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High voltage high repetition rate pulse using Marx topology

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Abstract. The paper describes Marx topology using MOSFET transistors. Marx circuit with 10 stages has been done, to obtain pulses about 5.5KV amplitude, and the width of the pulses was about 30μsec with a high repetition rate (PPS > 100), $V_{dc} = 535$VDC is the input voltage for supplying the Marx circuit. Two Ferrite ring core transformers were used to control the MOSFET transistors of the Marx circuit (the first transformer to control the charging MOSFET transistors, the second transformer to control the discharging MOSFET transistors).

Key words. Marx Topology, MOSFET transistors, High Voltage Pulse

1. Introduction

The conventional Marx is not suitable for most of the applications because it needs long charging time (the charging current flows through the charging resistors), Low efficiency, Low repetition rate, few output voltage appearance in charging period, "turn off" is impossible because of using the spark gap switches, short life time of the spark gap switches [1-5].

2. Experimental Setup

Fig.1 demonstrates the Marx circuit with two stages (in our case we have 10 stages). The MOSFET transistors (Tch1-Tch10) constitute a charging group, and the MOSFET transistors (Tdisch1-Tdisch10) constitute the discharging group. (C1-C10) are the storage capacitors.

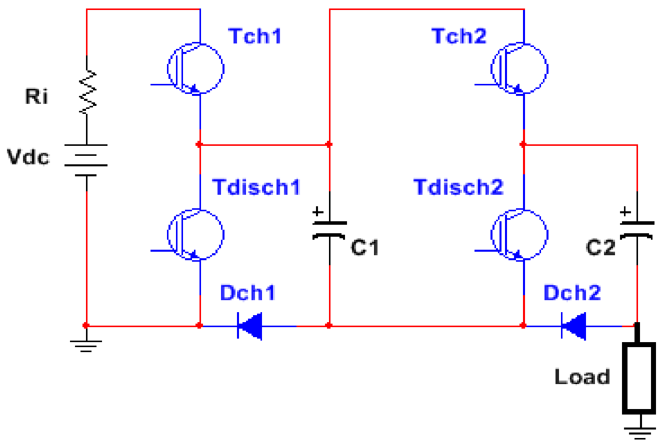

Figure 1. Marx circuit with two stages

Fig.2 demonstrates the equivalent charging circuit with two stages (in our circuit we have 10 stages). In this case of the MOSFET transistors (Tch1-Tch10) are in "turn on" position, and the MOSFET transistors (Tdisch1-Tdisch10) are in "turn off" position. All capacitors (C1- C10) are charged via diodes (Dch1-Dch10). For example, the capacitor (C1) is charged via the diode Dch1.
The input DC voltage is given by:

$$V_{dc} = V_{IN} \approx 1.41V_{p-p} \approx 535\text{V}$$

Where $V_{p-p} = 380V$ is a phase to phase voltage.

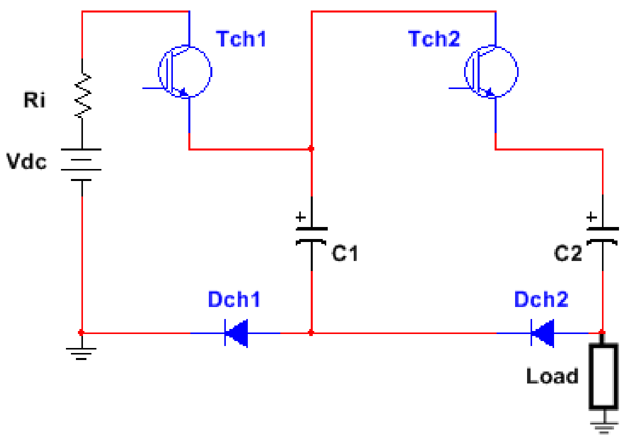

Figure 2. Equivalent charging circuit with two stages

Fig.3 demonstrates the equivalent discharging circuit with two stages (in our circuit we have 10 stages). In this case the MOSFET transistors (Tdisch1-Tdisch10) are in "turn on" position and the

MOSFET transistors (Tch1-Tch10) are in "turn off" position. All capacitors (C1- C10) are discharged via the load resistance.

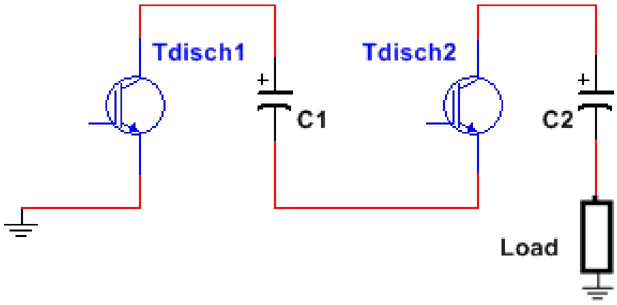

Figure 3. Equivalent discharging circuit with two stages

Note that the charging voltage of each capacitor is V_{dc}.
Fig.4 demonstrates the all signals of Marx circuit.
The output voltage is given by:

$$V_0 \approx \text{n}.V_{dc} \approx 5.5\text{KV}$$

Where n: Number of stages (in our case $n = 10$)
t_c: off time (charging time).
t_d: on time (discharging time).

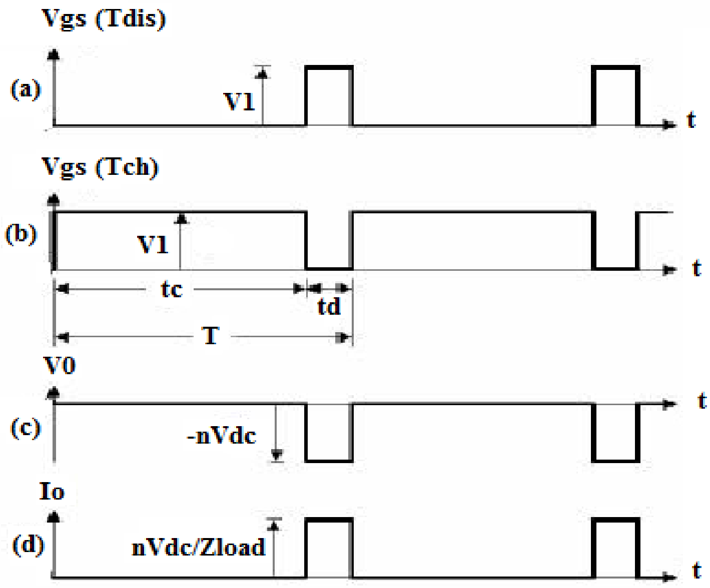

Figure 4. Signals of Marx circuit
(a) Control signals of the transistors T_{disch1} - $T_{disch10}$, (b) Control signals of the transistors T_{ch1} - T_{ch10}, (c) Output voltage pulse, (d) Output current pulse

Fig.5 demonstrates the control circuit of the MOSFET transistors (charging). The input control signal U1 of the circuit originates from the control unit.
The transformer T1 generates the pulses Vgs1-Vgs10 (as shown in Fig.4-b) in order to control the MOSFET transistors (Tch1-Tch10). It means that all transistors (Tch1-Tch10) are in same position.
During the charging period, all the transistors (Tch1-Tch10) are in “turn on” position. On the other hand, all the transistors (Tdisch1-Tdisch10) are in “turn off” position as shown in Fig.2.

The storage energy in the capacitors given by [6]:

$$E_C = \frac{n}{2} C_i {V_{dc}}^2$$

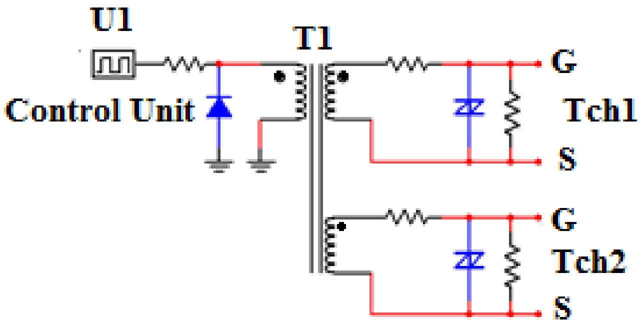

Figure 5. A control circuit (two stages) of the MOSFET transistors (Charging)

Fig.6 demonstrates the control circuit of the MOSFET transistors (discharging), where the input control signal U2 of this circuit originates from the control unit.
The transformer T2 generates the pulses Vgs1-Vgs10 (as shown in Fig.4-a) to control the MOSFET transistors (Tdisch1-Tdisch10). It means that all transistors (Tdisch1-Tdisch10) are in same position.
During the discharging period all the transistors (Tdisch1-Tdisch10) are in “turn on” position and all the transistors (Tch1-Tch10) are in “turn off” position. This is shown in Fig.3.
The pulse energy during the discharging period t_d is given by [7]:

$$E_{Pulse} = nV_{dc} i_o t_d$$

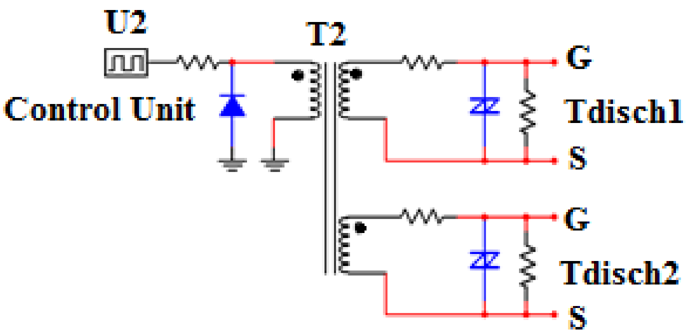

Figure 6. A control circuit (two stages) of the MOSFET transistors (Discharging)

3. Conclusion

Marx circuit with 10 stages was made, in order to obtain pulses that have the amplitude of about 5.5KV, and the width of the pulses is about 30μsec with high repetition rate ($\text{PPS} > 100$). $V_{dc} = 535\text{VDC}$ is the input voltage used for supplying the Marx circuit. Two Ferrite ring core transformers were used to control the MOSFET transistors. The circuit shown in Fig.1 had a very short charging time, high efficiency, and a high repetition rate. These pulses can be used in many applications such as a plasma ignition, flash lamp trigger.

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