



Edited by Bill Schweber

Digitally control room light intensity

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MANY PEOPLE FAVOR different light and temperature settings for different rooms depending upon their mood or whether they are working or relaxing. The circuit in **Figure 1** controls the intensity of the artificial light in a room and monitors the temperature of two zones. The two main circuit blocks are the PIC16C67 master controller and the ADT7516 temperature-sensor interface, which includes a four-channel ADC and a quad voltage-output DAC. Other components include a photodiode and an op amp that monitor the ambient light; a rotary potentiometer that sets the light intensity; an LED bar array and display driver, which indicate the light-intensity setting; a light-dimmer-control circuit; and a 16×two-character LCD,

which indicates the temperature of the two zones.

On power-up, the PIC16C67 configures its ports to control the LCD and the ADT7516. The ADT7516 has a dual interface, comprising I²C and SPI, so the master communicates in SPI mode. The ADT7516 operates in SPI mode, once the controller initializes the LCD.

The ADT7516 senses both its internal temperature and the temperature of a remote thermal diode (Q₁ configured as a diode), and the PIC16C67 displays these temperatures on the LCD. One of the ADT7516's analog inputs monitors a potentiometer that you adjust to set the required light intensity. The PIC controller reads the potentiometer value from the ADT7516 and outputs a corresponding

Digitally control room light intensity 103

Circuit tests V_{COM} drivers 104

Use two picogate devices for bidirectional level-shifting..... 106

Simple nanosecond-width pulse generator provides high performance .. 108

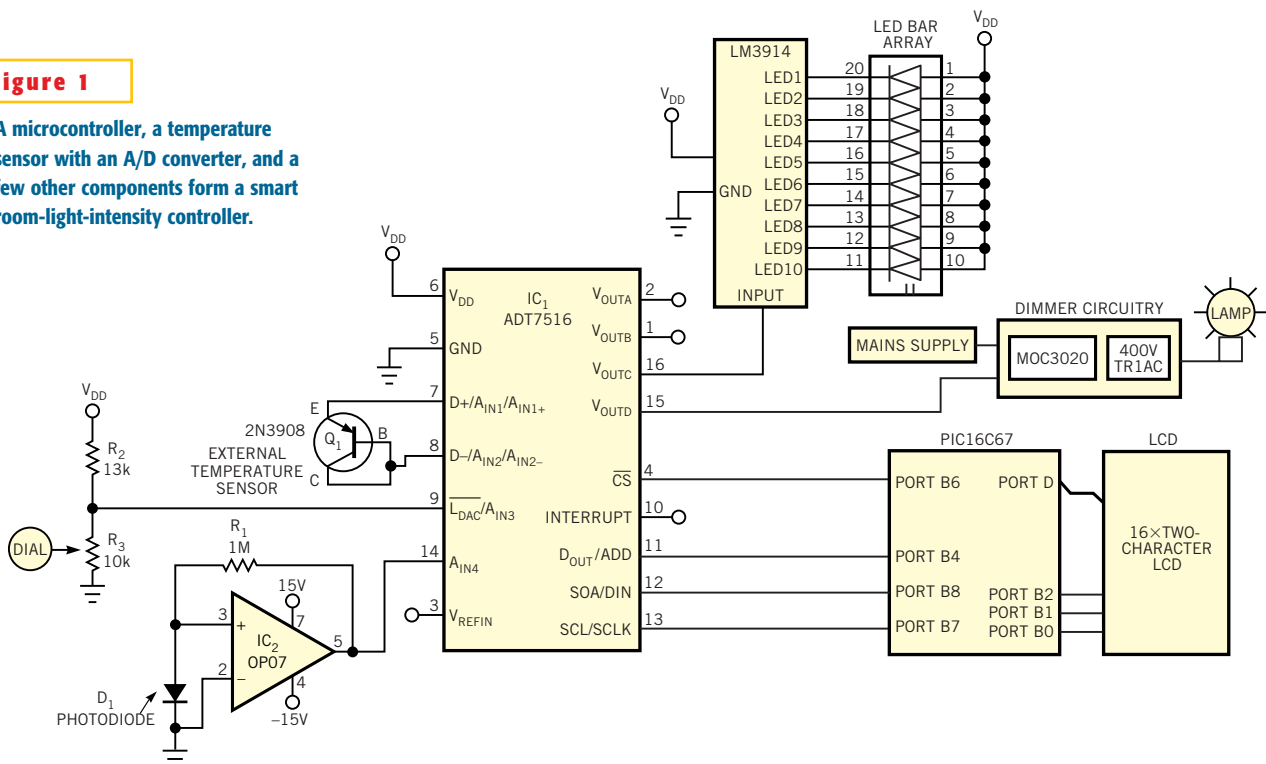
Accurately measure resistance with less-than-perfect components 110

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DAC value. The DAC controls an LM3914 LED-bar-array controller that shows the potentiometer setting on the array. If you set the potentiometer half-

Figure 1

A microcontroller, a temperature sensor with an A/D converter, and a few other components form a smart room-light-intensity controller.



way, for example, then half of the LEDs turn on, indicating that you want an intensity that is half of what the light source can deliver.

A second DAC output controls a DIAC-based (X1) light-dimmer circuit. This dimmer circuit operates like any other light dimmer, except that the DAC controls it instead of a potentiometer. A photodiode monitors the intensity from the light bulb. An OP07 amplifies its output and feeds it into one of the ADT7516's analog inputs. The PIC con-

troller uses the potentiometer and photodiode values, which the ADT7516 digitizes, to maintain equilibrium between the light intensity and the required light setting. If the photodiode reading is less than the potentiometer setting, the controller increases the dimmer DAC value; it decreases the dimmer DAC value if the reading is greater.

One of the features of the ADT7516 is its round-robin mode, in which it constantly monitors all of its measurement channels. The master need not initialize

any conversions during its operation; all it has to do is read back from four value registers and act according to its program. This circuit ensures a constant light intensity within a room, saving power when daylight takes over as the main light source. It also extends the lifetime of a light bulb, thus saving on maintenance bills in a large office environment. You can also extend the application to include control of air conditioning and to memorize heat and light settings that suit individuals tastes. □

Circuit tests V_{COM} drivers

Soufiane Bendaoud, Analog Devices, San Jose, CA

FLAT-PANEL LCD monitors offer excellent image quality and more compact form factor than CRTs—hence, their steadily increasing popularity. Unfortunately, the complexity of their manufacturing process makes LCD monitors considerably more expensive than CRTs. The amplifier that drives V_{COM} the voltage on the backplane of the LCD panel, must be able to drive large capacitive loads, deliver high peak output currents, and maintain a constant output voltage. This Design Idea describes a simple test to measure the usefulness of

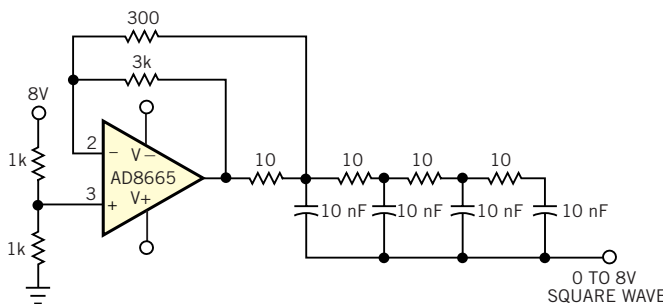


Figure 1

In this typical V_{COM} driver, an array of capacitors simulates the subpixel load.

an amplifier used as a V_{COM} driver. First, consider some video theory. Flat-panel television screens differ in the rate at which the screen refreshes. The refresh rate for TVs depends on the standard you

use, such as NTSC, PAL, or SECAM. Computers, on the other hand, typically refresh the screen at a 75-Hz rate. A single picture element, or pixel, on an LCD screen comprises three subpixels, one each of red, green, and blue.

Electrically, the subpixels behave like capacitors, storing a certain voltage until the next voltage arrives. Changing the voltages on the subpixels, one row at a time, refreshes the screen. These voltages use V_{COM} as a reference. The absolute value of the voltage differences, V_{COM} , represents the brightness of the subpixels. The video signal undergoes inversion on a frame-by-frame basis to ensure that the time average of the pixel voltages is zero, thus preventing screen burnout. The circuit of **Figure 1** tests the V_{COM} driver by applying a square wave to a capacitor array representing the subpixels in the panel. This circuit simulates the worst-case condition, in which all the subpixels switch on or off simultaneously. A pair of high-power, low-on-resistance MOSFETs generates the square wave. A nonoverlapping drive

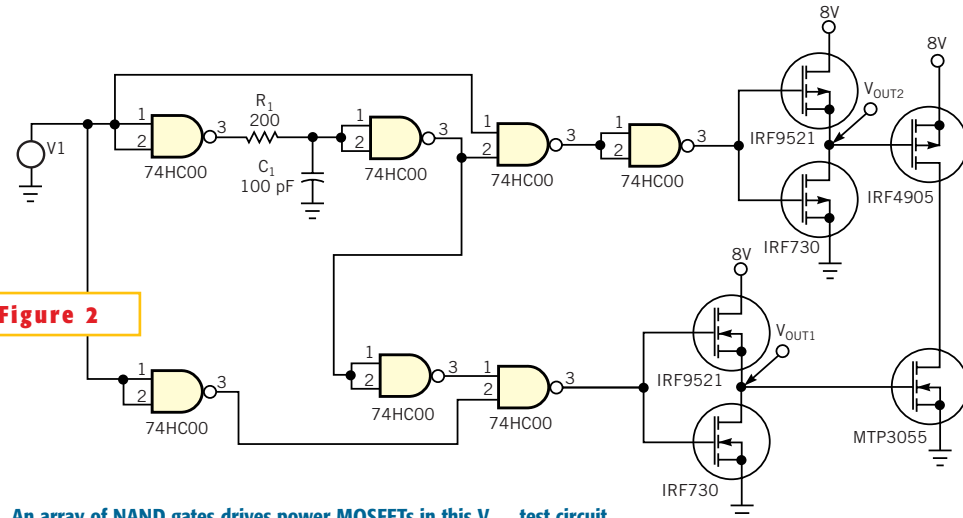


Figure 2

An array of NAND gates drives power MOSFETs in this V_{COM} test circuit.

scheme ensures that both MOSFETs do not turn on at the same time. Otherwise, simultaneous conduction would give rise to high shoot-through currents. **Figure 2** shows the MOSFETs and the nonoverlapping drive scheme. The drive scheme

uses high-speed NAND gates. An RC network at the input of the second NAND gate controls the nonoverlap delay. The first pair of MOSFETs acts as predrivers to provide the current needed to drive the power-MOSFET output

stage. **Figure 3** shows the nonoverlapping drive to the gates of the output stage. **Figure 4** shows the instantaneous peak output current of the AD8565 in response to a pulse from the test circuit. □

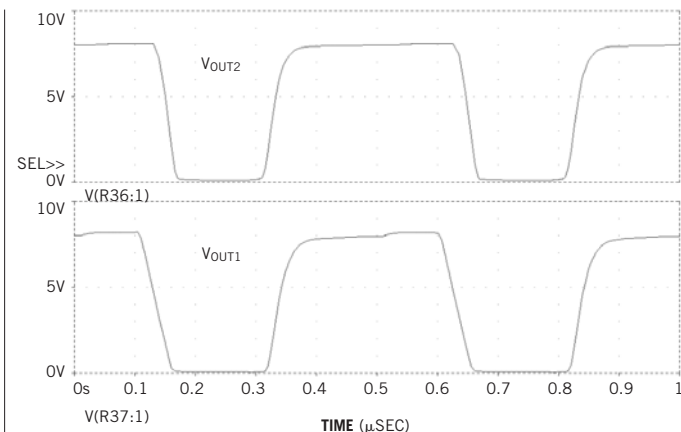


Figure 3 Nonoverlapping gate drive prevents large shoot-through currents in the output stage of Figure 2's circuit.

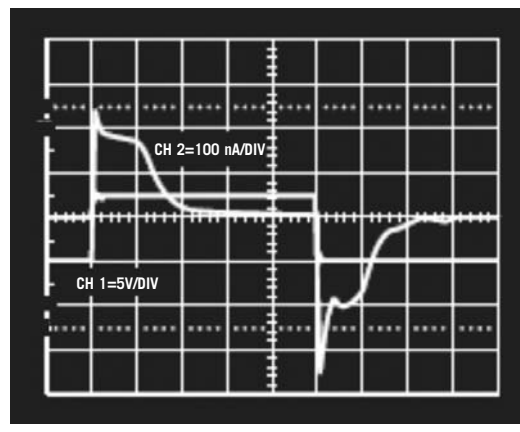


Figure 4 The AD8565 exhibits peak currents greater than 250 mA in response to a test-circuit pulse.

Use two picogate devices for bidirectional level-shifting

Bob Marshall, Philips Semiconductors

IN NEW MIXED-VOLTAGE systems, it is often necessary to level-shift a control signal from a high level to a low level. An open-drain device, such as the 74LVC1G07, easily performs this shift. However, when a bidirectional signal requires level-shifting, it takes a bit more circuitry, because simply tying two open-drain devices pins together generates just a latch function.

The circuit in **Figure 1** shows how to connect the 74LVC2G241 and 74LVC2G07 devices together to shift the signal at A from a high level to a low voltage at B and to shift a low level at B to a higher level at A. The \overline{DIR} signal controls the direction of the transfer. When \overline{DIR} is low, the A side is the input, and the B side is output. When \overline{DIR} is high, B becomes the input, and A becomes the output. To have B behave as an input when the \overline{DIR} signal is low, redo the circuit so that Pin 3 of the 74LVC2G241

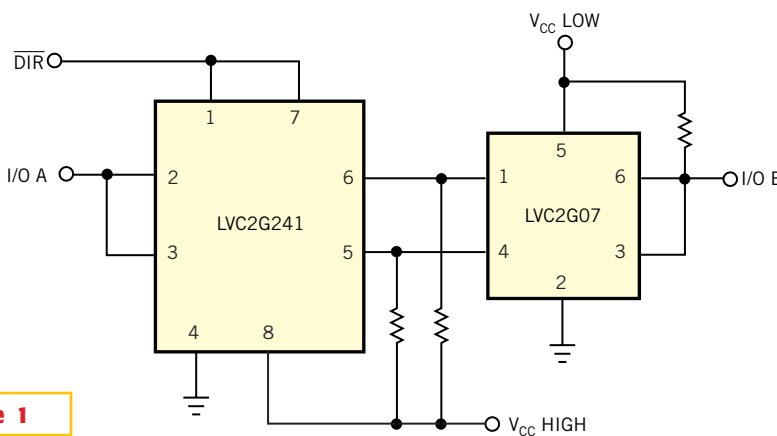


Figure 1

A two-IC circuit allows signal level-shifting in both directions; signal-flow direction is under circuit control.

becomes the input to Pin 1 of the 74LVC2G07 and Pin 4 of the 74LVC2G07 becomes the input to Pin 2 of the 74LVC2G241.

The highest voltage V_{CC} should supply

the 74LVC2G241, and the lowest voltage level supply necessary should supply the 74LVC2G07. For example, to shift a signal from 3.3 to 1.8V, the 1.8V V_{CC} should supply the 74LVC2G07 device. The size

of the pullup resistor is unimportant, but, for best speed, it should be as small as practical to reduce the RC change time of the output signal of the 74LVC2G07. The current output of the 74LVC07A is 24 mA at 3.3V; at that V_{CC} , the pullup resis-

tor could be as low as 150Ω. It should be as large as possible to reduce power consumption.

The 74LVC2G07 supply level determines V_{OL} and V_{OH} at B. At 1.8V, the V_{OH} would be near V_{CC} , and V_{OL} is 0.45V or

lower when driving a 4-mA load. The 74LVC2G07 and 74LVC2G241 provide a quick and easy way to obtain a bidirectional level translation and take up little board space. □

Simple nanosecond-width pulse generator provides high performance

Jim Williams, Linear Technology Corp

If you need to produce extremely fast pulses in response to an input and trigger, such as for sampling applications, the predictably programmable short-time-interval generator has broad uses. The circuit of **Figure 1**, built around a quad high-speed comparator and a high-speed gate, has settable 0- to 10-nsec output width with 520-psec, 5V transitions. Pulse width varies less than 100 psec with 5V supply variations of 65%. The minimum input-trigger width is 30 nsec, and input-output delay is 18 nsec.

Comparator IC_1 inverts the input pulse (**Figure 2**, Trace A) and isolates the 50Ω termination. IC_1 's output drives fixed and variable RC networks. Programming resistor R_G primarily determines the networks' charge-time difference and, hence, delay at a scale factor of approx 80Ω/nsec.

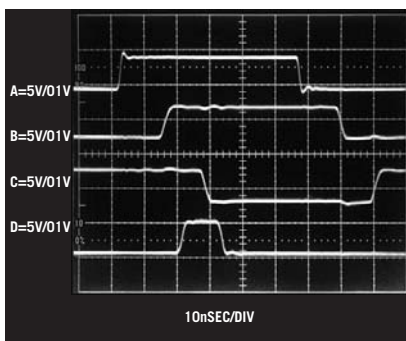


Figure 2 Pulse-generator waveforms, viewed in 400-MHz real-time bandwidth, include input (Trace A), IC_3 (Trace B) fixed and IC_2 (Trace C) variable outputs and output pulse (Trace D). RC networks differential delay manifests as IC_2 - IC_3 positive overlap. G_1 extracts this interval and presents circuit output.

Comparators IC_2 and IC_3 , arranged as complementary-output-level detectors, represent the networks' delay difference as edge-timing skew. Trace B is IC_3 's fixed-path output, and Trace C is IC_2 's variable output. Gate G_1 's output (Trace D), which is high during IC_2 - IC_3 positive overlap, presents the circuit output pulse. **Figure 2** shows a 5V, 5-nsec width, measured at 50% amplitude, output pulse with $R=390\Omega$. The pulse is clean and has well-defined transitions. Post-transition aberrations, within 8%, derive from G_1 's bond-wire inductance and an imperfect

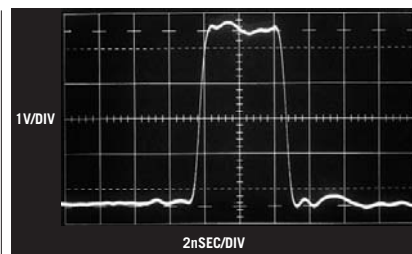


Figure 3 The 5-nsec-wide output with $R=390\Omega$ is clean with well-defined transitions. Post-transition aberrations are within 8% and derive from G_1 bond-wire inductance and an imperfect coaxial probe path.

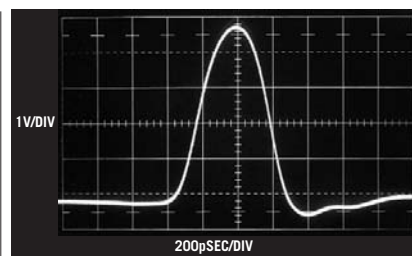


Figure 4 The narrowest amplitude pulse width is 1 nsec, and the base width measures 1.7 nsec. Measurement bandwidth is 3.9 GHz.

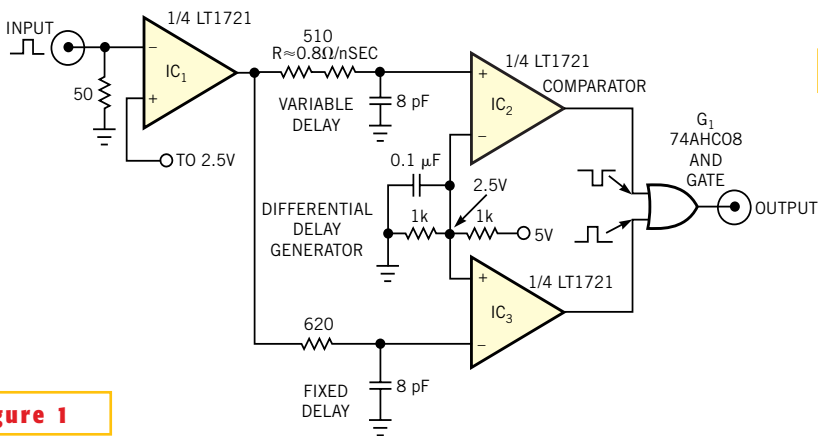


Figure 1

This pulse generator has 0- to 10-nsec width and 520-psec transitions. IC_1 unloads termination and drives the differential delay network. The IC_2 - IC_3 complementary outputs represent delay difference as edge timing skew. G_1 , which is high during IC_2 - IC_3 's positive overlap, presents circuit output.

coaxial probing path. **Figure 3** shows the narrowest full amplitude, 5V pulse available. Width measures 1 nsec at the 50% amplitude point and 1.7 nsec at the base in a 3.9-GHz bandwidth. Shorter widths are available if partial amplitude pulses are acceptable. **Figure 4** shows a 3.3V, 700-psec width (50%) with a 1.25-nsec base. G_1 's rise time limits minimum achievable pulse width. The partial-amplitude pulse, 3.3V high, measures 700 psec with a 1.25-nsec base (**Figure 5**). **Figure 6**, taken in a 3.9-GHz sampled bandpass, measures 520-psec rise time. Fall time is similar. The transition of the probe edge is well-defined and free of artifacts. □

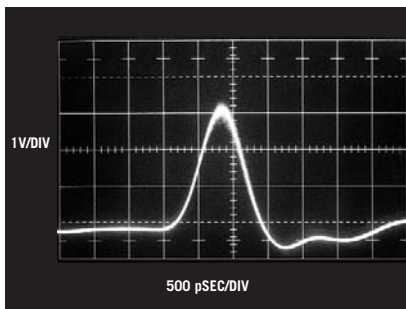


Figure 5 The partial-amplitude pulse, 3.3V high, measures 700 psec wide with a 1.25-nsec base. The trace granularity is an artifact of the 3.9-GHz-sampling-oscilloscope operation.

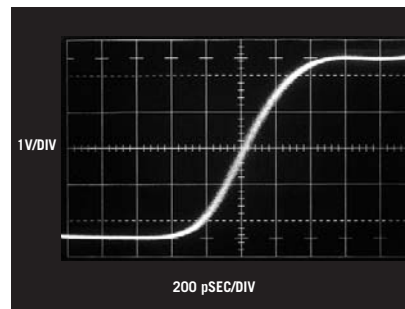


Figure 6 A transition detail in the 3.9-GHz bandpass with rise time of 90 psec shows 520-psec rise time; fall time is similar. The granularity derives from sampling-oscilloscope operation.

Accurately measure resistance with less-than-perfect components

Dave Van Ess, Cypress Semiconductor

FOR TRANSDUCERS, such as strain gauges or thermistors, you must accurately and inexpensively measure resistance using circuitry built with imperfect components and in which gain and offset errors can

significantly limit the accuracy of ohmic measurements. The right circuit topology makes it possible to eliminate most error terms while measuring ohms, leaving the accuracy to be determined by just a single reference resistor.

Unlike measuring voltage or current, measuring a passive attribute, such as re-

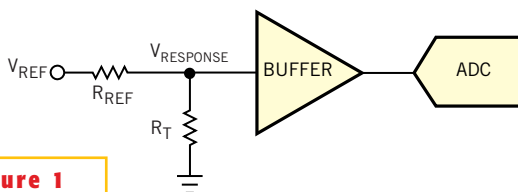


Figure 1

The resistive-divider topology provides a lower cost alternative to a current source and a precision resistor for calibration.

sistance, requires a stimulus. One method of measuring resistance is to force a known current through a resistor and measure the voltage across the resistor. Measuring ohms in this way means that, with the correct selection of stimulus

current, you need do no math, so this method was popular when the cost of computation was more than the cost of building an accurate current source. However, the accuracy of the current source directly limits the accuracy of the reading and any gain or offset errors from measuring the response voltage offsets the accuracy, as well. Additionally, the range of measurement is limited to the ADC's signal range, as the following equation shows:

$$R_T(\text{MAX}) = \frac{V_{\text{RESPONSE}}(\text{MAX})}{I_{\text{STIM}}}$$

ally, the range of measurement is limited to the ADC's signal range, as the following equation shows:

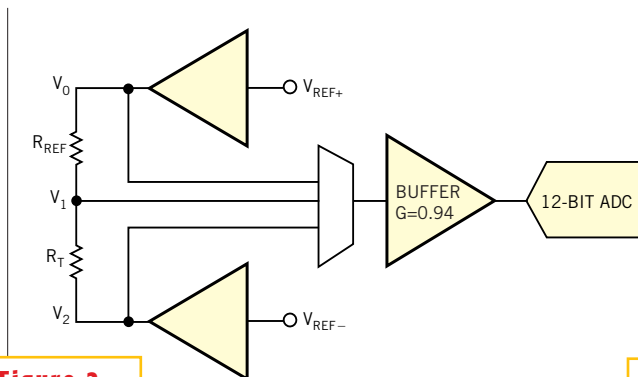


Figure 2

Remove most gain and offset errors using two measurements and a ratio calculation.

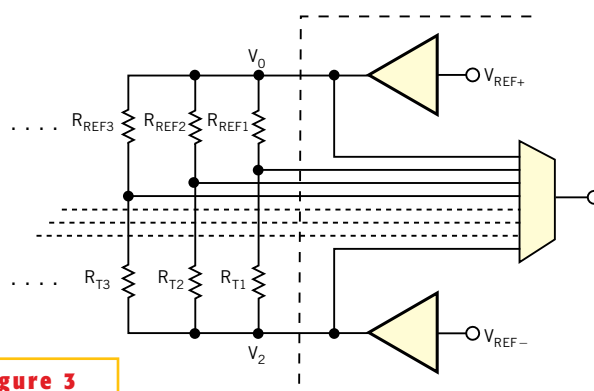


Figure 3

Extend the idea to handle multiple sensors and signal paths, using multiplexing through a single buffer and A/D converter.

With the development of more powerful microcontrollers and on-chip ratiometric ADCs, a resistor-divider block architecture (**Figure 2**) provides a less expensive approach:

$$R_T = R_{REF} \times \frac{V_{RESPONSE}}{V_{REF} - V_{RESPONSE}}$$

This architecture has a theoretical range of measurement from short circuit to open circuit, but any offset error from measuring the response voltage limits the actual range; the reference resistance limits overall accuracy and any gain and offset errors from measuring the response voltage.

The cost of the reference resistor determines the error that the reference resistor introduces, and you derive the supply voltage, V_{CC} , from the reference voltage, V_{REF} . The gain error of a ratiometric ADC is generally small and does not contribute much to the overall error, but this situation is not the case for the

offset error, which can be the largest contributor of error to the overall accuracy. Using more expensive and precise components reduces the offset error of any op amps in the measurement path.

Figure 2 shows how to significantly remove gain and offset errors, in which subtracting two measured voltages removes any offset errors in the measurement system:

$$R_T = R_{REF} \times \left(\frac{V_1 - V_2}{V_0 - V_1} \right)$$

The ratio of these two difference values removes any measurement-path gain error, leaving the reference resistance to determine the measurement error. This result is valid as long as the measured signal is never outside the range of the A/D converter. To guarantee this condition, set the sense buffer gain to slightly less than unity.

You can also measure multiple resistors, in which all the sense paths multi-

plex to a single buffer and A/D converter, and the eight analog pins let you measure as many as six transducers (**Figure 3**). Alternatively, you could connect each of four sense paths to its own buffer and converter.

Listing 1 at the Web version of this Design Idea at www.edn.com shows how you implement the circuit of **Figure 2** using a programmable analog system-on-chip controller. It uses the ADCINC12 user module, programmable-gain-adjustment user module, and two analog output buffers. Placing the analog block of the ADCINC12 just below the buffer and setting the clock for the ADCINC12 to 167 kHz for a sample rate of 10 samples/sec remove any 50- or 60-Hz interference from the signal. Increase the sample rate if the application requires a faster conversion. The control software is in C; the program calculates the resistance reading and leaves it in a global memory location. □