PICOSECOND PULSE SEQUENTIAL WAVEFORM GENERATION*

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Abstract

This paper describes a novel method of generating a pulse sequence using step-recovery diodes shunting a transmission line. Individual pulses in the train may have risetimes less than 60 ps with amplitudes greater than 10 V. The many potential applications of the device include a short RF pulse generator, an FM generator, and a high-speed word generator.

Introduction

Various applications in short pulse technology, such as high resolution radar and time domain metrology utilize very short ($\lesssim$ 1 ns) RF bursts. The sequence generator described here was developed to fill the need for an electronically tuneable solid state device that would provide microwave pulses with peak-to-peak amplitudes greater than 10 V. Known means of generating an RF pulse, such as a pulse-forming network,[1] shock excited filter and travatron,[2] were unsatisfactory for this application.

Description

The device as shown in Fig. 1 consists of two parts: the sequence generator and an input-output section. The output is a chopped version of the input but with faster risetime. A simple input-output device is a filter to separate the low frequency input from the higher frequency output. A circuit diagram of the generator portion is shown in Fig. 2. The entire structure is fabricated in a TEM transmission line for dispersionless propagation. The step-recovery diodes, $D_1, D_2 \ldots D_n$ are connected in shunt across the line with polarity shown for a positive input signal and negative bias supply voltages. The number of diodes, n, depends on the number of individual pulses required with each diode producing 1 pulse, while the distance between diodes (ℓ_{12}, ℓ_{23}, etc.) determines the interpulse spacing. Each diode, D_k, has its own dc blocking capacitor C_k and bias limiting resistor R_k for individual adjustment. R_o acts as a terminating resistor for the transmission line.

The generation of a particular sequence from a combination of SRD charge depletion times and transmission line lengths can be understood with reference to the bounce diagram shown in Fig. 3(a). A unit-incident positive pulse entering the generator in the upper left corner of the figure is reflected as a negative unit pulse from the forward-biased Diode #1. After a time t_{d1}, the stored charge is depleted and Diode #1 changes state abruptly producing two positive pulses of unit amplitude traveling away from the diode. The backward pulse cancels the original negative reflected pulse for all times $t > t_{d1}$, so that the net reflection from Diode #1 is a negative pulse of unit amplitude and width t_{d1}. Meanwhile, the sharpened positive pulse continues to Diode #2, where it is reflected as a negative unit pulse and the process repeated. Note that the beginning of this second reflected pulse will follow the end of the first reflected pulse by a time $t_{12} = 2\ell_{12}/v$, where ℓ_{12} is the length of line segment between Diode #1 and Diode #2, and v is the propagation velocity. The total reflected waveform is found by summing all the reflected waves leaving the generator and is shown in Fig. 3(b).

The sequence can be easily modified by changing the bias currents. For example, if the bias is removed from Diode #2, $t_{d2} = 0$ and the start of the reflection from Diode #3 will follow the end of the reflection from Diode #1 by a time $t' = 2(\ell_{12} + \ell_{23})/v$.

Experimental Results

Several sequence generators have been constructed in microstrip in L and C-band for use as RF pulse generators. The output waveform of a six-diode C-band generator is shown in Fig. 4. In one application, this generator was used to obtain the transfer function of an isolated array phase-shift element over a 1 GHz bandwidth centered at 5.5 GHz. The spectrum was peaked to the desired center frequency by changing the bias currents to produce a 1/5.5 GHz = 182 ps period between successive peaks. The unique features of the generator, the reasonable voltage amplitudes and ease of tuning, proved especially helpful for the above application.

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References

1. G. F. Ross, "Series and Parallel Pulse-Forming Networks for the Generation of Microwave Energy," Microwave Journal, Vol. 10, p. 98, September 1967.

2. J. M. Proud, Jr., "Radio Frequency Generators," U. S. Patent 3,484,619, December 16, 1969.

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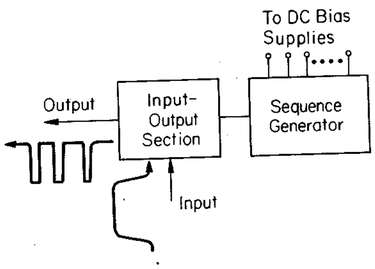

FIG. 1 Block diagram of the device.

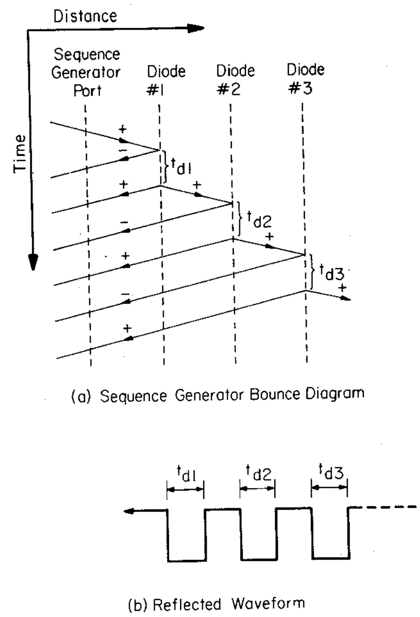

FIG. 3 Time history of sequence generation.

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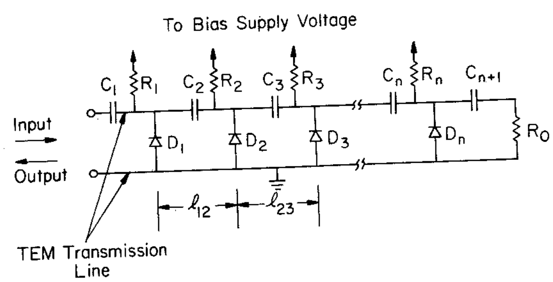

FIG. 2 Sequence generator circuit diagram.

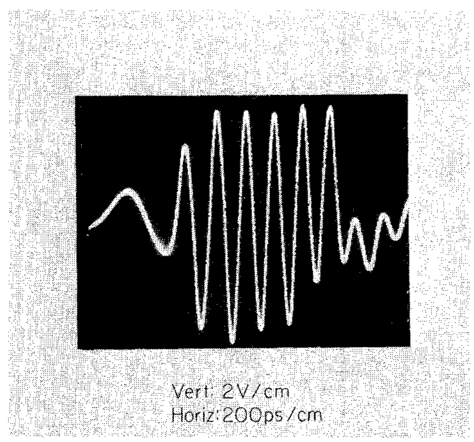

FIG. 4 C-band sequence generator waveform.