

Typical 2½- and 3½-digit meter circuits suggested by various semiconductor manufacturers are illustrated in Figures 1 through 4.

A word about "½ digits." Normally, each digit in a readout display represents a significant figure and can be any number from "0" to "9." Thus, a 2-digit instrument can provide readouts from "0" to "99" or decimal fractions thereof, depending on the instrument's sensitivity, number of ranges, and decimal-point placement. Whether the displayed reading is .01, .09, .99, 9.9 or 99, however, there can be only two significant figures. By adding the "half" digit—in reality a "1" with, sometimes, a polarity sign—the readout will display up to three significant figures for most applications. While a 2-digit instrument can furnish readings of only 0 to 99, then, a 2½-digit design can display readings from 0 to 199. Generally, the added cost and circuitry required to supply the extra ½ digit is nominal compared to that of providing a full 0 to 9 digit, hence the popularity of ½-digit circuits.

Featured in a four-page data bulletin published by the National Semiconductor Corporation (2900 Semiconductor Drive, Santa Clara, CA 95051), the 2½-digit meter circuit shown in Figure 1 requires only two active devices: an ADD2500 (DS8700) single-chip meter IC and a common-cathode 2½-digit LED readout similar to the NSB3881 or NSN333. The design requires +5-V (V_{CC}) and -15-V (V_{EE}) dc sources for operation and, with the component values specified, has an input impedance of better than a half megohm while offering a full-scale reading of up to 1.99 volts at an accuracy of $\pm 1\%$. Specified for operation over the range from 0°C to +70°C, the ADD2500 is supplied in either a side-brazed ceramic or Epoxy B plastic 24-pin DIP. It includes on-chip provisions for auto-polarity selection and identification, overrange and underrange output indication, LED segment and digit drivers, and programmable decimal-point selection. In addition, the device contains an internal clock and a built-in temperature-compensated reference source.

In operation, the ADD2500 utilizes a dual voltage-to-frequency (V/F) technique for analog-to-digital conversion. One V/F converter serves to develop a continuous signal with a frequency proportional to R_{IN} , C_{IN} , the zero adjust resistance, and the input voltage plus a fixed 3 volts. The second V/F converter acts both to provide a sample window and to determine the conversion rate for counting the input frequency. Since the output frequency of the first V/F converter is directly proportional to the input voltage, as modified by fixed constants, counting this signal for a known interval provides a digital signal which is also proportional to the input voltage. From this point, conventional digital logic is used to develop the output drive signals for the readout display. Auto-polarity selection is achieved by an offset counter controlled by analog inputs referenced to a -3-volt level, permitting the instrument to accept both positive and negative input voltages.

With neither layout nor lead dress overly critical, the digital meter circuit should not be too difficult a project for the average experimenter. The circuit can be assembled using either pc or perf board construction techniques. The data bulletin cautions, however, that a *single* connection point should be used for both the analog and digital grounds to avoid possible ground-loop problems. After assembly and check-out, the following calibration procedure is recommended:

1. Using an accurate voltmeter, adjust the SCALE ADJUST potentiometer for -3 volts at pin 5 (V_{REF}).
2. With V_{IN} at analog ground, adjust the ZERO ADJUST potentiometer for a display of ".00."

3. With 1.90 volts applied to V_{IN} , readjust the SCALE ADJUST for a display of "1.90."

4. Repeat steps 2 and 3, as needed, to achieve an optimum balance between the two adjustments.

Offering a greater challenge for the more experienced hobbyist, the 3½-digit meter circuit shown in Fig. 2 was abstracted from a six-page technical brochure issued by Micro Power Systems, Inc. (3100 Alfred St., Santa Clara, CA 95050). Using an MP7138 monolithic CMOS A/D converter IC, the circuit is designed for operation on a standard single-ended, 5-volt dc power supply. Supplied in both plastic and ceramic 28-pin DIP's, the MP7138 includes an on-chip clock and all the circuitry needed to provide a multiplexed BCD output with auto-zero, auto-polarity, and display hold features, the latter implemented by applying a logic "0" to pin 21. The device is specified for operation from -40 to $\pm 85^\circ\text{C}$ and needs only 10 mW, typical, in most applications. With an extremely high input impedance, the IC requires an input current of only 10 pA.

In addition to the MP7138, the digital meter circuit employs a DS-8857 BCD-to-7-segment LED driver, a DS75492 MOS-to-LED hex digit driver, four HP 5082 series LED displays, and a 74C04 hex inverter, plus an MPS5010 zener, a general-purpose npn transistor, and two general-purpose diodes. The 74C04 hex inverter, the two general-purpose diodes, and a pair of 10- μF , 20-V electrolytics are used as part of a negative voltage power supply which is not required if a dual $\pm 5\text{-V}$ dc source is available.

The MP7138 utilizes a dual-slope analog-to-digital conversion technique. In principle, the dual-slope technique involves

Field Service Technicians

We have immediate openings for people with technical training and one or more years of experience in the maintenance and repair of electronic equipment. These positions require travel ranging from a few days to several months at a time. Duties will involve using your technical knowledge and the latest test equipment to troubleshoot, diagnose and repair a broad range of sophisticated PABX and central telephone office equipment.

We offer excellent starting salaries and company benefits. If qualified, please send complete resume including salary history to Tom Edminson, ITT Telecommunications, 2000 S. Wolf Rd., Des Plaines, Illinois 60018.

TELECOMMUNICATIONS **ITT**
Switching Center

An Equal Opportunity Employer, M/F

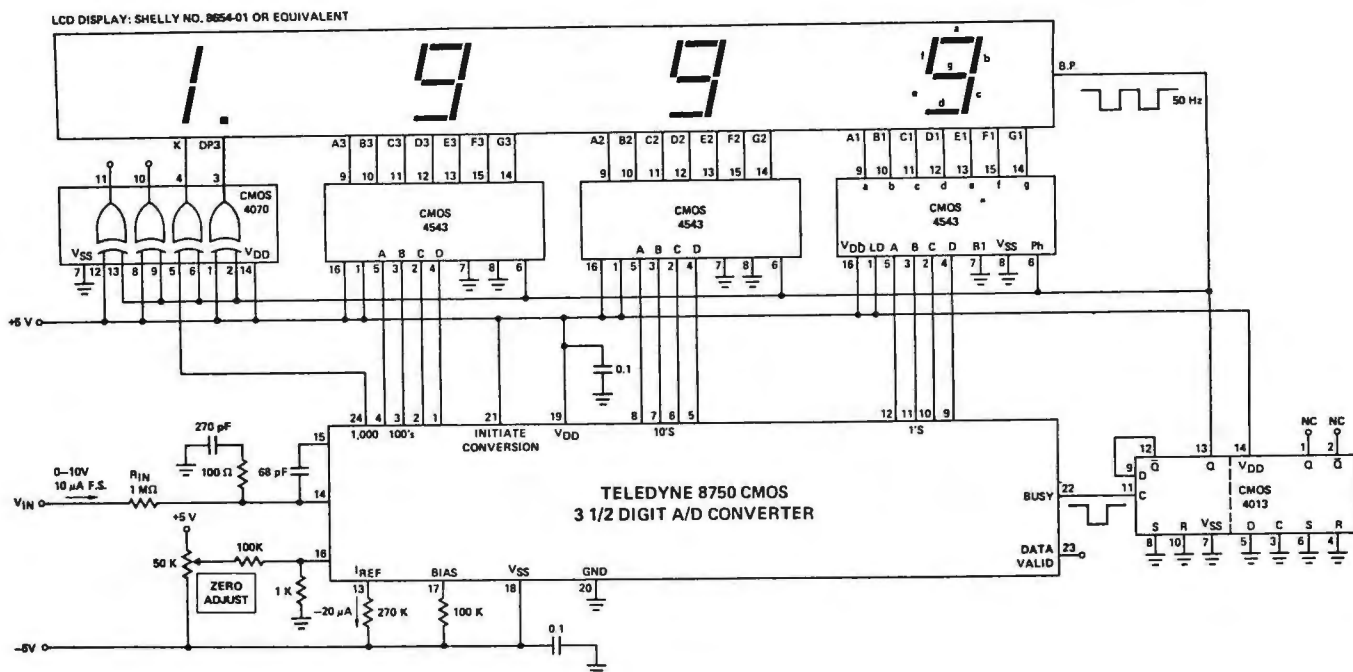


Fig. 3. Teledyne's 3½-digit meter circuit uses an LCD readout. Requiring only 20 mW, a full-scale reading indicates input of 10 volts.

the conversion of the input signal voltage to a proportional time interval, which is then measured digitally. This is accomplished by integrating the input signal for a fixed period and then applying a reference voltage of opposite polarity to the integration capacitor, causing it to discharge at a known rate. The discharge interval, converted to a digital number, is proportional to the average input signal voltage during the initial charge period. The conversion rate is determined by the circuit's clock frequency, with the MP7138 capable of making up to 15 conversions per second.

With the component values specified in Fig. 2, the meter has a full-scale range of 1.999 V, providing a typical accuracy of $\pm 0.05\%$ of reading. The display blanks automatically when the input voltage exceeds the full-scale range. If desired, the instrument's sensitivity may be increased to obtain a full scale range of 199.9 mV. This is achieved by replacing the capacitor between pins 1 and 28 with a 0.47- μF unit, by replacing the capacitor between pins 4 and 5 with a 0.47- μF unit, by replacing the resistor between pins 26 and 27 with a 100,000-ohm unit, and by readjusting the reference voltage applied to pin 6. For a nominal "2-volt" full-scale range, a 1.0-volt reference voltage is used (pin 6), while a 0.1-volt reference is used for a nominal "200 millivolt" range.

As the first circuit discussed, the 3½-digit meter may be assembled using the builder's choice of construction techniques, with both pc and perf board methods acceptable. Naturally, the customary precautions should be observed to avoid damage to the CMOS devices. After assembly and check-out, the only adjustment required is the reference voltage applied to pin 6, which should be set precisely for 1.0 V for a 1.999 V full-scale range or at 0.1 V for a 199.9 mV range. The negative voltage power supply (including the 74C04, two diodes and two 10- μF capacitors) may be omitted if a dual dc power supply is used by connecting the -5-V source to pin 24.

If your intended application requires the lower power consumption of an LCD readout as compared to an LED display, you may prefer the 3½-digit meter circuit illustrated in Fig. 3.

Described in the 6-page data bulletin for the 8750 A/D converter IC published by Teledyne Semiconductor (1300 Terra Bella Ave., Mountain View, CA 94043), the circuit uses this device in conjunction with a Shelly No. 8654-01 readout, a 4013 dual D flip-flop, a 4070 quad 2-input exclusive-OR gate, and three 4543 BCD-to-seven segment latch/decoder/drivers. The 8750 is a CMOS device supplied in 24-pin ceramic or plastic DIP's. Requiring only 20 mW, typical, for operation, the A/D converter provides a full-scale reading with an input current of only 10 μA , permitting the user to change the voltage range simply by changing the value of the input scaling resistor. With the value specified in the diagram (R_{1N} , 1 megohm), a full-scale reading indicates an input of 10 volts. The device does not have an auto-polarity circuit and requires a *positive* input voltage with respect to circuit ground.

Within the 8750 device, the analog-to-digital conversion is achieved using an incremental charge balancing technique. In operation, an amplifier integrates the sum of the applied (input) current and pulses of a reference current for a fixed number of clock periods. The reference current is of opposite polarity compared to the input current. The number of reference current pulses (charge increments) needed to maintain the amplifier summing junction near zero during the conversion period is counted. At the end of conversion, the total count is latched into the digital outputs in a 3½-digit BCD format. The number of pulses needed to maintain the charge balance near zero during each conversion period is, of course, directly proportional to the input current (or voltage). The 8750 makes approximately 100 conversions per second.

Requiring a dual $\pm 5\text{-V}$ dc power source for operation, the 3½-digit LCD meter circuit may be assembled using any standard construction technique, provided the usual care is exercised to avoid damage to the CMOS devices. The value of the input scaling resistor (R_{1N}) is determined by the full-scale voltage range required, based on an input of 10 μA for a full-scale readout. A precision resistor should be used for R_{1N} or, if preferred, a small potentiometer, permitting a precise ad-

justment of the full-scale reading. Other than the scaling resistor, the only other adjustment required is that for zero input, made with the ZERO ADJUST potentiometer.

Reader's Circuit. Peter Stys (44 Massey St., Brampton, Ontario, Can. L6S 2W3), an electric guitar enthusiast, was unhappy with the results obtained from various fuzz boxes he had tried with his instrument. None, he felt, provided the real "pro" sound he wished to achieve. So, he decided to tackle the problem head-on and design his own unit. His fuzz box circuit is illustrated in Fig. 4. Suitable for operation on dual dc power supplies from ± 5 to ± 18 volts, the design uses inexpensive, readily available, standard components and can be duplicated quite easily by the average hobbyist in one or two

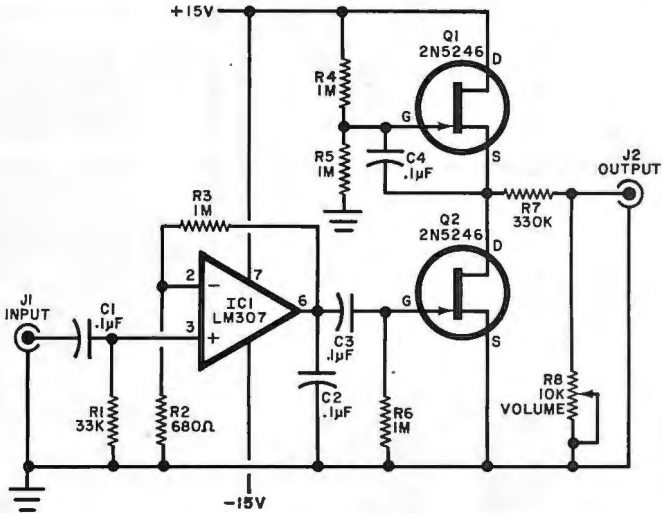


Fig. 4. Reader's fuzz-box circuit amplifies guitar's signal until clipping occurs and then overdrives output stage.

evenings. According to Peter, his unit changes the tones produced by an unaided electric guitar to sounds similar to those produced by an electronic music synthesizer.

For the uninitiated, old timers, and classical music lovers, a "fuzz box" is not a care package for police officers but a device used to introduce distortion deliberately in a sound system in order to create special effects. The device may be as simple as one or two diodes used to clip the signal or as complex as a multistage amplifier. In operation, Peter's circuit achieves the desired effect by amplifying the signal from the guitar's pick-up until clipping starts to occur and then overdriving a dual JFET output stage.

Neither parts placement nor the wiring dress should be overly critical and, therefore, prospective builders can use their choice of construction techniques when duplicating Peter's design. Except for VOLUME control, R8, all resistors are half- or quarter-watt types, while the capacitors are all low-voltage ceramic or plastic-film units. Either an integral or separate dc source may be used as a power supply, at the builder's option. If a lower voltage (below ± 15 V) supply is used, it may be necessary to reduce R7's value for optimum performance. Although not shown on the schematic diagram, most builders probably will include a combination ON/OFF and system bypass switch in their models. In practice, the fuzz box is connected between the guitar's pick-up (microphone) and the audio amplifier's preamp (or input jack). \diamond