International Journal of Latest Engineering and Management Research (IJLEMR)
ISSN: 2455-4847
www.ijlemr.com || Volume 03 - Issue 02 || February 2018 || PP. 19-25

Implementation of a Ramp Output Waveform Generator using DAC 0800

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Abstract: The state of the art presented in the paper is the generation of Digital Ramp waveform using the Digital to Analog conversion technique. The process of converting the Digital signal into an equivalent Analog voltage is known as Digital to Analog conversion (DAC). This operation is somewhat simple compare to the converse operation of Analog to Digital conversion (ADC). The process of converting an analog voltage into an equivalent digital signal is known as Analog to Digital conversion (ADC). The ramp waveform can be constructed in a number of different ways. One way is to use a DAC driven by a simple binary counter, generating a staircase waveform in the form of a ramp. Another way is to use an operational amplifier (opamp) connected as an integrator. In this paper the ramp waveform is generated using the former case.

Keywords: Analog to Digital conversion, Analog voltage, Binary counter, Digital to analog conversion, Digital signal, Ramp waveform, Staircase waveform.

I. INTRODUCTION

The term digital signal processing familiarly known as DSP is a very general term used to describe any system which accepts samples of a signal with an Analog to Digital converter (A/D converter) processes the samples with a microcomputer and sends the computed results to a Digital to Analog converter (D/A converter) or some other device. A wide range of signals generated are analog in nature. Therefore these signals are converted into digital form by the use of analog to digital converter. Hence the A/D converter generates an array of samples and sends it to the Digital signal processor. The array of samples or sequence of samples is nothing but the digital equivalent of input analog signal. The digital signal processor processes this digital signal and generates another digital signal at its output. Usually, the digital output signal from the digital signal processor is given to the digital to Analog converter. The digital to analog converter gets an analog equivalent of the output digital signal. Fig.1 depicts the basic elements of a Digital signal processor [1].

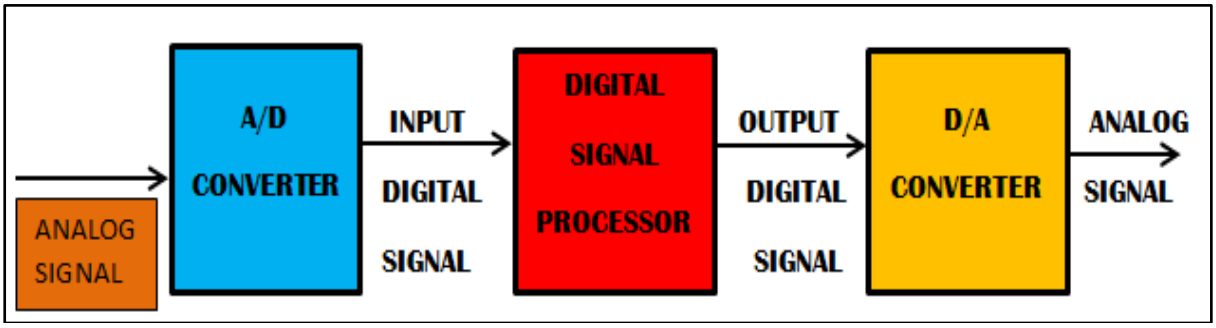

Fig.1 Basic elements of a Digital signal processor

Digital to Analog conversion (D/A) and Analog to Digital conversion (A/D) forms two very important aspects of digital data processing. Digital to analog conversion involves translation of digital information into equiv alent analog information. For example, the output of a digital system might be changed to analog form for the purpose of driving a pen recorder. Similarly, an analog signal might be required for the servomotors which drive the cursor arms of a plotter. In this respect, a D/A converter is sometimes considered a decoding device.
The process of changing an Analog signal to an equivalent Digital signal is accomplished by the use of an A/D converter. As an example, an A/D converter is used to change the analog output signals from transducers measuring temperature, pressure, vibration etc. into equivalent digital signals. These signals would then be in a form suitable digital system. An A/D converter is often referred to as an encoding device since it is used to encode the signals for entry into a digital system. Digital to Analog conversion is a straightforward process and is considerably easier than Analog to Digital conversion. In fact a D/A converter is usually an integral part of

any A/D converter [1] [2].

The waveform generator is one of the basic applications that can be achieved using the DAC module. Waveforms such as Sine wave, Ramp wave, triangular wave and saw tooth wave can be produced with configurable frequency. In addition to the DAC module, timer and event system will be used to accurately convert the input digital data into analog waveform [3] [4].

In this paper ramp output waveform is generated using the DAC I.C 0800. The rest of the paper is organized into sections as follows: section II describes the overview of DAC. Section III focuses on the system design. Results and discussions are reported in section IV. Finally section V summarizes the paper and presents the concluding remark.

II. DAC OVERVIEW

2.1 DAC Composition

A digital to analog converter is a module to convert one or multiple bits digital value into an analog value. Resistive divider or the ladder can be used as the basis for a digital to analog converter (DAC). The actual translation from a digital signal to an analog voltage takes place in the resistive network. Additional circuitry is needed to complete the design of the DAC. A register is an integral part of DAC that can be used to store the digital information. A register is simply a group of flip flops that can be used to store a binary number. The simplest register is formed by the use of RS flip-flops, with one flip flop per bit. Level amplifiers should also be there between the register and the resistive network in order to ensure that the digital signals presented to the network are all of the same level and are constant. Finally, some form of gating must also be there on the input of the register such that the flip flops can be set with the proper information from the digital system. A complete D/A converter in the block diagram form is illustrated in fig 2. [2]

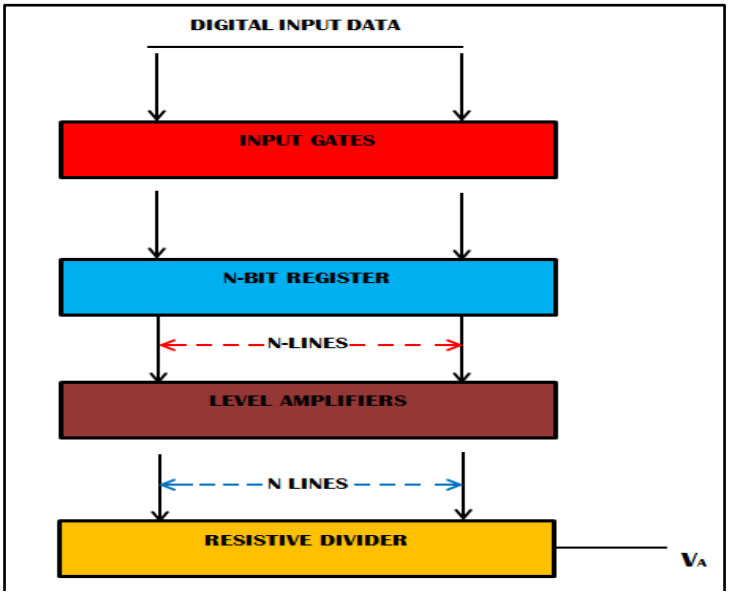

Fig.2 Block diagram of D/A converter

2.2 DAC Parameters

The DAC is defined through

1. Resolution: It defines the smallest increment in voltage that can be discerned. Resolution is primarily a function of the number of bits in the digital input signal, that is, the smallest increment in output voltage is determined by the least significant bit (LSB).
2. Conversion rate/ Conversion time: It is the time required for conversion of analog signal into its digital equivalent. It is also referred to as the settling time. It depends on the response time of the switches and the output of the amplifier.
3. Monotonicity: A converter is said to have good monotonicity if it does not miss any step backward when stepped through its entire range by a counter.
4. Accuracy: The accuracy of the D/A converter is primarily a function of the accuracy of the precision resistors used in the ladder and precision of the reference voltage supply. Accuracy is a measure of how close the actual output voltage is to the theoretical output value.

5. Stability: The performance of the converter changes with temperature, time and power supply variations. So all the relevant parameters such as offset, gain, linearity error and monotonicity must be specified over the full temperature and power supply ranges. These parameters represent the stability of the converter.

2.3 D/A converter testing

There are two simple and important tests which can be done to check the whether the operation of the D/A converter is proper. These include the steady state accuracy test and the monotonicity test. The steady state accuracy test involves setting a known digital number in the input register, measuring the analog output with an accurate meter and comparing with the theoretical value. Checking the monotonicity means checking that the output voltage increases regularly as the input digital signal increases. This test can be done by using a counter as the digital input signal and observing the analog output on the oscilloscope. For proper monotonicity, the output waveform should be a perfect staircase waveform as depicted in fig 3. The steps on the staircase waveform must be equally spaced and should be of exact same amplitude. Missing steps, steps of different amplitude or steps in downward fashion indicate malfunctions.

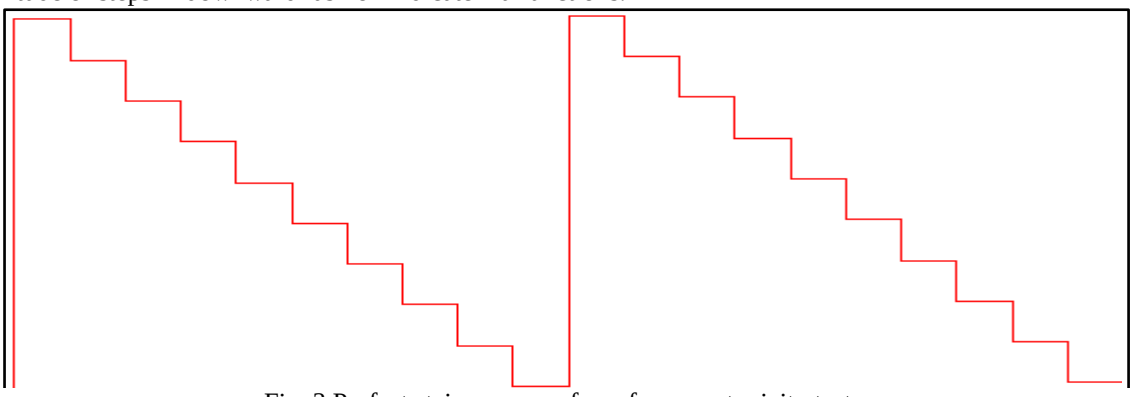

Fig. 3 Perfect staircase waveform for monotonicity test

III. SYSTEM DESIGN

3.1 Hardware design

The circuit schematic for system is depicted in fig 4.

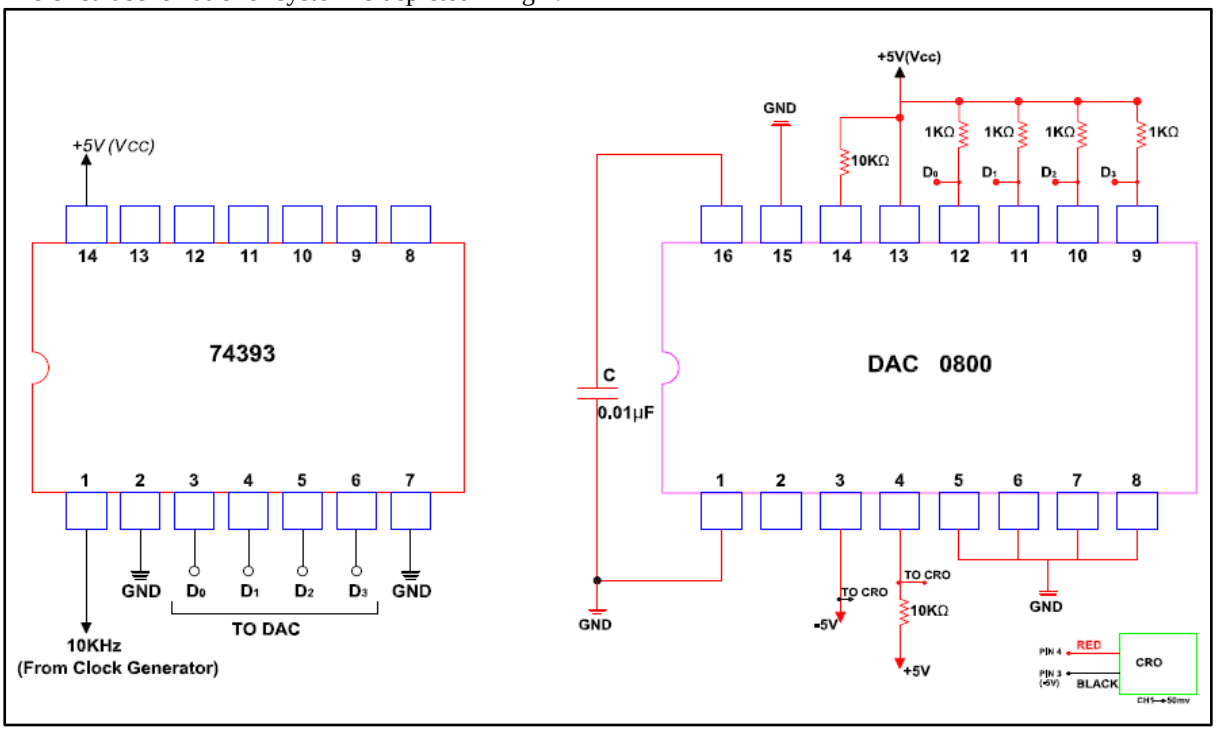

Fig.4 Circuit schematic of the system

The table I. illustrates the system specifications.

TABLE I. System Specifications

SL. NO	SPECIFICATIONS
1.	Domain: Analog electronics, Digital electronics, Electronic circuits, Logic design.
2.	Digital IC trainer kit
3.	Power supply : DC regulated power supply voltage of +5v, -5v
4.	DAC I.C: DAC 0800.
5.	Ripple counter I.C: 74393
6.	Resistors : 10KΩ, 1 KΩ
7.	Capacitor : 0.01µF
8.	Cathode ray oscilloscope
9.	Single stranded wires, connecting probes, patch cord, crocodile clips.
10.	Multimeter
11.	Simulation software: Proteus Isis.
12.	Application of DAC : Generation of voltage waveforms such as Saw tooth, Ramp, Triangular, Sinusoidal etc.

3.2 DAC 0800 IC overview

The DAC 0800 series are monolithic 8 bit high speed current output digital to analog converters (DAC) featuring typical settling times of 100ns. When used as a multiplying DAC, monotonic performance over a 40 to 1 reference current range is possible. The DAC 0800 series also features high compliance complementary current outputs to allow differential output voltages of 20 volt p-p with simple resistor loads. Figure 5 illustrates the pin diagram of DAC 0800 IC. It is a 16 pin IC and is packed and is packed in a dual In line package. [5]

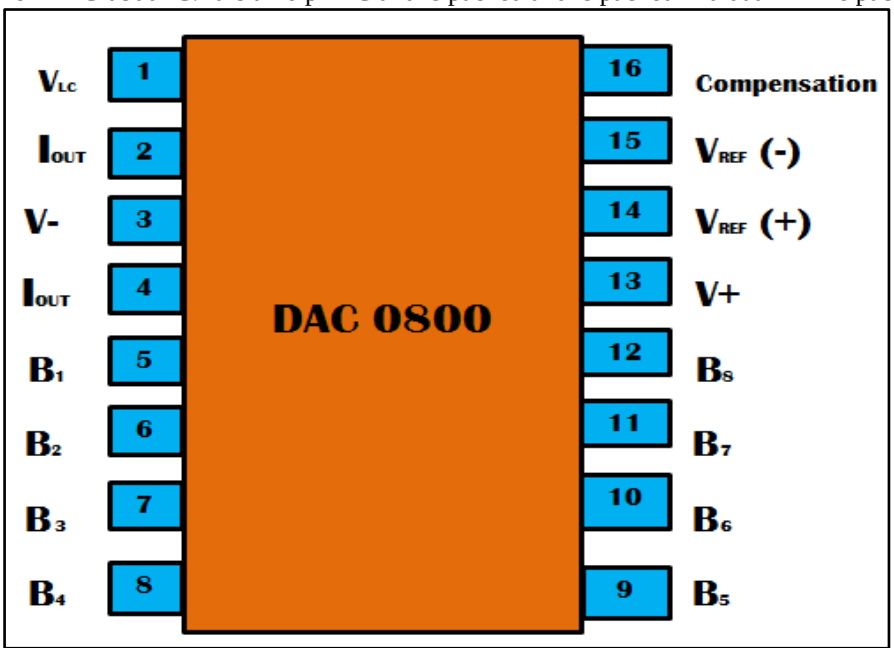

Fig. 5 pin diagram of DAC I.C 0800

3.3 Ripple Counter 74393 IC overview

The 74393 are high speed Silicon gate CMOS devices and are pin compatible with low power Schottky TTL. The 74393 are 4-bit binary ripple counters with separate clocks and master reset inputs to each counter. The counters are triggered by a HIGH-to-LOW transition of the clock inputs. The counter outputs are internally connected to provide clock inputs to succeeding stages. The outputs of the ripple counters do not change synchronously and cannot be utilized for high-speed address decoding. The master resets are active-HIGH asynchronous inputs to each 4-bit counter identified by the "1" and "2" in the pin description. A HIGH level on the nMR input overrides the clock and sets the outputs LOW. Figure 6 shows the pin diagram of IC 74393. It is

a 14 pin IC and is packed in a dual in line package. Different pins of the 74393 are designated as Clock inputs HIGH to LOW edge triggered (pin no 1 and 13), Asynchronous master reset inputs active HIGH (pin no 2 and 12), Flip-flop outputs (pin no 3, 4, 5, 6, 8, 9, 10, 11), Ground (pin no 7) and +Vcc (pin no 14). [6]

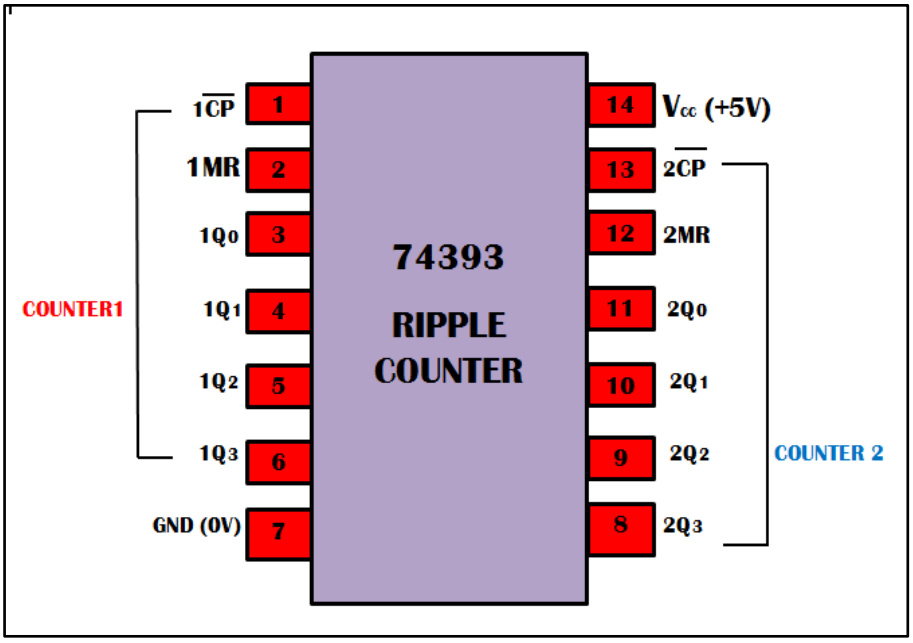

Fig.6 Pin diagram of Ripple counter I.C 74393

3.4 System set up

The experimental set up for the system was done in Analog and Digital electronics laboratory. Based on the system design the required components were taken and the resistors were checked using a Multimeter.The circuit was rigged up as per the circuit schematic and the power supply was switched ON, to get the required ramp waveform in the form of staircase waveform. The figure 7 depicts the photographic view of the system.

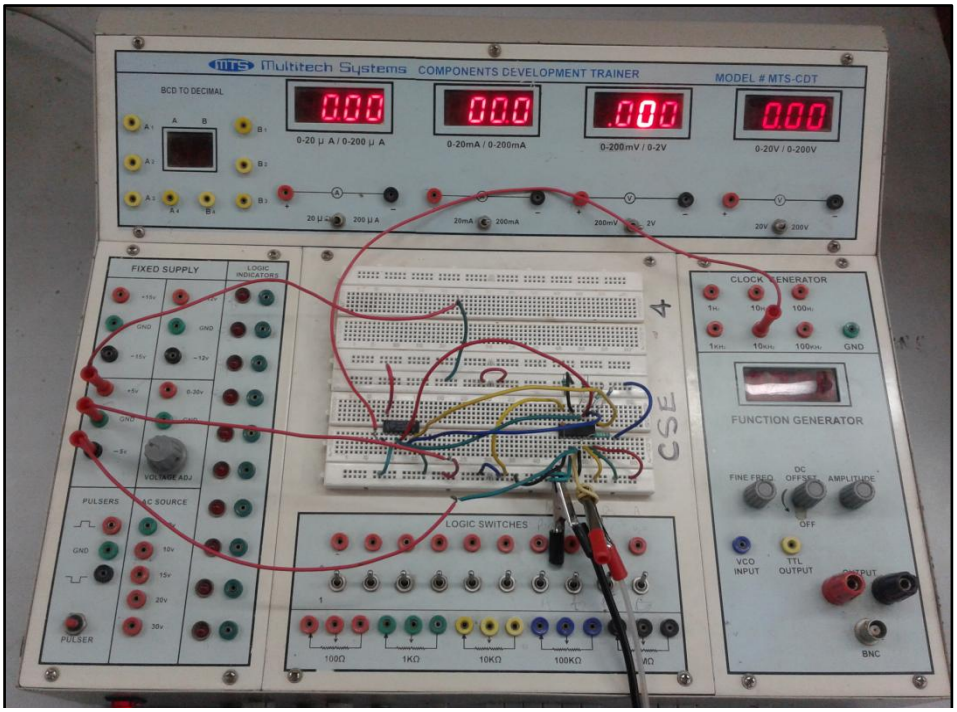

Fig 7 Photographic view of the system

IV. RESULTS AND DISCUSSION

4.1 Hardware Results

The desired ramp output waveform in the form of staircase waveform was obtained when the positive probe (with red crocodile clip) from channel 1 is connected to pin number 4 of the DAC 0800 IC and the negative probe (with black crocodile clip)connected to the pin number 3 of the DAC 0800 IC. Two channels are available on the CRO, namely channel 1 and channel 2, of these two channels any one can be used for viewing the output waveform. In the proposed system channel 1 is used. The output waveform is illustrated in fig. 8

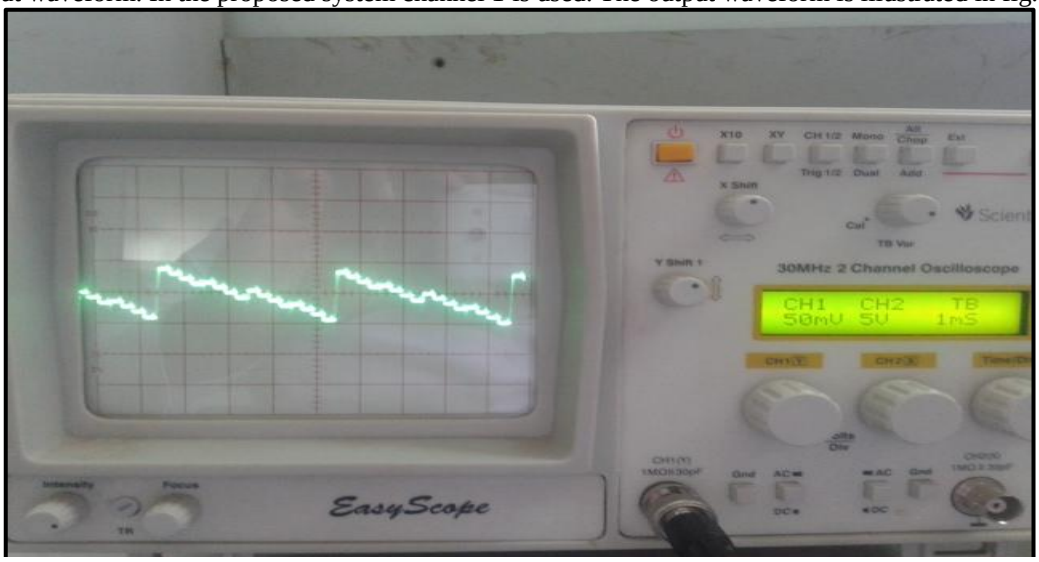

Fig.8 Photographic view of the output waveform

4.2 Simulation Results

The Simulation was done using Proteus Isis software. Fig. 9 shows the Simulation circuit along with the desired output waveform.

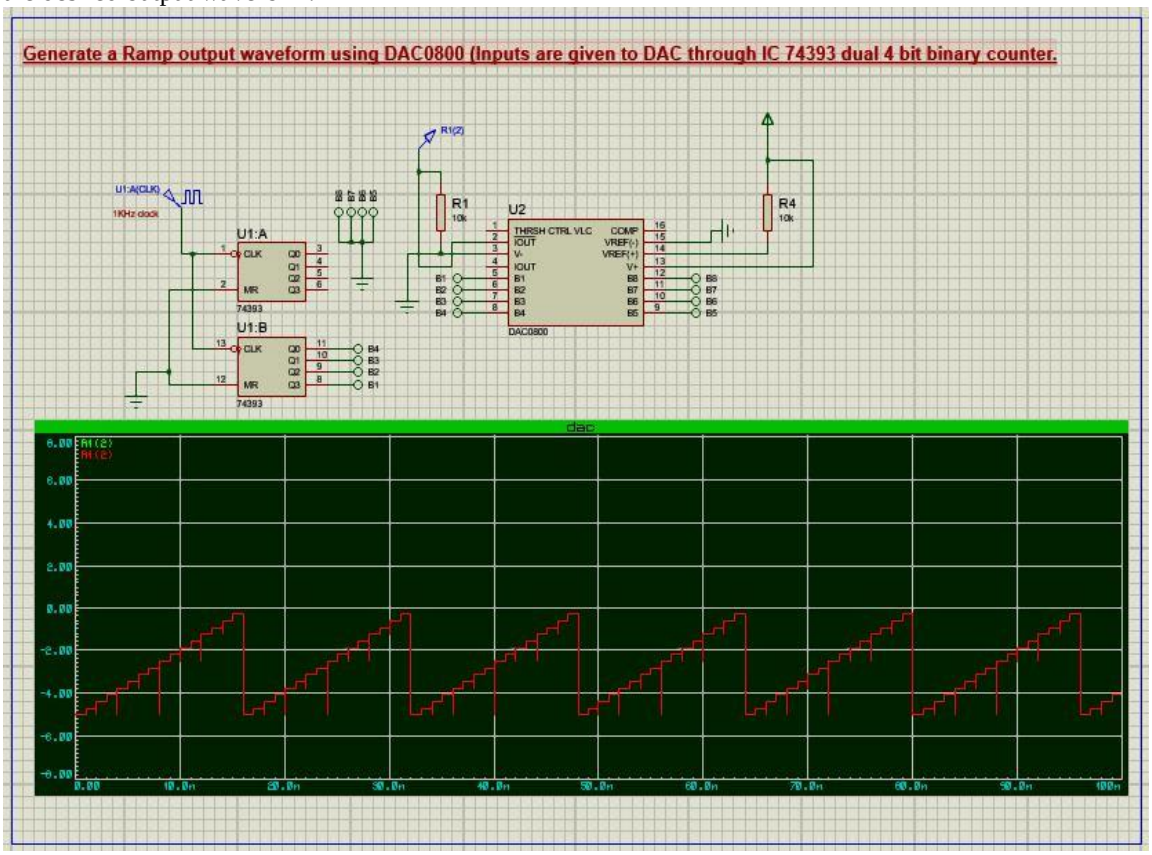

Fig. 9 simulation circuit and the simulated output waveform

V. CONCLUSION

The Ramp output waveform was generated through the designed system using DAC 0800, where the inputs to the DAC is given through Ripple counter IC 74393, which is a dual 4-bit binary counter. The system designed for the purpose displayed excellent characteristics. The designed system is very stable, easy to use and is reliable for generating the digital ramp waveform. Owing to the simple circuit design the system is cost effective. Furthermore, due to the use of DAC IC 0800 and Ripple counter IC 74393, the system requires low power consumption

VI. ACKNOWLEDGEMENTS

First of all I would like to thank Almighty Allah by the grace of whom, I reached the stage of completion of this work. This avenue has been a turning point in my career to mold me into a thorough and dynamic professional. My sincere thanks to the principal Dr. S K Md Azam, Vice principal Dr. Ruksar Fatima and Dr. Asma Parveen H.O.D CSE department of my esteemed institution Khaja Banda Nawaz college of Engineering for their worthy advice, inspiration and encouragement. I am also thankful to my beloved parents who have helped me pave this path to success.

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