—Research Note—

A programable switching system for biological rhythm study

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Detection of special phases in biological rhythms based on the compiled data of the responses to periodic stimuli given at different time of the day, has been the strategy of our laboratory (OHTA *et al.*, 1984)¹⁾. In practice, however experiments of this category force one to work irrespective of the clock time, which ironically disrupts the rhythm of the researcher. Probably by this reason, reports of animal experiments dealing with biological changes at night are still meager in spite of the recent findings which strongly suggest many important changes in the biological system are taking place at night. In this paper, we introduce a prototype of versatile automated system that would meet with the general demand of rhythm studies. This system is consisted of a small hand-held computer and a time sharing unit that enables activation of multiple output channels by a single stimulator according to the preset commands.

Design and components of the system**A) System block**

- 1) A hand held computer with battery backup (CASIO FP-200) (can be replaced by any computer of *i*-8080 family).

2) Parts of output interface^{2,3)}.

- a) 8 bit latch buffer (SN74LS373N, Texas Inst. USA)
- b) Relay drivers (HD7406P, Hitachi) × 2
- c) An array of 5V relays (NR-H-5V, Matsushita) × 8

B) Functions of the parts

- 1) Working pattern of indwelling clock of the computer is programmed for switching of the output.
- 2-a) Transient memory between strobe pulses (Strobe pulse: Timing signal)
- 2-b) Power amplifier
- 2-c) Switching devices

C) Logic (See Table 1 and Fig. 1)**D) Wiring** (See Fig. 2 and Fig. 3)**E) Use of the system**

- 1) Simultaneous stimulation or activation via multiple channels.
- 2) Regulation of the chronological chain of switching, which can be designed for any type including random series.

Combination of 1) and 2) is changeable.

Example of the use (E-1)

Usually, the recommended number of the animals in an experimental trial would be more than 5. In the electrical experiments, however the limited number of available channels of the stimulator (or recorder) be-

Table 1. Logic. State "1" of the output signal turns on and state "0" turns off the switch. Command "CALL 48896, 2^i " ($i=0, 1, 2, \dots, 6, 7$) turns on the i -th switch, and turns off all the rest. In this table only switch No. 3 is on.

8 bit signal:	0	0	0	1	0	0	0	0
S.W. No.:	0	1	2	3	4	5	6	7
S.W. state:	OFF	OFF	OFF	ON	OFF	OFF	OFF	OFF

Fig. 1. Logical circuit of individual unit. STB: Strobe. O.C.: Open-collector-type output which goes to 5V power line via resistor ($1-10 \times 10^3 \text{ ohm}$). OPC: Out put control pin of 74373.

Fig. 2. Block diagram of one of 8 switching units. STB: Strobe. OPC: Output control pin of 74373.

Fig. 3. Setting for (E-1). Stimulation parameters (pulse width, amplitude and frequency) for each animal can be set separately. These parameters should be monitored through oscilloscope (B). Knobs (A) and (C) are for adjustment. a: High capacity relay (DS2-M, Matsushita) for switching the stimulator.

comes the bottle neck to achieve this. Application of the program as shown below increases the number of usable channels up to 8 per one stimulation output. (See Fig. 3) In this program, one channel was shared for the switching of the stimulator.

```

10 '*****
20 '
30 '      TIMER CONTROL & CHANNEL MULTIPLEXER ROUTINE
35 '
40 ' Variables : Function
45 '
50 ' TMON$: time set for multiplexer to start
60 ' NONP: duration (sec) of ON state per one channel
70 ' NOCY: number of stimulation cycles
75 ' NC: loop counter for stimulation cycle
80 ' NS: active channel No.
90 ' NP: duration of active period
100 ' DATE$: date
110 ' TIME$: time (h/m/s)
120 ' SMON$: time set for stimulator to start
130 '
140 '*****
145 '
150 POKE 48896,211:POKE 48897,128:POKE 48898,201
160 CALL 48896,0
170 CLS:PRINT "Multi-timer"
180 PRINT " STR ON Time 00:00:00"
190 INPUT " ";SMON$
200 PRINT " MLP ON Time 00:00:00"
210 INPUT " ";TMON$
220 INPUT " Duration in sec.":NONP
230 PRINT " 1 Cycle":7*NONP;"sec."
240 INPUT " How many cycles":NOCY
250 CLS:PRINT "Multi-timer"
260 PRINT " STR ON Time":SMON$,NONP;"sec ON"
270 PRINT 7*NONP;" sec/C1":NOCY;"C1s"
280 PRINT :INPUT " OK? Y/N ";Q$
290 IF Q$="N" THEN 170
300 '
310 NC=1:NS=1:NP=0
320 LOCATE 1,5:PRINT DATE$;" ";TIME$
330 IF SMON$<>TIME$ THEN 320
340 CALL 48896,128
345 LOCATE 1,5:PRINT DATE$;" ";TIME$
350 IF TMON$<>TIME$ THEN 345
355 CALL 48896,2*(NS-1)+128:T$=TIME$
357 IF T$<>TIME$ THEN 380
360 LOCATE 1,5:PRINT DATE$;" ";TIME$
370 PRINT " SW";NS;" ON";NC;"C1s":GOTO 357
380 'counting routine
390 T$=TIME$:NP=NP+1:IF NP<NONP THEN 357
400 NP=0:NS=NS+1:IF NS<8 THEN 355
410 NS=1:NC=NC+1:IF NC<NOCY+1 THEN 357
420 LOCATE 1,6:PRINT "
425 CALL 48896,0
430 GOTO 300

```

Machine language

Address	Operand	Mnemonic
BF00(48896)	D3(211)	OUT
BF01(48897)	80(128)	80(output port No.)
BF02(48898)	C9(201)	RET

Example of the use (E-2)

In some experiments, a series of stimuli at a specified time schedule are needed. The

schedule may be periodical or non-periodical depending upon objectives of the study. The following program may handle long sequence of on-off time as desired.

```

10 '*****
15 '
20 '           Programable timer routine
25 '
31 ' First, make the RAM file (FL) using following format.
40 '
41 ' 1) Enter year/month/day as "85/03/03" into the
42 '    first column. If you don't care for the date,
43 '    enter "CYCLE" instead.
44 ' 2) Enter hour:minute:second as "$$: $$: $$" into the
45 '    second column. In case of repeated use, enter
46 '    "CYCLE" at the bottom of second column.
47 ' 3) Input switch no. to be turned on as "#####".
48 '    (ex. "#1#3#5#7") A skip of a "#" means the switch
49 '    remains off.
50 '
52 '    D$: Time schedule in day      T$: Time schedule in
53 '    hh:mm:ss.                    R: Record no.
54 '
55 '*****
56 '
57 POKE 48896,211:POKE 48897,128:POKE 48898,201
58 CALL 48896,0
60 CLS:PRINT " Program timer"
70 PRINT:INPUT " File no. ";N
75 R=0
80 CLS:PRINT:PRINT " Program timer"
90 PRINT:PRINT " File no. ";N
95 R=R+1
100 D$=FL(N,1,R):T$=FL(N,2,R)
105 IF T$="CYCLE" THEN 75
110 S$=FL(N,3,R):NS=0
120 FOR I=1 TO 8
130 SS$=MID$(S$,I,1):IF SS$="#" THEN 145
135 NSS=VAL(SS$)
140 NS=NS+2^NSS
145 NEXT I
150 LOCATE 1,3:PRINT S$;" ON"
160 PRINT " ";D$;" ";T$
170 LOVCATE 1,6:PRINT DATE$;" ";TIME$
180 IF D$="CYCLE" THEN 190
185 IF D$<>DATE$ THEN 170
190 IF T$<>TIME$ THEN 170
200 CALL 48896,NS:GOTO 95

```

We have shown the outline of a program-mable stimulation system. Major advantages of this system are:

1) Number of experimental animals in one trial can readily be increased at will with slight modification of the program.

2) Each switching time can be controlled with an accuracy of m.s. order.

3) The test unit of this system assembled in our laboratory has been working trouble free, showing its high fidelity.

Undoubtedly this system has a wide range of application to various types of time consuming experiments of long run, where repeated treatments under precise time control is desired. Future combination with appro-

priate peripheral devices, it would easy to accomplish automated drug administration, blood sampling etc., on a preset schedule. Application as such depends upon your demand and design.

References

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 - 3) Component Data Catalogue, INTER, 1984.
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生物リズム研究を目的とした刺激装置とプログラム

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動物の日周活動の研究は、長期にわたる連続実験を必要とするが、その実施は夜間や休日を含むことになるのが難点で、データの収集は自記記録装置によるのが普通である。しかし動物に処置を施す場合は、依然として研究者の労力に依存していることが多いものと思われる。

実験計画に従って、任意の時刻に動物に処理を加える

ことを目的として試作した多チャンネル用の刺激装置の大略を本文で紹介した。小型マイコンを利用した簡単なものであるが、現在実験に使用しよい結果を得ている。

このタイマーで、周辺機器を駆動すれば、希望時刻に注射や採血を自動的に行なうことも可能であろう。