ICSE 2009

PROCEEDINGS OF THE FIRST INTERNATIONAL CONFERENCE ON SCIENCE AND ENGINEERING

Volume - 1

Electronics
Electrical Power
Information Technology
Engineering Physics

Sedona Hotel, Yangon, Myanmar
December 4-5, 2009

PROCEEDINGS OF THE FIRST INTERNATIONAL CONFERENCE ON SCIENCE AND ENGINEERING

Volume - 1

Electronics
Electrical Power
Information Technology
Engineering Physics

Organized by
Ministry of Science and Technology

DECEMBER 4-5, 2009
SEDONA HOTEL, YANGON, MYANMAR

ELECTRONIC ENGINEERING

Design and Implementation of Pulse Generator Circuit for Marine Radar Application

Nang Lao Kham[#1], Zaw Min Naing[*2]

[#]Department of Electronic Engineering
Technological University (Monywa), Monywa, Myanmar
*Technological University (Maubin), Myanmar
[1]nangkham@gmail.com
[2]zawminnaing@pmail.ntu.edu.sg

Abstract— **This research work focuses on design and implementation of pulse generator circuit for marine radar application. In this research, the pulse generator is designed for generating rectangular pulses having 200 μs pulse width of which rates are 3200 pulse per second (pps) and 800 pulse per second (pps). This circuit is also designed for working in high power radio frequencies. Discrete devices are used extensively for ruggedness and robust system design. Since the stability of trigger generator is essential, performance tests were carried out by using multitestmeter, oscilloscope and frequency counter. Circuit simulation was done by using Circuit Maker Version 2000 software. Experimental results are analyzed and compared with the theoretical findings and simulation results. The investigation shows that the results were found to be within the rated value of 3200 ± 32 Hz and 800 ± 8 Hz.**

Keywords— **Pulse Generator, pulse width, pulse per second (pps), Pulse Repetition Frequency (PRF), Pulse Repetition Rate (PRR)**

I. INTRODUCTION

Pulse generating section plays a major role in the Transmitter Portion of Radar. Pulse generating section controls the repetition frequency of the transmitter pulses. The principle of trigger pulse generating section is like the principle of a gun. When the trigger pulse hits the base of the bullet, the bit of the bullet is sent out. In most of the system, the main pulse generator needs the trigger pulses to start transmitting the electromagnetic energy to detect the targets. In any radar set there is a pulse generator circuit to operate the radar for required range. The pulse generator is a free-running oscillator which generates a continuous succession of low voltage pulses known as synchronizing pulses, or trigger pulses. Commonly they are referred to simply as triggers. Each trigger causes the remainder of the transmission elements to generate a radio frequency pulse which is sent up to the antenna. The pulse generator thus controls the number of pulses transmitted in one second. The latter quantity is referred to as the pulse repetition frequency (PRF) or sometimes the pulse repetition rate (PRR). Because the trigger generator controls the PRF, it is sometimes referred to as the PRF generator [1].

II. SYSTEM METHODOLOGY

The implementation block diagram of Pulse Generator for marine radar system is shown in Fig. 1. This Pulse Generator is designed to generate two pulse repetition rates; one at 3200 pps and one at 800 pps. The 3200 pps repetition rate is used on the 0.5 to 1.5 Nautical Miles ranges. The 800 pps repetition rate is used for 3 to 48 Nautical Miles. In this circuit Switching Amplifier, Relaxation Oscillator, Master Oscillator, Buffer Amplifier, Phase Inverted Amplifier and other electronic components are included.

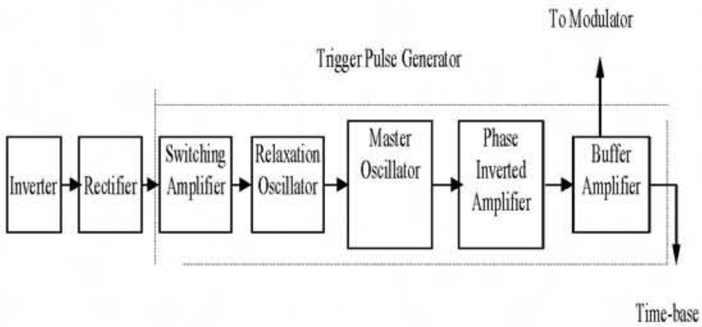

Fig. 1 Block Diagram of Pulse Generator used in Marine Radar

For long ranges, the supply 20V AC at 800 Hz is fed to the switching amplifier stage. Switching amplifier stage generates rectangular pulse with 800 Hz to the relaxation oscillator stage. The relaxation oscillator generates two pluses repetition rate 3200 pps and 800 pps. The output of relaxation oscillator is fed to master oscillator. When the range switch is selected for short range, +100V is fed to the Switching amplifier to be cut off. The relaxation oscillator oscillates and provides pulses at the rate of 3200 pps. The master oscillator generally is a monostable multivibrator. There are two transistors in a multivibrator. The tow output voltages are equal in amplitude but are 180° out of phase. The output of the master oscillator is the positive going rectangular pulses having 200 μs pulse width. Negative going pulse is taken out from the phase inverted amplifier. These pulses are fed to Time-base and Modulator simultaneously through the buffer amplifier.

A. Relaxation Oscillator

In this system, to get the required pulse repetition frequency, main components used in relaxation oscillator stage is calculated by (1)

$$f_0 = \frac{1}{\mathrm{RC}\ln\left(\frac{1}{1-\eta}\right)} \tag{1}$$

f_0 = oscillator frequency
R = resistor
C = capacitor
η = transistor stand-off ratio

B. Master Oscillator

In this system, to get the required pulse repetition frequency, main components used in master oscillator is calculated by using equation (2).

$$T = 0.69\ \mathrm{RC} \tag{2}$$

T = pulse width
R = resistor
C = capacitor

III. Design consideration

This trigger generator circuit is considered for working in high power radio frequencies. Transistorized type was chosen because The Bipolar Junction Transistor (BJT) can handle signals of very high frequencies up to several hundred GHz.

A. Switching Amplifier Stage

Switching amplifier is needed to generate 800 Hz positive going voltage at its collector. For this type of service, the BJT 2SA495 (PNP) is appropriate. It has a beta spread from 70 to 140 at high frequency (f_T = 200MHz) and a collector to emitter breakdown voltage of -30V. The maximum permissible value of collector current is negative 100mA.

B. Relaxation Oscillator Stage

This Relaxation Oscillator Stage is designed to generate 800 Hz rectangular pulse for long ranges and 3200 Hz rectangular pulse for short ranges with the help of input 20 VAC switched by switching amplifier. For this type of service, the UJT 2SH20 is appropriate. It has intrinsic stand-off ratio (η) spread from 0.7 to 0.85 and a base-1 to base-2 voltage of 55V.

C. Master Oscillator Stage

This master oscillator stage is designed to generate the positive rectangular pulse having peak to peak voltage of 9V and pulse width 200 μs at the frequency of 3200 Hz and 800 Hz. For this type of service, the BJT 2SC752 is appropriate. It has a beta spread from 70 to 140 at high frequency (f_T = 400 MHz) and a collector-to-emitter breakdown voltage of 15V. The maximum permissible value of collector current is 200 mA. Calculation result for this stage is shown in Fig. 2.

D. Phase Inverted Amplifier Stage

Phase Inverted Amplifier stage is designed for phase inverting of the input pulses having 200μs (peak to peak voltage of 9V) pulse width rectangular pulse at 800 Hz and 3200 Hz. For this type of service, BJT 2SC752 is appropriate. It has a beta spread from 70 to 140 at high frequency (f_T = 400MHz) and a collector to emitter breakdown voltage of 15V. The maximum permissible value of collector current is 200mA.

For fast switching time between master oscillator stage and phase inverted amplifier stage, the selection of commutating capacitor is also important for switching response. The function of the commutating capacitor is to reduce the switching time between stages. The appropriate capacitance value can be calculated by (3)

$$\tau = \mathrm{RC} \tag{3}$$

τ = switching time
R = resistor
C = commutating capacitor

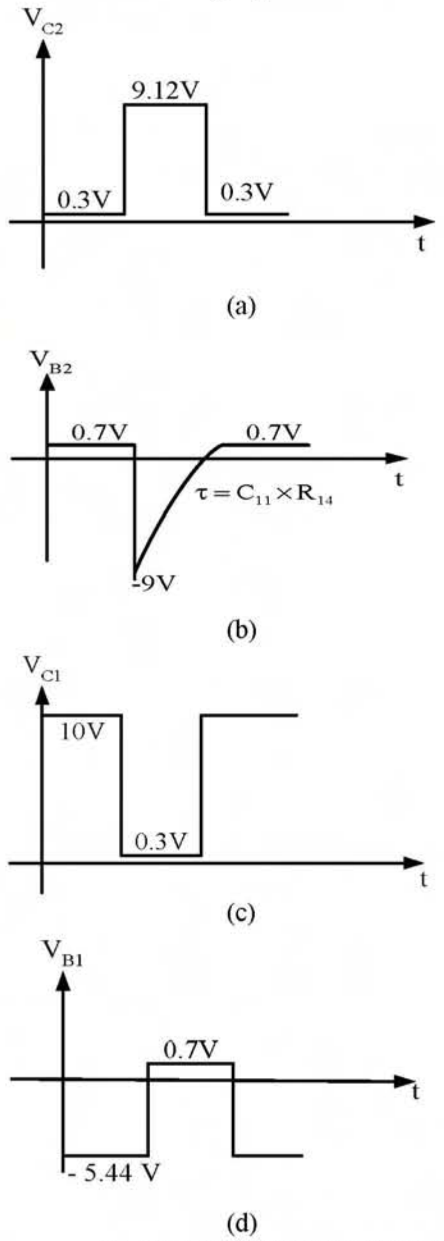

Fig. 2 Output Waveform of Master Oscillator Stage

E. Buffer Amplifier Stage

Buffer Amplifier stage is designed to exhibit a relatively high input resistance and a relatively low output resistance. For this type of service, BJT 2SC367 is appropriate. It has a beta spread from 70 to 140 at high frequency (f_T = 150 MHz) and a collector to emitter breakdown voltage of 20V. The maximum permissible value of collector current is 400mA.

IV. SIMULATION RESULTS FOR PULSE GENERATOR

In this section, simulation for two nonsinusoidal waveform generators which rely on RC charge time to determine frequency or timing intervals are implemented and simulated by Circuit Maker Version 2000.

The circuit diagram is drawn by loading components from the library. Wiring and proper net assignment has been made. The values are assigned for relevant components. The circuit is preprocessed. The test points and waveform markers are placed at the desire output point. The Transient Analysis parameters have been set. The Transient Analysis is executed and output observed in the waveform viewer.

A. Simulation for UJT Relaxation Oscillator Stage

In this simulation, the following input parameters are used:

UJT Type 2SH20, set the biasing voltage 10V,

R1 = 12 kΩ,

RB1 = 10Ω,

RB2 = 680Ω,

and use several different values for C1 to verify the timing relation of the output waveforms.

To simulate this circuit, selected three capacitance values for Relaxation Oscillator: 0.001 μF; 0.01 μF; 0.1 μF

By simulation this relaxation oscillator stage, the output waveform with different values of capacitor is acquired as shown in Fig. 4 to Fig. 6. Table I shows the comparison of simulated values and desired values.

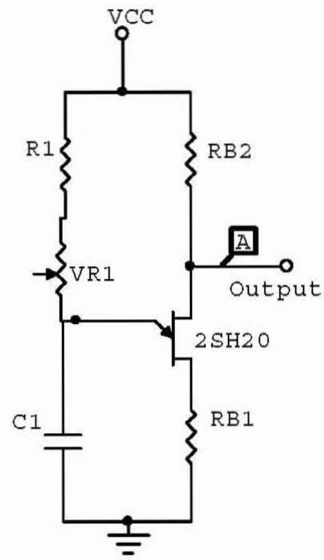

Fig. 3 Schematic Diagram of UJT Relaxation Oscillator

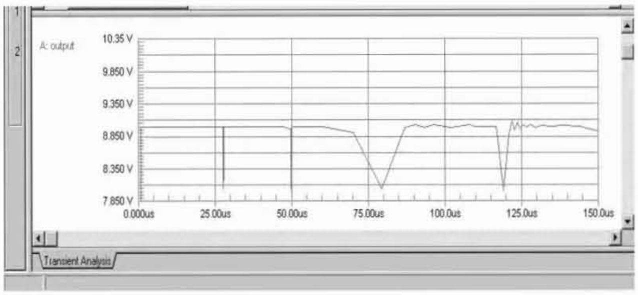

Fig. 4 Simulated Output Waveforms for Relaxation Oscillator (C1 = 0.001 μF)

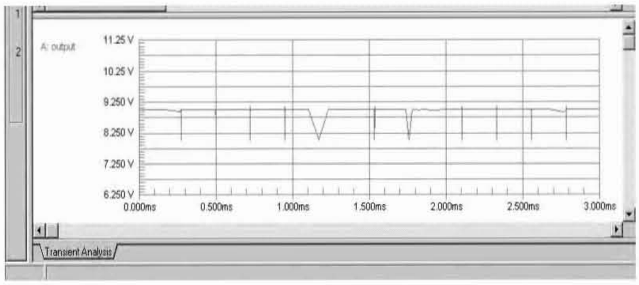

Fig. 5 Simulated Output Waveforms for Relaxation Oscillator (C1 = 0.01 μF)

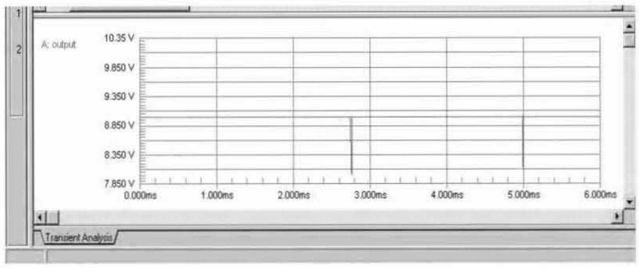

Fig. 6 Simulated Output Waveforms for Relaxation Oscillator (C1 = 0.1 μF)

TABLE I
COMPARISON OF SIMULATED AND DESIRED VALUES FOR RELAXATION OSCILLATOR

C1	Pulse width (Simulated Output)	Pulse width (Desired Output)
0.001 μF	28 μs	312.5 μs
0.01 μF	280 μs	312.5 μs
0.1 μF	2800 μs	312.5 μs

B. Simulation for Master Oscillator Stage

The following devices are set for the simulation of Master Oscillator,

Transistor type: 2SC752

V_{BB} = -20V, V_{CC} = 10V, other values are set as shown in Fig. 7 and use three different values for C1: 500 pF, 5000 pF and 50 nF to verify the timing relation of the output waveforms. Input pulse generator is set at the frequency of 3200Hz for short range. Other parameter values are set as shown in Fig. 7.

Simulated Results of Master Oscillator stage are shown in Fig. 8 to 10. Table II shows the comparison of simulated values and desired values for master oscillator stage.

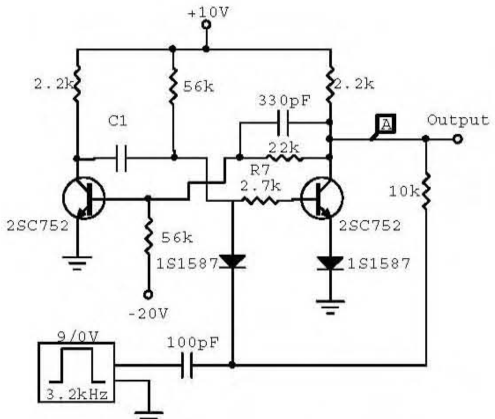

Fig. 7 Schematic Diagram of Master Oscillator

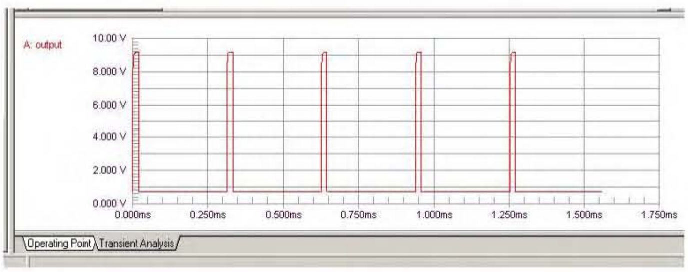

Fig. 8 Simulated Output Waveform of Master Oscillator (C1 = 500 pF)

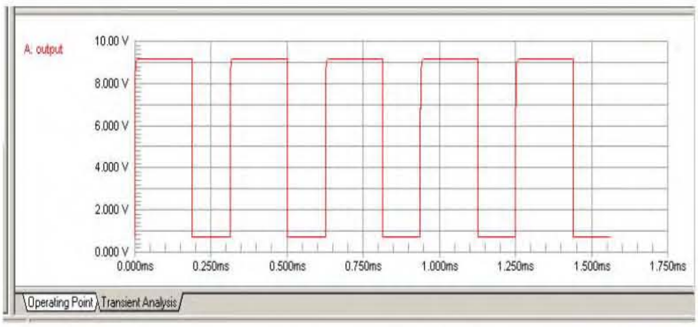

Fig. 9 Simulated Output Waveform of Master Oscillator (C1 = 5000pF)

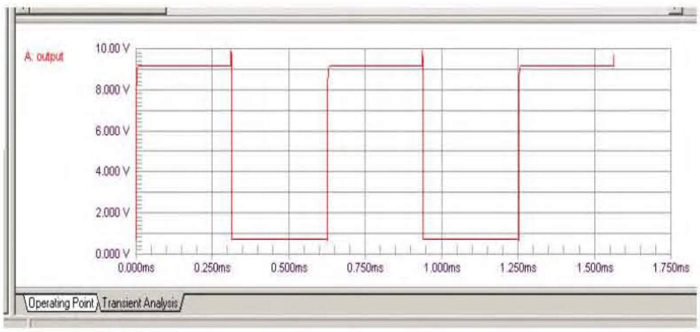

Fig. 10 Simulated Output Waveform of Master Oscillator (C1 = 50 nF)

TABLE II
COMPARISON OF SIMULATED AND DESIRED VALUES FOR MASTER OSCILLATOR

C1	Pulse width (Simulated Output)	Pulse width (Desired Output)
500 pF	20 μs	200 μs
5000 pF	200 μs	200 μs
50 nF	312.5 μs	200 μs

According to the simulation results, the capacitance value of 5000 pF is the most suitable to get the desired pulsewidth.

All these simulation results show that the required pulses can be generated by using the parameters set in this circuit simulation.

V. TEST AND RESULTS FOR PULSE GENERATOR

In order to carry out the test procedure, the following instruments are required:

1. Frequency Counter (Voltcraft 7202 Sweep/ Function Generator)
2. Oscilloscope (HM 407, HAMEG Instrument)
3. Multitestmeter of 20 kΩ/V Sanwa model YX-960TR

The measurements were made using a storage oscilloscope (HAMEG) and the results are produced as shown in Fig. 11 and Fig. 12.

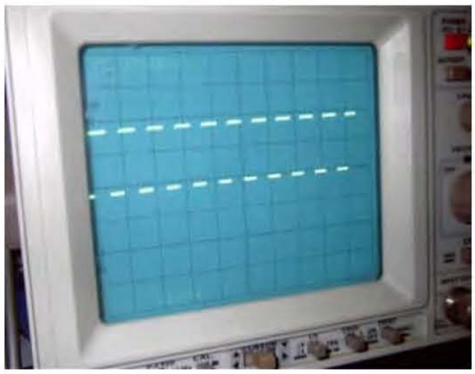

Fig. 11 Test result of Pulse Generator for Long Ranges

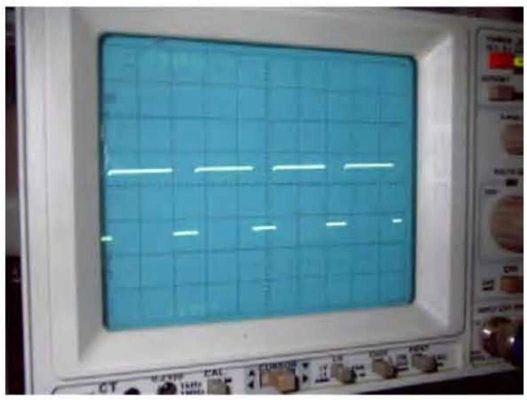

Fig. 12 Test result of Pulse Generator for Short Ranges

TABLE III
TEST RESULTS FOR TRIGGER PULSE GENERATOR

Item	Short range	Long range	Remarks
Amplitude of Trigger Pulse	2.8 – 3.2 V p-p	2.8 -3.2 V p-p	Measured by Oscilloscope
Pulse width of Trigger Pulse	200 -220 μs	200 -220 μs	
Pulse repetition rate	3200 pps	800 pps	

Test results for pulse generator circuit are tabulated in Table III. The test results of pulse generator show that the fabricated circuit can provide the required output values.

VI. CONCLUSION

This research paper explores the detail design procedures required to construct the pulse generator used in Marine Radar. The component values and their tolerances can affect the whole system and 1% tolerant capacitors and resistors should be used throughout. Special capacitors for specific applications such as tantalum, ceramic, paper and mica capacitors are not readily available locally and some discrepancies were seen during the fabrication and tests. This research and implementation of pulse generating section was conducted and this investigation shows that local design and fabrication is possible. Experimental Results show that the constructed circuit is able to provide require amplitude and pulse width of trigger pulse and pulse repetition rate for short range as well as long range for Marine Radar.

REFERENCES

[1] Bole, A.G., and Dineley, W.O. 1990. Radar and ARPA Manual. Oxford:Butterworth-Heinemann Ltd, Linacre House, Jordan Hill.

[2] Anonymous, 2002. Factors affecting the performance of Pulse-ModulatedRadars.December2004http://www.radarpages.co.uk/theory/ap3302/sec1/ch3 sec1ch327.htm

[3] Anonymous. No Date. Schmitt Trigger. September 2004 < http://www.visionics.ee/curriculum/Experiments/UJT%20Oscillator/UJT%20Relaxation%20Oscillator1.html>

[4] Ferris, C.D. 1995. Elements of Electronic Design. U.S.A.: West Publishing Company. ISBN 0-314-03942-2.

[5] Millman, J., and Taub, H. 1965. Pulse, Digital and Switching Waveforms. International Student Edition. McGraw-Hill Kogakusha, Ltd.

[6] http://www.ic666.com/jszl_show.asp?id=5033

[7] Anonymous. No Date. Radar System. December 2004 <http://www.fas.org/ man/ dod-101 /navy/docs/es310/radarsys/radarsy s .htm>[

[8] Kolawole M.O. 2002. Radar Systems, Peak Detection and Tracking. Oxford, Boston: Linacre House, Jordan Hill. ISBN 0 7506 57731

[9] Selenia, S.p.A. 1978. Radar Techniques Basics. Rome, Italy: Alenia.

[10] Anonymous. No Date. Radar Cross Section (RCS) January 2005. <http://www. tscm.com/rcs.pdf

[11] Morchin, W. 1993. Radar Engineer's Source. Artech House

[12] Edde, B. 1995. RADAR Principles, Technology, Applications. Prentice Hall, PTR.

[13] Mahafza, B.R., and Elsherbeni, A.Z. 2004. MATLAB Simulationsfor Radar Systems Design. London New York Washington, D.C.: Chapman & Hall/CRC CRC Press LLC.

[14] Sloan, F.E., and Cote, G.J. 1998. NAVEDTRA 1490: Radar Principles. Naval Education and Training Professional Development and Technology Center, Pensacola, FL.