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Realization of VLSI Architecture of Defuzzifier Unit

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Abstract - Fuzzy system used in control system, data mining, expert system. The fuzzy logic control system consist of a fuzzifier, fuzzy rule base , inference engine and defuzzifier .fuzzification and defuzzification are the two important process in the fuzzy logic control system. Fuzzification process used to convert the crisp data into the linguistic variable and defuzzification is to convert that fuzzy data into crisp data. The output of fuzzification process is not suitable for real time application that data can be converted into crisp data by using defuzzifier. In this paper we are study the defuzzifier and work is done in Tanner tool software.

There are different methods of defuzzification but most commonly used method are center of gravity and weighted average method .in this paper we are study the center of gravity method and calculate the value manually and verify it by using hardware realization of defuzzifier in tanner tool.

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Keywords- *Center of gravity* (COG); *Defuzzification; Fuzzy processor; Fuzzification; Weighted average method (WAM);*

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I. INTRODUCTION

Fuzzy logic control is the range-range control .fuzzy logic used in our day to day life. The modern concept of this fuzzy logic given by Lotfi Zadeh. Fuzzy logic applicable to the real time system by using fuzzy inference system. The important part of fuzzy system is the fuzzy inference system. The digital hardware fuzzy inference processor was developed by Togai and Watanabe. Fuzzy inference system consists of different parts fuzzifier, defuzzifier, and inference engine and rule base. In this paper we are study the defuzzifier. There are different methods for defuzzifier but most commonly used two method weighted average method and center of gravity method. In this paper we are study the defuzzifier by using Center of gravity because weighted average method is not suitable for asymmetrical function this drawback is overcome in COG method and this work is done in tanner tool.

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II. FUZZY INFERENCE SYSTEMS

Fuzzy inference is the process of mapping from an input to an output using fuzzy logic concept. The fuzzy inference systems having different parts fuzzifier, inference engine, defuzzifier, fuzzy knowledge base.

Fuzzifier- is used to convert the crisp data into linguistic variable using the membership function and stored in the fuzzy knowledge base In a more complex case, where observed data are disturbed by random noise, a fuzzifier should convert the probabilistic data into fuzzy numbers, fuzzy data.

Fuzzy knowledge base- Fuzzy control rules are characterized by a collection of fuzzy IF-THEN rules.

The generally used rule is MISO (multiple input single outputs) like,

IF(X is A1) AND (Y is B1) then (Z isC1)

IF(X is A2) AND (Y is B2) then (Z isC2)

Inference engine - are used if-Then type rules and convert the fuzzy input into the fuzzy output. It has the capability of simulating human decision making by performing approximate reasoning to achieve a desired control strategy

Defuzzifier - used to convert fuzzy output of inference engine into the crisp output using membership functions.

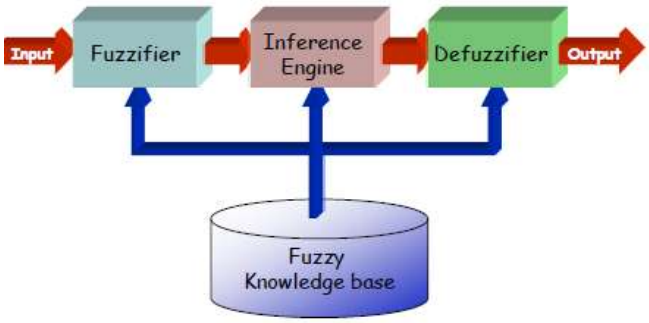

FIGURE 1. THE FUZZY INFERENCE SYSTEM

III. DEFUZZIFICATION PROCESS

Defuzzifier is used to convert fuzzy output of inference engine into the crisp output using membership functions analogous to the ones used by the fuzzifier.defuzzification process reduces the number of membership function into a single quantity. Sajad A. Loan proposed the defuzzifier is shown in figure.

Block diagram of defuzzifier consist of input in the form of fuzzy data and defuzzifier convert that data into the form of crisp value which is required to the control the process.

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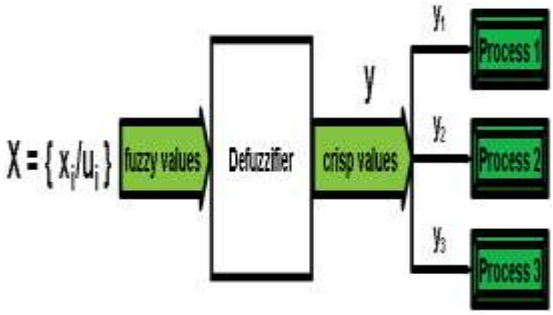

Figure 2: Block diagram of a defuzzifier.

IV. DEFUZZIFICATION METHODS

The defuzzification methods are used as follow

- Max-membership principle.
- Centroid method.
- Weighted average method.
- Mean-max membership.
- Centre of sums.
- Center of largest area.

Two commonly used methods of defuzzification are the center of gravity (COG) method and the mean of maximum (MOM) method.

Defuzzifier output by using MOM method

$$MOM(FAST) = \frac{\sum_{x \in T} x}{T} \qquad T = \{x \mid \mu_{FAST}(x) = \text{Support } \mu_{FAST}(x)\}$$

(1)

Graphical representation of MOM method is shown below

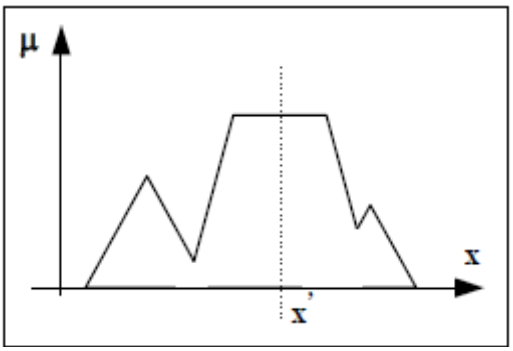

Figure3 Graphical representation of: MOM Method

Defuzzifier output by using COG method

for discrete-

$$COG(FAST) = \frac{\sum_{x} \mu_{FAST}(x) \times x}{\sum_{x} \mu_{FAST}(x)}$$

(2)

For the continuous-

$$COG(FAST) = \frac{\int \mu_{FAST}(x) x dx}{\int \mu_{FAST}(x) dx}$$

(3)

Graphical representation of COG method is shown below

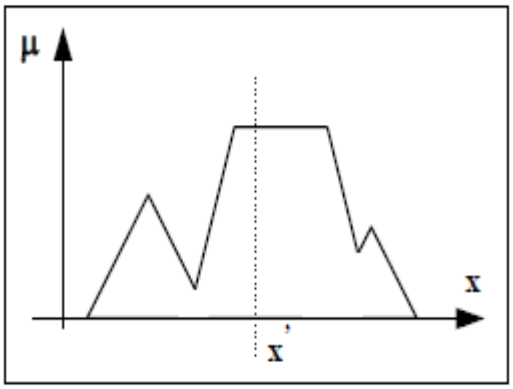

Figure3: Graphical representation of COG Method

V. CENTER OF GRAVITY METHOD

The Center of Gravity method (COG) is the most popular defuzzification technique and it is applicable to the only asymmetrical membership function. Trapezoid-Shaped Membership Function is shown in model .by using this model first calculate the value manually and then match this value with the hardware design .for the manual calculation use the formula from equation 2 and 3 .[9]

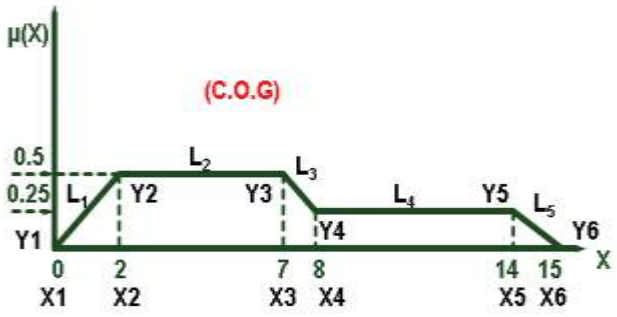

Figure 5. Model for center of gravity

The COG based defuzzification for the model shown in Figure5. To calculate the defuzzifier value for Figure 5 Apply equation 2 and 3 to the model. Model consist of different level like L1,L2,L3,4,L5 and L6 and by combining all these level we get the architecture of COG based defuzzifier .From Figure 5 that there are three types of lines, first with positive slope, like L1, second with zero slopes, like L2

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Applying equations 2 and 3to the model level1 (L1) and L4 and third with negative slopes, like L3 and L5.

$$N1 = \int_{X1}^{X2} \left(\frac{Y2-Y1}{X2-X1} X\right) X dX = \int_0^2 (0.25\,X)\, X dX$$

$$D1 = \int_{X1}^{X2} \left(\frac{Y2-Y1}{X2-X1} X\right) dX = \int_0^2 (0.25\,X)\, dX$$

Applying equations 2and 3 to the model level2

$$N2 = \int_{X2}^{X3} \left(\frac{Y3-Y2}{X3-X2} X + C1\right) X dX$$

$$\text{Since } Y3 = Y2 \Rightarrow N2 = \int_{X2}^{X3} (C1)\, X dX = \int_{X2}^{X3} 0.5\, X dX$$

$$D2 = \int_{X2}^{X3} \left(\frac{Y3-Y2}{X3-X2} X + C1\right) dX = \int_{X2}^{X3} 0.5\, dX$$

Applying equations2 and 3 to the model level3

$$N3 = \int_{X3}^{X4} \left(\frac{Y4-Y3}{X4-X3} X\right) X dX$$

$$D3 = \int_{X3}^{X4} \left(\frac{Y4-Y3}{X4-X3} X\right) dX$$

Applying equations 2 and 3 to the model level4

$$N4 = \int_{X4}^{X5} \left(\frac{Y5-Y4}{X5-X4} X + C2\right) X dX$$

$$\text{Since } Y4 = Y5$$

$$N4 = \int_{X2}^{X3} (C2)\, X dX = \int_{X2}^{X3} 0.25\, X dX$$

$$D4 = \int_{X4}^{X5} \left(\frac{Y5-Y4}{X5-X4} X + C2\right) dX = \int_{X2}^{X3} 0.25\, dX$$

Applying equations 2 and 3 to the model level5

$$N5 = \int_{X5}^{X6} \left(\frac{Y6-Y5}{X6-X5} X\right) X dX$$

$$D5 = \int_{X5}^{X6} \left(\frac{Y6-Y5}{X6-X5} X\right) dX$$

The final defuzzification is given by using center of gravity method

YCOG= (N1+N2+N3+N4)/ (D1+D2+D3+D4)

= (0+11-[14 – 13]+16-[52-50]) / (0+2-[1-1] +1-[3-3])

= 8

VI. HARDWARE REALIZATION OF DEFUZZIFIER

For the level L1 the hardware realization of N1 and D1 by using tanner tool and it result is shown below

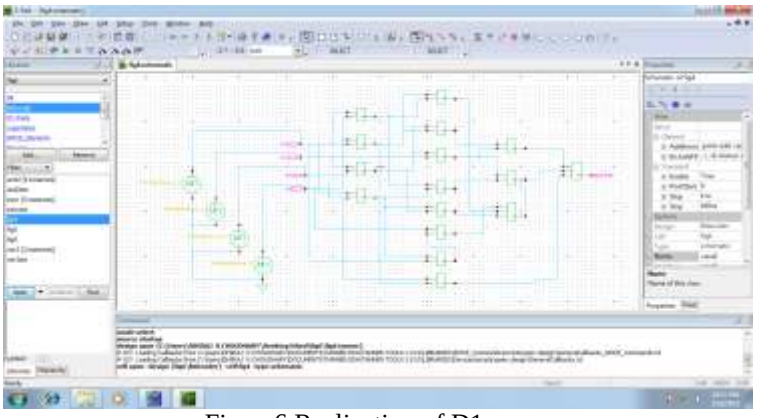


Figure6.Realization of D1

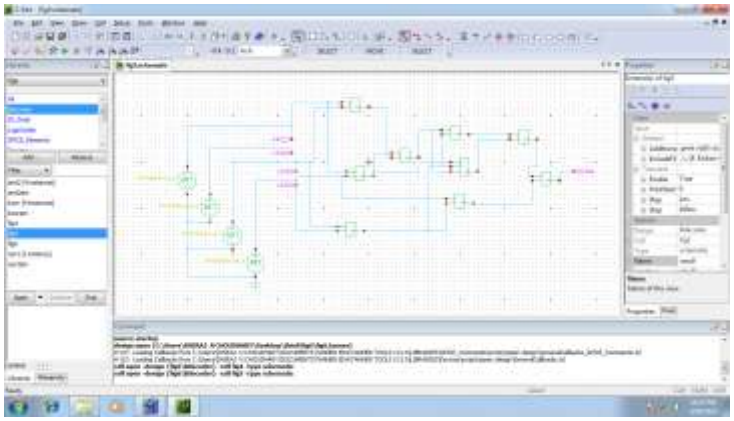


Figure7.Realization of N1

Result of N1 and D1 is shown below

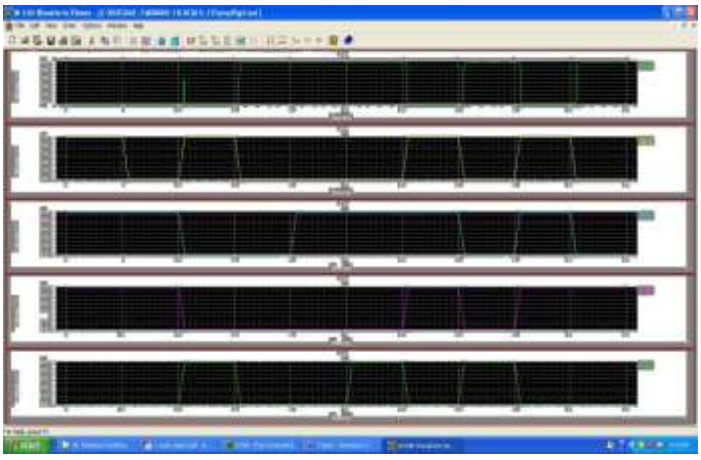


Figure8.Result of N1

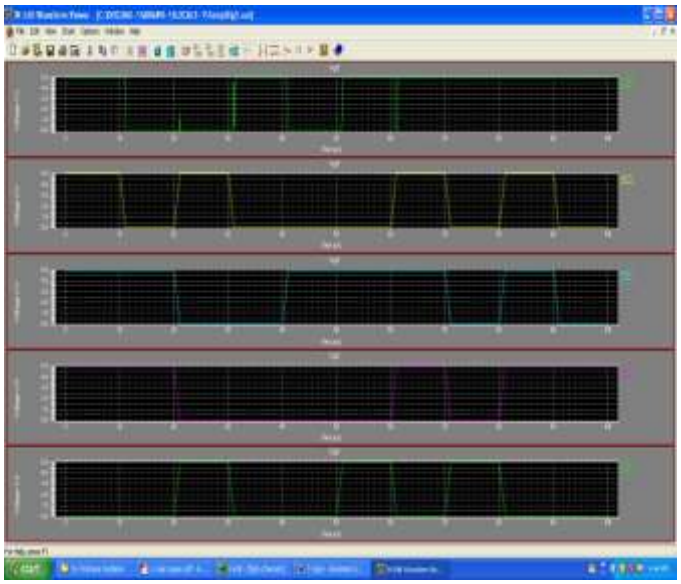


Figure9.Result of D1

For the level L2 the hardware realization of N2 and D2

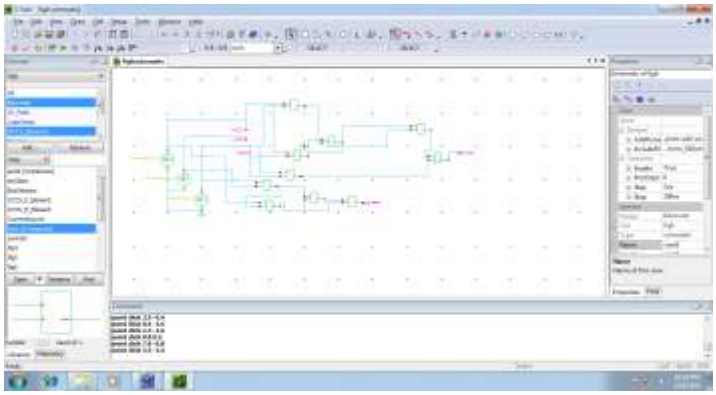
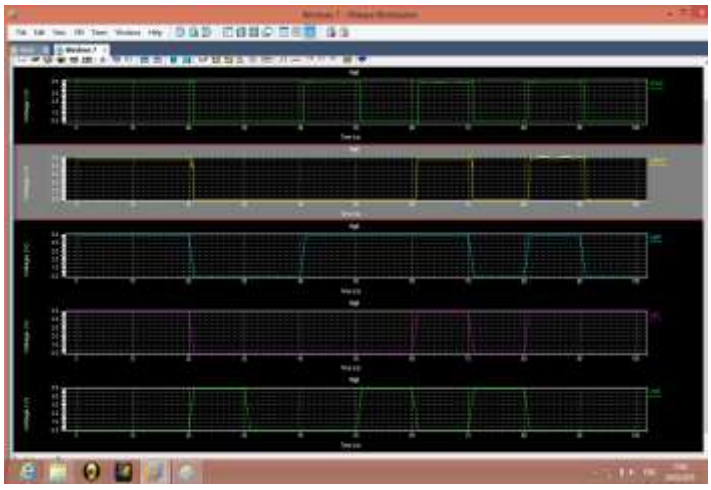


Figure10.Realization of N2 and d2

Result of N2 and D2 is shown below



VII. PROPOSED WROK

Realization of all other level like L3,L4,L5,L6 and then combine to get the defuzzifier output value which is match with value calculated by manually.

VIII CONCLUSION

In this paper we are study the fuzzy inference system and the method of defuzzifier i.e. COG. COG method is more suitable than the WAM method Realize the hardware design of the COG based defuzzifier in the tanner tool and calculates the defuzzifier value manually by using COG method and then verify by using hardware design.

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