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An automatic brightness controller

ROBERT F. SCOTT, SEMICONDUCTOR EDITOR

A UNIQUE DEVICE THAT IS QUITE VERsatile in applications that require the automatic adjustment of the brightness of a display in relation to variations in ambient light, is the new Optron OPL 100 automatic brightness controller. That device from TRW Optron can operate from a supply voltage of from 4.5 to 24 volts DC, and can source 50 mA or sink 20 mA to control the brightness of various types of displays from 0 to 100 percent. The display types that it can control include vacuum fluorescent, incandescent, and LED's. The OPL 100 can be used to control TV screens, instrument displays in aircraft and automobiles, industrial light levels, and outdoor lighting for signs and security purposes. The device can also be used to keep the indoor light level constant, regardless of variations in light coming in from outdoors.

Pulse-width modulation is the key to the controller's operation. The duty cycle of the output is proportional to the ambient light level and is the basis for controlling external displays. Ambient light levels are detected by a 2500 square mil (0.0025 square inch) photodiode that is built into the device.

Figure 1 shows a block diagram of the OPL 100, an 8-pin IC. Figure 2 shows how it's used to control the brightness of LED's, 7-segment numeric displays, and vacuum-fluorescent displays. In each case, the displays are driven by the pulse-width-modulated output from pin 7. Potentiometer R1 is the external adjustment for light sensitivity level. The resistance needed depends on the ambient light level, and on the display brightness desired—it ranges between 25K and 200K.

In Fig. 2-a, the device controls the brightness of a standard LED. With a 12-volt DC supply, the controller furnishes a maximum of 32 mA to the LED. Figure 2-b shows how the controller is connected to a numeric display through a BCD-to-7-segment latch/decoder/driver like the CD4511. Several drivers can be used and multiplexed by connecting the strobe or enable line of each driver to pin 4 of the controller through suitable logic circuitry.

In Fig. 2-c, we see how to connect the OPL 100 to a vacuum-fluorescent display device to control display brightness between 0% and 100% intensity. Resistor R2 (shown as dashed lines) is needed in this application to prevent the display from going completely off when the sensor is in total darkness. The OPL 100 should be mounted so that its photodiode sensor receives light from the direction from which the display will be viewed. Potentiometer R1 should be adjusted for a satisfactory display brightness in normal ambient light. Now, the controller will detect changes in ambient light and adjust the brightness of the display. Because of that, the display brightness will appear to remain constant.

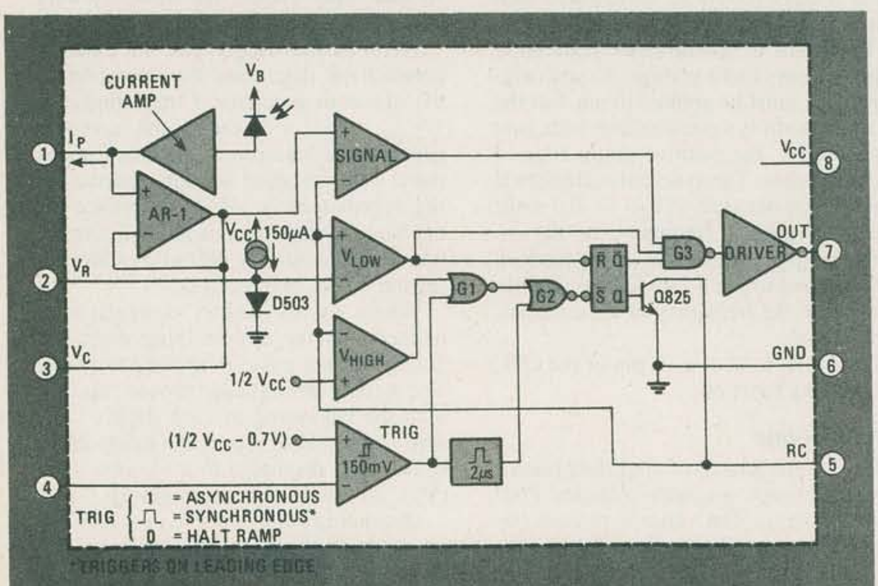

FIG. 1

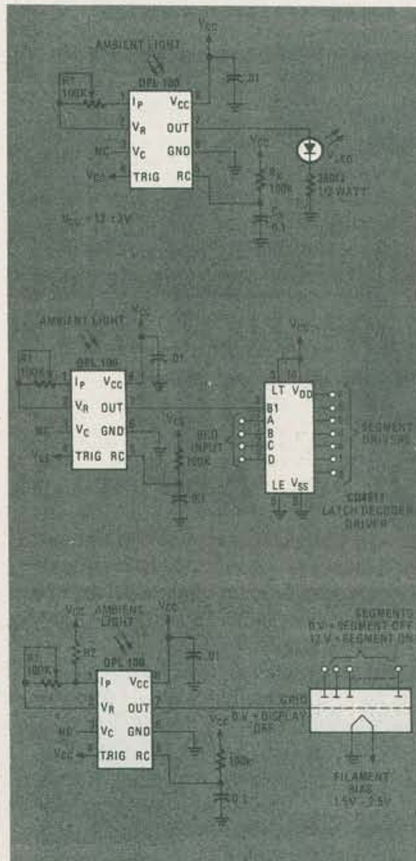

FIG. 2

How the OPL 100 works

Referring to the block diagram in Fig. 1, we see that, in addition to the photodiode, the OPL 100 includes a voltage regulator, a constant-current source, a high-gain temperature-compensated current amplifier, an op-amp, four comparators, an R-S latch, logic including NAND and NOR gates, and an output driver. The width of the device's output pulse is determined by the relationship between an analog control-voltage that is proportional to ambient light, and the instantaneous voltage level of the ramp of an internally generated sawtooth.

The sawtooth frequency is determined by an external R-C network (100K and 0.1 μF in Fig. 2) connected to pin 5 of the IC. The output of the sawtooth generator is connected to the signal comparator. The analog control-voltage—proportional to the ambient light level—is connected to the second input terminal of the signal comparator. The comparator switches on when the control voltage is higher than the instantaneous sawtooth-

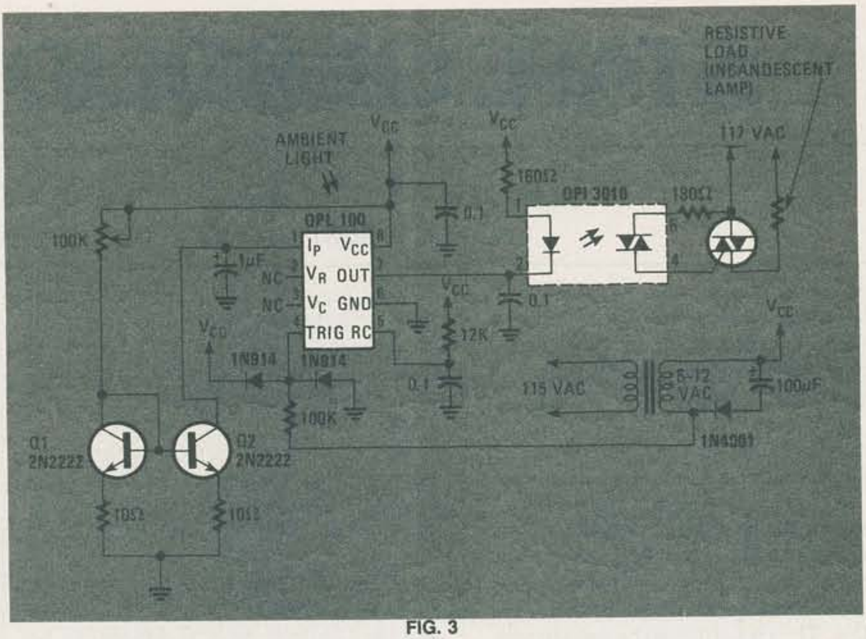

FIG. 3

ramp voltage, and switches off when the control voltage is lower.

The "on" portion of the output pulse and the sawtooth ramp start at the same time. The output-pulse width continues to rise until the ramp voltage is higher than the control voltage V_C. At that point, the signal comparator switches off. Since the control voltage rises with ambient light, we see that as light level increases, V_C rises, causing an increase in the width of the output pulse. That causes an increase in the display brightness.

The sawtooth frequency is approximately $1.44/(R_xC_x)$ where R_x and C_x are the values of the external timing components. The maximum recommended value for R_x is 100K. To obtain an asynchronous (free-running) sawtooth, connect pin 4 of the IC to V_{CC} as shown in the applications in Fig. 2. That lets the ramp voltage to rise to ½ V_{CC} and then fall to 0.7 volt.

To obtain a synchronous (externally triggered) sawtooth voltage, a sync (trigger) pulse must be applied to pin 4 of the IC. The ramp is synchronized with, and triggered on, the positive-going edge of the sync pulse. The sync-pulse amplitude must be greater than $½V_{CC} - 0.7$ volt. The free-running frequency of the internal ramp generator—as set by the R-C network tied to pin 5—should be slightly lower than the frequency of the external-sync signal.

Let's now look at each pin of the OPL 100 and its function.

Pin functions

Pin 1 is the source of amplified photocurrent through an open-collector PNP current source. The variable resistor between pins 1 and 2 is the load resistor for the current source. Photocurrent I_P is ½ mA under normal room light. In addition providing the dimming function, pin 1 can be used for on-off control of the display. Connecting pin 1 to V_{CC} forces the output terminal (pin 7) to a logic-1 ($V_{CC} - 2$ volts), driving the displays to full brilliance. Connecting pin 1 to ground forces pin 7 to logic-0, and turns the display off.

Pin 2 is the source of reference voltage V_R (approximately 680 mV) set by a constant current of approximately 150 μA through diode D503. That voltage determines the lower voltage extreme for the sawtooth waveform. Pin 2 is the tie-point for the lower end of the sensitivity control.

Pin 3 is the source of a buffered analog control-voltage that is proportional to the incident light level. In applications where several OPL 100's are used in a system, control voltage V_C from the main unit is applied to pin 1 on the remote OPL 100's so their duty cycles will track the duty cycle of the main unit.

Pin 4 is the trigger pin. Its external connections determine the operation of the sawtooth generator. Connecting it to $½V_{CC} - 0.7$ volt causes the sawtooth generator to free-run in an synchronous mode with the upper voltage-extreme being approximately $½V_{CC}$ (reference for the V_{HIGH} comparator) and the lower extreme approximately 680 mV (reference for the V_{LOW} comparator).

When synchronous operation is needed—as for multiplexing digits—a positive-going pulse is applied to pin 4. The leading (rising) edge should coincide with the beginning of each digit's "enable" time. That causes the sawtooth to stop rising, discharge to its lowest level (V_R), and then begin its ramp-up.

Grounding pin 4 stops the sawtooth and causes pin 5 to rise to V_{CC} and remain at that level until the ground is lifted and a logic-1 or a pulse is applied (for

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asynchronous or synchronous operation, respectively).

Pin 5 is the tie-point for R_x and C_x, which control the frequency or repetition rate of the sawtooth. The average discharge-time is 4 μs for a 0.1 μF timing capacitor. The sawtooth repetition rate is determined from the formula $1.44/(R_xC_x)$, where C_x is in μF and R_x is in megohms.

Pin 6 is the ground terminal for the device.

Pin 7 is the output of the driver amplifier. It will directly drive the grid of a vacuum-fluorescent display. In addition, it can source 50 mA at a minimum voltage of $V_{CC} - 4$ volts, and can sink 20 mA with a maximum of 0.4 volt. Incandescent lamps and 7-segment numeric displays require additional interfacing components.

Pin 8 is the input terminal for supply voltage V_{CC}, which can range from 4.5 to 24 volts DC. Supply current is around 12 mA and is relatively constant over the operating-voltage range when in total darkness. Supply current increases with light intensity.

Ambient-light controller

Figure 3 is a circuit you can use to keep the ambient indoor light level constant. For example, it can be used when you must increase the artificial indoor lighting level to compensate for a decrease in incoming natural light. The brightness of an incandescent light source is controlled by varying its duty cycle through a power triac. The triac, in turn is controlled by the OPL 3010 optoelectronic triac-driver. When that is done, the OPL 100 controller must be synchronized with the AC power line to ensure proper triggering of the power triac. That is accomplished by developing a sync pulse from the secondary winding of a small 6–12-volt transformer and a 1N4001 diode in the circuit between pin 4 and V_{CC}.

The 100K pot sets the ambient light level by establishing a constant current through transistor Q1. The photodiode sensor in the OPL 100 then sets the output duty-cycle to a point that produces enough light to generate an amplified light-current (I_P) at pin 1 that is equal to the current through Q1. As the incoming light fades, the output duty cycle is altered to increase the "on" time of the indoor incandescent lighting to keep the ambient light level constant.

This item was prepared from material supplied by TRW Optron. If you'd like additional information on the OPL 100 Automatic Brightness Controller, write to TRW Optron, 1201 Tappan Circle, Carrollton, TX 75006 and ask for Product Bulletin 2091 and Application Bulletin 115. **R-E**