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Rebirth of Bass-Reflex Speakers
TRS-80 Computer "Real Time" Timer
Low-Cost "Micro Meter" for DC Volts

A Personal Radiation Monitor

- Solid-State Detector
- Portable
- Chirp Alarm

Tested In This Issue

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BY HOWARD BERENBON

Simple hardware addition plus BASIC Level-1 program creates a multipurpose timer to operate electric appliances, for timing chess games, and other useful control applications

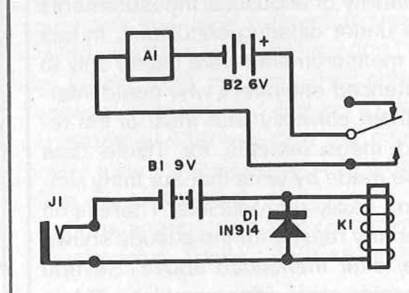
A SIMPLE "REAL TIME" TRS-80 TIMER

A relatively simple BASIC program and an even simpler hardware addition to a TRS-80 Level I 4K digital computer, forms a programmable timer that can be set for a time period of one second to almost any desired interval. The BASIC program uses two "for-next" loops to calculate the desired delay. INPUT #A at line 590 activates the cassette relay which, in turn, operates the control circuit shown in the figure.

When the program is run, the user is prompted when it is necessary to enter a delay time, etc. For example, assume a three-minute timing interval. When the display indicates "ENTER DELAY TIME MODE," type "2" (for selecting minutes) on the keyboard, the computer will then prompt, "DELAY IN MINUTES," which is answered by typing in "3". The machine will then display "PRESS ENTER TO START THE TIMER." Once this is done, the timer is in operation. After three minutes, the TRS-80 will activate an external alarm. To de-activate the alarm, depress the TRS-80 "RESET" pushbutton (located behind the rear expansion door).

Construction. The circuit shown can be assembled on a small piece of perforated board, just large enough to hold the components.

Insert the subminiature phone plug of the TRS-80 cassette interface connector into jack *J1*. Relay *K1* can be used to activate a heavy-duty relay operated by the ac power line for higher-current applications. ◇



Control circuit is activated by cassette relay at line 590.

PROGRAM

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10 CLS
20 PRINT "TRS-80 REAL TIME TIMER"
30 PRINT
40 PRINT "A PROGRAMMABLE TIMER"
50 PRINT
60 PRINT "ENTER DELAY TIME MODE"
70 INPUT "(1) FOR SECONDS (2) FOR
   MINUTES (3) FOR HOURS";B
80 IF B=1 GOTO 500
90 IF B=2 GOTO 600
100 IF B=3 GOTO 700
110 GOTO 60
500 PRINT
510 G=1
520 INPUT "DELAY IN SECONDS";S
530 INPUT "PRESS ENTER TO START
   THE TIMER";A$
540 FOR J= 1 TO S
550 FOR K= 1 to 470 • G
560 NEXT K
570 NEXT J
580 PRINT "DELAY COMPLETED, CIR-
   CUIT ACTIVATED"
590 INPUT #A
600 PRINT
610 G=60
620 INPUT "DELAY IN MINUTES";S
630 GOTO 530
700 PRINT
710 G=60
720 INPUT "DELAY IN HOURS";S
730 INPUT "PRESS ENTER TO START
   THE TIMER";A$
740 FOR J= 1 TO S
750 FOR K= 1 TO 60
760 FOR L= 1 TO 470 • G
770 NEXT L
780 NEXT K
790 NEXT J
800 GOTO 580
810 END
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PARTS LIST

A1—6-V alarm (Sonalert or similar)
B1—9-V battery with holder
B2—6-V battery with holder
D1—1N914 or similar
J1—Subminiature jack
K1—Miniature relay, 500-ohm coil, 6-V dc (Radio Shack 275-004 or similar)
Misc.—Perforated board, mounting hardware, cable, etc.

Measure Weak Direct Currents with the Sensitive Micro Meter

BY I. QUEEN

Low-cost op-amp system can measure solar-cell output and currents in other low-level circuits.

IF YOU PLAN to measure the output of a solar cell under low-light conditions, to work with micropower ICs, or otherwise experiment with weak-current circuits, you'll need a sensitive current meter. The Sensitive μ Meter presented here will allow you to measure direct currents as small as a fraction of a microampere. Moreover, it is not subject to the disadvantages associated with standard panel microammeters—high cost, fragile movements, and relatively high internal resistance.

The project employs an operational amplifier to increase the sensitivity and effectively decrease the input impedance of a moderately priced, readily available 0-to-50 microammeter. It has three switch-selected scales; 0 to 0.5 μ A; 0 to 5 μ A; and 0 to 50 μ A. The circuit can be powered by a supply furnishing as little as ±2 or +4 V, and can be constructed for about $15.

Circuit Operation. A simple circuit for current-measuring applications is shown in Fig. 1. When an input current *I* is applied to the inverting input of the op amp, an inverted output signal is generated by the op amp. If the gain of the operational amplifier is very high, we can consider that the entire input current flows through feedback resistor *R*. An output voltmeter *M*, which is calibrated in terms of *I*, measures the product *IR*. The voltage drop across the operational amplifier is practically zero (the output voltage divided by the op amp's open-loop gain).

The schematic of the Sensitive μ Meter is shown in Fig. 2. Switch *S2* selects the range and determines the feedback resistance of the stage. When the switch is in its center (off) position, the feedback resistance is *R3*, one megohm. An input current of 0.5 μ A will cause the output of the op amp to be 0.5 volt above ground when only *R3* is in the feedback loop.

This output voltage will cause full-scale deflection of 0-to-50-microammeter *M1* if the effective resistance between the output terminal of the operational amplifier and the negative terminal of the meter is 10,000 ohms. The internal resistance of the meter specified in the parts list is 1620 ohms, so the balance of the required resistance is supplied by *R4*. This trimmer potentiometer is adjusted for full-scale deflection of the meter movement when the op amp output is at +0.5 volt.

The project is most sensitive when *S2* is in its center (off) position and the feedback resistance is one megohm. In this operating mode, full-scale deflection of the meter corresponds to an input current of 0.5 μ A. Higher-current ranges are obtained by shunting *R3* with other resistors to lower the overall feedback resistance. This is accomplished by placing *S2* in one of its two other positions. When the range switch is placed in its 5 μ A position, the parallel combination of *R1* and *R3* causes the meter to deflect to full scale if the input current is five microamperes. Similarly, placing *S2* in its 50 μ A position shunts *R3* with *R2* and causes full-scale deflection of the meter movement when an input current of fifty microamperes exists.

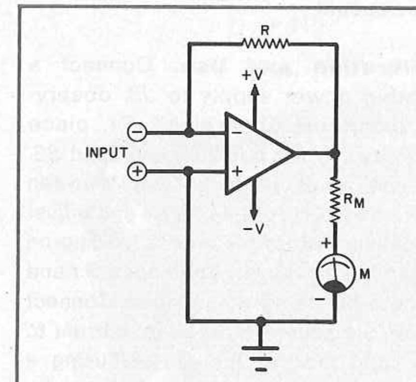

Fig. 1. Schematic of simple current-measuring circuit.

Two shorting switches are included in the circuit. Switch *S1* shorts the input of the project. It is used in conjunction with potentiometer *R5* to zero the meter movement. The other switch (*S3*) is used to short the terminals of *M1* when the meter is not being used. This minimizes mechanical shocks to the meter movement when the project is being transported. Diodes *D1* and *D2* protect the project from excessive input voltages. Jack *J2* provides access to *M1* so that the meter can be used in isolation from the rest of the project.

You might wonder why the circuit provides for a 0-to-50-microampere scale when meter movement, *M1*, covers this range on its own. The following exercise performed by the author will illustrate the need for such a scale. A solar cell was connected across input jack *J1* and illuminated so that the Sensitive μ Meter indicated a current of 50 μ A. The cell was then connected to *J2* and its output current measured using *M1* alone. It indicated a current of 1 μ A.

The reason for this discrepancy between the two readings is that *M1* presents a higher resistance to the solar cell when it is used independently than the project as a whole does. It is desirable to keep the internal impedance of a current-measuring instrument as low as possible. Thus, it is better to employ the project as a whole (as opposed to *M1* or a similar meter alone) in the measurement of currents up to 50 μ A.

There is another significant advantage to the use of the Sensitive μ Meter as opposed to a microammeter alone. Due to the clipping action of protective diodes *D1* and *D2*, the maximum output voltage of the op amp on any of the three ranges is