DEVELOPMENT OF AN RF CIRCUIT AMPLIFIER FED BY A LOW POWER NONLINEAR TRANSMISSION LINES

L. P. SILVA NETO[1], H. M. MORAES[1], J. O. ROSSI[2], J. J. BARROSO[2], E. G. L. RANGEL[2] AND A. F. CONCEIÇÃO[1]

[1]FEDERAL UNIVERSITY OF SÃO PAULO, INSTITUTE OF SCIENCE AND TECHNOLOGY , S.J. CAMPOS, SP, BRAZIL.

[2]NATIONAL INSTITUTE FOR SPACE RESEARCH, ASSOCIATED PLASMA LABORATORY, S. J. CAMPOS, SP, BRAZIL.

OBJECTIVE

The objective of this paper is to amplify the voltage modulation depth -VMD of soliton oscillations generated by a low power capacitive NLTL. For this, an amplifier using a MOSFET technology switch was designed. The MOSFET used was the RD06HVF1 model manufactured by Mitsubishi Electric Corporation.

INTRODUCTION

Recently Nonlinear Transmission Lines (NLTLs) have been studied for several applications such as in satellite communications, military radars and biomedical area. This system is interesting due to its simple construction with the use of passive components composed by a network of inductors and varactor diodes as a nonlinear medium. The line using a varactor diode produces a soliton oscillation with Voltage Modulation Depth (VMD) of the order of 10.7 V and a frequency near 33.3 MHz. In this work the goal is to amplify the VMD produced by a low power NLTL using MOSFET technology. MOSFET technology is widely used to make integrated circuit due to their faster switching and smaller size than Bipolar Junction Transistor (BJT), allowing construction of devices (processors and memories) with reduced size. Other technology characteristics are high impedance input, of the order of some tens of megaohms, better stability in temperature compared to BJT, and control by voltage. However, the disadvantage is its electrostatic voltage sensibility due to the silicon dioxide used to isolate the gate terminal of the substrate. The results show a good perspective using a MOSFET switch to obtain higher VMD of oscillations.

EXPERIMENTAL SETUP

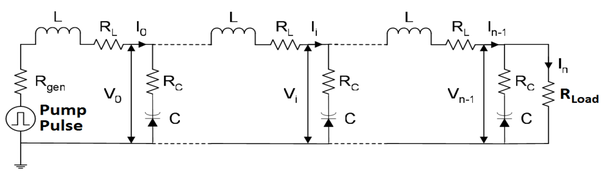

Fig. 1. A standard varactor diode line used to produce RF in the MHz range.

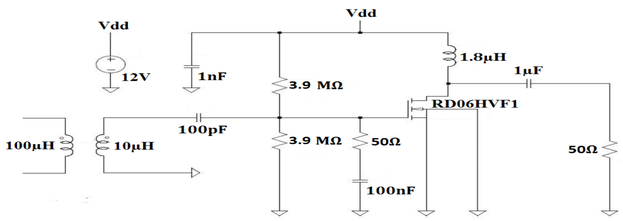

Fig. 2. Power amplifier circuit using a MOSFET RD06HVF1.

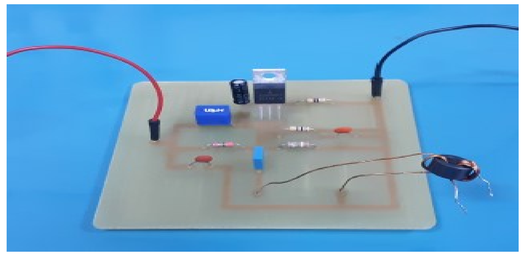

Fig. 3. Power amplifier circuit on a PCB.

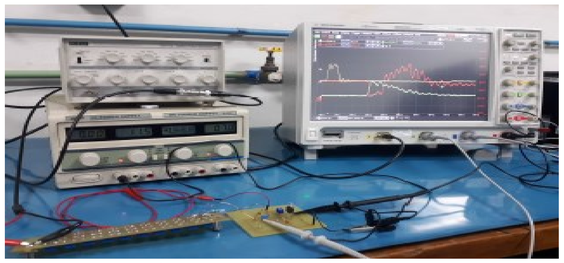

Fig. 4. Experimental setup using a pulse generator, NLTL, source, power amplifier and oscilloscope.

SIMULATION AND EXPERIMENTAL RESULTS

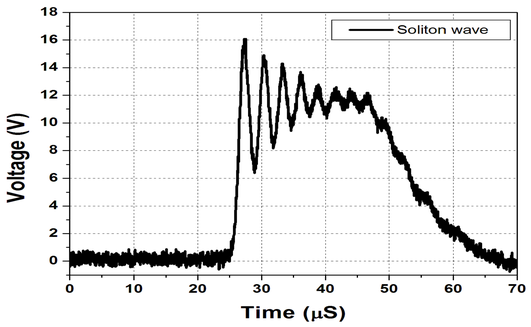

Fig. 5. Soliton oscillations obtained at the NLTL output.

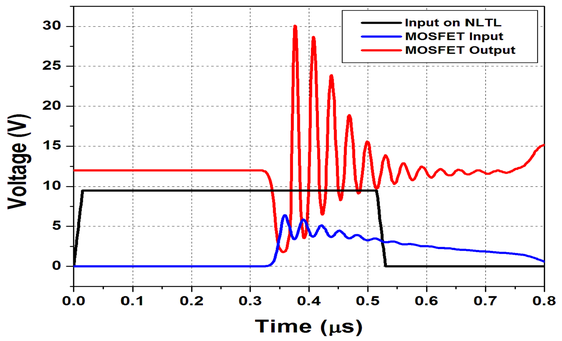

Fig. 6. Simulation result for solitons amplified by MOSFET using a 50 Ω load.

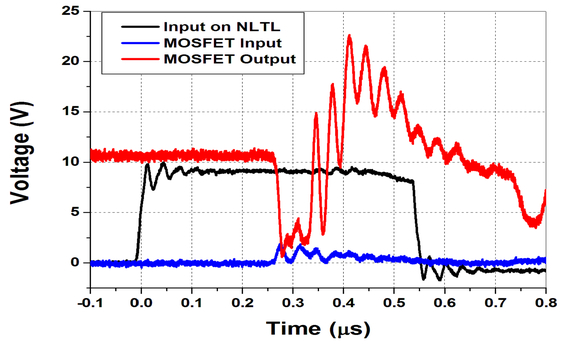

Fig. 7. Experimental result for solitons amplified by the MOSFET using a 50 Ω load.

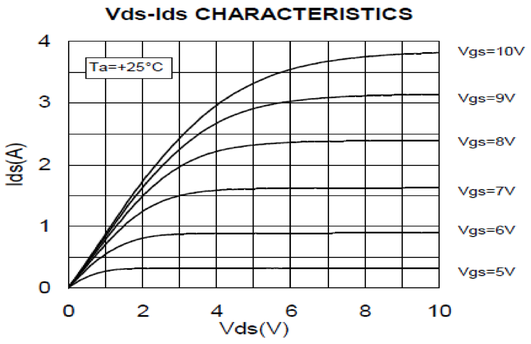

Fig. 8. Polarization curve of the RD06HVF1 MOSFET.

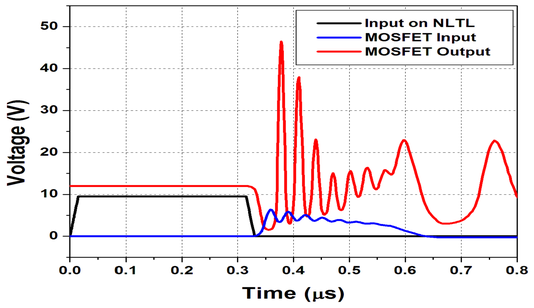

Fig. 9. Simulation result for solitons amplified by the MOSFET using a 1 kΩ load.

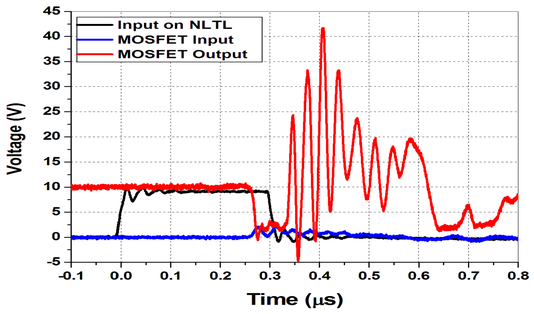

Fig. 10. Experimental result for solitons amplified by MOSFET using a 1 kΩ load.

Table 1. Parameters obtained from Figs. 7 and 8 using the MOSFET with a 50 Ω load.

Parameter	Simulation	Experimental
No. of oscillations	6	3
No. of oscillations	9	9
Frequency (MHZ)	33.3	31.2
VMD input (V)	3.01	1.72
VMD output (V)	26.63	12.07
Gain (dB)	18.94	16.92

Table 2. Parameters obtained from figs. 10 and 11 using the MOSFET with 1 kΩ load.

Parameter	Simulation	Experimental
No. of oscillations	6	6
No. of oscillations	7	7
Frequency (MHZ)	33.3	33.3
VMD input (V)	3.03	1.94
VMD output (V)	43.53	36.81
Gain (dB)	23.14	25.56

RESULTS AND DISCUSSION

In the Fig. 5, it is shown soliton oscillations generated by the NLTL with the VMD of the order of 10.7 V and frequency of 33.3 MHz. The LTSpice software was used to simulate the NLTL, by setting the pulse input amplitude at 10 V, rise time near 10 ns and pulse duration at 500/300ns (see corresponding black lines in the Figs. 6 and 9). The same setting was taken for the experimental results shown in Figs. 7 and 10. The NLTL output pulse is applied to the input of the amplifier as presented by the blue line and the amplified pulse obtained on the load is shown by the red line. The simulation results are presented in Figs. 6 and 9 and the experimental results in Figs. 7 and 10. In Fig. 8, it is shown the polarization curve of the MOSFET using a VGS (Voltage across the Gate to Source) higher than 5 V, which is the minimum value to obtain IDS >0. Tables 1 and 2 summarizes and compares the simulations with the experimental results showing the main parameters such as number of oscillations, VMD obtained at the input and output, generated frequency, and the gain of the amplifier in dB.

The VMD obtained at the output of the line without using the amplifier was of the order of 10.7 V. The simulation results employing the amplifier with a 50 Ω load give a VMD of about 26.63 V and with a 1 kΩ load VMD reaches 43.53 V, while the experimental results show a VMD of the order of 12.07 V and of 36.81 V for 50 Ω and 1.0 kΩ loads, respectively. The amplifier gain was taken considering the VMD ratio between the input and output. The simulation gives gains of about 18.94 dB and 23.14 dB for 50 Ω and 1kΩ loads, respectively, and the experimental results corresponding gains of the order of 16.92 dB and 25.56 dB.

CONCLUSION

In this work, it was shown that a MOSFET amplifier can increase the voltage modulation depth (VMD) of the soliton oscillations generated by a capacitive NLTL using varactor diodes as nonlinear elements. The main challenge of this wok was to match the NLTL varying impedance (increasing with the voltage) to the input impedance of the amplifier by means of a pulse transformer. Both experimental and simulation results show soliton oscillations with better VMD, of higher gain and with an increased number when using an amplifier, which means that soliton waves can propagate at longer distances if irradiated.

ACKNOWLEDGMENTS