this original file for use in both high-level and assembly programs if the need for repeating the process ever arises.

The macro in **Listing 1** performs the following tasks:
● Prompts the user for a comment as-

sociated with this character.
● Creates a line consisting of a leader, data separated by a delimiter, a comment symbol, and the comment already entered.
● Takes the file name from the spreadsheet. If the file does not exist, the macro creates a file with the line appended to it. Each time the macro runs, it opens, adds to, and closes the file.
● Clears the entries in the LCD matrix and sets the top-left cell of the matrix as active, ready for the next character.

All the parameters represent data in the cells of the spreadsheet. The file name is in cell A1. (The macro appends the ".txt.") Cell B26 has the leader, B27 has the comment symbol, and B28 has the delimiter between the numbers in the file. You can use this data in assembler or C or some other language, so the **listing** generalizes. C would ignore the "/* db */," and you could universally replace it with "db" if you use an assembler. Similarly, you could globally modi-

fy the comment notation, " ;//" (with a space before the semicolon), in the text file as well. The trailing comma of the line of data is needed in C as part of a constant array but in assembler would generate an error. If you're using an assembler, the global search would look for the sequence " ;//" and replace it with a space and a semicolon. Because of the inconsistent way text editors deal with tabs, the **listing** avoids using the tab character. By modifying the cells, you can easily customize the format. You can implement other changes by modifying the macro, written in Visual Basic for Applications. The following is a sample line from a file:

/* db */ 4 , 12 , 4 , 4 , 4 , 4 , 14 ,;//this is a "1" on a 5×7 matrix.

A button on the spreadsheet allows you to run the macro with a single click (**Figure 1**), so you need not switch from the mouse to the keyboard to run the macro. You can also run the macros from Ctrl-key combinations. (In Excel, you should note that, to run a macro, you must have completed data entry into a cell.) The matrix's 10×16-cell format is also generalized. You can alter this format by entering the number of columns in B3 and the number of rows in B4 and clicking on the Shade Matrix button. This action activates a second macro that shades out the cells not in use. Clicking on the Update to File button triggers a pop-up window requesting a comment. You need not enter the comment symbol, because the macro

automatically enters it. The macro then appends the line to the file. The unused rows do not appear in the file. You can download the Excel file in **Listing 1** from the Web version of this Design Idea at www.endmag.com.

REFERENCE
1. Bitti, Alberto, "Excel offers painless LCD initialization" (*EDN*, Sept 20, 2001, pg 98).

Is this the best Design Idea in this issue? Select at www.ednmag.com.

LISTING 1—SAVE-CHARACTER EXCEL MACRO

```
Sub SaveCharacter()
'
' SaveCharacter Macro
' Macro recorded 11/16/01 by Aubrey Kagan
'
' Keyboard Shortcut: Ctrl+Shift+T
'
'if file does not exist then create it.
    Dim sFname As String
    Dim sX As String
    Dim iPoint As Integer
    Dim sComment As String
    Dim iUtil As Integer
    Dim iFileExists As Boolean

    sFname = Range("A1").Value
    sFname = sFname & ".txt"

    sX = Dir(sFname)
    If sX <> "" Then
        iFileExists = True
    Else
        iFileExists = False
        Open sFname For Output As #1
        'take the comment symbols an place the file name as the first
        'comment

        sX = Range("B27").Value & sFname
        Print #1, sX
        Close #1
        'file created and saved
    End If
    'now we print a range of values across the page
    'associated with the bytes for the pixels
    iPoint = 24
    iPoint = iPoint - (Range("B4").Value - 1)
    sX = iPoint
    'converting typ to string
    sX = "R" & sX
    sX = sX & "C14"
    'pointing at the start of the data
    Application.Goto Reference:=sX

    'get character description

    sComment = InputBox("Enter you comment for this Character", "Comment
Creation")

    Open sFname For Append As #1
    Print #1, Range("B26").Value;

    For iUtil = 0 To (Range("B4").Value - 1)
        sX = (iPoint + iUtil)
        sX = "R" & sX
        sX = sX & "C14"
        'placing the cursor at the data address
        Application.Goto Reference:=sX
        Print #1, ActiveCell.Value;
        Print #1, Range("B28").Value;
        'print value followed by the delimiter
    Next

    sComment = Range("B27").Value & sComment
    Print #1, sComment

    'ensure all files are closed
    Close
    'as a final step clear the page for the next character
    Range("D9:M24").Select
    Selection.ClearContents
    'move to the top left hand of screen
    'first deal with rows
    iPoint = 24
    iPoint = iPoint - (Range("B4").Value - 1)
    sX = iPoint
    'type conversion
    sX = "R" & sX & "C"
    'concantenate for rows and add C for columns
    iPoint = 13
    iPoint = iPoint - (Range("B3").Value - 1)
    sX = sX & iPoint
    'should do the conversion as well
    Application.Goto Reference:=sX

End Sub
```

Unidirectional counters accumulate bidirectional pulses

Stephen Woodward, University of North Carolina, Chapel Hill, NC

QUADRATURE-OUTPUT incremental optical shaft encoders are popular in high-performance, bidirectional rotation-sensing applications. Available with resolution options extending beyond 2000 pulses/revolution, incremental encoders provide a fast, inexpensive, and reliable way to digitally read out bidirectional mechanical motion. The encoders are fast, too; you can usually operate them at 10,000 rpm and faster. However, the interface logic they need can sometimes be somewhat problematic. Such logic typically includes at least one long-bit-length (for example, 16-bit) bidirectional counter. Although several handy peripheral chips, such as the 8253, 8254, and 9511, are available that implement flexible *unidirectional* counting, *bidirectional*-counter chips are relatively scarce. ASICs exist that can provide the needed function, and hard-wired or programmable logic is a viable approach. Unfortunately, none of these alternatives is ideal from a cost or pc-board-area standpoint. The configuration in **Figure 1** combines the industry-standard 82C54 unidirectional counter-timer peripheral chip with simple software to provide a convenient interface of quadrature encoders with the ISA I/O bus. The technique digitizes bidirectional motion without tears.

As **Figure 2** illustrates, the trick is to use two unidirectional counters of the three that the 82C54 contains. You use one counter for each encoder-rotation direction. One of the encoder quadrature-output signals, A, drives the gate pins of both counters. This connection selectively enables counting once every encoder-output cycle. A couple of Schmitt-trigger inverter stages phase-split the other encoder output, B, into two complementary signals. One phase drives the trigger input of the clockwise counter (82C54, Counter 1); the other phase drives the trigger input of the
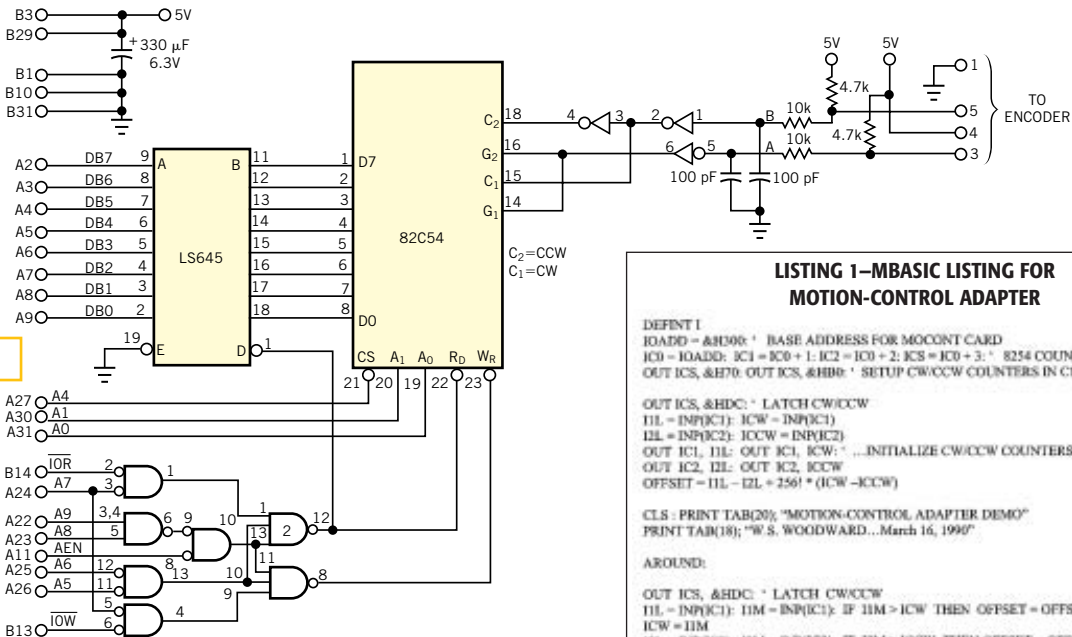
Figure 2

These timing signals illustrate the operation of the circuit in Figure 1.

Figure 1

This technique uses unidirectional counters to encode bidirectional encoder signals.

counterclockwise counter (82C54, Counter 2). The result is that only the clockwise counter, Counter 1, is active during the active B transition during clockwise rotation, and only the counterclockwise counter, Counter 2, is active during counterclockwise rotation.

Listing 1, written in MBasic, suffices to periodically latch, read, and sum the counter contents to produce a continuous 32-bit readout of encoder position. You can download **Listing 1** from the Web version of this Design Idea at www.ednmag.com. The technique can easily accommodate pulse rates as high as 500 kHz. Passive RC filtering and Schmitt-trigger signal conditioning provide robust rejection of noise pickup in the encoder cabling. The design is thus suited for typical industrial motion-sensing applications.

Is this the best Design Idea in this issue? Select at www.ednmag.com.

Build a UPS for USB devices

Mark Cherry and Jean-Claude Ailloud,
Maxim Integrated Products, Sunnyvale, CA, and France

PORTABLE SYSTEMS OFTEN include circuitry that derives power from an external source, such as USB. When the system disconnects from the USB supply, a battery takes over and supplies current via a dc/dc converter. A diode-OR connection (**Figure 1**) offers the easiest way to ensure that the supply voltage doesn't sag during this switchover to the battery. The diode's forward voltage drop, however, can reduce battery life and efficiency. The single-cell, boost-converter circuit with external PFET (**Figure 2**) is an improvement over the diode-OR connection. The PFET, Q_1, coupled with IC_1's internal gain block, forms a linear regulator. The

Figure 1
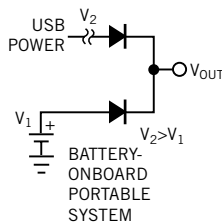
A diode-OR connection is effective but lossy.

USB power supply has a diode-OR connection to Q_1's source. Setting the boost converter's output to 3.4V allows the drain of Q_1 to regulate to 3.3V. This con-

figuration produces negligible loss in Q_1.

The bus-supply voltage available to USB devices ranges from 4.4 to 5.25V. When you connect the bus, it forward-biases D_1 and causes the boost converter to idle. The converter continues to idle as long as its output remains above the 3.4V regulation point. The bus supply serves the load and activates the current source to charge the battery. Adjusting R_1 allows you to set the current-source output to charge the nickel-metal-hydride cells at a level one-tenth the battery's capacity. Disconnecting the circuit from the USB supply causes the boost converter to cease idling and supply current to the load via the battery. **Figure 3** shows that the load current suffers no interruption during a switchover from USB to battery.

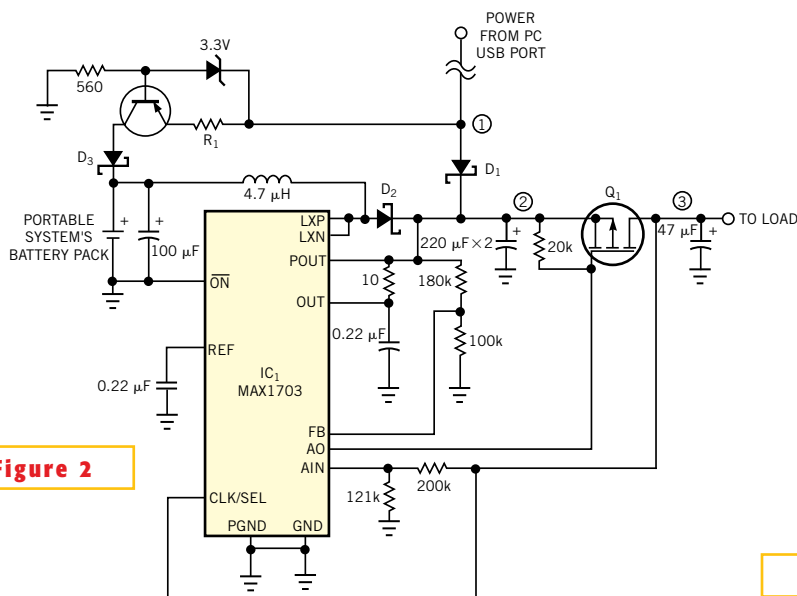**Is this the best Design Idea in this issue?** Select at www.ednmag.com.

Figure 2

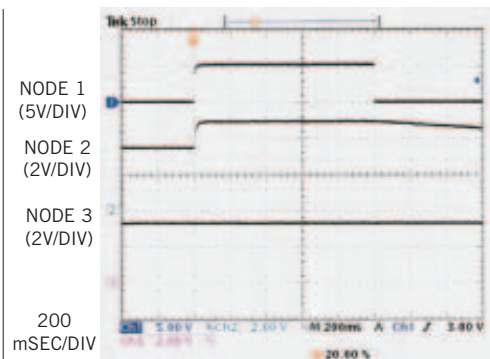**A boost-converter circuit is an improvement over the simple diode-OR connection.**


Figure 3

These waveforms (bottom trace, load voltage) show that the load current suffers no interruption during a switchover from USB to battery.

Circuit forms high-frequency polarity clamp

Shyam Tiwari, Sensors Technology Private Ltd, Gwallor, India

YOU NEED A NEGATIVE signal clamp to protect an ADC against negative-going signals while measuring the positive pulse shape of the signal by digitizing the waveform. In other words, you must clamp negative signals at 0V. The circuit in **Figure** 1 can clamp either positive or negative pulses to ground. The circuit uses a fast MAX-477EPA amplifier to drive the Q_1 or Q_2 to clamp signals of either positive or negative polarity. Q_1 forces negative signals to a 0V level; Q_2 does the same for positive signals. You use an spdt switch to choose the transistor of interest. The circuit works over 1 kHz to 10 MHz. You can also make the clamp operate at frequencies as high as 100 MHz by replacing C_1 with a 1-kΩ, 0.5W resistor. However, the output would need another

Figure 1
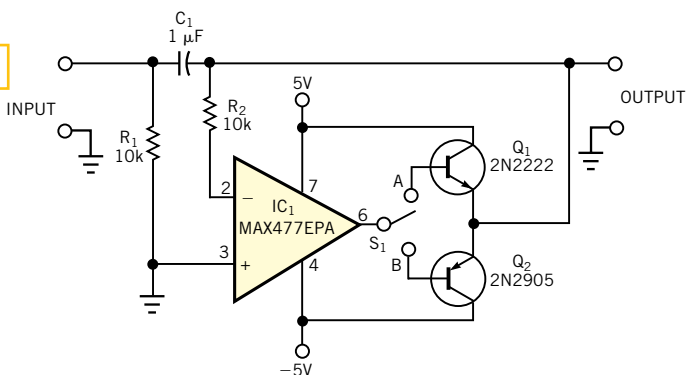
This simple circuit clamps either positive or negative signals to ground.

MAX477EPA buffer amplifier to drive the 50Ω signal cable, because the circuit's output impedance increases to 1 kΩ.

Is this the best Design Idea in this issue? Select at www.ednmag.com.