Picosecond MODFET IC Pulse Sharpener

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Abstract

We have fabricated a monolithic synthetic transmission line pulse sharpener using a high power .25 µm InGaAs / GaAs MODFET IC process. This circuit sharpens a dc-to-5 GHz input to a pulse of at least 5 psec, 2V output transition. This first implementation of a pulse sharpening circuit in a MODFET IC process demonstrates the broadband capabilities of this technology for picosecond pulse sharpening applications.

Introduction

Recently there has been a great deal of work on fast transient generation using shock wave devices. One such device, the Nonlinear Transmission Line (NLTL) has been used to generate picosecond transients for high repetition rate sampling applications[1,2,3]. In this paper, we report the development of a new configuration of the NLTL pulse sharpener, the Nonlinear Impedance Transformer (NIT). This circuit was implemented in a MODFET IC process and demonstrated the sharpening of an input transition from over 100 psec to less than 5 psec for input rates from near DC to over 5 GHz.

Circuit Design and Fabrication

The NIT pulse sharpener [4,5] is an $L_1C_1L_2C_2$ .... synthetic transmission line network where diodes form the capacitors. Because the capacitance decreases with increasing reverse bias, the peak of the wave near zero bias will experience a greater delay than the more negative portion. As a result, the falling edge will tend to steepen as it propagates until dispersion due to conductor losses, line periodicity, and diode parasitics just balance the compression due to the nonlinear capacitance. The NIT was fabricated using .25 µm gate P-MODFET process [6,7] that has been developed for power performance and offers a typical f_t of 50 GHz and f_{max} of 100 GHz with V_b of -10 V. The MODFET NIT schematic is shown in Fig. 1.

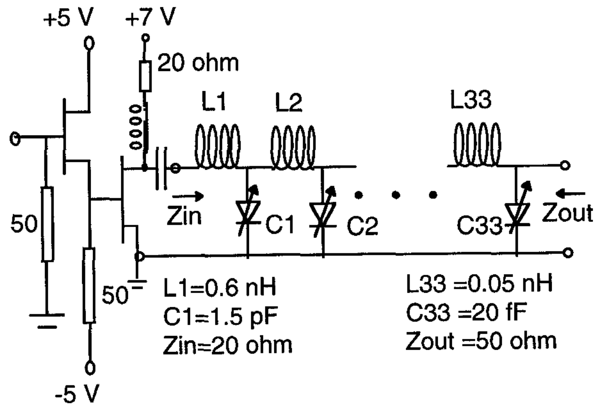

Fig 1. Schematic of the MODFET IC pulse sharpener

It consists of a 1.6 mm predriver FET and a 3 mm power FET followed by 33 LC sections which transforms smoothly the 20 ohm impedance of the power FET to 50 ohm as shown in Fig. 2. Furthermore, the time constant associated with each LC section has been transformed from the 100 psec input transition to the faster output transition in order to improve the efficiency of the device, minimizing both loss and area.

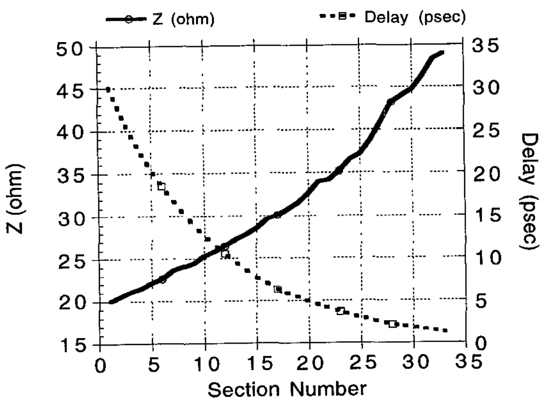

Fig. 2. MODFET IC NIT design (delay and impedance of each LC section)

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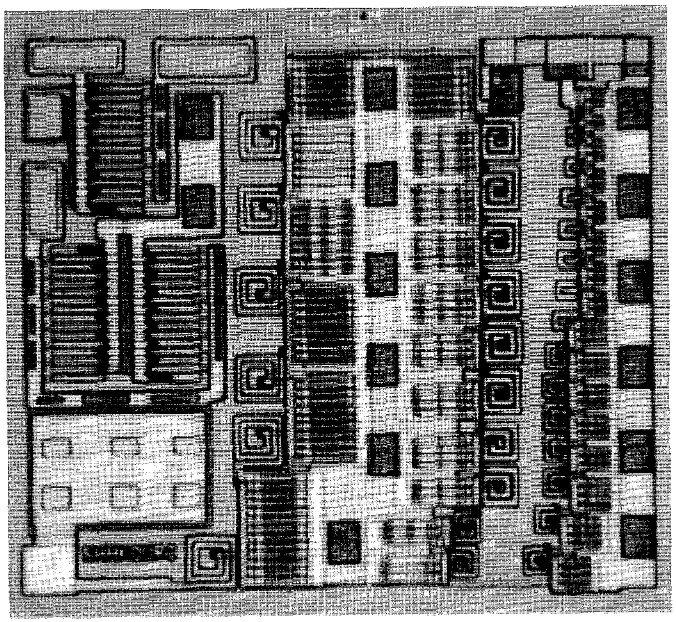

Fig. 3. Photograph of the MODFET IC pulse sharpener

All inductors greater than 150 pH were minimum area high Q spiral inductors. A high impedance microstrip transmission line was used for smaller inductors. The diodes were formed by connecting the drain and source of the .25 μm MODFET. The diode zero bias capacitance was 1400 fF/mm and the ratio of diode capacitance ratio C(+.7V) / C(-1.4 V) was measured to be 4. The ratio of the output fall time over the input fall time of each section was approximated to be 0.9 using the disperse-compress model of the NLTL[8]. Using the first estimate of the values of inductances and capacitances, an SPICE simulator was used to optimize the circuit performance. The MODFET NIT photograph is shown in Fig. 3.

Circuit Performance

The MODFET NIT was mounted on a 50 GHz HP modular package and the output waveform was measured by a 50 GHz HP71500 microwave transition analyzer. The output transition was less than 10 psec when the NIT circuit was driven with HP8133A pulse generator for rep rates from 500 MHz to 3 GHz. A 6 psec, 2V output transition was measured when the NIT circuit was driven by a 2-5 GHz microwave source as shown in Fig. 4. This 6 psec system rise time is the root-mean-square convolution of the NIT circuit, the microwave transition analyzer and the package rise times. Therefore, the MODFET NIT has at least 4-5 psec output transition time. By extending the bias circuitry, this circuit can be driven from DC - 5 GHz with less then 10 psec output transition.

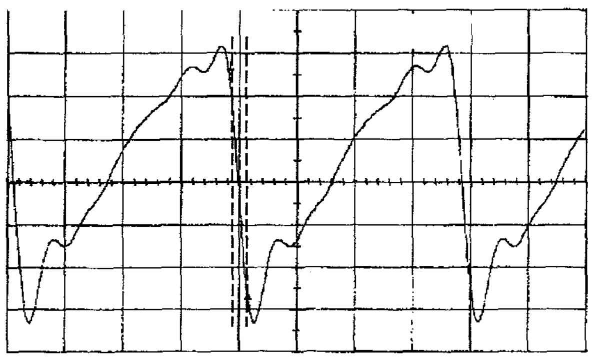

Fig. 4. 6 psec output transition time and 2 V amplitude at the output of a MODIC NIT pulse sharpener when driven by a 3 GHz microwave source

Conclusion

We have fabricated a 5 psec, 2 V output transition pulse sharpener circuit with input rates near DC to over 5 GHz using a high power .25 μm InGaAs / GaAs MODFET IC process. This pulser can be driven from a commercial pulse generator with less than 10 psec output transitions. This design is the first pulse sharpening circuit that has been implemented in a MODFET IC process.

Acknowledgement

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