

TECHNICAL NOTES

A MODULATOR FOR DISCRETE TRAINS OF PULSES

B. PERETZ

*Mental Health Research Institute, Department of Psychiatry, School of Medicine,
University of Michigan, Ann Arbor, Mich. (U.S.A.)*

(Accepted for publication: October 16, 1964)

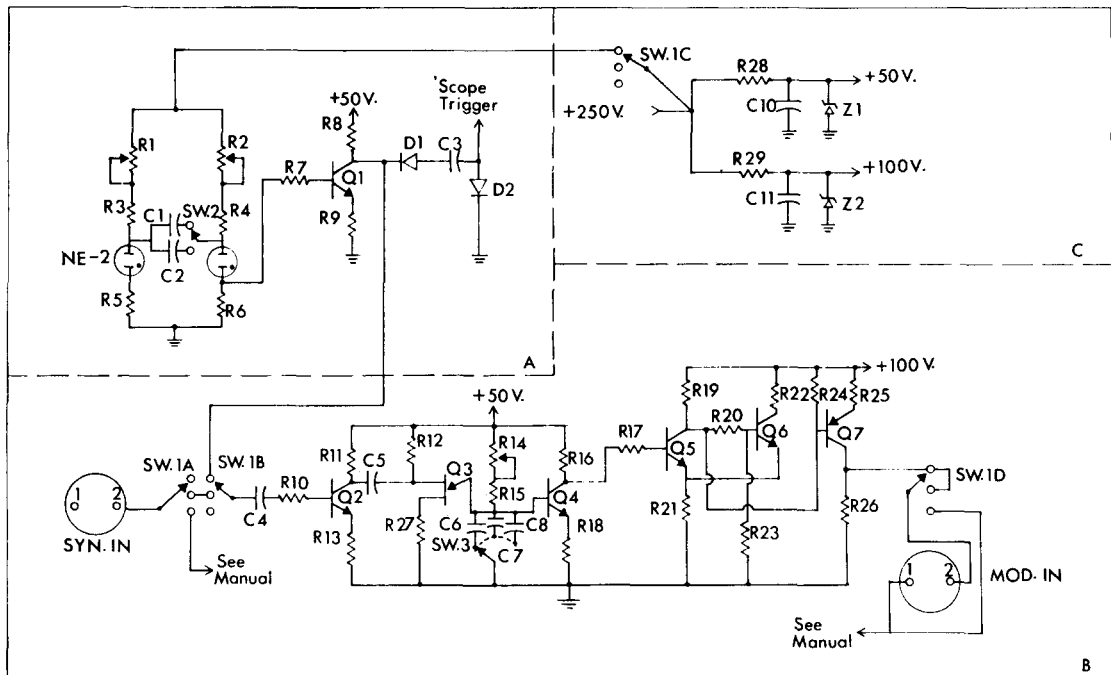


Fig. 1

A: Neon multivibrator used to set the modulator repetition rate and also used for delaying the onset of the modulator from the beginning of the sweep. *B*: The modulator circuit. The switch (SW1) wired to the plugs on the stimulator for different modes of operation. *See manual* - refers to the normal wiring of the stimulator. *C*: Zener diode regulated supplies derived from the 250 V supply. The zeners are mounted on the phenolic but the capacitors and resistors are mounted on the underside of the chassis.

INTRODUCTION

The circuit described below grew out of the need to increase the versatility of the stimulators used in our laboratory; these are manufactured by the Grass Instrument Co., Quincy, Mass. It is well known to the users of these stimulators that two units are needed to generate trains of pulses: one is used to modulate the output of the other. The circuit in Fig. 1, *A* eliminates the need for the modulating stimulator and is powered from the supplies contained in the stimulator. When the modulating circuit is not being used, the stimulator can be used in its usual capacity.

CIRCUIT DESCRIPTION

The circuit consists of four functional stages. The first stage is an inverting amplifier, containing Q2, which permits the synchronization of the trains circuit with external synchronization pulses; *i.e.*, another stimulator. The values shown permit positive pulses (capacitively coupled) between 40 V and 70 V to trigger the circuit. (If negative pulses of 50 V in amplitude are available, then Q2 may be omitted and the pulses can be fed to the input circuitry of Q3.) The output of the inverter is then fed to the sawtooth generator, consisting of Q3 and

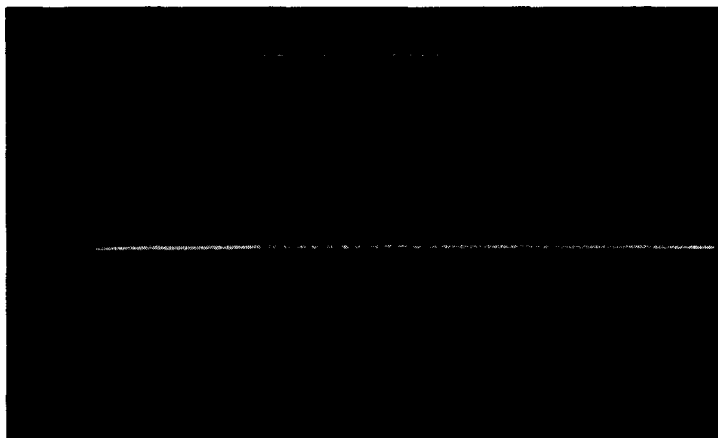


Fig. 2

This is an overlapping of 25 sweeps to show the reliability of the modulator circuit. Trains of pulses delayed 170 msec from beginning of the sweep. White dot on the lower beam shows the beginning of the sweep. Duration of trains: 120 msec; stimulus rate: 100 p/sec.

Q4, with Q4 adding linearity and reliability¹. The duration of the sawtooth wave is varied by a coarse control, C6, C7, and C8, and a fine control, R14. The values shown give a range of train durations from 1 msec up to 1.5 sec. The output of the sawtooth generator is coupled directly to the third stage which is a Schmitt trigger, Q5 and Q6, which converts the sawtooth wave into a square wave (see Hurley 1958). The duration of the sawtooth determines the length of time the trigger circuit remains turned on. Rather than adjusting the bias level of the Schmitt trigger, the duration of the sawtooth is adjustable for better stability. The fourth stage is a transistor switch, or amplifier, Q7, which is fed directly by the trigger. This receives a square wave pulse from the Schmitt trigger. The output of the transistor switch is then used to control the MOD IN of the stimulator. It was found that for reliable modulating of the astable multivibrator, designated as T-1 in the Grass manual, the output of Q7 need not be greater than 80 V.

Finally, the entire circuit is powered from the supplies contained in the stimulator which are dropped down to the desired voltages by means of zener diodes. The 250 V supply already present on the chassis was used for both the 100 V and the 50 V supplies (see Fig. 1, C). The reason two supplies were used was to keep the cost of the circuit down. Transistors for 100 V operation are more expensive than those used in 50 V circuits, and 100 V transistors were used only where necessary.

As the circuit stood, any positive or negative going pulses would initiate the trains of pulses without any time delay. Fig. 1, A shows a circuit that was added which would trigger an oscilloscope sweep, then after a delay, which is adjustable from 5 msec up to 400 msec, pulse the modulator circuit; R1 varies the delay. It simply consists of a neon multivibrator whose rate can be changed by switching between C1 and C2 and varying R2; R2 varies

the repetition rate of the neon multivibrator from 100 p/sec to 1 p/2.5 sec.

CONSTRUCTION

The entire circuit including the zener diodes was mounted on a phenolic board whose dimensions were 4.5×2 in. The board was mounted behind T10 and T3. Since the circuit board is mounted among tubes, it was necessary for the transistors to be able to operate at elevated temperatures. The transistors used here have an operating temperature of 100°C or better. The controls for the duration adjustments as well as the switches for the mode of operation of the stimulator were mounted on the front panel.

Precision components were not used because it was felt that calibrated dial settings were not necessary. The oscilloscope with which the stimulator was used provided the rate and duration of the stimulus trains. The cost of precision components would have made the incorporation of the circuit prohibitive. Fig. 2 shows a multiple trace of a delayed train of impulses; the 25 overlapping sweeps show no sign of jitter.

PARTS LIST

| Resistors | |
|-----------------------|---------------------------------------|
| R1 | 5 M Ω , Pot. $\frac{1}{2}$ W |
| R2 | 10 M Ω , Pot. $\frac{1}{2}$ W |
| R3 | 1.5 M Ω |
| R4 | 4.7 M Ω |
| R5 | 56 k Ω |
| R6, R8, R10, R17, R24 | 10 k Ω |
| R7 | 15 k Ω |
| R9 | 100 Ω |
| R11 | 6.8 k Ω |
| R12, R21 | 4.7 k Ω |
| R13 | 2.2 k Ω |
| R14 | 350 k Ω , Pot. $\frac{1}{2}$ W |
| R15, R19 | 22 k Ω |
| R16 | 8.2 k Ω |
| R18, R25 | 2.7 k Ω |
| R20 | 100 k Ω |
| R22 | 18 k Ω |
| R23 | 150 k Ω |
| R26 | 33 k Ω |
| R27 | 10 Ω |
| R28 | 10 k Ω , 5 W |
| R29 | 20 k Ω , 5 W |

(All resistors are $\frac{1}{4}$ W except when noted.)

¹ See G.E. Transistor Manual, 6th Ed., G.E. Corporation, Syracuse, N.Y., 1962, Chapter 13.

Capacitors

C1, C3, C4, C5 0.01 μ F, 100 V
 C2 1.0 μ F, 100 V
 C6 0.1 μ F, 100 V
 C7 1.0 μ F, 100 V
 C8 10 μ F, 100 V
 C9 560 m μ F, 100 V
 C10 8 μ F, 50 V (electrolytic)
 C11 20 μ F, 100 V (electrolytic)

Diodes

D1, D2 - IN34AS
 2 - NE - 2's

Transistors

Q1, Q2, Q4 2N2107
 Q3 2N491
 Q5, Q6 2N657A
 Q7 2N398B
 Z1 IN3037A
 Z2 IN3044A

Switches

SW1 4P3 position
 SW2 SPDT
 SW3 SP3 position

to 1.5 sec. This device was especially designed for use with Grass Instruments Co. stimulators so that only one stimulator is needed for generating trains of pulses. In addition, there is a neon multivibrator which controls the repetition rate and also can delay the turn-on of the modulator from the beginning pulse of the multivibrator. The circuits and power supply are contained on the chassis and the controls are mounted on the front panel of the stimulator.

I should like to thank J. Mullison for his technical assistance. Part of this work was supported by NSF-G21446 awarded to Dr. S. S. Fox.

SUMMARY

A circuit is described which provides a means of modulating trains of pulses of duration from 1 msec up

REFERENCE

HURLEY, R. B. *Junction transistor electronics*. Wiley, New York, N.Y., 1958, Chapter 21: 412-416.

Reference: PERETZ, B. A modulator for discrete trains of pulses. *Electroenceph. clin. Neurophysiol.*, 1965, 18: 508-510.

ANNOUNCEMENTS

AMERICAN ELECTROENCEPHALOGRAPHIC SOCIETY

The American Electroencephalographic Society held its 18th Annual Meeting in Santa Fe, N.M., October 1-5, 1964. The following officers were installed for 1964-1965:

President: Dr. Donald B. Lindsley
 President-Elect: Dr. David Daly
 Secretary: Dr. Robert J. Ellingson
 Treasurer: Dr. Donald W. Klass

The 19th Meeting will be held in Boston, Mass., June 14-16, 1965. Further information can be obtained by writing to the Secretary of the Society: R. J. Ellingson, Nebraska Psychiatric Institute, 602 South 44th Ave., Omaha, Nebraska 68105.

Electroenceph. clin. Neurophysiol., 1965, 18: 510

HUGHLINGS JACKSON LECTURE

The thirty-first Annual Hughlings Jackson Lecture of the Montreal Neurological Institute will be given on the afternoon of Wednesday, May 5th, 1965, by Dr. Paul C. Bucy, Professor of Surgery (in charge of Neurological

Surgery) at Northwestern University Medical School and head of the Section on Neurological Surgery at the Chicago Wesley Memorial Hospital. His title will be "The Delusion of the Obvious".

Electroenceph. clin. Neurophysiol., 1965, 18: 510