A Picosecond Pulse generator Using SRD diodes: Design, Analysis, and Measurements

Daniel Oloumi and Elise Fear

Schulich School of Engineering, University of Calgary, Calgary, Alberta, Canada

***Abstract*—In this paper, generating a sub-nanosecond Gaussian pulse using a very simple circuit configuration is demonstrated. The design is based on SRD diodes fed with a sinusoidal input. The generated pulse is a Gaussian with a full width at half maximum (FWHM) of 286ps and 1.586V of amplitude. Circuit operation is studied through multiple simulations and measurements.**

***Index Terms*—UWB radar, high spatial resolution, SRD based pulse generator.**

I. INTRODUCTION

Ultra-wideband (UWB) radar technology is a generation of radar systems with the ability to provide high resolution by operating based on short electromagnetic pulses. UWB radar technology holds great potential for a variety of applications [1], [2].

Properties of a UWB radar system are determined by in part by the characteristics of UWB pulses, typically pulse width and shape [3]. A variety of methods have been proposed to generate UWB pulses based on different application requirements including: fast switching devices such as complementary metal-oxide-semiconductor (CMOS) architecture [4], avalanche transistors [4], field effect transistor (FET) [5], non-linear transmission lines [5], and step recovery diodes (SRD) [6]. Realizing pulse generators using SRD diodes is simpler compared to other methods since neither DC biasing or a complicated circuit such as non-linear transmission lines are required. Using SRD diodes, sub-nanosecond pulses with several volts amplitude are straightforward to attain [2].

In this paper, a pulse generator based on SRD diodes with a very simple circuit is designed, analyzed and measured. A combination of series and shunt diodes [6] is used to shape the input sinusoidal wave to a Gaussian pulse. Simulation and measurement results demonstrate the capability of this circuit to generate a high-quality Gaussian pulse suitable for imaging applications, particularly biomedical imaging, where range and cross-range resolutions of about 1cm are demanded.

II. CIRCUIT CONFIGURATION AND SIMULATIONS

A. Circuit configuration

SRD-based pulse generators can be realized with different configurations, where the diode is in series, shunt or a combination of both arrangements, shown in Fig.1 (a)-(c).

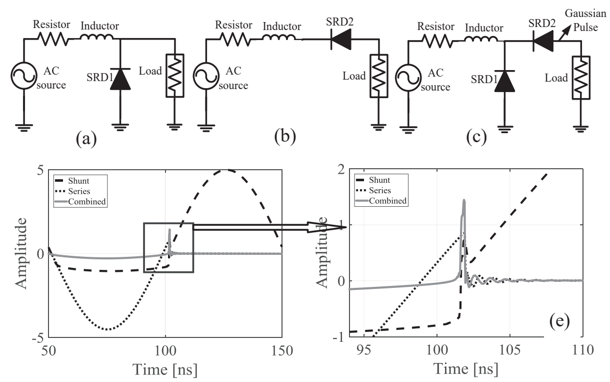

Fig.1. Circuit model for SRD based pulse generator: (a) shunt configuration, (b), series configuration, (c) mixed configuration, (d) circuit response in shut, series, and mixed configurations, (e) zoomed version of (d).

Here, the input signal is a sinusoidal wave, where the frequency determines the pulse repetition frequency, however other inputs such as square waves can be used as well. There are two different mechanisms in shunt and series formations, where an amalgamation of these mechanisms results in a Gaussian pulse.

In the shunt arrangement during the forward bias, most of the charges are accumulated across the junctions. Once the polarity changes, negative charges start accumulating across the junction and cancel out positive charges. Throughout the recombination process, the diode stays in forwarding bias. Once the charges are removed, the diode reverses the biasing in an instant of time, equal to the diode transition time, and disruptions the input signal. In the series configuration, reversed biased, the diode shows high impedance in the positive cycle and low impedance in the negative cycle. Switching from negative to positive cycle, equal to the transition time of the diode, creates a sharp step.

Combining shunt and series diodes [10] results in an overlapped area resembling the Gaussian pulse as shown in Fig. 1 (d)-(e). Note that the diode connection should be either on their anodes or cathodes. Pulse narrowness is limited by physical characteristics of diodes, namely transition time.

B. Simulations

An optimum pulse shape requires the adjusted values of input voltage and inductance. Simulations are performed

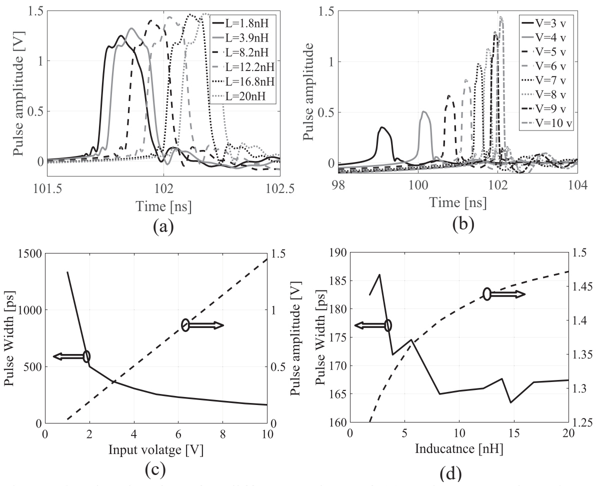

Fig.2. Simulated pulses for different values of (a) Inductance where input voltage is 10 volts, (c) Voltage, where L1 is equal to 14.7nH. Pulse amplitude and width variation based on: (c) Input voltage, (d) Inductance value

using ANSYS Electronic Desktop, by combining both circuit components and full-wave modeling. Two identical SRD diodes (MMDB30-Aeroflex) are used. Diodes with different transition times can also be used to adjust the amplitude and pulse width [7]. The input is a 10MHz sinusoidal signal. The inductor mostly adjusts the pulse amplitude and slightly impacts the pulse width. To compensate for limitation in SRD diode modeling and improve convergence of the simulations, a small series resistor (40Ω) is used while simulations; however, it is not necessary to include this component in fabrication. 50Ω microstrip transmission lines on 20 mils TMM4 are also included in simulations to consider the parasitic effects.

Pulses for different values of inductances and input voltages are shown in Fig. 2. As can be seen, increasing the inductance and input voltage produces pulses with higher amplitude and narrower width. For this circuit configuration, a minimum of 3V input is required to obtain a proper response from the diodes; however, after 8V of input, the pulse width does not change significantly. The input voltage can be increased, up to diodes' breakdown voltage, if higher pulse amplitude is required. Based on simulation results, inductance and voltage are selected as 14.7nH and 10V.

III. Fabrication and Measurements

The fabricated pulse generator is shown in Fig. 3 (a). Measurement setup contains the pulse generator, a sinusoidal signal generator, and a sampling oscilloscope. Measurements are done for different values of voltage and inductance to evaluate the operation of the designed pulse generator (Fig. 3 (a)). The optimum generated pulse by this configuration is attained with 14.7nH and 10V, which is consistent with simulation results. Simulations and measurements followed the same trend; however, pulse width, for the best case, enlarged from 168ps to 286ps. This discrepancy is mainly due to limitations in the modeling of SRD diodes and parasitic effects due to soldering.

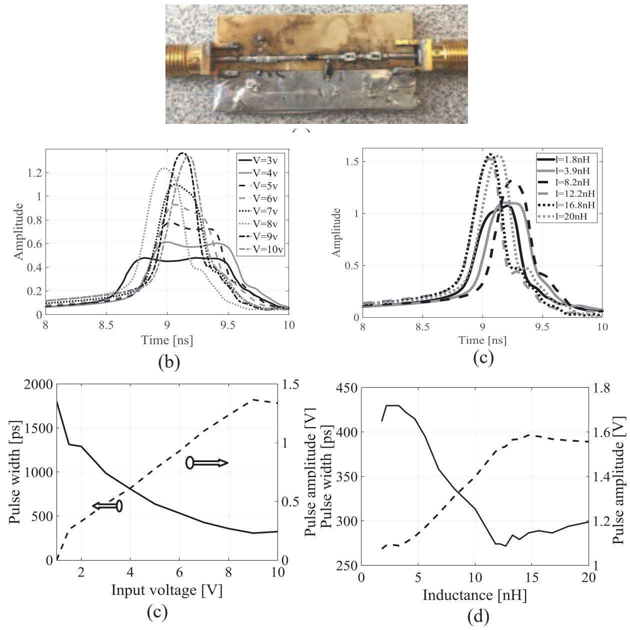

Fig.3. (a) Fabricated pulse generator. Measured pulses for different values of (b) Inductance where input voltage is 10 volts, (c) Voltage, where L1 is equal to 14.7nH. (d) Input voltage effect on pulse amplitude and width, (e) Inductance effect on pulse amplitude and width

IV. Conclusion

This paper reported a picosecond pulse generator with a simple circuit configuration based on SRD diode, without any DC biasing and using a sinusoidal input. Simulations and measurements demonstrated the ability of this circuit to generate high-quality Gaussian pulses.

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