

# DESIGN AND IMPLEMENTATION OF FUZZY MEMBERSHIP FUNCTION USING DISCRETE CIRCUIT ELEMENT

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## Abstract

The generations of fuzzy membership function and partition of domain by linguistic labels is central to the process of fuzzy inference. A novel hardware approach is presented for the implementation of electronic fuzzy membership function using discrete analog and digital components. MultiSim simulation results are presented that reveals the possibility of generating the triangular fuzzy membership function by hardware approach.

**Index Terms:** Fuzzy logic, membership function, electronic design, circuit simulation.

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## 1. INTRODUCTION

Since its inception the fuzzy logic has remained one of the most successful technologies. Its wide availability has led to the rapid growth of the technique in the different areas. Fuzzy Set an enrichment of Crisp Set was introduced by Lotfi Zadeh in 1965 as a mathematical way to represent imprecision in everyday life. The fuzzy set allocates the continuing assessments of the membership elements in a set and allows choosing an arbitrary real value over 0 to 1. Fuzzy set is an extension of crisp set, where elements have degrees of membership. The two truth values: true and false are based on logic and are in number of situations insufficient while dealing with human reasoning. Fuzzy logic uses complete interval between true and false for describing the human reasoning.

A membership function is priori-requirement of fuzzification and defuzzification steps of a Fuzzy Logic System, and defines how each point in the input space is mapped to different degree of membership in the interval between 0 and 1. There are different types of membership functions such as triangular, trapezoidal, piecewise linear, Gaussian, or singleton. The most common types of the membership functions are triangular, Gaussian shapes and trapezoidal. The type of the membership function can be condition dependent and it is generally chosen randomly according to the user experience. Due to their simple formulas and computational efficiency, both trapezoidal and triangular membership functions have been used extensively, more than ever in real-time implementation. The Bell membership function and the Gaussian membership function provides non-linear smooth functions that can be used by the learning systems like Neural Networks. Fuzzy membership functions generally precious by subjective decision having great manipulated over the performance of the system. There are different ways to

constructing of fuzzy membership functions such as statistical method,  $\alpha$ -cut fuzzy set method, clustering, mathematics method etc.

Two approaches are probable for realization of fuzzy logic systems: to use computer aided software or to develop committed hardware using digital or analog circuitry. Hardware structures can be either analyzed through application specific integrated circuits. The most important advantages of this approach are: (i) real-time performance, (ii) no special hardware device design, and inexpensive (iii) thus, suitable for industrial and educational purposes and user oriented.

The block diagram is shown in Figure-1 gives proposed concept of generating the membership functions that includes a 5-bit Ring Counter, Triangular Wave Generator, Switching Circuit, Amplifier and Phase Shift Circuit. The proposed hardware prototype was designed and simulated using the MultiSim software package of National instrument System. The paper reports the exploring of digital and analog modules for generating the membership function for data of interest. The paper is organized in three sections. Section 1 gives the introduction and the necessary theoretical background of triangular wave generation.

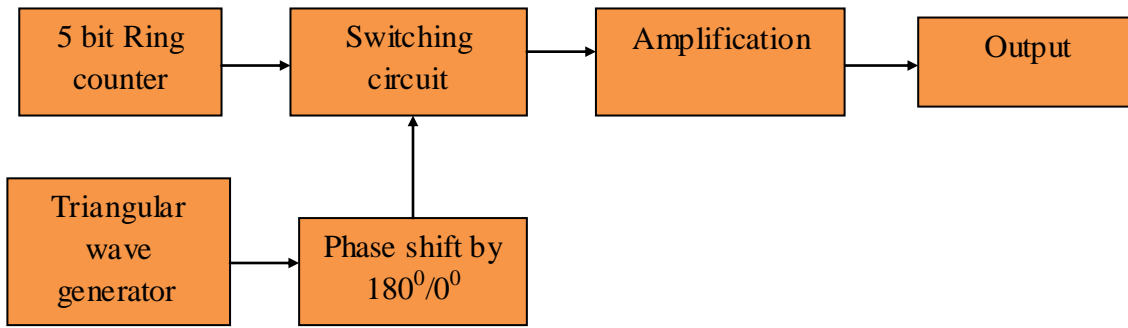


Fig- 1: Block diagram of proposed implimention of electroics membership function

The proposed circuit design and corresponding hardware implementation are discussed in Section 2. Finally, the conclusions and simulation result are presented in Section 3.

## 2. CIRCUIT DESIGN AND HARDWARE IMPLEMENTATION

The proposed hardware of generating the triangular membership function is shown in figure 2 and 3. It comprises

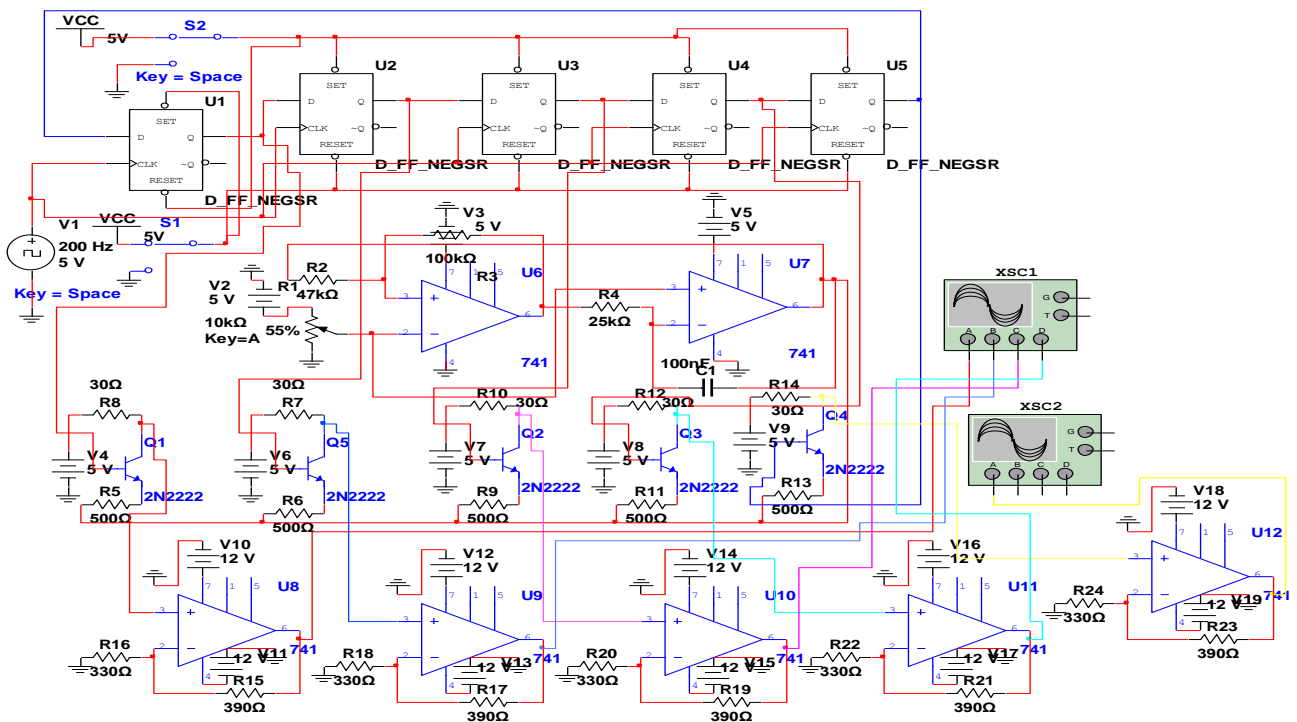


Fig- 2: circuit diagram of triangular membership function generator.

The combination of digital and analog circuit is challenging for researcher. The figure 2 shows the triangular membership function generator. It consists of five bit ring counter, Triangular wave generator, switching circuit and amplifier. The ring counter is a sequential device that can be composed of a type circular shift register and utilizes one flip flop for

each state in it's sequence. Which generate the pulses will appear to the inputs of switching transistors shown in dotted green line box. A simple circuit diagram for generation of a triangular wave using op-amp is shown by dotted black color block, The Triangular wave generator can be formed by simply cascading an integrator and square wave generator

(comparator). The switching transistor operates on logic of triangular wave generator. Switching transistor switch the triangular wave according to the output sequence of each flip-flop depicted by dotted brown colour block. The dotted pink colour block detect non inverting amplifier which followed by output of switching transistor signal. Non-inverting amplifier amplifies the input signal and output V0 is in phase with the input. The resultant output is to find the triangular membership function.

generation of triangular membership function to added the circuit diagram of phase shifting using all pass filter is depicted by dotted black colour line box. The triangular wave generator generate the triangular wave and this triangular wave is given to the input of all pass filter, all pass filter pass the triangular wave without attenuation and providing the phase shift by 180. The shifted triangular wave is given to the input of emitter of switching transistor, switching transistor switch the triangular wave according to the output of flip-flop and then shows the generated triangular membership function get amplified in phase with input using non-inverting operational amplifier. The resultant output is to find the triangular membership function.

A circuit diagram of triangular membership function generator with phase shifting circuit is shown in figure: 3. To generates the triangular membership function described without phase shifting circuit in figure: 2, but in this section we describe the

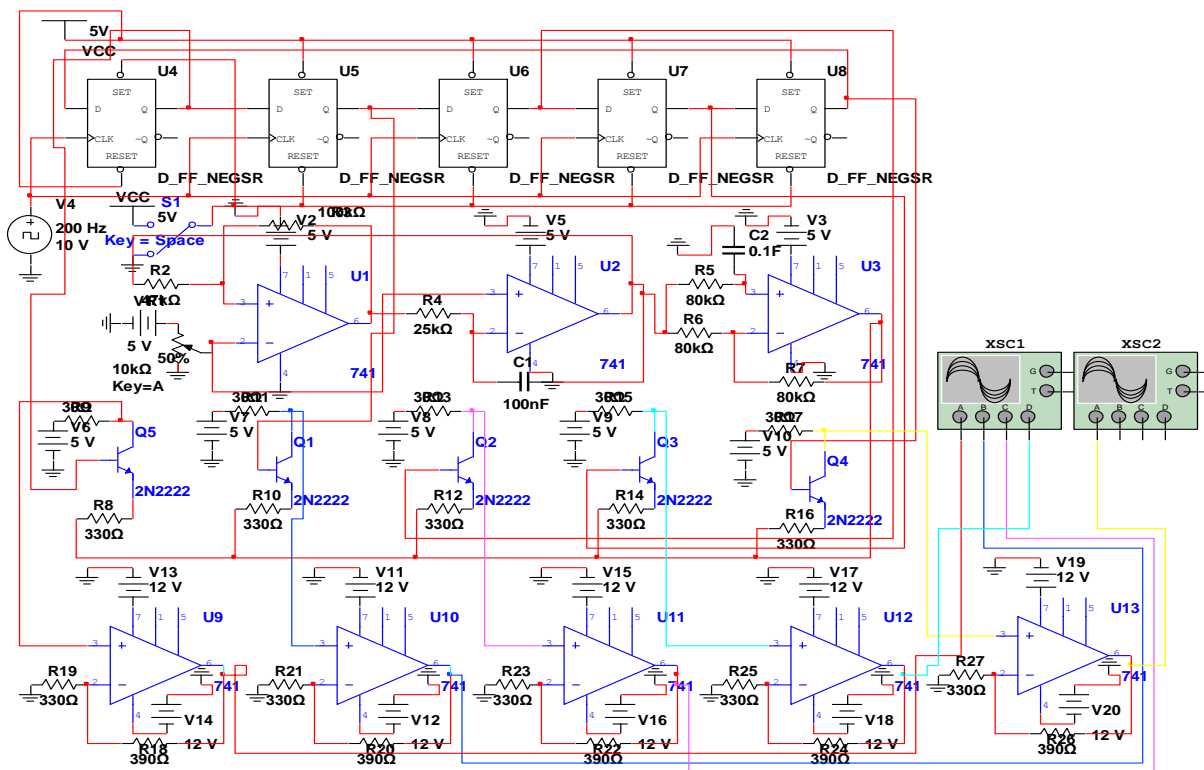
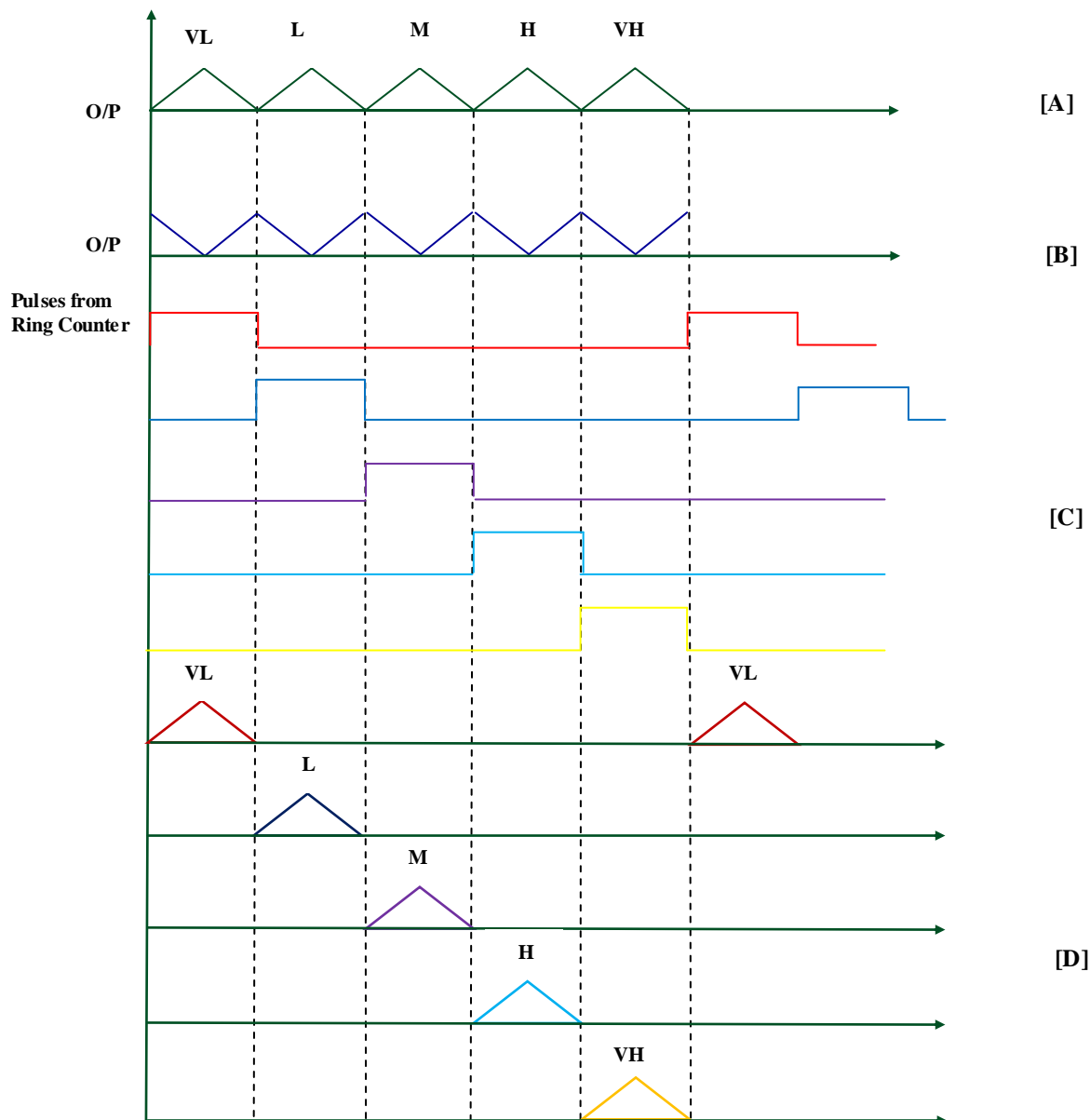


Fig-3: Circuit diagram of Triangular membership function.

### 3. RESULT



**Fig-4: Gated Waveforms**

With aid of software any membership function can be easily generated but at the cost of software. Fuzzy membership function generated directly by hardware can be a good alternative. Without using Microcontroller or CPU the implementation of fuzzy sets is challenging for Researchers. The proposed idea of generating membership function using commonly used discrete components is novel and easy to implement. The simulation results of generating the fuzzy membership function are depicted in Figure4. The simulated output waveforms of triangular wave generator without phase

shifting and with phase shifting by 1800 is shown in [A] and [B] respectively. The overlapping of these two emulates the fuzzy partition of domain under fuzzification. The simulated timing signal can be generated by 5 bit counter that goes through five distinct states generates the essential sequence of timing signals as depicted in [C]. The pulses select one partition label at a time as shown in figure [D].

### 3. CONCLUSION

Fuzzy Membership Function generation using digital and analog circuits has been described in this paper. It has been shown that through the use of integrated circuit and the digital counter module help generate a real-time triangular membership functions.

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