



Edited by Brad Thompson

Camera serializer/deserializer chip set reduces wire count for keypad

Wallace Ly, National Semiconductor Corp

MANY SYSTEMS that require a user to manually enter data feature a keypad similar to that in **Figure 1**. Although early keypads comprised arrays of individually wired switches, a typical modern keypad comprises a matrix of x and y lines. Pressing a key creates a momentary connection between an x line

and a y line. For example, an individually wired keypad comprising discrete switches arranged in four rows and three columns (also known as a 4x3 layout) would require 24 wires. The more economical matrix approach in **Figure 2** requires only seven signal wires, but even that number can sometimes prove difficult to route to a microcontroller. To further reduce the number of interconnecting wires from seven to three, plus a ground return, you can adapt a configurable serializer/deserializer such as National Semiconductor's LM2501.

The device typically finds use in adapting video buses, such as wide, low-voltage CMOS-video interfaces for portable

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electronics to Mobile Pixel Link service. The LM2501's typical application circuit features low-voltage and low-current operation and produces low levels of EMI (**Figure 3**). The circuit requires only two support devices—a counter (a CMOS CD4017 decade counter) and a 10-MHz clock-oscillator module (**Figure 4**). In operation, the host microcontroller drives the deserializer's WCLK input pin with a low-voltage-CMOS clock pulse,

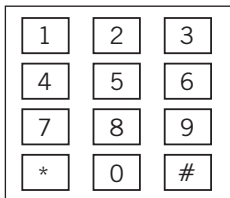


Figure 1

A typical keypad provides a limited number of numeric keys and two symbols—the asterisk (*) and the octothorpe (#).

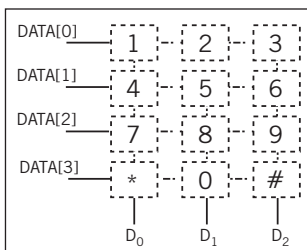


Figure 2

In a matrix keypad, pressing a key creates a connection between a row wire and a column wire.

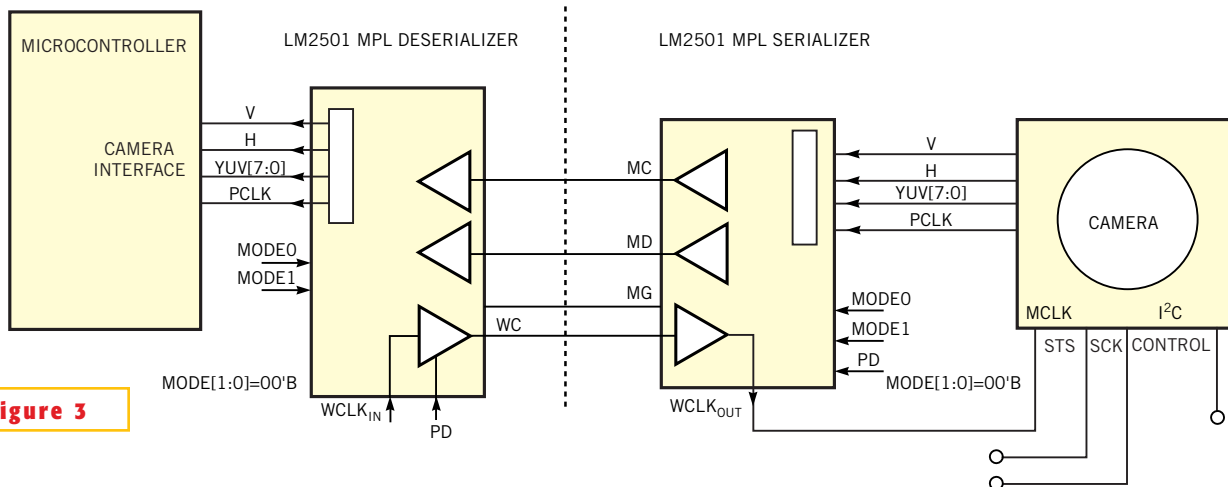


Figure 3

In a typical application, a pair of LM2501s converts multiconductor video data to serial data and restores the data to multiconductor format.

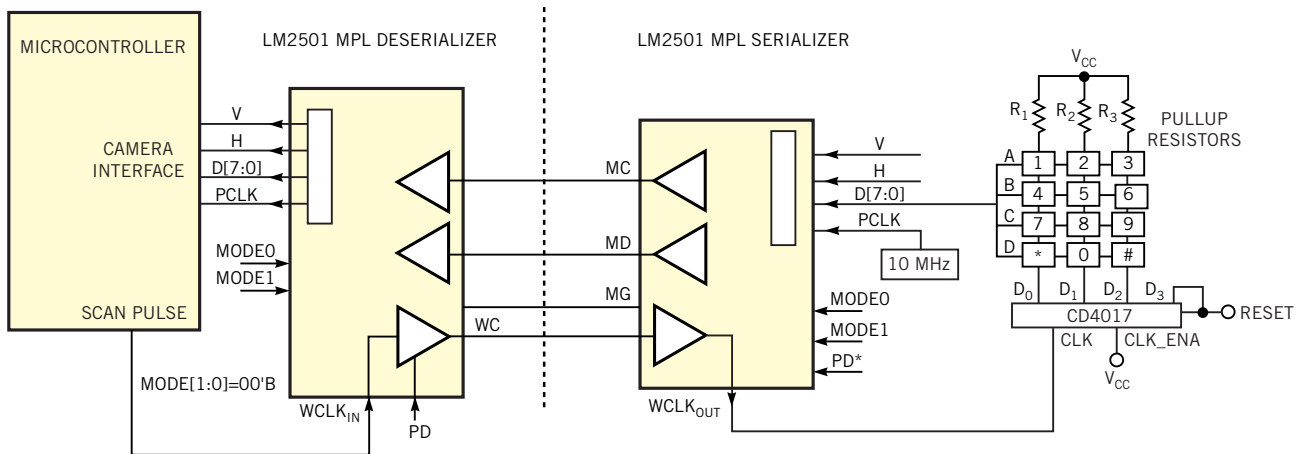


Figure 4 You can apply the LM2501 to reduce the number of signal lines a keypad-to-microprocessor interface requires.

which translates to an MPL-level signal and then is applied to the serializer. The serializer reconverts the WCLK pulse, which drives the counter's clock input.

Unlike divide-by-10 encoded-output decade counters, the CD4017's internal organization comprises a Johnson counter that activates only one of its 10 outputs at a time. Thus, the counter's outputs D_0 , D_1 , and D_2 sequentially apply a logic one to the keypad's column lines, and output D_3 resets the counter to zero. When a user presses a key and connects a column line to one of four row lines, the serializer samples the keypad's row lines,

converts the selected active line to a serial signal, and transmits the signal to the deserializer.

For example, suppose that the user presses the 5 key. The first clock pulse that the CD4017 receives drives column line D_0 to a logic one, but, because the user does not press keys 1, 4, 7 and *, row lines A, B, C, and D remain at logic zero. The second clock pulse drives column line D_1 to a logic one, and pressing key 5 connects row line B to logic one, whereas lines A, C, and D remain at logic zero. The pseudocode fragment in **Listing 1**, available in the online version of this De-

sign Idea at www.edn.com, instructs the microcontroller to decode which key a user is currently pressing. In practice, additional code enables the microcontroller to reject multiple simultaneous key closures.

You can expand the architecture to accommodate a keypad matrix as large as 8×10 keys by using more of the counter's outputs and wiring the Nth output to the counter's reset input. The keypad's rows connect to the serializer's data inputs, and both of the LM2501s' unused inputs connect to pullup resistors, ground, or V_{CC} . □

Rearranged reference helps ADC measure its own supply voltage

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IF YOU USE AN ADC to monitor a system's power-supply voltage, you may encounter situations in which the supply voltage exceeds the ADC's reference voltage (**Figure 1**). However, the ADC's input voltage cannot exceed its reference voltage. You can use an external resistive divider to bring the supply voltage within the ADC's input range, but even 0.1%

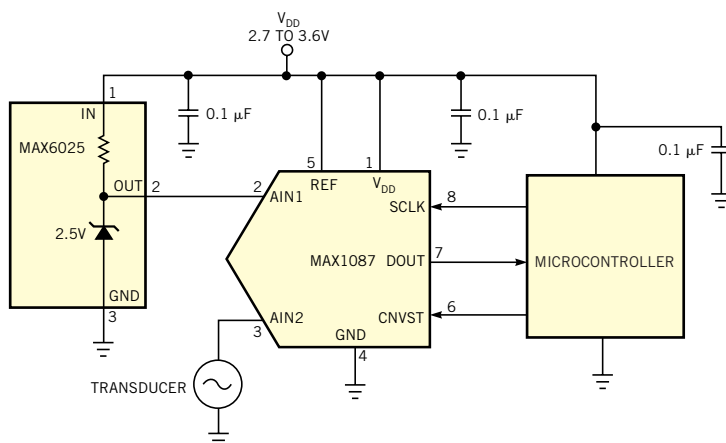


Figure 1 A precision resistive divider brings the power-supply voltage within this ADC's input range but introduces measurement errors.

tolerance resistors may introduce an objectionable error. You can solve the problem by eliminating the divider, connecting the ADC's reference input to its power supply, and connecting one of the ADC's inputs to a precision voltage reference—in this case, a 2.5V MAX6025A (Figure 2).

In this configuration, the ADC measures its inputs with respect to the supply voltage. Using the digitized reference voltage as a standard, the system's software computes the ratio of the reference voltage with respect to the power-supply voltage and corrects the remaining inputs' measurements. The ADC must accommodate an external reference voltage that equals its power-supply voltage, and any noise on the supply rail disturbs measurements of all channels. Thus, to quiet the supply rail in electrically noisy environments, you may need to add a lowpass filter to provide extra decoupling at the ADC. □

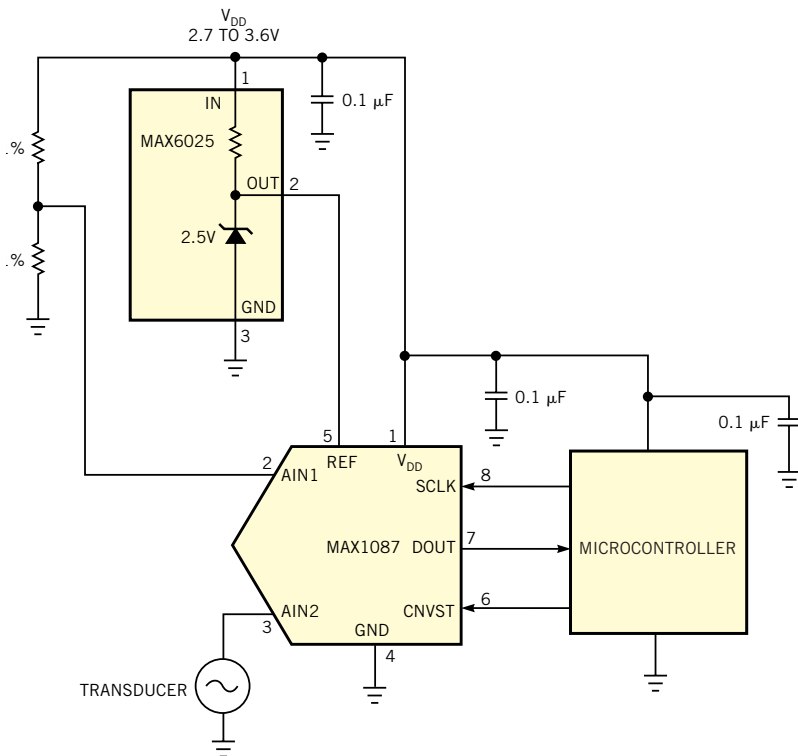


Figure 2 To eliminate the resistive divider, you connect the ADC's reference voltage to its power supply and measure the precision voltage reference's output.

Difference amplifier measures high voltages

Moshe Gerstanhaber and Chau Tran, Analog Devices, Wilmington, MA

FIGURE 1 shows two large-signal-measurement methods. The first uses a two-resistor voltage divider and an output buffer, and the second comprises an attenuating inverter and a high-value input resistor. Both of these approaches introduce measurement-linearity errors because only a single resistor dissipates power, which leads to self-heating and its associated change in resistance. In addition, the amplifier and the remaining resistors introduce a combination of offset current, offset voltage, CMRR (common-mode-rejection-ratio) effects, gain error, and drift, which may significantly reduce the system's overall performance.

Based on Analog Devices' AD629, the circuit in Figure 2 can measure inputs in excess of 400V p-p with less than 5-ppm linearity error. The circuit attenuates its input signal by a factor of 20 and delivers a buffered output. Packaging the am-

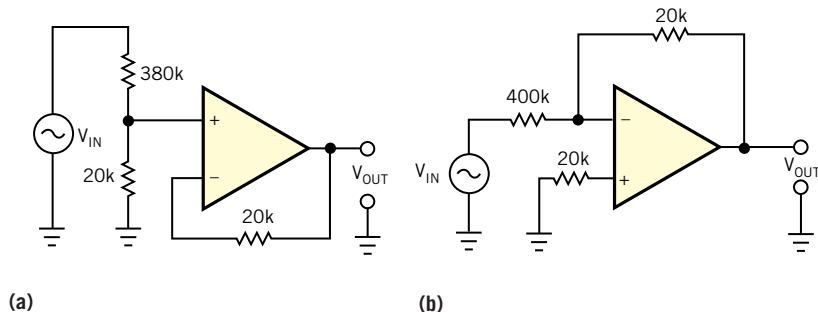


Figure 1 To measure high voltages, you can use discrete resistors to assemble an input voltage divider and buffer (a) or an attenuating inverter (b), but performance suffers due to thermal mismatch.

plifier and attenuator resistors together ensures that both resistors in the attenuator string operate at the same temperature. The amplifier's input stage employs superbeta transistors to minimize offset current and errors due to bias current errors. Applying 100% feed-

back at low frequencies introduces no noise gain, and the offset voltage and its drift add almost no error.

The AD629 is unstable with 100% feedback, and the 30-pF capacitor adds a pole and a zero to the feedback gain to stabilize the circuit and maximize the

system bandwidth. The following equation calculates the pole frequency, f_p : $f_p = 1/(2\pi(380\text{ k}\Omega + 20\text{ k}\Omega) \times 30\text{ pF} = 13\text{ kHz}$. The following equation determines the zero frequency, f_z : $f_z = 1/$

$$(2\pi(20\text{ k}\Omega) \times 30\text{ pF}) = 265\text{ kHz.}$$

Figure 3 shows the amplifier's performance with a 400V p-p input (upper trace) and its corresponding 20V output (lower trace). In **Figure 4**, a cross plot

shows linearity for a 50V/division input signal and a 5V/division output. **Figure 5**, a linearity-error plot, shows nonlinearity versus a 400V p-p input signal. □

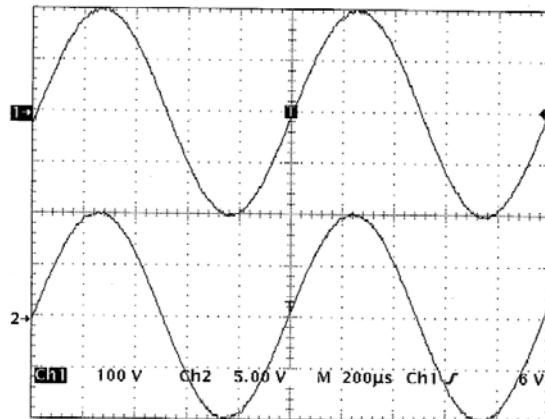
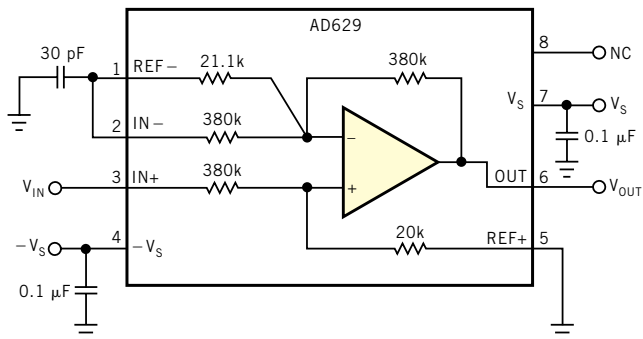


Figure 2 An integrated approach moves external resistors into the device's package for improved thermal tracking and greater accuracy.

Figure 3 The circuit in Figure 2 delivers a 20V p-p output for a 400V p-p input.

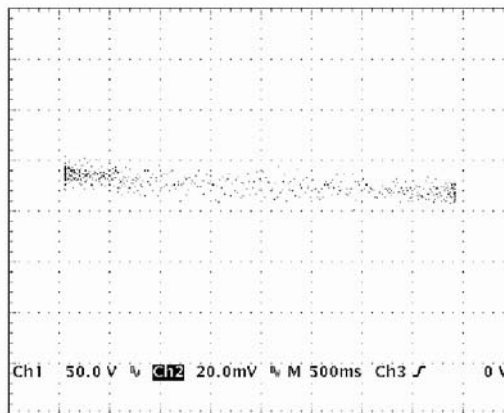
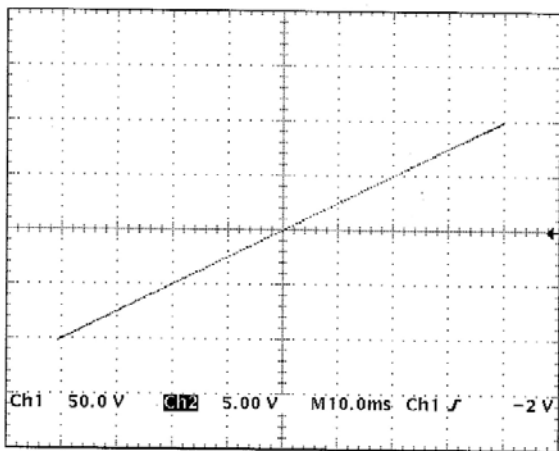


Figure 4 Plotting input versus output shows minimal departure from an ideal straight line for a 400V p-p input.

Figure 5 A scatter plot of nonlinearity error for a 400V p-p input displays error of less than 10 ppm over the input range.

Linear potentiometer provides nonlinear light-intensity control

Stephan Goldstein, Analog Devices, Wilmington, MA

THE HUMAN EYE's highly nonlinear response to light levels poses problems for designers of adjustable lighting.

Simple hardware or software linear-control methods compress most of the apparent intensity variation into a relative-

ly small portion of the adjustment range. A strongly nonlinear control characteristic is necessary. Such a characteristic

spreads the intensity adjustment over a wider range and offers a more natural feel. This Design Idea shows how to use an inexpensive linear potentiometer to develop a satisfactory hardware technique. In an experiment in a darkroom, one of the room's corners was too dark because a fixed barrier shielded safe light. Using spare parts from a junk box, you could assemble a simple red LED-based auxiliary safe light, but if the light level were adjustable, you could balance the light levels and minimize the risk of fogging the printing paper. However, the experimenters in this case lacked an audiometer intensity-control potentiometer and wanted to avoid paying for one.

Figure 1 shows a simplified version of the technique. Diode-connected transistor Q_1 and an AD589 1.235V reference, IC_1 , produce a reference voltage of $1.235V + V_{BE}(Q_1)$ at Node A. Connected

between Node A and Q_2 's emitter, linear potentiometer R_2 and resistor R_3 cause Q_2 's emitter and collector current to vary as $1.235V/(R_2 + R_3)$. The relationship isn't exact because the V_{BE} voltages of Q_1 and Q_2 vary slightly as you adjust the potentiometer, but, in practice, this nonlinear—if not logarithmic—characteristic works well.

Transistor Q_2 's collector current generates the control voltage across R_4 , and, whereas Q_2 always operates close to saturation, the components limit Q_2 's collector-base forward bias to an acceptable 200 mV. When you set R_2 to its minimum resistance for maximum light intensity, resistor R_3 limits LED current, and, when you set R_2 to its maximum resistance for minimum intensity, R_1 limits the current through IC_1 .

The reference voltage produced at Q_2 's collector drives a standard integrating

servoamplifier comprising an AD8031 rail-to-rail op amp, IC_2 ; an IRFD010 low-power MOSFET, Q_3 ; R_5 , R_6 ; and C_2 . The servo sets the current through R_5 to R_4/R_5 times the current through R_4 . Resistor R_7 isolates Q_3 's gate capacitance to prevent load-induced instability in IC_2 . A 12V-dc module supplies power to the circuit and allows the use of four LEDs per string, for a total voltage drop of approximately 8V across each string. To prevent current hogging and provide a maximum of approximately 20 mA for each series-connected LED string, resistors R_8 through R_{11} divide Q_3 's drain current into four. Voltage drop across each resistor is 1V, leaving Q_3 to support a 3V drain-source voltage and an approximately 250-mW power dissipation. If you increase the number of LEDs or the power-supply voltage, you may need to replace Q_3 with a higher dissipation MOSFET. □

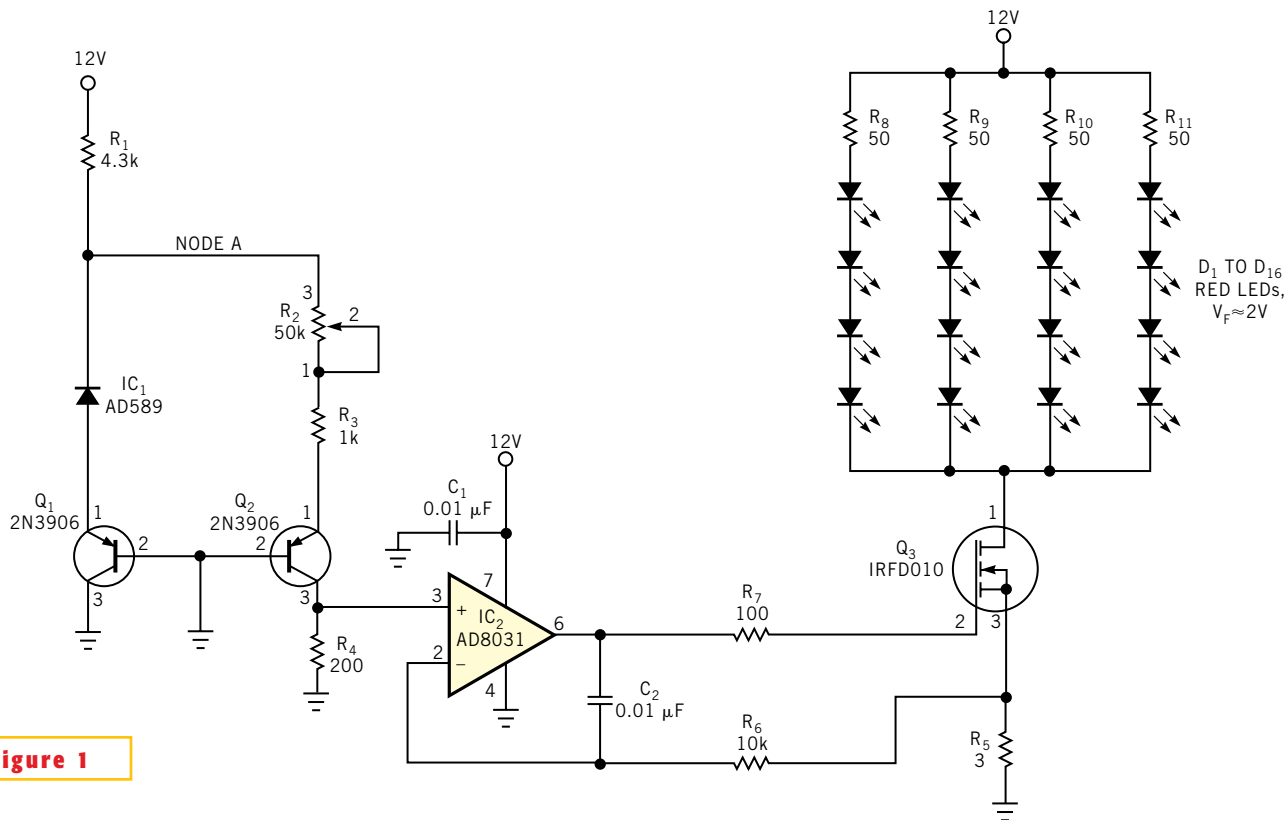


Figure 1

A handful of components provides linear adjustment of a darkroom's safe light.