Dress Up Audio Projects With Solid-State Level Indicators

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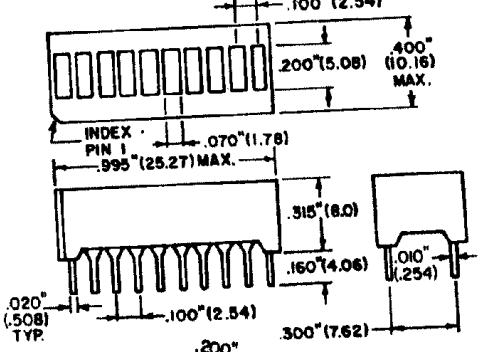
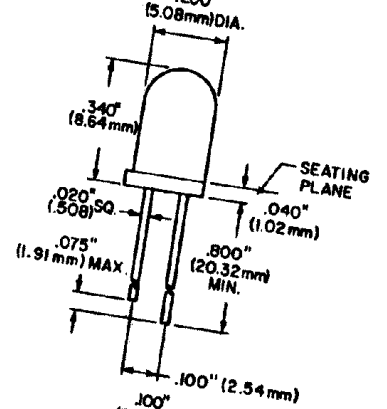
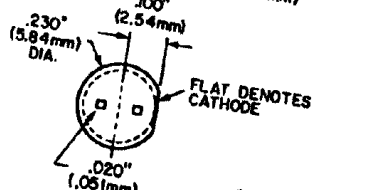
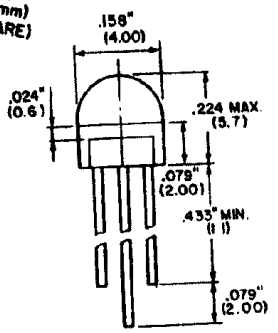
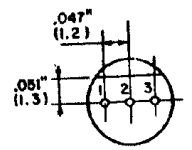


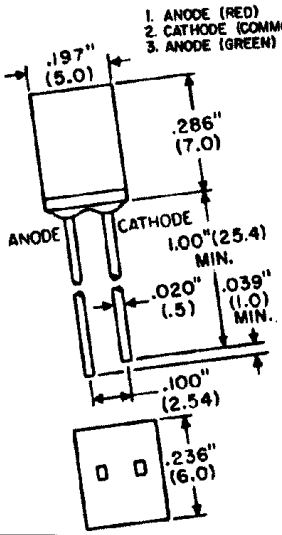








1. ANODE (RED)
2. CATHODE (COMMON)
3. ANODE (GREEN)



THE D'ARSONVAL (MOVING NEEDLE) analog meter has been the instrument of choice for setting input levels in audio systems for years. Now that most audio equipment has been miniaturized an analog meter will no longer fit on the front panel of the equipment.

This role has been filled by light-emitting diode circuitry. Solid-state level indicators based on a string of LEDs instead of a moving-coil meter are now included in most consumer audio products: from tape decks to baby monitors. They are small, lightweight, inexpensive, and immune to shock damage that could damage an analog meter's delicate meter movement.

This article describes three different methods for adding solid-state LED level indicators to your audio projects. In each, the level indicator selected gives the equipment a more professional appearance than in the original project while providing a useful function.

Typical amplifier

Figure 1 is a block diagram of a typical audio amplifier. The input signal is applied to an adjustable-gain amplifier stage. This first stage raises the voltage of the input signal to a higher audio level for the power amplifier stage, and the amplifier's gain is controlled by the operator with a front-panel knob. The output of this first stage is fed to a power amplifier that drives a loudspeaker. The gain in the adjustable amplifier stage must be high enough to allow the signal from the loudspeaker to be heard after the power amplifier has been amplified. However, this gain must not be so high that the signal becomes clipped and distorted. There is also the possibility that the loudspeaker could be damaged if it is overdriven.

The level indicator circuit shown in the dashed box (Fig. 1) is useful in alerting the user that the gain of the adjustable amplifier is set improperly. This circuit consists of a signal-averager stage that clips audio signal peaks for a smooth display and an LED level indicator display consisting of from one to ten LEDs. By observing this LED display, the operator can adjust the amplifier for minimum distortion and proper operation.

Signal averager

The signal averager circuit in Fig. 2 will be shared by all of the LED level indicators described in this article. The operational amplifiers are general purpose types. The TL072 dual operational amplifier will save PC board space, and it is a reliable, inexpensive, medium-quality device. The first operational amplifier, IC1-a, is an inverting amplifier whose gain can be adjusted up to 5. Adjustable feedback resistor, R2, sets the circuit gain. It is a PC- board-mounted trimmer that is set once and never adjusted again.

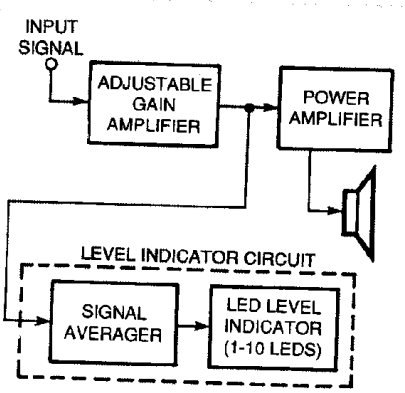


FIG. 1—A TYPICAL AUDIO AMPLIFIER block diagram with a LED level indicator circuit added.

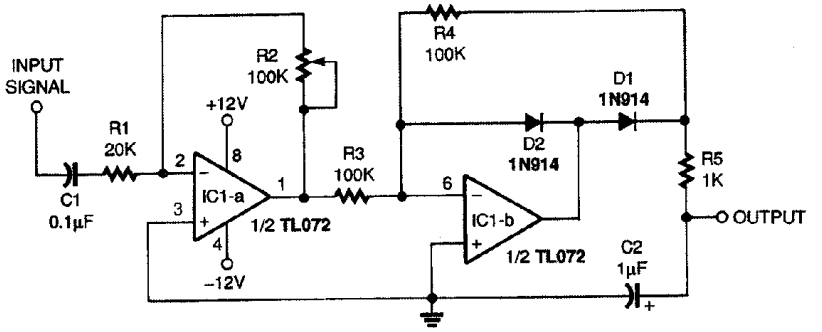


FIG. 2—A SIGNAL-AVERAGER circuit for use with the LED level indicator circuits discussed in the text.

This gain stage links a specific input voltage level to a specific LED indicator.

The second operational amplifier, IC1-b, forms a half-wave rectifier and signal averager that clips the brief peaks and displays them over a longer period of time. By stretching out and smoothing those peaks, as seen on the LED-level display, it will be easier to set the input adjustable-gain amplifier, IC1-a.

One-color LED peak indicator

The simplest solid-state level indicator is a single LED that flashes ON when the input level is high enough to drive the remaining audio stages. However, if you install only one LED, it is more important that it be used to alert the operator to an overload condition. The input level can then be reduced to avoid signal clipping and distortion. It can also reduce the possibility of damage due to excessive heat in the power amplifier and speaker. Most commercial amplifiers have indicators that will signal an overload before the level is high enough to cause an overload. This margin of safety is called *headroom* and it protects the equipment from the consumer who isn't satisfied unless the peak LED flashes occasionally.

The single-color, peak LED circuit is shown in Fig. 3. Unlike the TL072 operational amplifier discussed previously, the LM339 is a comparator. As shown in Table 1, whenever the voltage at the inverting input (labeled "−") of the LM339 is higher than the voltage at the noninverting input (labeled "+"), the output of the comparator is internally grounded. However, whenever the voltage at the inverting input is lower than the voltage at the noninverting input, the output of the comparator floats (effectively an open circuit) and no current flows.

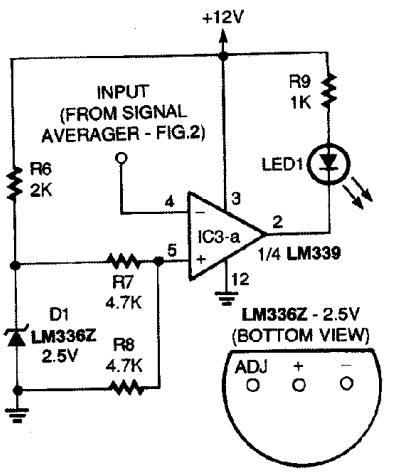


FIG. 3—A SINGLE-COLOR LED peak indicator circuit.

The voltage divider consisting of resistor R6 and 2.5-volt precision voltage reference IC2 form a precision voltage reference whose voltage is divided in half at the junction of resistors R7 and R8. This places a reference voltage of 1.25 volts at the comparator noninverting input. Whenever the inverting input voltage exceeds the reference voltage, the output will be connected to ground internally and LED1 will light. By connecting the input of this circuit to the output of the averager circuit, the LED will flash on whenever the audio input exceeds the level set with gain potentiometer R2 in Fig. 2. Adjust R2 by applying a maximum level signal to the input of the averager, and then reduce the level slightly to allow for headroom. With the input level now set, adjust R2 until the peak LED just turns on.

Usually the maximum audio level can be determined by listening carefully to the loudspeaker's output. If this method is not sensitive enough for proper calibration, connect an audio signal generator to the input and an oscilloscope across the loudspeaker's terminals. Examine the overload effects on sinewave, squarewave and sawtooth-waveforms as you adjust the setting of R2.

Tri-color LED level indicator

Some LEDs will light in three colors. Tri-color LEDs have two LED dies in one package (generally one red and one green) which are controlled independently. By applying a voltage greater than about 2 volts to the separate pins, the LED can glow red, green, or yellow (when both dies are on). Figure 4 is a tri-color LED circuit. With a low input level, LED2 is off. As the input voltage increases, LED2 turns on and first glows green, then yellow, and finally red.

Resistor R10 and 2.5-volt precision voltage reference IC4 provide a precision voltage reference that is further subdivided by resistors R11, R12, R13, and R14. This chain of resistors creates three different reference voltages that set the voltage thresholds for the three LED

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TABLE 1—COMPARATOR OUTPUT STATES

Inverting Input (−)	Noninverting Input (+)	Output
3 Volts	1 Volt	Ground
1	3	Float