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TIMER MODULES FOR RADIATION DETECTION SYSTEMS

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Product and Health Physics Research
ELECTRONICS GROUP

Modules for Radiation Detection Systems and related items will be grouped in a series of reports beginning with RFP-2300 through RFP-2325. RFP-2300 represents the first report in the series.

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SUBJECT DESCRIPTORS

Timer Modules
Alpha Detection Systems
Wound Counting Systems
Gamma Spectrometers
Electronics
Monitoring Systems
Nuclear Instrumentation BIN

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TIMER MODULES FOR RADIATION DETECTION SYSTEMS

Bradley E. Martin

Abstract. In developing radiation detection instrumentation at Rocky Flats, a system concept using plug-in modules was planned. Losses of operational time due to maintenance are drastically reduced as a malfunctioning module can be replaced within minutes. Versatility is another advantage of the modular concept and a particular module can be used in many different system designs. A significant cost savings in system development can also be realized.

Two of the timers described are housed in two-wide Nuclear Instrumentation Bin (NIM-BIN) modules and a third model in a one-wide NIM-BIN module. The design uses the latest COS/MOS (complimentary symmetry metal-oxide semiconductor) integrated circuitry, featuring low power, low cost, and high reliability. These modules were developed specifically for radiation detection systems. For clarity, models will be referred to as A, B, and C. Model 24370-21, or A, is used in gross alpha detection systems. Model 27213-21, or B, appears in a medical wound-counter system and the third, Model 27213-23, or C, operates in a gamma spectrometer system. These modules can have application in other related systems as well.

Operational procedures and servicing are included.

INTRODUCTION

Three timer models are described. Model A (24370-21) was developed for gross alpha-detection systems and Model B (27213-21) was developed for a medical wound-counter system. Model C (27213-23) was developed for a gamma spectrometer system and any of the modules can be used in other related applications.

The timers offer capabilities in collecting data for analysis of levels of radioactive contamination which might occur during plant activities. Under the Health Physics monitoring program at Rocky Flats Plant, concerted efforts are directed towards improvements in safety, state-of-the-art applications, and the reduction of operating costs.

DISCUSSION

Descriptions:

The timer modules are accurate timing and control devices and can be used in most data accumulating systems. They provide a *reset* function, an *enable* function, and a *regulated* plus five volts as outputs to external modules. The timing cycle is presettable by means of a thumbwheel switch located on the front panel. Models A (24370-21) and B (27213-21) provide time-interval selections from 00.01 to 99.99 minutes, and Model C (27213-23) is selectable from 0.1 to 9.9 minutes.

Once the desired time has been preset, the timer can be set into operation by depressing the pushbutton switch on the front panel. While the switch is held in, the circuitry generates a lamp-test function for checking light-emitting diode (LED) displays within the timer and external modules. When the switch is released, the timer is reset and begins the counting interval. A reset function is also provided for external modules such as a scaler. The timer produces an enable function during the counting interval as a control function for other modules. When the preset time is reached, the timer stops and the enable function terminates. On all models, a lamp inside the pushbutton switch illuminates

during the counting interval. Model B (27213-21) features an elapsed-time readout.

The complete modules are shown in Figure 1.¹ The thumbwheel switch snap-fits into the front panel and the timer printed circuit board (PCB) plugs onto the switch. Model C (27213-23) uses an adapter PCB between the timer PCB and the switch. The adapter reduces the preset time from four-to-two decades and allows the circuitry to be mounted in a one-wide module. The elapsed-time readout PCB in Model B (27213-21) mounts on top of the timer PCB (Figures 2, 3, and 4).

Input-output wiring goes to the rear panel connector and the control wiring runs to the pushbutton switch.

The +5-volt regulator mounts on the rear panel and a test point is provided (Figure 5).

Model B (27213-21) uses a *black magic* type front panel. The panel is made of red translucent plastic and the back side is painted flat black, with exception of the LED viewing area. The panel appears dark, but the LEDs show through and provide a clearly visible and eye-pleasing display.

Block Diagrams:

Figure 6 shows a block diagram of Model A (24370-21). The +12-volt input is reduced by the regulator to +5 volts, necessary for powering the integrated circuits (IC). The regulator, one of the new *three-legged* types packaged in a TO-3 case, is capable of handling currents in excess of one ampere. The 5-volt potential is used within the timer module and also fed into the NIM-BIN for use by other modules.

The pushbutton switch, S1, provides the control action for the reset and count-start functions. The switch contains an indicator lamp which illuminates during the timing interval.

¹ Figures are included at end of text.

The thumbwheel switch, comprised of four sections and 16 diodes, makes up a positive *AND* gate.

The timer PCB receives 2.5 volts AC as a 60-hertz (Hz) reference frequency. When the reset-count switch is activated, the timer PCB counts up the 60-Hz reference and provides the enable output. When the preset time on the thumbwheel switch is reached, the timing interval stops and the enable output terminates.

Figure 7 illustrates Model C (27213-23). It operates the same as Model A (24370-21), except that a two-decade adapter PCB exists between the thumbwheel switch and the timer PCB. This reduces the overall timing capability, however the one-wide module has an advantage where NIM-BIN space is a premium.

Figure 8 shows Model B (27213-21) which operates the same as Model A with the inclusion of an elapsed time readout assembly. The readout driver PCB senses the binary-coded decimal (BCD) outputs of the timer PCB and converts the BCD to seven-segment outputs. The readout PCB contains four MAN-64A seven segment LED displays.

Circuit Analysis:

In Figure 9, a schematic diagram of Model A (24370-21), the ICs A1 and A2 form a control logic circuit. The ICs, A3 and A4, are divide-by-six counters and A5 through A8 are decade (divide-by-ten) counters. The positive *AND* gate formed by the thumbwheel switch senses the BCD outputs of the decade counters at J1 through J4.

The control logic circuit is triggered by the pushbutton switch, S1, noted in Figure 6. As the pushbutton switch is depressed, R3 pulls the reset line high (+5 volts) and the counters reset to zero. The counters, A5 through A8, use a ground on the jam inputs, with the reset applied to the preset enable input to force-reset

the counters to zero. The switch forces to ground Pin 8 of A2. The circuit of A2 forms a switch contact debounce and control flip-flop. Pins 2, 10, and 13 of A2 and Pins 9, 11, and 14 of A1 all go high. This causes Pins 10, 12, and 15 of A1 to go low (zero volts) and produce the enable output. Pin 1 of A2 receives the 60-Hz input and passes it to Pin 14 of A3, the input of the counters. Counting will not yet begin, as the reset line, still high, holds the counters in the reset condition.

When the pushbutton switch is released, Pins 8 and 12 of A2 go high and Pin 2 of A1 goes low allowing Q1 to conduct and turn on the lamp. The reset is removed from the counters which will begin counting the 60-Hz reference.

The timing interval, then in progress, will continue until all inputs of the diode positive *AND* gate formed by the thumbwheel switch are satisfied.

For example, suppose 1.5 minutes are selected on the thumbwheel switch. The diodes connected to Pins 2 and 11 of J3 and Pin 2 of J2 will form the gate. All other diodes are disconnected from the gate because of the mechanical construction of the thumbwheel switch. At a count of 1.5 minutes, these inputs will be high allowing the output of the gate to be pulled high by R4. The output is common at Pin 8 of J1 through J4. The high from the gate output is applied to Pin 7 of A1 causing Pin 6 of A2 to go low and reset the flip-flop of A2. Pin 10 of A2 goes low driving Pin 11 of A2 high which shuts off Q1 and turns off the lamp. Pins 10, 12, and 15 of A1 go high changing the enable output to a disable. Pin 2 of A2 goes low and prevents A2 from passing the 60-Hz reference frequency to the counters. The timing interval, then complete, will remain in this state until the pushbutton switch is pressed.

Capacitors C1 and C2 provide proper filtering for COS/MOS circuitry.

Figure 10 shows Model C (27213-23). The circuit operates the same as Model A. The decade timer

adapter PCB senses the BCD outputs from A6 and A7 and couples them to the thumbwheel switch. This limits the timing capability to two-decades. The J5 connector of the timer PCB plugs into the adapter and the adapter plugs onto the thumbwheel switch.

Figure 11 shows a schematic diagram of the readout driver PCB and the readout PCB, used in Model B (27213-21). Plug 5 of the readout driver PCB plugs onto J5 of the timer PCB. The readout driver and the readout PCBs are permanently affixed together by a right angle connector. The BCD outputs from the timer PCB are sensed by A1 through A4 and converted to seven-segment outputs which will drive the MAN-64A displays on the readout PCB. Resistor R1 limits the current to the decimal point display. Diode D1 is an isolation diode for the lamp test circuit and C1 provides decoupling.

Figure 12 gives component layouts and switch data for the PCBs used in the timers. Component layout for Model B (27213-21) is given in Figure 13(a), readout components in 13(b), and readout driver components in 13(c).

Adapter component layout for Model C (27213-23) is given in Figure 14.

OPERATING PROCEDURES

The following procedures and requirements are recommended for use with the timer models described, Models A, B, and C.

1. Plug timer module in NIM-BIN.
 - a. Power requirements :
 - (1) +12 volts DC, Pin 16
 - (2) 2.5 volts AC, Pin 26
2. Turn on NIM-BIN power.
3. Set the thumbwheel switch for desired time.
4. Timer is ready for operation. Press push-button switch to operate.

SERVICING OF MODULES

The chart has been included as a troubleshooting guide to assist in the performance of unscheduled maintenance.

Problem	Cause
No +5 volts DC	<ol style="list-style-type: none"> 1. No +12 volts DC input 2. Short on +5 volt line 3. Faulty regulator
Does not Time No Enable No lamp	<ol style="list-style-type: none"> 1. No +5 volts DC input 2. Faulty A2 3. Faulty A1

Problem	Cause
Does not Time Lamp and Enable OK	<ol style="list-style-type: none"> 1. Faulty A2 2. No 60-hertz input
No Enable output	<ol style="list-style-type: none"> 1. Short on enable line 2. Faulty A1
No Lamp indication	<ol style="list-style-type: none"> 1. Bulb burned out 2. Faulty Q1 3. Faulty A1
Times-Out incorrectly, or Does not Time-Out at all	<ol style="list-style-type: none"> 1. Faulty Counter (A3 through A8) 2. Faulty diode on thumbwheel switch

FIGURE 1. Front View of Timer Modules.

17698-10

FIGURE 2. Interior View of Model A (24370-21).

17698-12

FIGURE 3. Interior View of Model B (27213-21).

17698-1

17698-11

FIGURE 4. Interior View of Model C (27213-23).

FIGURE 5. Rear View of Timer Modules.

17698-4

FIGURE 6. Timer Block Diagram, Model A (24370-21).

FIGURE 7. Two-Decade Timer Block Diagram, Model C (27213-23).

FIGURE 8. Timer Block Diagram, Model B (27213-21).

FIGURE 9. Timer Printed Circuit Board, Model A (24370-21).

FIGURE 10. Timer Printed Circuit Board of Model C (27213-23).

FIGURE 11. Schematic of Readout and Driver for Model B (27213-21).

FIGURE 12. Component Layout and Switch Data for Model A (24370-21).

FIGURE 13 (a), (b), and (c). Component Layout for Model B (27213-21) is shown in (a); Readout Components (b); and Readout Driver Components (c).

FIGURE 14. Adapter Component Layout for Model C (27213-23).