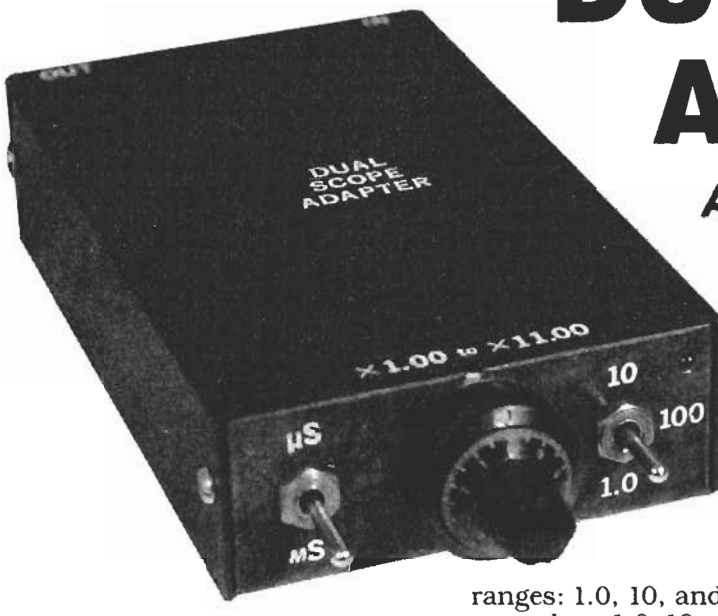
DUAL SCOPE ADAPTER

Add time period cursors and delayed sweep to your oscilloscope with this handy, precision adapter

SKIP CAMPISI



WOULD YOU LIKE TO HAVE AN OScilloscope accessory that makes precise pulse-width or time-period measurements so you do not have to count graticule graduations? Frustrating and time-consuming, manual counting frequently leads to measurement errors. Also, could you use an oscilloscope accessory that permits you to look closer at the leading edges of fast, low-duty cycle pulses at high sweep speeds so you can eliminate all the annoying oscillations in the circuit under test?

The Dual Oscilloscope Adapter offers both of these features. It will permit you to make both pulse-width or time-period measurements and observe leading edges of pulses. It gives you precise time measurements and a rock-solid delayed-sweep mode that requires only that the output cable be switched from one jack to the other. The Voltage Cursor Adapter (*Electronics Now*, May 1995) is the companion to the Dual Oscilloscope Adapter. Together, both accessories will endow your oscilloscope with features available only in far more costly laboratory models.

The Dual Oscilloscope Adapter is essentially a precise (±1%) monostable multivibrator with six, switch-selectable output ranges: 1.0, 10, and 100 microseconds or 1.0, 10, and 100 milliseconds. Each range can be varied with a precision ten-turn potentiometer equipped with a precise turns counter. With this ×1.00 to ×11.00 turns-counter scale, the total range will be 1.0 microsecond to 1.10 seconds.

The adapter output pulse is applied to your oscilloscope's Z axis input (EXT—blanking/intensity modulation input) to provide the time period cursor. It intensifies that part of the oscilloscope trace to be measured (to the exact pulse width set on the adapter), while dimming the rest of the trace.

This method makes reading the measurement both easy and precise. By adjusting the adapter's slope controls, either any section or the entire waveform period can be measured. The sweep is delayed by applying the output of the adapter to the TRIGGER input of your oscilloscope in the external trigger mode.

The adapter was designed to operate from an external ±5-volt supply to minimize the pickup of hum and noise from the AC line. A schematic diagram and parts list for a suitable wall-outlet-mounted dual power supply is included in this article for those who do not have a suitable one or cannot find a convenient source for purchasing one.

How does it work?

Figure 1 is the schematic for the dual oscilloscope adapter. The input stage is the trigger amplifier based on the two channels of an LM319 dual comparator (IC1-a and IC1-b). The input signal is taken from the CHANNEL 1 output jack of your oscilloscope, and it is applied to J1 on the adapter.

The author's prototype was designed to work with a Hitachi V-212 oscilloscope, which has an output of 25 millivolts per division on its vertical signal display into a 50-ohm load. Assuming a normal display of about six divisions, a trigger level of about ± 150 millivolts is desired. This range is set by the ratio of the values of resistor R4 to R5, and is varied by voltage divider R6, the TRIGGER LEVEL control.

This ratio can be altered to be compatible with your brand of oscilloscope, but be sure to maintain the ratio of R3 to R5, which gives the correct amount of hysteresis for proper triggering. The INPUT SLOPE is selected by switch S1, and the signal is coupled to C3 and IC2, the multivibrator stage.

Capacitor C3 provides the proper negative-going pulse to trigger IC2, a TLC555 CMOS timing IC circuit, and it also limits the minimum required input pulse width to about 500 nanoseconds. Switch S2 selects the desired range—either milliseconds or microseconds, and

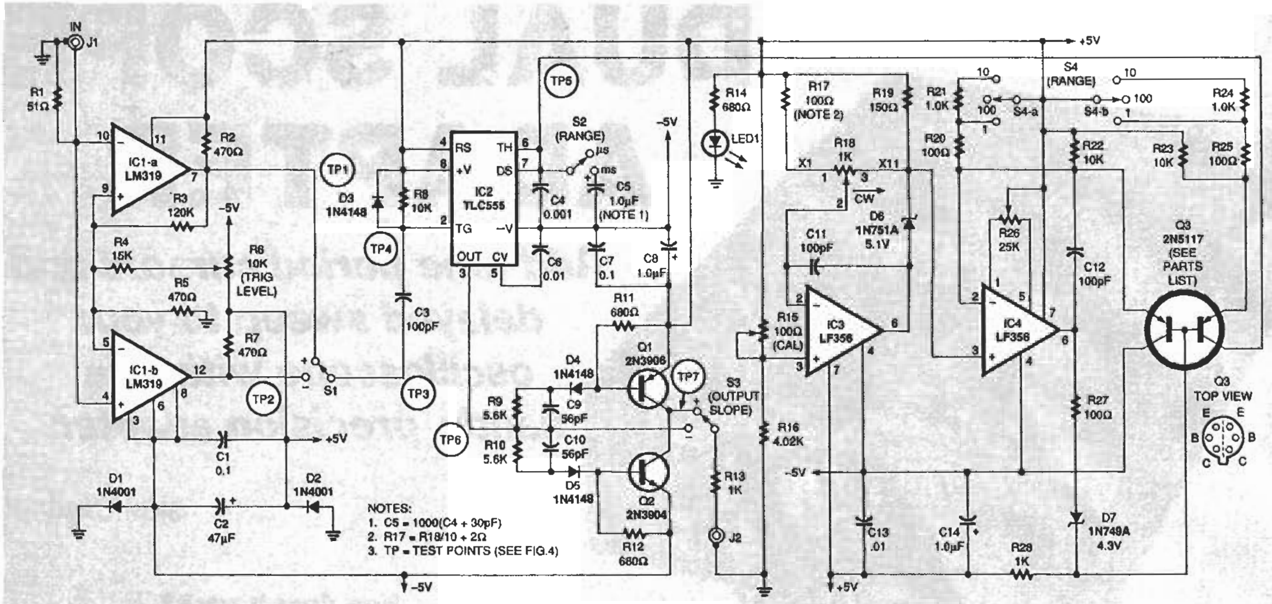


FIG.1—SCHEMATIC FOR THE DUAL OSCILLOSCOPE ADAPTER. The components are assembled on a multipurpose PC board.

switch S3 selects the polarity of the output slope. About 30 pF of stray capacitance exists at the junctions of C4, Q3, and IC2. Thus, to obtain the highest accuracy, select or trim capacitor C5 or C4 so that C5 = 1000 × (C4 + 30 pF).

Transistors Q1 and Q2 form a fast (less than 10-nanosecond delay) inverting output stage. The output from switch S3 is ±5 volts, which is sufficient for excellent contrast in intensity modulation. It is also satisfactory for stable triggering in the adapter's delayed-sweep mode. Resistor R13 (1 kilohm) isolates the output stages from the capacitance of the connecting cable. This value provided the necessary isolation on a 3-foot length of RG-174 and 6-foot length of RG-58 coaxial cable. However, you might have to select a different value for your brand of oscilloscope.

Precise input current to capacitors C4 and C5 is supplied from the collector of dual transistor Q3, a 2N5117. It is a dual matched PNP pair in one package. Each transistor is electrically isolated but thermally coupled. Operational amplifier IC3, an LF356, is configured as a noninverting follower with gain. It supplies the correct reciprocal voltage reference function to IC4, the second LF356. It is a buffer with half of Q3 in its feedback loop.

Transistor Q3 is configured as an unusual "current mirror" that unloads the relatively slow operational amplifier, allowing the second half of Q3 to demonstrate its fast dynamic response. A reference voltage is developed across both sets of emitter resistors (R20 to R25) to produce the constant charging current for capacitors C4 and C5. The two sections of switch S4 (S4-a and S4-b)) select the range—either 1.0, 10, or 100, in conjunction with switch S2 (milliseconds or microseconds).

Zener diodes D6 and D7 permit the operational amplifier outputs to operate in their linear regions. Variable resistor R18 (1 kilohm, 10-turn) is the range multiplier. It has a 15-turn counting dial mounted on its shaft. See the directions in the construction section for mounting this dial to the shaft of the precision potentiometer.

TABLE 1—SPECIFICATIONS FOR THE DUAL OSCILLOSCOPE ADAPTER

Power Supply: ±5 Volts (regulated), 100 mA

Parameter	Value	Units	Condition
Input voltage (max)	±5	V	
Input voltage (min)	±25	mV	
Trigger voltage range	0.0±150	mV	
Input rise/fall (max)	00		
Input frequency (max)	500	KHz,	(min)
Input pulse width (min)	500	ns	(typ)
Propagation delay (J1 to J2)	250-300	ns	(typ)
Input Impedance	51	ohms,	(typ)
Output pulse range	1.0-1.10	ms-s	
Output pulse voltage	±5	V	
Output impedance	1000	ohms	(typ)
Output Pulse Accuracy	+1	%	10µs-1.10s
Output Rise/Fall Time	20	ns	(typ)
Reference Voltage (x1.00 to x11.00)	670-61	mV	(typ)

Building the adapter

All of the circuitry for the author's prototype fit in a standard, off-the-shelf, two-part aluminum case that measures approximately 1¼×3 ×5 inches. These cases are available from many different suppliers. The circuit board is a

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standard universal component board with power buses that measures $1\frac{7}{8} \times 2\frac{3}{4}$ inches. A larger board will fit in the case, but it is important that the signal leads be kept as short and direct as possible. They must also be electrically isolated from each other. If the circuit board does not have mounting holes in the corners, drill them at this time.

Refer to the parts placement diagram, Fig. 2. It is recommended that you lay out the components on the board first, following the general locations shown in Fig. 2, to be sure that you have an appreciation for the size of the components before you begin to insert and solder them. Avoid running DC signal lines parallel to AC lines when you wire the board.

Cut off pins 1, 2, 13, and 14 on the 14-pin DIP socket (these pins are not connected within IC1). Install the socket flush with the edge of the circuit board. (This saves solder pads on the circuit board.) Install and solder the three 8-pin DIP sockets, leaving space for resistor R2, transistor Q3, and capacitors C4, C6, and C7. Install and solder R15, R26, Q1, Q2, and Q3. Then install the remaining passive components, leaving long leads where necessary for interconnections to the board and front and rear panel controls and jacks.

Make the power connections on the under side of the board to the power bus strips. Power lines from J3 go to IC1. NOTE: The ± 5 volts required by resistor R6 is taken directly from J3. Double and triple check the wiring, looking particularly for inadvertent solder bridges or cold solder joints. Make any corrections necessary at this time.

Mechanical work

Refer to the assembly diagram Fig. 3. Begin the mechanical part of the project by locating, center-punching, and drilling or forming all of the

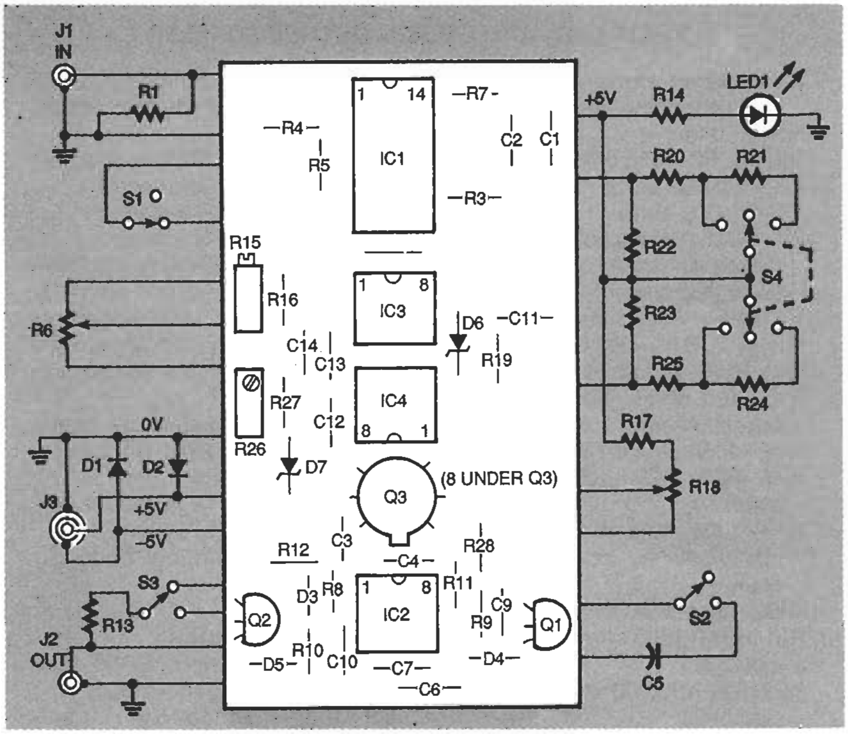


FIG. 2—PARTS PLACEMENT DIAGRAM for the adapter showing approximate locations of components on the circuit board. Many other components are chassis mounted and wired to the circuit board.

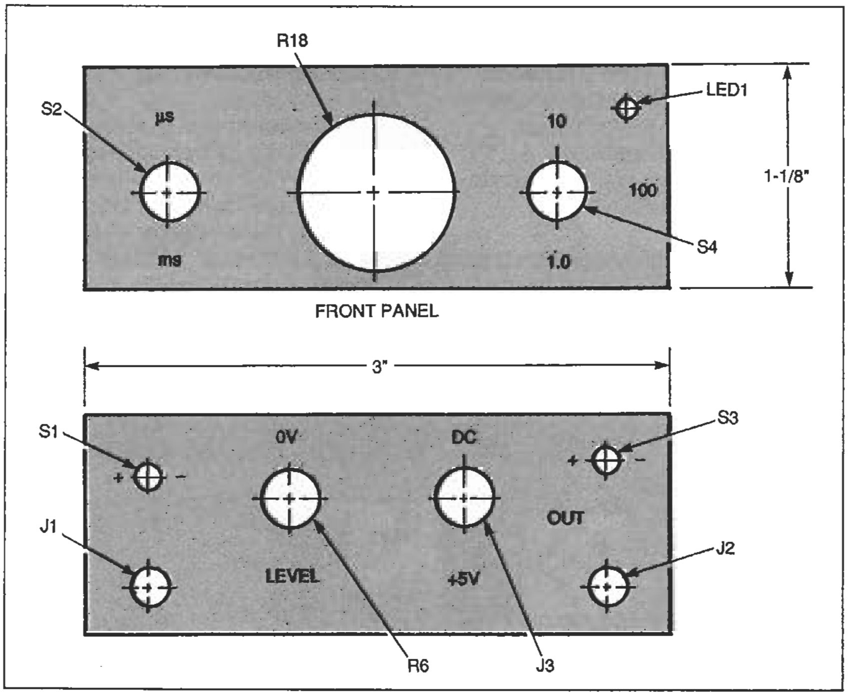


FIG. 3—DRILL PATTERN AND LABELS for the end panels of the lower half of the project case.

holes on the front and back vertical panels on the lower half of the case, using Fig. 3 as a guide. Drill or form the holes on the front panel for LED1, S2, S4, and precision potentiometer R18. Drill the hole for LED1 just large enough to permit a press fit of the top of the lens. Then drill the holes in the back panel for S1 and S3, R6, and J1, J2, and J3.

Using the circuit board as a template, locate, center punch

PARTS LIST—DUAL OSCILLOSCOPE ADAPTER

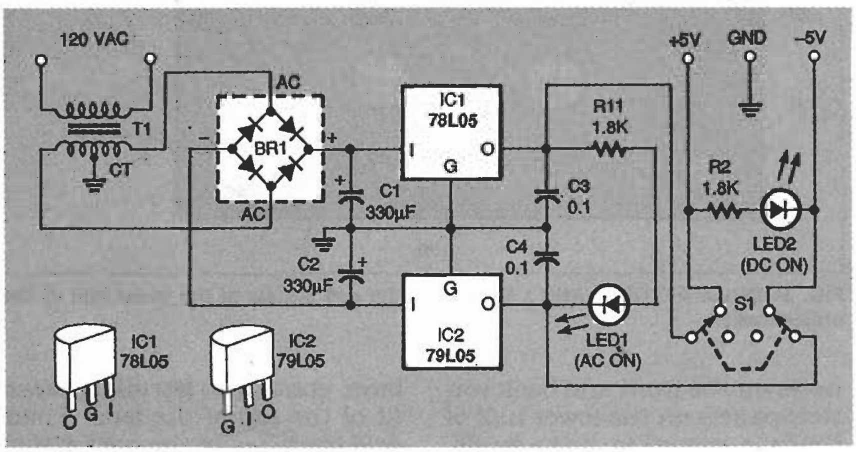
All resistors are ¼-watt, 5%, unless otherwise specified.
R1—51 ohms
R2, R5, R7—470 ohms
R3—120,000 ohms
R4—15,000 ohms
R6—10,000 ohms potentiometer, ⅛-inch dia. shaft
R8—10,000 ohms
R9, R10—5600 ohms
R11, R12, R14—680 ohms
R13, R28—1000 ohms
R15—100 ohms, cermet trimmer poitentiometer, multiturn
R16—4020 ohms, 1%, metal film
R17, R20, R25—100 ohms, 1%, metal film
R18—1000 ohms, 10-turn, precision potentiometer, Bourns 3540S or equiv.
R19—150 ohms
R21, R24—1000 ohms, 1%, metal film
R22, R23—10,000 ohms, 1% metal film
R26—25,000 ohms cermet trimmer potentiometer, multiturn
R27—100 ohms

Capacitors
C1, C7, C13—0.1µF monolithic ceramic
C2—47µF, 16 V, solid tantalum
C3—100 pF, 10% ceramic disc
C4—0.001µF, 5% polyester
C5—1.0µF, 5% polyester
C6—0.01µF, monolithic ceramic
C8, C14—1.0µF, 35V, solid tantalum
C9, C10—56 pF monolithic ceramic
C11, C12—100 pF monolithic ceramic

Semiconductors
IC1—LM319, dual comparator, National or equiv. IC2—TLC555 CMOS timer Texas Instruments or equiv.
IC3, IC4—LF356 JFET operational; amplifier, National or equiv.
Q1—2N3906, PNP transistor
Q2—2N3904, NPN transistor
Q3—2N5117 or 2N3810, matched dual PNP transistors (2N5117, Semiconductor Technologies, or 2N3810, NTE 82), T0-78 package
D1, D2—1N4001, 1-A silicon rectifier, 50 PIV
D3, D4, D5—1N4148 silicon diodes
D6—1N751A/1N5231B, 5.1 V Zener diode, 5%, 500mW
D7—1N749A/1N5229B, 4.3 V Zener diode, 5%, 500mW
LED1—Light-emitting diode, T1 case, red

Other components
S1, S3—toggle switch, SPDT, subminiature, 1 A, panel mount
S2—toggle switch, SPDT miniature, 1 A panel mount
S4—toggle switch, DPDT miniature, center off, 1 A, panel mount
J1, J2—jack, BNC female, panel mount
J3—phone jack, ⅛ (3.5 mm) 3 conductor w/matching plug

Miscellaneous: circuit board (see text), Radio Shack 276-150 or equivalent; two-part aluminum project case (see text); precision potentiometer counter dial, 15-turn, Clarostat Clarodial or equiv.); 8-pin DIP sockets, three; 14-pin DIP socket; plastic standoffs, ⅜-inch; screws and nuts, solder.



SCHEMATIC FOR A ±5-VOLT, REGULATED dual power supply.

and drill the four mounting holes approximately in the center of the base of the lower half of the case. Then drill a hole for the solder terminal strip between S4 and the circuit board ,as shown in Fig. 4. This might be the right time to label the control positions for jacks, switches and potentiometers to be mounted on the front and rear panels by some convenient method, as shown in Fig. 3.

Assembling the adapter

Insert and fasten all of the panel-mounted components on the front and back panels, as shown in Fig. 4. Install the terminal strip with a screw and nut. Refer to the off-board component schematics on parts placement diagram Fig. 2. Position and solder a length of No. 22 AWG bare bus wire from the ground lug on J1 to the ground lug on J3 and on to the ground lug on J2. Insert and solder resistor R1 on J1, resistor R13 from J2 to S3, and diodes D1 and D2 from J3 to the ground bus.

PARTS LIST—POWER SUPPLY

Resistors are ¼ watts, 5% unless otherwise specified
R1, R2—1800 ohms

Capacitors
C1, C2—330µF, 16 V, aluminum alectrolytic
C3, C4—0.1 µF, 25 V, monolithic ceramic

Semiconductors
IC1—78L05 voltage regulator, +5V, 100 mA, National or equiv.
IC2—79L05 voltage regulator, −5V, 100 mA, National or equiv.
BR1—full-wave bridge rectifier, 1 A, 50 PIV
LED1—light-emitting diode, red, T1 case
LED2—light-emitting diode, yellow, T1 case

Other components T1—transformer 120 VAC primary, 12.6 VAC center-tapped, 0.2 A
S1—toggle or slide switch, miniature, DPDT, 1 A

Miscellaneous: project case, (see text), circuit board, ⅛ jack, panel-mounted AC line plug, insulated hookup wire, solder, screws, and nuts.

Note: One source for Q3, the 2N5117 matched dual PNP transistor, is Johnson Shop Products, P.O. Box 2843, Cupertino, CA 95015, 408-257-8614

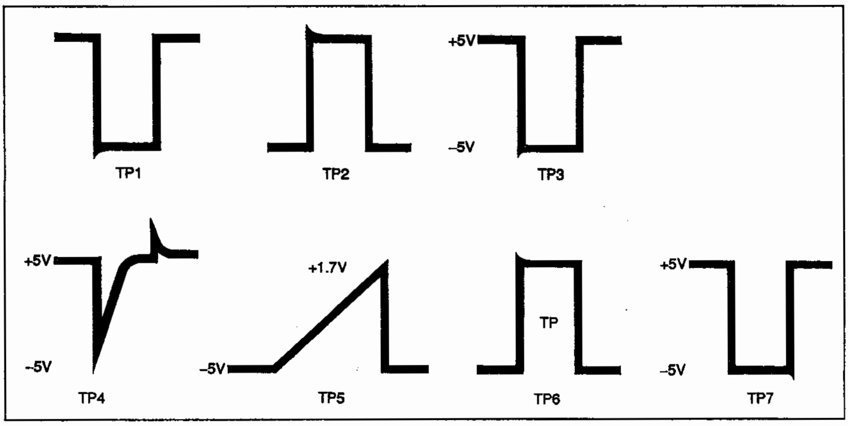


FIG. 5—OSCILLOSCOPE WAVEFORMS at selected test points, as shown on Fig. 1

cuit board so that there is a reading of 0.0 millivolts between pins 2 and 3 of IC4.

If you should encounter any problems with the circuit at this time, you might want to observe the waveforms at the test points identified in the schematic, Fig. 1. Figure 5 illustrates the wavforms to be expected at those test points.

Introduce a 60-Hz signal from a separate, low-voltage filament-style transformer to CHANNEL 1 of your oscilloscope, and display two or three cycles at about six divisions of vertical height. With the adapter set at 10 milliseconds, you should see a waveform with about 50% or more of each cycle in bold relief (intensified) with the remainder dimmed.

Adjust your oscilloscope's intensity control for the best contrast of the two parts of the trace. The positive half of each cycle should be bold. If it is not, set rear panel switch S3 (OUTPUT SLOPE) to (−), to allow the bold section to lengthen as the multiplier (R18) is advanced clockwise. Rotate the knob of panel potentiometer R6 (TRIGGER LEVEL) back and forth and observe how the cursor can be triggered at any point on the positive-going slope. (Reverse S1's position to trigger on the negative-going slope.)

Advance the turns counterclockwise, and observe the bold section lengthening towards the next cycle so that it eventually forms a complete bold trace. At this setting, the adapter output pulse is equal to the time period of the 60-Hz signal (16.7 milliseconds). A very small advance of the turns counter will cause each alternate cycle to dim. Adjust your oscilloscope's sweep speed to see this clearly, and then set the turns counter to ×1.67. Now adjust calibration trimmer R15 to locate the trace exactly at the point where it changes from full bold on each cycle, to bold on each alternate cycle.

This completes the calibration and operating instructions for the time period mode. As expected, any type of waveform can be measured by simply manipulating the slope, range, and multiplier controls of the unit.

To use the delayed sweep mode, connect output jack J2 to the TRIGGER INPUT jack on your oscilloscope (instead of the Z axis jack). Introduce the signal to CHANNEL 1, set switches S1 and S3 to match the oscilloscope waveform's slope, and adjust the range controls to the approximate signal time period. Switch the oscilloscope to EXT. TRIGGER), and rotate the turns counter to keep that part of the signal-to-be-viewed on screen as you increase sweep speed to expand the signal.

Regulated power supply

A schematic for a wall outlet mounted ± 5-volt power supply for this oscilloscope accessory is included because commercial versions are not widely available. The author built the supply into a two-part aluminum project case measuring 3¼ ×1½ ×2 inches. These cases are standard, off-the-shelf items. Ω