Electronics/Computers

High-Voltage, Asymmetric-Waveform Generator

This circuit would be optimized for a capacitive load.

NASA's Jet Propulsion Laboratory, Pasadena, California

The shapes of waveforms generated by commercially available analytical separation devices, such as some types of mass spectrometers and differential mobility spectrometers are, in general, inadequate and result in resolution degradation in output spectra. A waveform generator was designed that would be able to circumvent these shortcomings. It is capable of generating an asymmetric waveform, having a peak amplitude as large as 2 kV and frequency of several megahertz, which can be applied to a capacitive load. In the original intended application, the capacitive load would consist of the drift plates in a differential-mobility spectrometer. The main advantage to be gained by developing the proposed generator is that the shape of the waveform is made nearly optimum for various analytical devices requiring asymmetric-waveform such as differential-mobility spectrometers. In addition, this waveform generator could easily be adjusted to modify the waveform in accordance with changed operational requirements for differential-mobility spectrometers.

The capacitive nature of the load is an important consideration in the design of the proposed waveform generator. For example, the design provision for shaping the output waveform is based partly on the principle that (1) the potential (V) on a capacitor is given by $V = q/C$, where C is the capacitance and q is the charge stored in the capacitor; and, hence (2) the rate of increase or decrease of the potential is similarly proportional to the charging or discharging current.

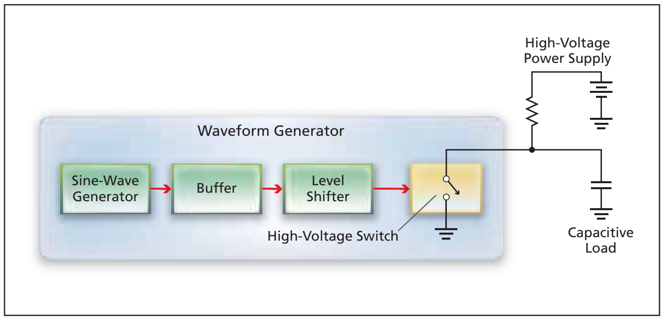


Figure 1. The **Waveform Generator** would cause the capacitive load to be alternately (1) charged from the high-voltage power supply, then (2) discharged to ground.

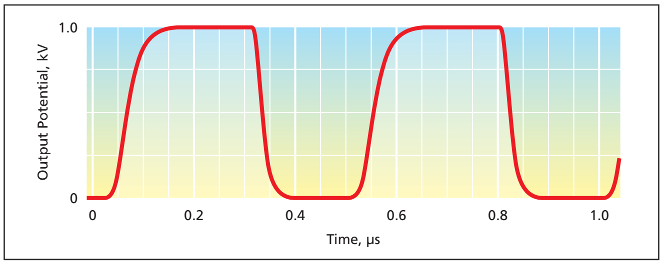


Figure 2. This **Typical Output Waveform** of the proposed waveform generator was simulated, assuming a design supply potential of 1 kV and a design frequency of 2 MHz.

The proposed waveform generator would comprise four functional blocks: a sine-wave generator, a buffer, a voltage shifter, and a high-voltage switch (see Figure 1). The sine-wave generator would include a pair of operational amplifiers in a feedback configuration, the parameters of which would be chosen to obtain a sinusoidal timing signal of the desired frequency. The buffer would introduce a slight delay (≈20 ns) but would otherwise leave the fundamental timing signal unchanged. The buffered timing signal would be fed as input to the level shifter. The output of the level shifter would serve as a timing and control signal for the high-voltage switch, causing the switch to alternately be (1) opened, allowing the capacitive load to be charged from a high-voltage DC power supply; then (2) closed to discharge the capacitive load to ground. Hence, the output waveform would closely approximate a series of exponential charging and discharging curves (see Figure 2).

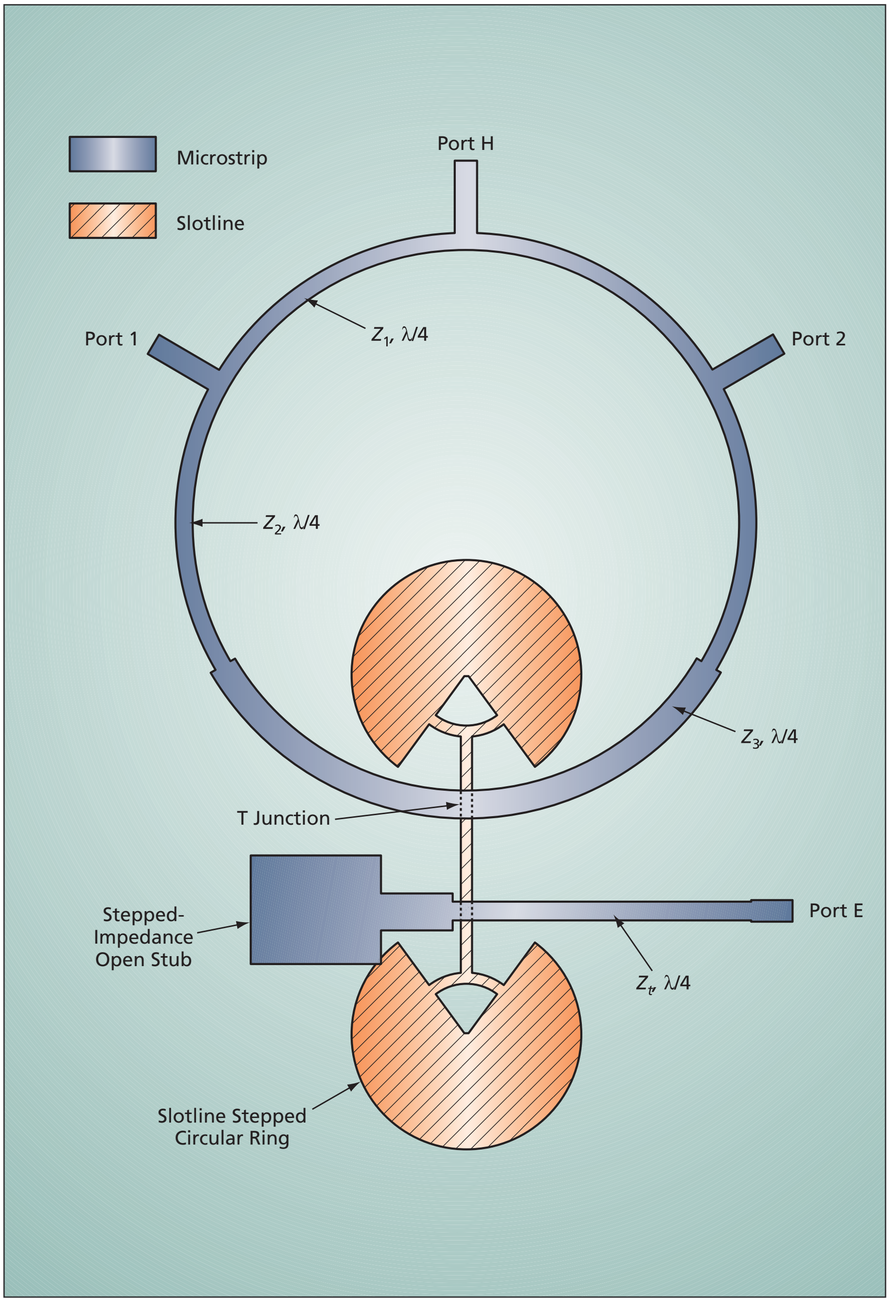
This work was done by Luther W. Beegle, Tuan A. Duong, Vu A. Duong, and Isik Kanik of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-45665

Magic-T Junction Using Microstrip/Slotline Transitions

Economical broadband junctions have potential utility in diverse microwave systems.

Goddard Space Flight Center, Greenbelt, Maryland

An improved broadband planar magic-T junction that incorporates microstrip/slotline transitions has been developed. In comparison with a prior broadband magic-T junction incorporating microstrip/slotline transitions, this junction offers superior broadband performance. In addition, because this junction is geometrically simpler and its performance is less affected by fabrication tolerances, the benefits of the improved design can be realized at lower fabrication cost. There are potential uses for junctions like this one in commercial microwave communication receivers, radar and polarimeter systems, and industrial microwave instrumentation.



The **Improved Broad-Band Planar Magic-T Junction** incorporates a unique microstrip ring structure, microstrip/slotline transitions, and impedance-matching λ/4 transmission-line sections.

A magic-T junction is a four-port waveguide junction consisting of a combination of an H-type and an E-type junction. An E-type junction is so named because it includes a junction arm that extends from a main waveguide in the same direction as that of the electric (E) field in the waveguide. An H-type junction is so named because it includes a junction arm parallel to the magnetic (H) field in a main waveguide. A magic-T junction includes two input ports (here labeled 1 and 2, respectively) and two output ports (here labeled E and H, respectively). In an ideal case, (1) a magic-T junction is lossless, (2) the input signals add (that is, they combine in phase with each other) at port H, and (3) the input signals subtract (that is, they combine in opposite phase) at port E.

The prior junction over which the present junction is an improvement affords in-phase-combining characterized by a broadband frequency response, and features a small slotline area to minimize in-band loss. However, with respect to isolation between ports 1 and 2 and return loss at port E, it exhibits narrowband frequency responses. In addition, its performance is sensitive to misalignment of microstrip and slotline components: this sensitivity is attributable to a limited number of quarter-wavelength ($\lambda/4$) transmission-line sections for matching impedances among all four ports, and to strong parasitic couplings at the microstrip/slotline T junction, where four microstrip lines and a slotline are combined.

The present improved broadband magic-T junction (see figure) includes a microstrip ring structure and two microstrip-to-slotline transitions. One of the microstrip/slotline transitions is a small T junction between the ring and a slotline; the other microstrip/slotline transition effects coupling between the slotline and port E. The smallness of the T junction and the use of minimum-size slotline terminations help to minimize radiation loss. An impedance-transformation network that includes multiple quarter-wavelength sections is used to increase the operating bandwidth and minimize the parasitic coupling around the microstrip/slotline T junction. As a result, the improved junction has greater bandwidth and lower phase imbalance at the sum and difference ports than did the prior junction.

The upper portion of the ring between ports 1 and 2, consisting of two $\lambda/4$ transmission-line sections that have a characteristic impedance of Z_1 and meet at port H, serves as an in-phase combiner. The portion of the ring below ports 1 and 2 consists of two pairs of $\lambda/4$ transmission-line sections having characteristic impedances of Z_2 and Z_3 connected in series and meeting at the T junction. These sections are used to transform between the microstrip and the slotline, which has a characteristic impedance of Z_{sl}. The slotline is terminated at both ends with stepped circular rings to provide a broadband virtual open circuit. Finally, the slotline output is transformed to a microstrip output at port E by use of a microstrip-slotline transition.

An experimental version of this junction, optimized for operation at a nominal frequency of 10 GHz, was built and tested. The experimental results show that this junction functions over the frequency band from 6.6 to 13.6 GHz (as defined by falloff of 1 dB) with an insertion loss of less than 0.6 dB, phase imbalance of less 1°, and amplitude imbalance of less than 0.25 dB.

This work was done by Kongpop U-yen, Edward J Wollack, and Terence Doiron of Goddard Space Flight Center. Further information is contained in a TSP (see page 1). *GSC-15470-1*