XII. PROCESS ANALYSIS AND SYNTHESIS*

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A. RECTANGULAR WAVE GENERATOR

In the course of our present research, a need arose for a device capable of generating a rectangular wave of finite duration in which the interval and the amplitude of each segment are adjustable. Such a device has been developed. The basic building block for the system is an adjustable delay circuit from which an adjustable level is brought

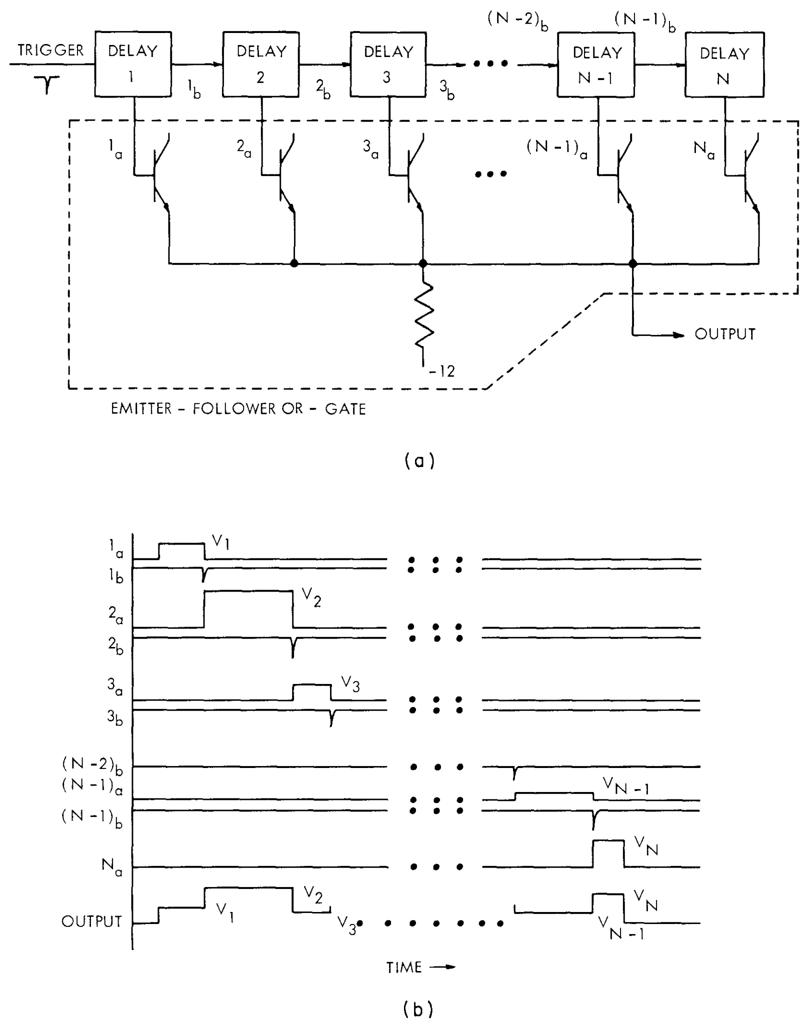

Fig. XII-1. System operation.

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out. The delay circuit, which is housed on a standard printed circuit plug-in card may be generally useful, and since it is inexpensive and easy to build, it is reported here in some detail.

A block diagram of the rectangular-wave generator appears in Fig. XII-1a. Waveforms pertinent to Fig. XII-1a appear in Fig. XII-1b. The delay circuits fire in sequence after a trigger fires delay 1. Their level outputs pass through the emitter-follower or-gate shown in Fig. XII-1a which selects the most positive of its inputs which, of course, comes from the particular delay circuit that is on at any given time. A typical output waveform is shown in Fig. XII-2.

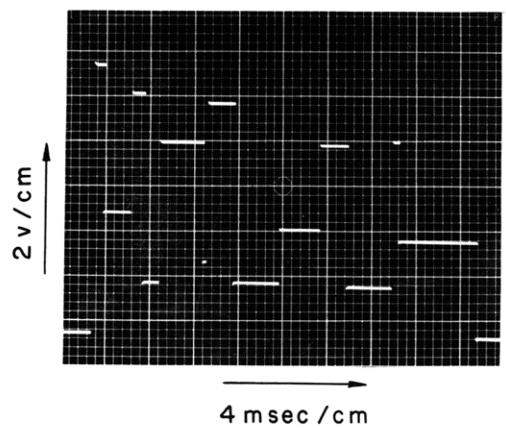

Fig. XII-2. Typical output waveform.

The detailed circuit diagram of the delay unit is shown in Fig. XII-3, in which Q_1 and Q_2 form a conventional monostable multivibrator. The range of time delay available with the values shown is from ~0.2 msec to ~8 msec. The circuit requires a trigger current of approximately 0.2 ma flowing out of the base of Q_1 in order to turn this transistor on. This means that with R_{12} = 15 K as shown, the minimum trigger pulse is approximately 3 volts negative. Lowering R_{12} lowers the required trigger voltage. The recovery time of the monostable circuit is approximately $5R_1C_1$ or 0.75 msec for the values shown. The duty cycle is thus limited on short delays. CR_3 serves to decouple the collector of Q_2 from C_2 and C_5 during the turnoff of Q_2. This hastens the fall time of the collector waveform of Q_2.

In order to trigger an identical circuit from the trailing edge of the monostable waveform, an inversion of the differentiated trigger pulse is required. This is provided by Q_3.

Q_5 acts as the contribution of this particular delay unit to the emitter-follower or-gate referred to in Fig. XII-1. Note that full advantage is taken here of the unusually high reverse base-emitter voltage rating of the 2N1306.

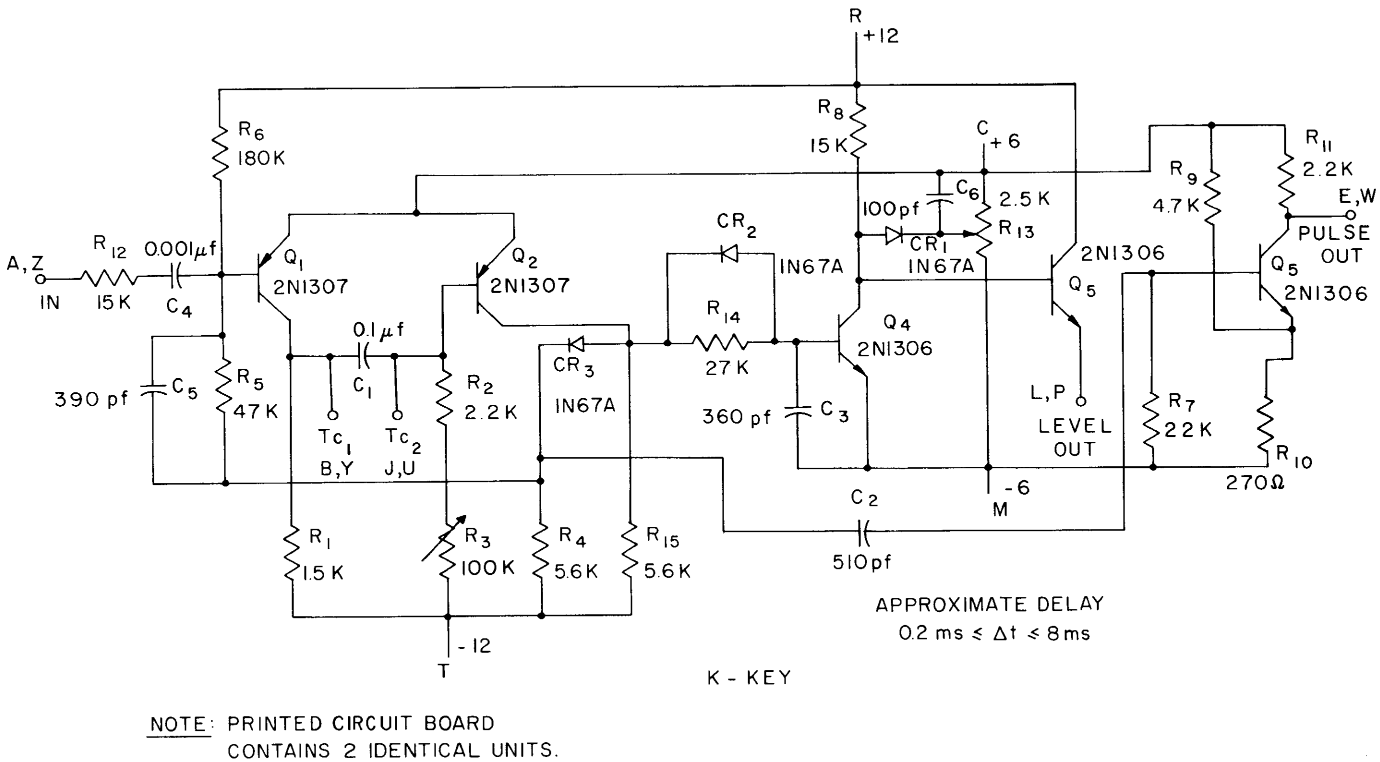

Fig. XII-3. Circuit diagram.

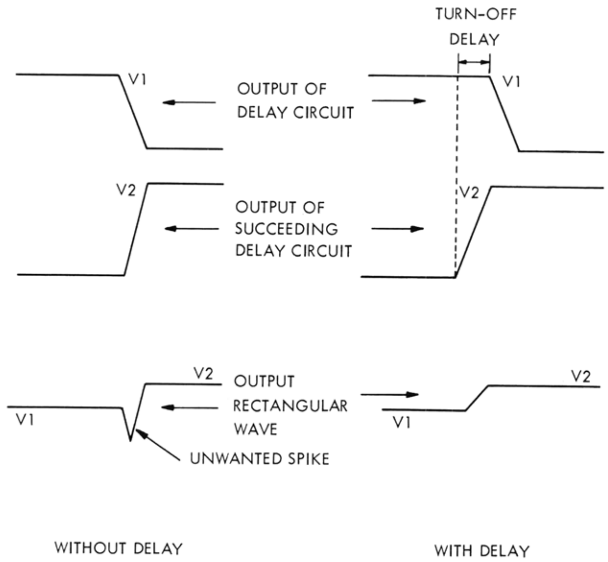

Fig. XII-4. Effect of delaying turnoff.

In order to ensure clean transitions of the output rectangular wave, it is necessary to delay the turnoff of one delay circuit until the succeeding one has come full on. This is illustrated in Fig. XII-4. In the circuit shown in Fig. XII-3, the delay of the turnoff is ~4 μsec, and is accomplished by C_3 in conjunction with R_{14} and CR_2. R_{13}

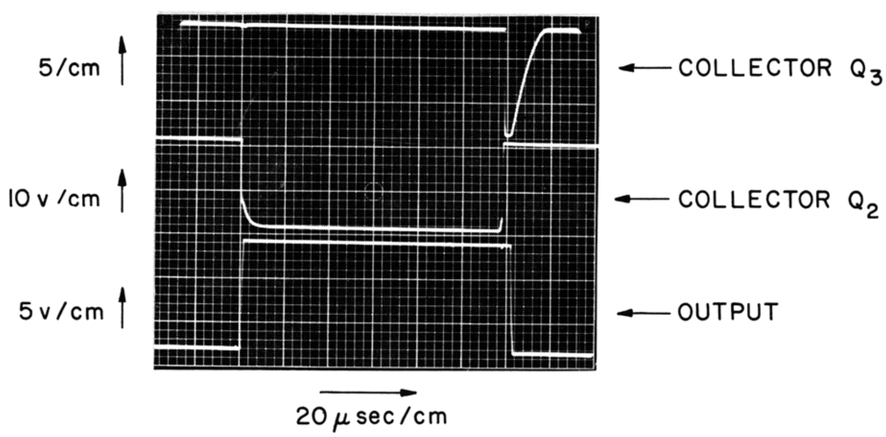

Fig. XII-5. Circuit waveforms.

determines the amplitude of that segment of the rectangular wave controlled by this delay unit. R_3 clearly controls its time duration. Actual waveforms from the circuit appear in Fig. XII-5. Rise and fall times are ~1 μsec.

The physical layout of the delay unit is shown in Fig. XII-6. The printed circuit card

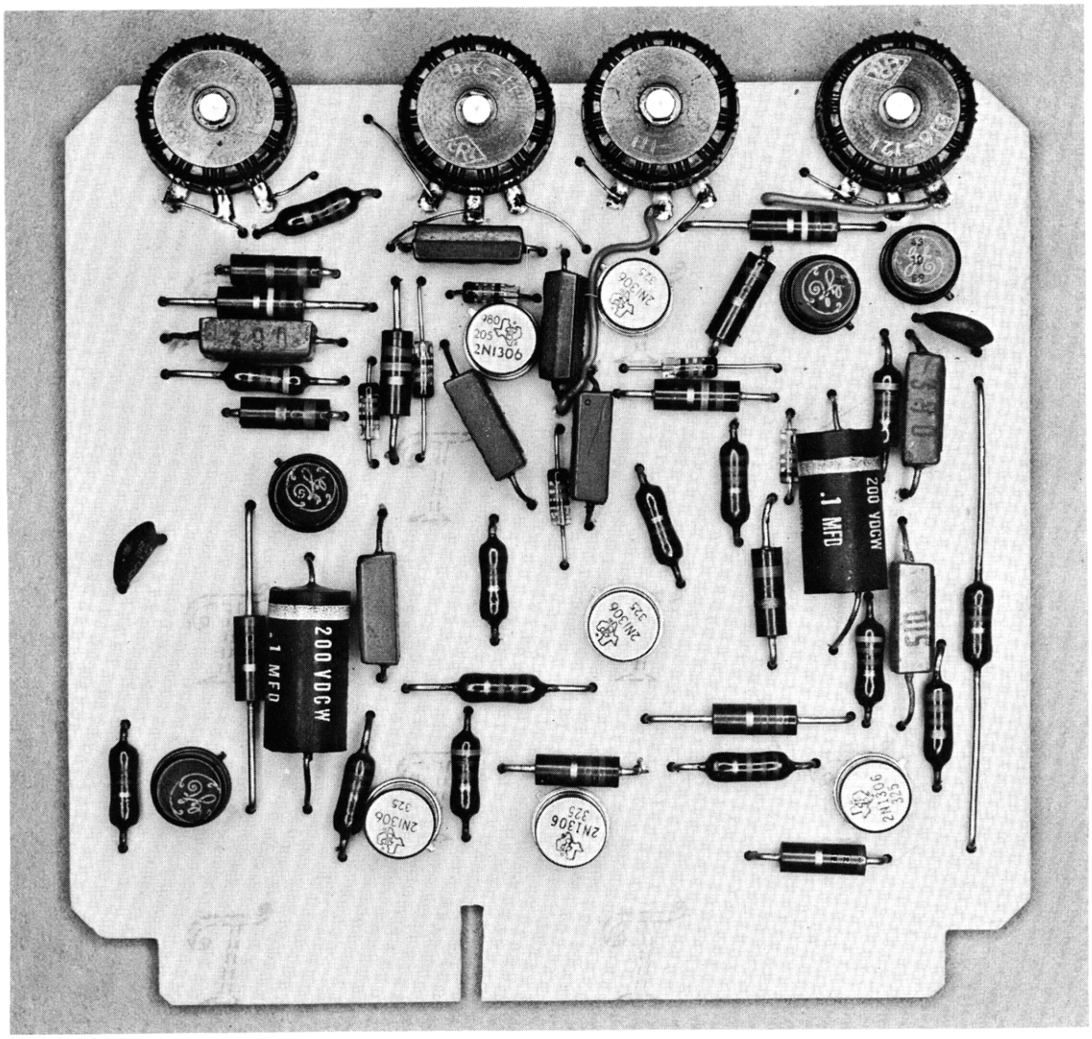

Fig. XII-6. Printed circuit card.

measures 4.2 inches × 4.375 inches, and each card houses 2 delay circuits. It mates with a standard 22-pin connector.

Power requirements for each card (2 delays) are as follows:

+12 volts,	2.5 ma
+6 volts,	32 ma
-6 volts,	17 ma
-12 volts,	17 ma

The circuit shown in Fig. XII-3 was designed to fulfill our needs; minor modifications, however, would make it suitable for other applications in which a similar waveform is needed.

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