Tittle: 200 Characters

A Novel Ultrashort Electric Field Pulse Generator using Avalanche Breakdown Transistors and the Open Circuit Transmission Line Technique for Nanosecond Electroporation.

Body 3000 Characters

Ultrashort electric field pulses with steep symmetrical rise (t_r) and fall (t_f) times of less than 2ns have been generated using the open-circuit co-axial transmission line (TL) technique in conjunction with a stack of low-cost avalanche transistors (AT) to operate as a fast switch.

Pulse generation is possible by using a TL as a low-cost high Q storage element consisting of distributed inductors (L) and capacitors (C). By discharging an open-ended line through a fast switch, provides a means of producing a pulse with t_r/t_f of less than 2ns. The TL with a characteristic impedance Z_0, and an associated delay time T (function of L-C), is charged to voltage level V_{cc} through resistor R_C. The charged TL is discharged through a load resistance R_L by closing a switching element. The switching element determines the t_r of the pulse. Assuming $Z_0=R_L$, the amplitude of the voltage pulse is $V_{CC}/2$ and the pulse width is 2T. Essentially, the relationship between Z_0 and R_L imitates a potential divider circuit, where $V_L=(R_L/(R_L+Z_0))V_{cc}$

AT can be configured as high speed, high current/voltage switches, t_r as low as 300ps can be achieved if good practice microwave component layout techniques are considered when it comes to connecting the transistors in series (minimisation of lead inductances and additonal capacitance due to PCB layout are important considerations). In the design presented here, a FMMT417 AT is used, with avalanche breakdown voltages BV_{CEO} of 100V and BV_{CBO} of 320V. Utilising a single AT with a charged TL, the maximum amplitude of the pulse, $V_{Lmax,}$ is limited to $BV_{CBO}/2$ and staking ATs in series results in a pulse voltage of V_{Lmax} x n, where ‘n’ is the number of transistors in the stack number of AT required to generate a specific pulse amplitude is determined by $2V_{Lmax}/\ BV_{CES}$.

Initially, all staked AT are in there off-state, but when a positive trigger signal is applied to the base of the first AT the collector voltage will be near ground potential. This overvolts the second AT to create the desire condition. This causes a knock-on effect to the next AT resulting in the overvolting of the third AT and so on. When the final AT stage is turned ON, a fast t_r is produced at the load, thus allowing the TL to discharge through R_L generating a pulse with:

- Pulse width = 2T: Determined by the TL length;
- Pulse Amplitude = $0.5V_{CC}/2$. Require specific number of stacked AT;
- Repetition frequency determined by the trigger signal (the fastest repetition frequency is limited by the TL time constant).
- Positive going pulse if the R_L is placed between the first AT emitter and ground; Negative going pulse if R_L is placed between the TL outer conductor and ground;

The use of conventional components and techniques allows for a cost-effective solution in developing an ultrashort electric field pulser in comparison to commercially available generators.

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