[54] SPARK GAP NANOSECOND PULSE GENERATOR

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[57] ABSTRACT

An apparatus for generating a short duration higher peak voltage pulse from a basic lower pulse voltage of longer duration. A series of spark gaps are arranged such that the total voltage from the basic long duration pulse is applied to each gap in succession. A delay line with a fixed delay which is equal to the total breakdown time of all the other gaps is connected across each spark gap.

2 Claims, 1 Drawing Figure
SPARK GAP NANOSECOND PULSE GENERATOR

BACKGROUND OF THE INVENTION

The present invention relates broadly to a pulse generator apparatus and in particular to a spark gap pulse generator producing a short duration higher peak voltage pulse.

In the prior art, impulse generators have been utilized to produce high voltage pulses and in general, comprise parallel arrangement of capacitors to be charged to a particular voltage. By this technique a very high-voltage impulse may be obtained and the actual voltage is dependent upon the charging voltage and the number of capacitors. The charging current and the shape of the impulse voltage waveform are controlled through the use of resistors in association with the capacitors.

Prior art devices to produce high-voltage pulses with short duration have been produced from spark equipment using resonating dipoles in an insulating fluid. Such devices, however, produce sparks which are accompanied by damped waves of random phase and have a limited power output. There have been attempts to increase the power output by having a number of resonant dipoles arranged in long series arrays but it has been found that any increase which is realized is not proportional to the added number of dipoles. The foregoing devices may be termed harmonic generators in that they are oscillating devices which are by a resonating element to establish the fundamental frequency. In the application of pulsed microwaves to peak power radar systems, the resolution which is obtainable is a function of the pulse duration.

With conventional prior art techniques, it is extremely difficult to obtain pulses of durations shorter than microseconds. Further, once a voltage pulse is formed, it cannot be changed in duration without dissipating the energy which is contained in the excess length of the pulse in a useless load. The present invention provides pulse time compression and simultaneously increases the peak voltage by an amount which is proportional to the pulse width decrease.

SUMMARY OF THE INVENTION

The present invention utilizes a number of spark gaps in series with a delay line connected across each spark gap to produce a pulse of short duration and higher peak voltage from a pulse of a longer duration. The delay lines have a fixed delay equal to the total breakdown time of all the other spark gaps which are broken at later successive intervals. The present method of voltage summation provides a high peak voltage from a lower voltage pulse while the pulse duration is simultaneously shortened without any significant reduction in pulse energy.

It is one object of the invention, therefore, to provide an improved spark gap nanosecond pulse generator apparatus having a pulse time compression while simultaneously increasing the peak voltage of the pulse by substantially the same proportion as the pulse width decrease.

It is another object of the invention to provide an improved spark gap nanosecond pulse generator apparatus wherein the total pulse voltage is the voltage summation of a series of spark gaps in succession.

It is yet another object of the invention to provide an improved spark gap nanosecond pulse generator apparatus having a delay line which is connected across each spark gap with a fixed delay equal to the total breakdown time of the sum of the gaps which are broken down at later intervals.

These and other advantages, objects and features of the invention will become more apparent from the following detailed description when taken in conjunction with the illustrative embodiment in the accompanying drawing wherein, the FIGURE is a schematic diagram of the spark gap nanosecond pulse generator apparatus in accordance with this invention.

DESCRIPTION OF PREFERRED EMBODIMENT

Referring now to the FIGURE, there is shown a spark gap nanosecond pulse generator apparatus having a high-voltage pulse generator 10 to provide an electrical impulse voltage. A voltage 12 having a pulse width σ and an amplitude E₀ is applied by pulse generator 10 to spark gap 14a. When the spark gap 14a breaks down in relation to the applied voltage pulse 12, the resultant voltage waveform is applied to delay line 16a which has a delay time equal to σ. The delayed waveform is then applied to spark gap 14b which breaks down and applies the waveform to delay line 16b where it is further delayed. The spark gap breaks down and the voltage waveform delay process continues in spark gaps 14c-14n and delay lines 16c-16n in a similar manner until all the spark gaps and delay lines have been utilized. The delay lines 16a-16n have resistors 18a-18n to connect them to each other respectively and to the pulse generator 10. The output waveform which is of a substantially shorter pulse width and higher peak voltage than the applied input pulse 12 is formed between terminals 20 and 21 which sums up all the individual pulse voltages on the individual delay-line outputs. The character in which is utilized to describe the last of the series spark gap and delay line may be any positive integer greater than one. The connection between spark gap 14f, delay line 16f and spark gap 14n, delay line 16n is schematically shown as broken to further emphasize that any desired length of spark gap delay line combination may be utilized.

The spark gap pulse generator apparatus utilized the rise time of the voltage pulse from the generator 10 across the open or untriggered spark gap to determine the pulse width and the transit times needed in a number of delay lines in order to add the pulses which are developed across a number of gaps in series. The statistical variations in the breakdown time in the series of spark gaps is optimized by proper gap electrode design, adequate over voltaging and gas input rise times to the spark gap-delay line array. The delay lines 16g-16n vary inversely with the order in which they appear in the array. The delay time variation of each delay line 16g-16n is determined by the formative time which is required for each successive spark gap to break down. The various factors, such as the pressure of the gas which surrounds the gap, the electrode material, the electrode condition, all influence the breakdown time but in general a delay time of approximately 10 nanoseconds may be expected. The statistical variation in the onset of triggering which establishes the beginning of the fall time for the pulse voltage AC across any spark gap or the beginning of the rise time for the voltage pulse across the following spark gap may be critically adjusted through the spark gap opening and the delay line delay time. Further, it is possible to reduce this statistical variation to very small values (e.g., less than 5 nanoseconds) by a number of techniques. For example, ultraviolet light photon priming may be utilized to aid electron avalanche in the spark gap area or a number of sharpening spark gaps may be utilized in series with the main pulse cable just prior to spark gap 14a to reduce the variation in spark gap firing time.

While in accordance with the provisions of the statutes, we have illustrated and described the best forms of the invention now known to us, it will be apparent to those skilled in the art that changes may be made in the form of the apparatus disclosed without departing from the spirit of the invention as set forth in the appended claims, and that in some cases certain features of the invention may be used to advantage without a corresponding use of other features.

1 claim:

1. A spark gap pulse generator apparatus for providing a short pulse width higher peak voltage pulse form a longer pulse width lower peak voltage pulse comprises in combination:

A pulse generator for providing input pulses;

A plurality of spark gaps connected in series with said pulse generator to receive said input pulses;

A plurality of delay lines arranged in parallel with respect to said pulse generator, one end of said plurality of delay lines being connected respectively between said plurality of spark gaps to delay said input pulse prior to application
3. A spark gap pulse generator apparatus as described in claim 1 wherein said plurality of delay lines have delay times which vary inversely with the order in which they appear with respect to their spark gaps.

4. A second terminal connected to an output delay line-resistor pair, said second terminal providing the low-voltage output for said pulse generator.