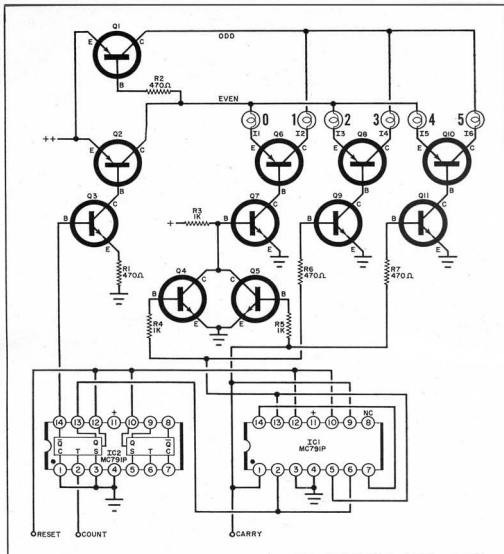


# **BUILD THE SPORTS TIMER**

**Get thousandths-  
of-a-second  
accuracy up to 10  
minutes—useful  
for a variety  
of sports events**



**T**HE AVAILABILITY OF LOW-COST decimal-readout counting units has created an entirely new "ball park" of experimentation for the advanced electronics hobbyist. This new area is digital-readout instruments and we will be publishing several articles on such projects in the months to come. The first is the "Sports Timer," a real-time clock, described here.



The clock is basically a combination of two previous projects ("Low-Cost Counting Unit," February 1968, page 27, and "Ultra-Fast Electronic Stopwatch," March 1968, page 27) with the addition of a mod-6 counter that counts, and indicates, to 5 and then returns to zero. This counter is required in real-time measurements in order to get the 5 needed in measuring 59 seconds or 59 minutes before switching to the next register. (Remember that the original counter reads out to 9 before returning to zero.)

The "Sports Timer" is designed to read out to 9 minutes and 59.999 seconds,

Fig. 1. The mod-6 counter indicates only up to five, then returns to zero. Simultaneously, it passes a carry (trigger) pulse to the next decade counter.

#### PARTS LIST

I1-I6—6.3-volt, 50-mA pilot lights and cap assembly (Southwest Technical Products #U-6.3 or similar)

IC1, IC2—MC791P dual JK flip-flop integrated circuit (Motorola)

Q1, Q2, Q4, Q6, Q8, Q10—MPS3638 or 2N5139

Q3, Q5, Q7, Q9, Q11—MPS2923 or 2N5129

R1, R2, R6, R7—470-ohm, 1/2-watt resistor

R3, R4, R5—1000-ohm, 1/2-watt resistor

A complete kit of parts for the mod-6 counter is available from Southwest Technical Products Corp., 219 W. Rhapsody, San Antonio, Texas 78216, for \$10.00, postpaid in U.S.A.



Fig. 2. Actual-size foil pattern for the modulo-six counter. It is the same size as the boards used for the other circuits (see text) simplifying construction of timer.

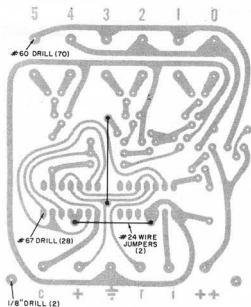


Fig. 3. Drill the PC board as shown here, and add the two insulated jumpers on component side of board.

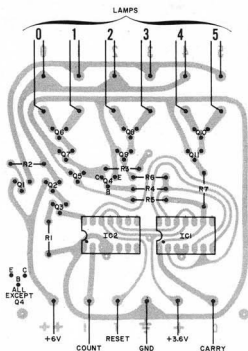
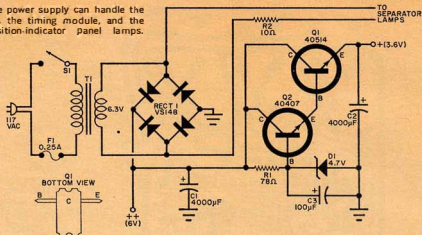


Fig. 4. Mount the components as illustrated here making sure that you orient the semiconductors properly. Note Q4 is not installed in same way as Q1-Q11.

Fig. 5. The power supply can handle the six DCU's, the timing module, and the three position-indicator panel lamps.



### PARTS LIST

C1, C2—4000- $\mu$ F, 6-V electrolytic capacitor  
 C3—100- $\mu$ F, 15-V electrolytic capacitor  
 D1—4.7-V silicon diode  
 F1—0.25-A fuse  
 R1—78-ohm, 1-W resistor (two 39-ohm, 1-W resistors in series)  
 R2—10-ohm, 1/2-W resistor  
 RECT1—Full-wave bridge rectifier (Vaco VS148, or similar)

S1—S.p.s.t. switch

T1—Filament transformer: secondary 6.3 V, 2 A

Q1—40514 power transistor (RCA)

Q2—40407 transistor (RCA)

Misc.—Heat sink for Q1, fuse holder, silicone grease, wire, solder, four standoffs, etc.

A complete kit of parts is available from Southwest Technical Products Corp., 219 W. Rhapsody, San Antonio, Texas 78210, for \$9.75, postpaid in U.S.A.



Fig. 6. Actual-size foil pattern for power supply. Like all the other PC boards, this one is also available etched and drilled (see Parts List for ordering details).

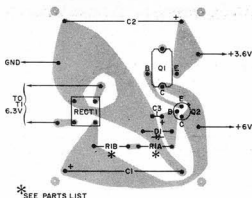


Fig. 7. Component installation on the power supply PC board. Note that R1 is two resistors in series.

which should be sufficient for the majority of track events, auto races, swimming contests, ski runs, etc. If desired, however, the maximum time can be extended to read up to 9 hours, 59 minutes and 59.999 seconds. Besides sporting events, the clock can be used to time tape recordings and speeches and has applications in laboratories, photo darkrooms, or any other activity where an illuminated readout clock capable of measuring to small parts of a second can be used.

The clock can be started and stopped in a variety of ways. A photoelectric start-and-stop circuit (described in this article) is one way; others include the operation of mechanical contacts, such as pushbutton switches or step-on door-mat switches. If desired, the clock can be started from a microphone and amplifier system adjusted to pick up the crack of the starter's pistol. The number of triggering methods possible is limited only by the imagination of the user.

**Construction.** Because the decade counting units and the crystal-controlled timing circuit have already been described in detail (see the previously mentioned issues of *POPULAR ELECTRONICS*) only the modulo-6 counter will be covered here.

The basic modulo-6 counter (schematic shown in Fig. 1) uses two low-cost IC's, eleven transistors, 7 resistors, and six incandescent bulbs. Cost of this counter is \$10 (see Parts List). An actual-size printed-circuit-board foil pattern is shown in Fig. 2, while Fig. 3 shows how the board is to be drilled and the location

of the two jumpers required. These jumpers are made from #24 solid wire and are added on the component side of the board.

When mounting the components, as shown in Fig. 4, be sure to observe the correct positioning of all semiconductors, noting that the IC's are identified by a notch and dot code at one end. Use a low-wattage soldering iron and fine solder to make all connections.

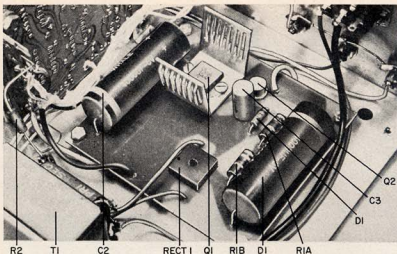
If desired, a readout-lamp display bracket can be cut and bent from a piece of  $\frac{1}{32}$ " aluminum similar to that shown in the February issue. Pop rivets can be used to secure the bracket to the board. Press the plastic lamp covers into the six holes, then press the bulbs into the plastic covers. After each bulb is wired to its correct terminals, use black "instant transfer" numerals to identify them, coating the numbers with a clear acrylic spray to prevent accidental removal.

Note that, in the finished clock, lamp mounting brackets are not used on any of the readouts, but holes are drilled in the front panel using the lamp brackets (provided with each kit) as a template. If you select this method of construction, be sure to leave all lamp leads as long as possible before soldering the far ends to the PC boards.

To duplicate the "Sports Timer" shown in the photos, you will need five 0-9 counting units, one 0-5 counting unit, a crystal-controlled timer, three 6.3-volt lamps and plastic covers, a power supply, and a chassis.

**Power Supply.** The power supply provides 3.6 volts at very low ripple for use by the IC's, 6 volts for the numerical-display incandescent lamps, and approximately 6.3-volts a.c. for the three position-indicator lamps (two making up the colon, and one for the decimal point). A suitable supply, shown in Fig. 5 consists of a transformer-powered bridge rectifier followed by a two-transistor, zener-diode-controlled regulator. The separator lamps get power from T1 through dropping resistor R2.

The power supply can be assembled on the printed board shown actual size in Fig. 6. All parts, with the exception of power transformer T1, fuse F1, and dropping resistor R1 are mounted on the board as shown in Fig. 7.



To prevent components from shorting against chassis, install spacers between the chassis and the power supply board.

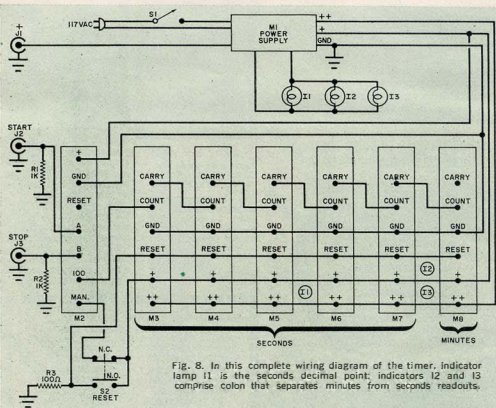


Fig. 8. In this complete wiring diagram of the timer, indicator lamp I1 is the seconds decimal point; indicators I2 and I3 comprise colon that separates minutes from seconds readouts.

#### PARTS LIST

- I1, I2, I3—5.5-V, 50-mA pilot light and cap assembly, two green, one red (Southwest Technical Products #0-6.5, or similar)  
 J1, J2, J3—Phono jacks, RCA types  
 M1—Power supply  
 M2—Timing module  
 M3, M4, M5, M6, M7—Decode counting unit  
 M8—Module counter  
 R1, R2—1000-ohm, 1/4-W resistor  
 R3—100-ohm, 1/4-W resistor

S1—S.p.s.t. switch

S2—S.p.s.t. momentary pushbutton switch

Misc.—Chassis, mounting hardware, line cord, adhesive-contact plastic (optional), wire, solder, etc.

The following parts are available from Southwest Technical Products Corp., 219 W. Rhapsody, San Antonio, Texas 78216: Timing module kit with 100-kHz, 0.005% crystal, \$24; decade counter, \$12; chassis, punched, primer coated, and with covering material for top, \$6.50.

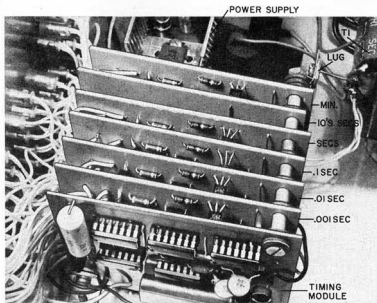


Fig. 9. Timing module and DCU circuit boards should be stacked for space conservation and neatness. Use  $\frac{1}{2}$ "-long insulated spacers (or metal spacers and fiber washers) between each board for adequate separation. Board designations from bottom to top are M2 through M8.

**Assembly.** The 10" wide by  $3\frac{1}{2}$ " high by 7" deep metal chassis, used by the author consists of two U-shaped sections. One serves as the mounting chassis for the completed circuit (Fig. 8) and the other is used as the cover.

Start the assembly by drilling the required holes in the front panel for the readouts, using the lamp bracket as a template. The plastic lamp covers are press-fit into the holes, and the lamps are press-fit into their covers. Therefore, when assembling the counters, use the full length of wire provided with each lamp. Don't forget to drill the three holes for the position identifier lamps. Drill a hole to accept the RESET push-button S2, power ON-OFF switch S1, and three phono jacks J1, J2 and J3.

Before mounting any components on the front panel but after drilling the required holes, cover the entire front panel with a contact-adhesive plastic coating whose pattern or color appeals to you. Use a sharp knife to remove the material from the area where the holes are. Apply the front panel markings with any type of instant-transfer lettering. The box outline was made with thin black tape. The author used a red plastic cover for the decimal indicator (11) and a green cover for the colon indicator (12, 13).

The interior layout is shown in Fig. 9. The seven printed boards are separated from each other with  $\frac{1}{4}$ " spacers at the two rear mounting holes. If metal  
(Continued on page 112)

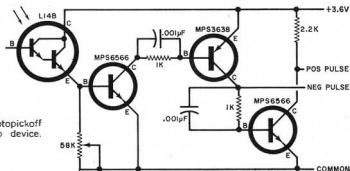


Fig. 10. Suggested photopickoff for use as a start/stop device.

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## SPORTS TIMER

(Continued from page 41)

spacers are used, place a non-conducting washer between each spacer and the adjacent foil section to avoid any chance of short circuits. Use 3"-long thin bolts to fasten the boards together. The bolt passing through the bottom portions has a small L bracket at each end to secure the bottom edges of the boards to the base of the chassis. A similar pair of L brackets is used to secure the outer boards at the front. Mount an insulated single-lug terminal strip at the nut end of the upper mounting bolt as shown in Fig. 9 to support resistor *R2*.

Drill suitable holes in the base to mount the fuse holder, power transformer, and power supply as shown in the photo. Mount the power supply using four small standoffs, then secure the transformer and the fuse holder.

Once all components have been mounted, insert the bulbs in the respective plastic holders and wire the components as shown in Fig. 8.

Testing. Once final assembly is complete, turn on the power (*S1*) and note that the decimal point and the colon indicator lamps come on. The various counters will be at some random numerical indication. Depressing the RESET button should cause all readouts to indicate zero.

Being very careful, use a small piece of wire to make an electrical contact between the center contact of the (+) jack *J1* and the similar contact on START jack *J2*. As soon as this is done, the counters will start to operate. The counter on the far right (thousandths of a second) will assume a dim, blurred condition, indicative of very fast counting. The counters to the left of it will operate much slower. The second to the left indicates hundredths of a second and the third indicates tenths of a second. The counter to the left of the decimal point indicates unit seconds, while the next counter to the left is tens of seconds. The latter is the modulo-6 counter that only goes to 5. At the 60th second, all counters to the right of the colon drop

to zero with the minutes counter advancing to the next count. The counters will not stop, and you will see them proceed to 9 minutes, 59.999 seconds and repeat.

To stop the counter at any time, insert the wire jumper between the center contact of *J1* and the similar contact on the STOP jack *J3*. The various counters will stop and the real time can be read on the front-panel indicator lamps. Depressing the RESET button will zero the count. If the RESET button is depressed while the counting is taking place, the indicated time value will drop to zero, but immediately start up again as soon as the RESET button is released. This push-button has no effect on the three fixed indicator lamps. To shut the system down, turn *S1* to OFF.

Before assembling the cover on the chassis, use contact-adhesive plastic to give it a finished look.

**Starting and Stopping.** There are many ways to start the clock, and all depend on providing the START input jack with a positive-going pulse. For races of all types, you can use the photopickoff shown in Fig. 10 at either the start or finish line. Place a light source on one side of the track, focused either by a lens or a length of tubing in front of the lamp so that the light beam strikes the photo-Darlington transistor. A similar lens system, or length of tubing can be placed over the photo transistor to prevent triggering by ambient light. The switch shown in Fig. 10 is used to select either the presence or absence of light as the trigger.

The (+) jack is used to provide 3.6 volts to power any external trigger circuit.

**Modifications.** The timing unit kit is supplied with a 100-kHz, 0.005% tolerance crystal. With this crystal, the last digit on the right will not be accurate, although it can be used as a relative time indicator. Replacing the 0.005% crystal with one with an accuracy of 0.001% will produce the correct timing in the thousandths column.

If you want to read times up to one hour, add another modulo-6 counter at the left, driven by the "carry" of the minutes counter *M8*. The clock will now

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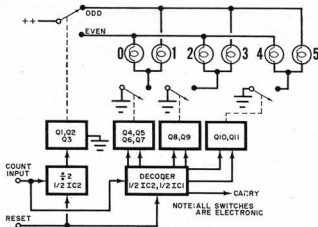
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### HOW IT WORKS

Operation of the decimal counting unit was described in the February 1968 issue and the timing unit in March 1968; therefore, only the operation of the modulo-6 counter will be described here.

The input pulse train is fed to a divide-by-two counter (half of IC2), a flip-flop which changes state with each input pulse. One state of the flip-flop indicates an odd number, while the other indicates an even number. The odd-even signal is processed by transistors Q1, Q2, and Q3 so that, on even numbers, the "even" bus is energized, and on odd numbers, the "odd" bus is energized. The five state-indicating incandescent lamps are connected in pairs to the odd and even buses, and each pair is connected to ground through a set of switching transistors. These transistors act as open switches when they are cut off and closed switches when saturated, thus determining when each bulb is lit.

After passing through the divide-by-two stage, the input signal goes to a decoder consisting of the other half of IC2 and half of IC1. This counter determines whether the number being counted is 0 or 1, 2 or 3, or 4 or 5. The correct switching signals are then passed to three sets of switching transistors which connect the bulbs to ground.

As an example of how the counter works, assume that the count has reached the number 4. The divide-by-two counter has determined that this is an even number and has supplied power to the even bus. The decoder has determined that it is either a 4 or 5, and thus turns on the Q8-Q9 combination. The other two switches are left open. Under these conditions, only bulb 5 is illuminated.

On each sixth input pulse, the counter automatically cycles back to the zero state, and supplies an output pulse to the "carry" terminal. This pulse is used as the count input for any succeeding counters.

read to 59 minutes, 59.999 seconds. If you want to read up to 10 hours, add both the tens-of-minutes counter and another decade counter driven by the last "carry" output. The clock will now read to 9 hours, 59 minutes, and 59.999 seconds.

This should be enough for almost any race. To convert the clock to read only hours, minutes, and seconds, as does a conventional clock, requires a little more logic and may be the subject of another article.



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