



## IMPLEMENTATION OF TRIANGULAR MEMBERSHIP FUNCTION USING CURRENT DIFFERENCING BUFFERED AMPLIFIER

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**Abstract—** This paper presents the implementation of triangular fuzzy membership function using current differencing buffered amplifier in SPICE. Spice is an interactive tool which gets the design requirements for the system to be designed from the user. I have calculated the electrical parameters like slew rate, common mode rejection ration, gain, power dissipation and resistances for triangular membership function and compare their results with two stage CMOS operational amplifier and operational transconductance amplifier. Out of which, parameters with CDBA are the best.

**Index Terms—** Current mode amplifiers, Fuzzy system, Membership functions, CDBA

### I. INTRODUCTION

Current feedback operational amplifier has advantages over voltage feedback operational amplifier [1]. The current feedback is a type of trans-impedance amplifier which takes current as input and gives the corresponding amplified output voltage. The current feedback amplifier has same ideal closed loop equations but has higher slew rate. A current amplifier is an amplifier with low input resistance, high output resistance and defined relationship between the input and output currents. There are several important advantages of a current amplifier compared with voltage amplifiers. The first is that currents are not restricted by the power supply voltages so the current will probably be

converted into voltages, which may limit this advantage. The second advantage is that -3 dB bandwidth of a current amplifier using negative feedback is independent of the closed-loop gain [1]. The new current-amplifiers such as two stage CMOS operational amplifiers, operational trans-conductance amplifiers (OTA), current conveyors (CCII), current-feedback op-Amps (CFOA), current differencing buffered amplifier (CDBA), and current differencing trans-conductance amplifier (CDTA) [2, 3]. In this paper I'll use CDBA. Fuzzy logic is a powerful problem solver methodology with wide range of applications in industrial control, consumer electronics, management, medicine, expert system and information technology [4-6]. There are five parts of the fuzzy system [6]. Fuzzification of the input variables, application of the fuzzy operator (AND or OR) in the antecedent, implication from the antecedent to the consequent, aggregation of the consequents across the rules, and defuzzification [7].

In this paper I will discuss regarding the implementation of triangular membership function using CDBA and simulating it with PSPICE software [8]. In last I'll compare all the electrical parameters of triangular membership function, two stage CMOS operational amplifier [1] and operational transconductance amplifier [9, 10].

II. CURRENT MODE ACTIVE BLOCKS

Operational Transconductance Amplifier (OTA) is a voltage controlled current source (VCCS) [1, 10].

A current differencing transconductance amplifier (CDBA) is a five terminal active component [2, 3] shown in fig 1 useful for realizing of class of analog signal processing circuits.

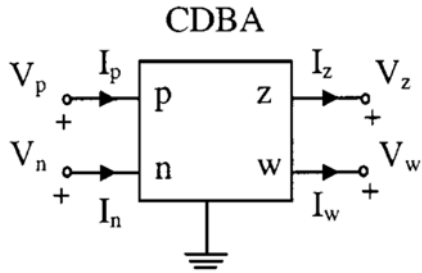


Fig 1 : Five terminal of CDBA

It can be operated both in voltage as well as current mode. The current difference at input is converted to voltage  $V_w$  and is connected to z. CDBA is made of 2 parts namely differential current controlled current source (DCCCS) and voltage buffer [2, 3] shown in Fig 2. DCCCS is obtained by little modification of CCII. DCCCS includes trans linear element. Voltage buffer amplifier is used to transfer a voltage from a first circuit, having high impedance to second circuit with low impedance. 2nd circuit basically prevents loading effect from the first circuit. The characteristics equation for this element is given as:

$$V_p = V_n = 0, \quad I_z = I_p - I_n, \quad V_w = V_z$$

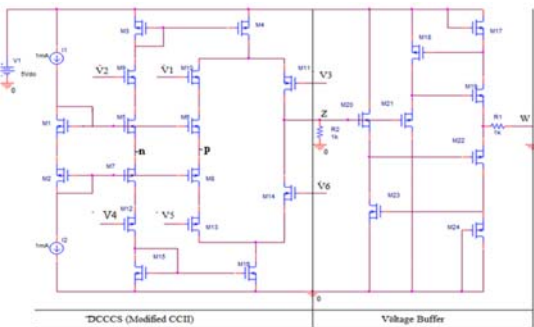


Fig 2: Internal diagram of Current differencing buffered amplifier

The CDBA can be considered as a collection of a non inverting and an inverting current-mode, and non-inverting voltage-mode unity-gain cells, which can be realized by a cascade connection of a current subtractor and a voltage follower. CMOS circuit realization of the CDBA is displayed in Fig 2.

For parameters:  $V_{DD} = 4V$ ,  $k'_N=110\mu A/V^2$ ,  $k'_P=50\mu A/V^2$ ,  $V_{TN}=0.7V$ ,  $V_{TP} = -0.7V$ ,  $\lambda_N=0.04V^{-1}$ ,  $\lambda_P=0.05V^{-1}$ ,  $-1.5V < I_{CMR} < 2V$ , I have calculated aspect ratio for every transistor.  $M1-M8, M15, M16, M20, M21 = 8$ ;  $M9=90$ ;  $M10, M11, M13, M14 = 18.4$ ;  $M12, M17, M18, M19, M23, M24 = 90$ .

III. METHODOLOGY

Our main target is to implement triangular membership functions using CDBA shown in Fig 3. Fig 4 shows how block diagram shown in Fig 3 works?

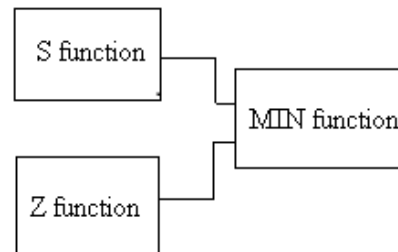


Fig 3 : Block diagram how to implement triangular function

S membership function : The S function can be generated by using the op-amp as a differential amplifier. The two inputs to the amplifier are  $V_x$  and  $V_c$ . The voltage  $V_x$  gives the variable crisp input voltage for which the fuzzified output is to be determined. The voltage  $V_c$  gives the constant input voltage upto which the output voltage will be zero. For voltages greater than  $V_c$ , the output voltage  $V_o$  will increase according to this slope of the S curve. The slope is given by the gain of the op-amp  $R_F/R_1$  [11, 12]. Fig 5 illustrates the electronic implementation of S function.

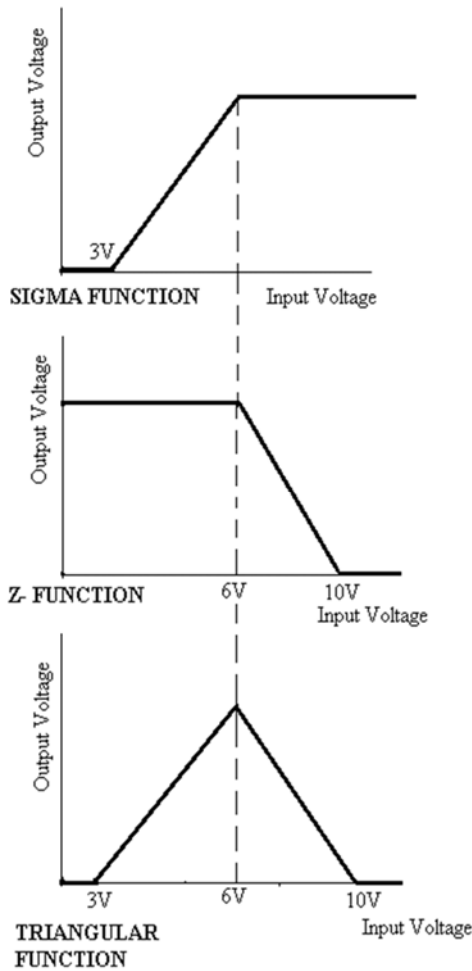


Fig 4 : How block diagram works.

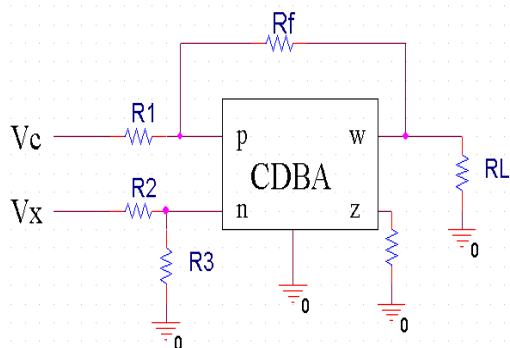


Fig 5: Electronic Implementation of S membership function

Z Membership function : The Z membership function generator can be designed by inverting the output of the circuit for the S function generator [11]. Fig 6 illustrates the electronic implementation of Z function.

I have successfully implemented the S and Z membership functions using CDBA.

Fig 7 shows the MIN function. As outputs of S and Z function is fed to MIN function and then the final output is triangular function. Fig 8 shows its corresponding output.

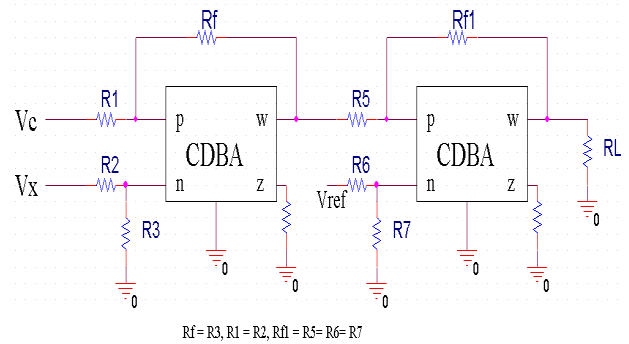


Fig 6: Electronic Implementation of Z membership function

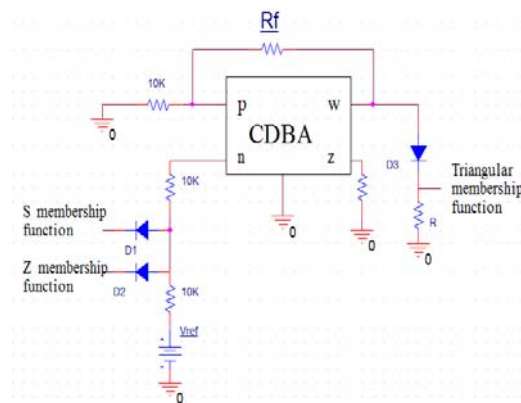


Fig 7: Electronic Implementation of triangular function membership function

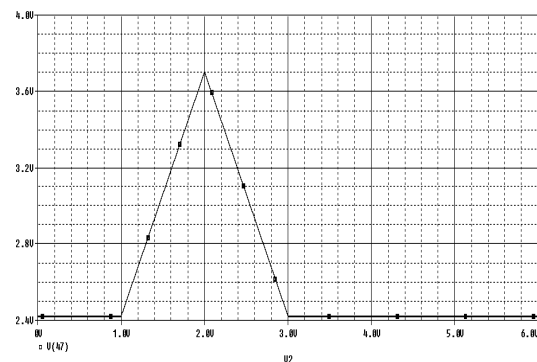


Fig 8 : Output of triangular membership function

Next part is calculation of electrical parameters like slew rate, common mode rejection ratio (CMRR), power dissipation, gain and their resistances corresponding to every membership function. Fig 9 shows the comparison of triangular membership function using two stage CMOS operational amplifier, OTA and CDBA.

#### IV. CONCLUSION

In this paper an attempt has been made for the electronic implementation of triangular fuzzy membership function using current differencing buffered amplifier. I have successfully designed and implemented triangular function. I have also calculated its various parameters like slew rate, CMRR, power dissipation, gain, input resistance and output resistance, and compare their results with two stage CMOS operational amplifier and operational trans-conductance amplifier. Parameters with CDBA are the best. In future i'll see the effect of feedback resistance and load resistance on the output. I'll also implement trapezoidal membership functions and compare the parameters with CDTA also.

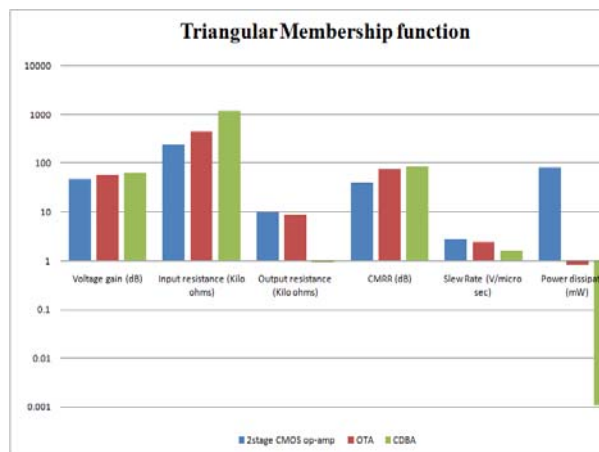


Fig 9: Comparison of electrical parameters of triangular membership function

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