Truly Balanced Step Recovery Diode Pulse Generator with Single Power Supply

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Abstract - A space efficient and simple circuit for ultra wideband (UWB) balanced pulse generation is presented. The pulse generator uses a single step recovery diode to provide truly balanced output. The diode biasing is integrated with the switching circuitry to improve the compactness of design. Two versions of the circuit with lumped and distributed pulse forming networks have been tested. The pulses' parameters for distributed pulse shaping network were: rise/fall time (10-90%) 168ps, pulse width (50-50%) 335ps, pulse amplitude ±880mV (11.9 dBm peak power) and for the lumped one: rise time (10-90%) 272ps, fall time (90-10%) 566ps pulse width (50-50%) 511ps, pulse amplitude ±1.6V (17 dBm peak power). In both cases excellent balance of two pulses at the output ports can be observed. It is worth to mention that above parameters were obtained with typical inexpensive RF components. The circuit reduces the complexity of the design because of lack of broadband baluns required for UWB balanced antennas. The circuit may be used as a part of an UWB transmitter.

1. Introduction

In recent times Ultra Wideband (UWB) has become an extensively researched area of modern communication. All around the world many research centres and the major electronic companies have been involved in various areas of UWB communication schemes. The main focus seems to be low power, short range, high data rate systems for personal communication. However, while these applications are important, extremely low power and low data rate systems such as sensor networks should be also considered as important application for UWB. Such applications require use of low power design, economical power management protocols etc. From a hardware designer's point of view, power efficient techniques have to be used in transceiver design. For sensor networks, achieving a small transceiver size is usually also a priority. While, an ultra wideband system is inherently rather uncomplicated at the block diagram level, further exploration shows that the hardware design is particularly demanding, because of the broadband components that need to be used in design.

Recently many efforts were put on the development of the ultra wideband generators. The most recent works focuses on the generation of the low power Gaussian monocycles [1], [2]. However the mentioned above methods for pulse generations creates pulses that approximate Gaussian monocycles quite well, they suffer from the unbalanced outputs, what in many cases needs utilization of an additional broadband balanced to unbalanced transitions. The design of the broadband baluns was presented in many publications, but the circuits are rather complicated and take a space in the final design and introduce unwanted losses [3], [4].

In this summary simple and attractive circuit for creation of truly balanced short electrical pulses (with duration less than 0.5 ns) is presented. Circuit employs only a few components – mainly passive and with proper design and components is useful in design of high power pulse generators.

2. Step recovery diode modelling

Step recovery diodes (SRD) have been extensively used in high order frequency multipliers and comb generators for many years [5]. Due to strong nonlinearities, the diode generates significant harmonic content and the desired frequency range can be obtained with the aid of microwave filters. However, such strong nonlinearity can cause serious convergence problems in harmonic balance analysis, but the model of the step recovery diode proposed by Zhang and Raisanen [6] that includes the voltage ramp occurring during the transition process, can be directly used in commercially available circuit simulators. In the work reported here, the model has been successfully implemented in the Ansoft Designer simulation package. On the basis of I-V DC measurements of the diode the capacitances can be determined and included in the modelling process [6]. The final paper will include comparison between modelling and real circuit measurements.

3. Pulse shaping network and balanced generator design

In order to achieve short in time, balanced Gaussian pulses at the output of the pulse generator properly designed pulse shaping network is needed. The circuit presented here was examined with two types of pulse shaping network – lumped and distributed. The first one is just a simple microwave capacitor of value 3.9pF that together with 50 ohm load acts as simple differentiator, the second consists of microstrip short circuited stub forming network. The second design using distributed pulse shaping network is more interesting, because creates the pulses with better symmetry around its peak value than in the lumped case. The network comprises combination of the transmission lines connected to a matched load. The idea of pulse forming is based on division of propagated wave along the transmission line between short circuited stub and the "main line" and utilization of occurring reflections to shape the output pulse. The pulse generator consists of two identical sections of the pulse forming network to achieve balanced output as it is shown in Fig.1. They were connected to anode and cathode of the SRD. Balanced "input generator – driver" created of cheap and uncomplicated, popular digital integrated circuits combines two features in one – biases and triggers SRD generator. It is worth to note that whole circuit uses only single positive 5V bias voltage. That feature is extremely useful in portable and handheld applications, where negative biasing is often simply not accessible or requires utilization of DC-DC converters.

The circuitry has been fabricated using inexpensive FR4 epoxy based substrate of a 1.6mm thickness.

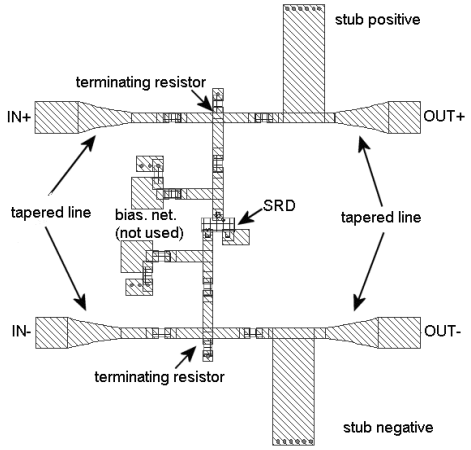

Fig 1. Layout of the SRD balanced pulse generator.

4. Measurements and results

The measured output balanced pulses in time domain are presented in Fig.2a) for the distributed pulse forming network and in Fig.2b) for the lumped one. The pulse repetition frequency was 6MHz (and was limited mainly by used square generator) and any additional biasing was omitted. The pulses' parameters are as follows:

Parameter	Distributed pulse forming network	Lumped pulse forming network
Rise/fall time (10-90%)	168ps	rise 272ps fall 566ps
Pulse width (50-50%)	335ps	511ps
Pulse amplitude	±880mV (11.9dBm -peak power)	±1.6V (17dBm peak power)

Table 1. Pulses' parameters.

It is worth to notice excellent balance of two pulses in both cases. The above results were achieved with typical inexpensive RF components and single positive power supply.

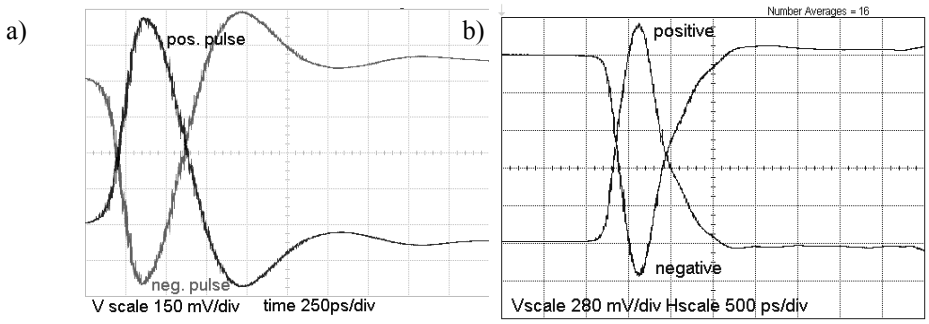

Fig 2. Balanced pulses of the distributed a) and of the lumped b) pulse shaping network.

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