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Fault Diagnosis of state Variable Biquad Using CFOAs and their Neural Predictive Model

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Abstract*— *A fault Diagnosis methodology is proposed based on feed forward neural networks to analyze the analog circuits. In this process, the frequency response of analog circuit is obtained to built the the fault dictionary. This paper present the fault Diagnosis of state variable biquad using CFOAs using feed forward neural predictive model. Workability of state variable biquad using CFOAs has been confirmed through Monte Carlo analysis using PSPICE. This technique is useful in diagnosing and locating fault exactly.

Keywords*— *Fault Diagnosis, Current feedback operational amplifier, neural predictive model

I. INTRODUCTION

The fault diagnosis of analog circuits has been received an attractive attention in research since 1970 see references [1]-[13] and the references cited therein. Generally, an analog circuit fault can be classified into two classes. (i) Catastrophic faults and (ii) parametric faults. Catastrophic fault are easy to detect the fault , whereas the parametric fault is very difficult to detect the fault in the circuits because relationship between parameters deviation and performance degradation can be difficult.In analog circuits design the fault diagnosis, of Sallen key filter using op-amp and state variable biquad using op-amps has been published by researchers. The fault diagnosis of the biquad filters using other than op-amp and OTAs, such as current conveyors, current feedback operational amplifiers, current differencing buffered amplifers (CDBA), Four terminal floating nullor (FTFN), current differencing transconductance amplifiers (CDTA) and operational Transresistance amplifiers (OTRA) etc. are not available in the literature for the best knowledge of the authors.

This paper presents the fau Due to the limitation of traditional voltage mode op-amp, such as confliction of gain and bandwidth and very high slew rate and ease of realising various functions with minimum number of passive components without requiring any component matching. The current feedback operational; amplifiers (CFOA) are prominent building blocks in the area of analog Integrated circuits design for signal processing /signal generation in the literature during last three decades. The large number of voltage mode biquads using CFOAs are available in the literature see reference [14] –[35] and the references cited therein. lt the fault diagnosis of state variable biquad using commercially available AD844-type CFOAs, though the Monte Carlo Analysis using PSPICE. Their neural predictive model can be obtained through MATLAB, which indicates the various faults.

II. STATE VARIABLE CFOAS-BASED BIQUAD

Consider a state variable biquad using four CFOA reported by [34] . Assuming ideal CFOAs, characterized by i_y= 0, i_x= i_z, V_y= V_x, and V_z, = V_w the three transfer functions realised by

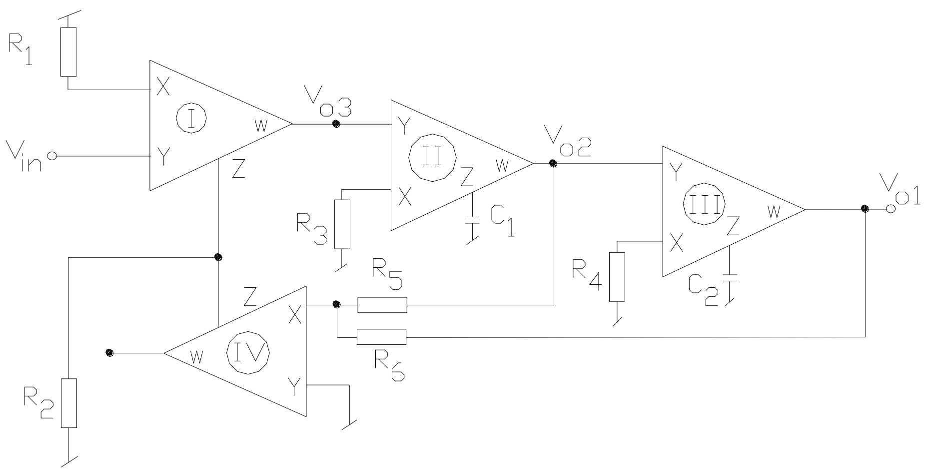


FIG.1 State variable biquad using CFOA [34]

$$T_{LP}(s) = \left(\frac{V_{01}}{V_{in}}\right) = \left(\frac{R_2 / C_1 C_2 R_1 R_3 \ R_4}{D(s)}\right) \quad (1)$$

$$T_{BP}(s) = \left(\frac{V_{02}}{V_{in}}\right) = \frac{s\left(R_2 / C_1 R_1 R_3\right)}{D(s)} \quad (2)$$

$$T_{HP}(s) = \left(\frac{V_{03}}{V_{in}}\right) = \frac{s^2\left(R_2 / R_1\right)}{D(s)} \quad (3)$$

where D(s) = $s^2 + s\left(\frac{R_2}{C_1 R_3 R_5}\right) + \frac{R_2}{C_1 C_2 R_3 R_4 R_6}$ (4)

Note that the filter parameters are given by

$$\omega_0 = \sqrt{\left(\frac{R_2}{R_6}\right)\frac{1}{R_3 R_4 C_1 C_2}} \quad (5)$$

Bandwidth = $\frac{R_2}{C_1 R_3 R_5}$ (6)

$H_{LP} = R_6/R_1$; $H_{BP} = R_5/R_1$ AND $H_{HP} = R_2/R_1$ (7)

From equations (5), (6) and (7), The centre frequency is independently through R_4, bandwidth is by R_5 and gains of LP, BP, and HP is varied by R_1

III. SIMULATION RESULTS

CFOA based Biquad has been simulated in using PSPICE with the micro-model of commercially availableAD844-type CFOA biased by ±12V, their Monte Carlo Analysis with 20 iteration is shown in Fig.2, along with the bandwidth performance by Histogram is shown in Fig.3.In all the twenty iteration, at each passes mean, sigma, F(L/H) and Nominal values are given in Table =II. From the PSPICE simulation results the voltages of each node are given in Table-II. Using neural fuzzy algorithm, these datas has been simulated through MATLAB. The Neural Network Training architecture is shown in Fig.4, Their Training Performance Results is shown in Fig.5. Training at gradient, mu, and fail values is shown in Fig.6. and Training Target is shown in Fig.7 The workability of the PSPICE simulations results and MATLAB results confirms with their theoretical results.

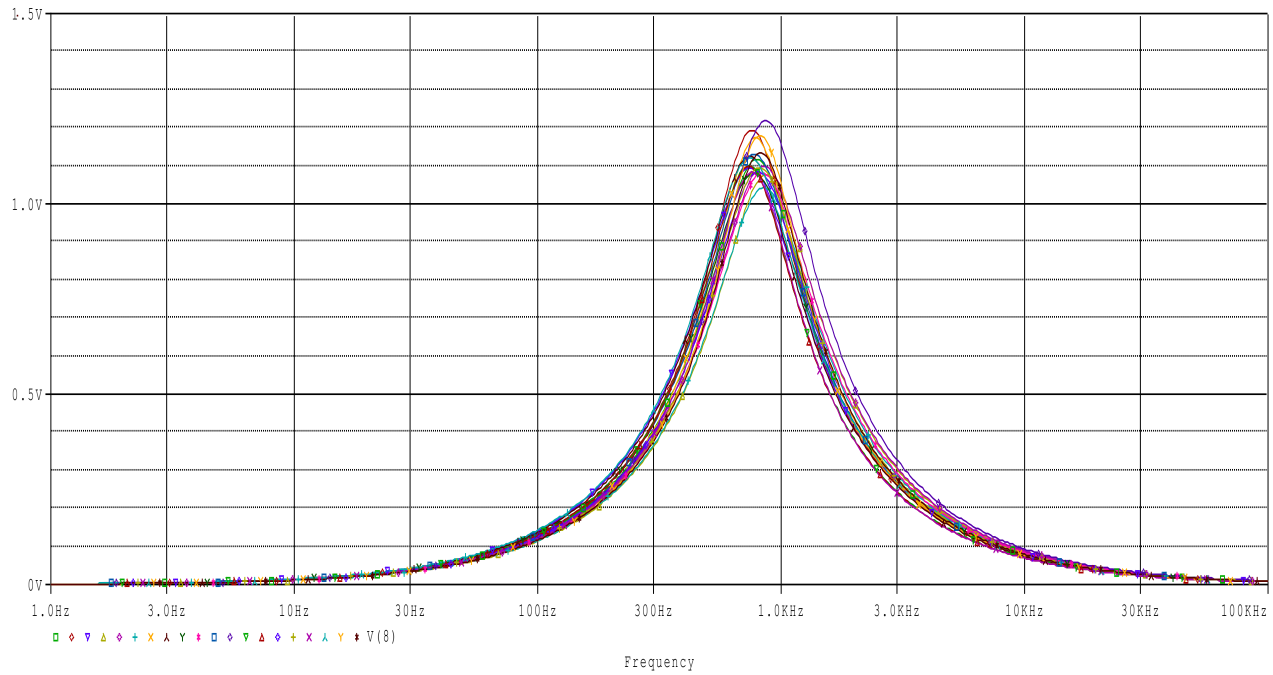
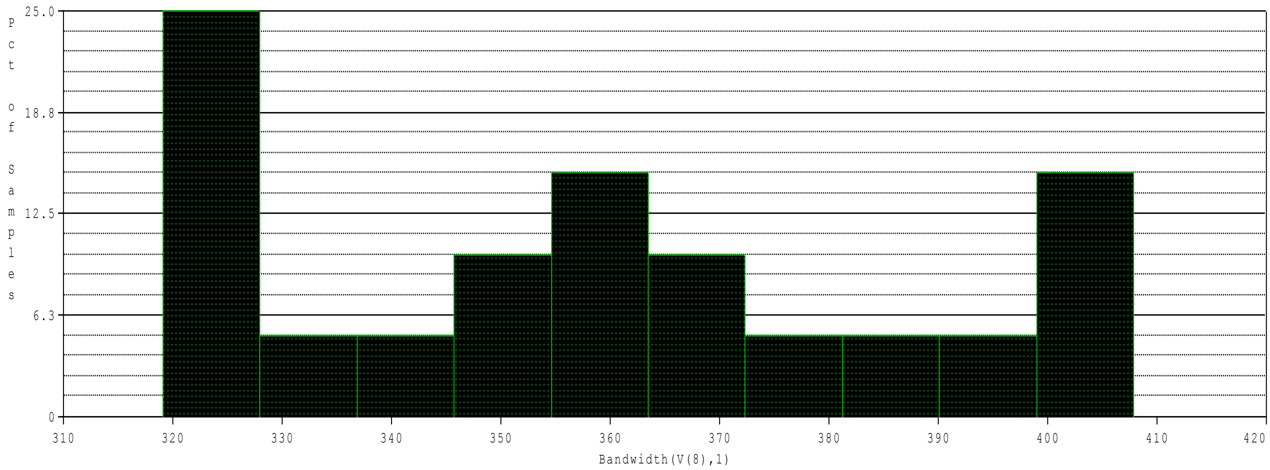


Fig.2.: Freqauncy Response of Bandpass filter of Fig.1. Monte carlo Analysis



n samples = 20 | mean = 359.094 | minimum = 319.091 | median = 356.887 | maximum = 407.864
n divisions = 10 | sigma = 29.5489 | 10th %ile = 323.141 | 90th %ile = 405.034

Fig.3. Histogram of Fig.1. of Bandpass filter

Table-I.: Mean, Sigma, F(L/H) and Nominal Values of Fig.1.

Pass	mean	Sigma	F(L/H)	Nominal
12	.1684	1.96	1.0715E+03(H)	118.17%
6	.113	1.32	645.65(L)	88.806%
4	.1129	1.31	616.6(L)	88.329%
14	.1059	1.23	1.0965E+03(L)	88.275%
13	.1023	1.19	1.0965E+03(L)	88.677%
2	.1016	1.18	660.69(H)	109.87%
17	.0963	1.12	1.1220E+03(L)	89.063%
18	.0857	1.00	524.81(H)	110.62%
8	.0763	.89	549.54(H)	108.95%
10	.0705	.82	630.96(L)	92.873%
3	.0702	.82	501.19(H)	109.21%
19	.0696	.81	891.25(H)	106.43%
5	.0672	.78	1.2589E+03(H)	108.76%
7	.0602	.70	741.31(H)	105.47%
9	.0497	.58	954.99(L)	95.192%
20	.048	.56	512.86(L)	93.881%
16	.0443	.52	588.84(L)	95.194%
11	.035	.41	602.56(H)	103.7 %
15	.0332	.39	724.44(L)	96.963%

Table-II: Node voltage of state variable biquad using CFOAs Fig.1

NODE	NODE VOLTAGE
(1)	0.0000
(2)	57.04E-06
(3)	12.0000
(4)	-12.0000
(5)	.0020
(6)	.0020
(7)	.0021
(8)	.0018
(9)	.0018
(10)	.0019
(11)	-.0087
(12)	-.0087
(13)	32.47E-06
(14)	.0020
(x1.3)	50.00E-06
(x1.4)	-.6796

(x1.5)	.6797
(x1.6)	.6797
(x1.7)	-.6796
(x1.8)	11.7420
(x1.9)	1.0000
(x2.3)	.0021
(x2.4)	-.6775
(x2.5)	.6817
(x2.6)	.6817
(x2.7)	-.6775
(x2.8)	11.7420
(x2.9)	1.0000
(x3.3)	.0019
(x3.4)	-.6777
(x3.5)	.6815
(x3.6)	.6815
(x3.7)	-.6777
(x3.8)	11.7420
(x3.9)	1.0000
(x4.3)	50.00E-06
(x4.4)	-.6796
(x4.5)	.6797
(x4.6)	.6797
(x4.7)	-.6796
(x4.8)	11.7420
(x4.9)	1.0000
(x1.10)	-11.7420
(x1.11)	-1.0000
(x1.13)	7.7000
(x1.14)	-7.7000
(x1.17)	.0020
(x1.21)	.0020
(x1.22)	0.0000
(x1.23)	.5020
(x1.24)	-.4980
(x1.25)	38.1690
(x1.26)	11.5330
(x1.27)	.0020
(x1.30)	57.04E-06
(x1.97)	0.0000
(x2.10)	-11.7420
(x2.11)	-1.0000
(x2.13)	7.7000
(x2.14)	-7.7000
(x2.17)	.0018
(x2.21)	.0018
(x2.22)	0.0000
(x2.23)	.5018
(x2.24)	-.4982
(x2.25)	11.5220
(x2.26)	38.1800
(x2.27)	.0018
(x2.30)	.0021
(x2.97)	0.0000
(x3.10)	-11.7420
(x3.11)	-1.0000
(x3.13)	7.7000
(x3.14)	-7.7000
(x3.17)	-.0087
(x3.21)	-.0087

(x3.22)	0.0000
(x3.23)	.4913
(x3.24)	-.5087
(x3.25)	38.2190
(x3.26)	11.4830
(x3.27)	-.0087
(x3.30)	.0019
(x3.97)	0.0000
(x4.10)	-11.7420
(x4.11)	-1.0000
(x4.13)	7.7000
(x4.14)	-7.7000
(x4.17)	.0020
(x4.21)	.0020
(x4.22)	0.0000
(x4.23)	.5020
(x4.24)	-.4980
(x4.25)	11.5930
(x4.26)	38.1080
(x4.27)	.0020
(x4.30)	32.47E-06
(x4.97)	0.0000

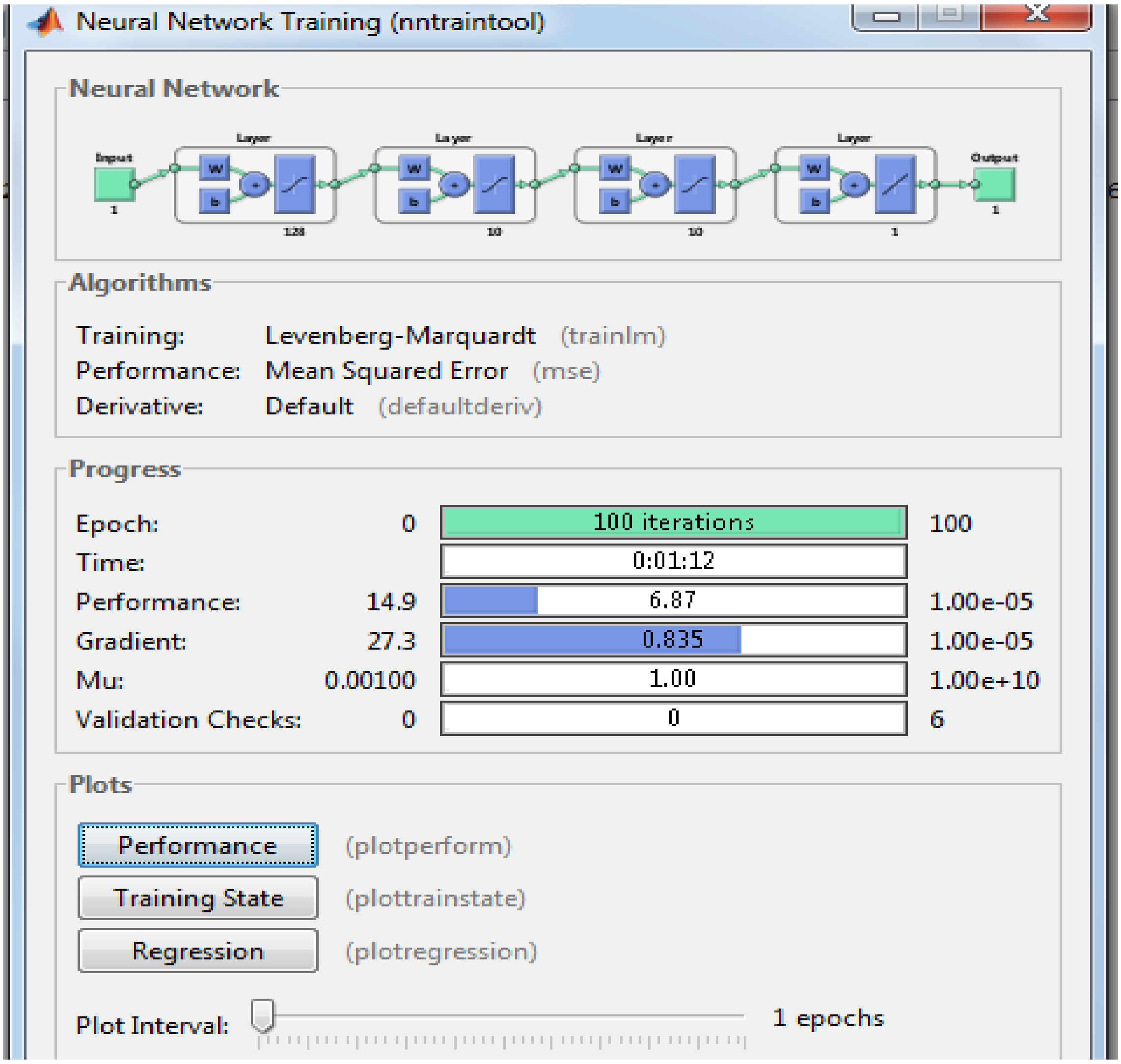


Fig.4: Neural Network Training architecture of table II

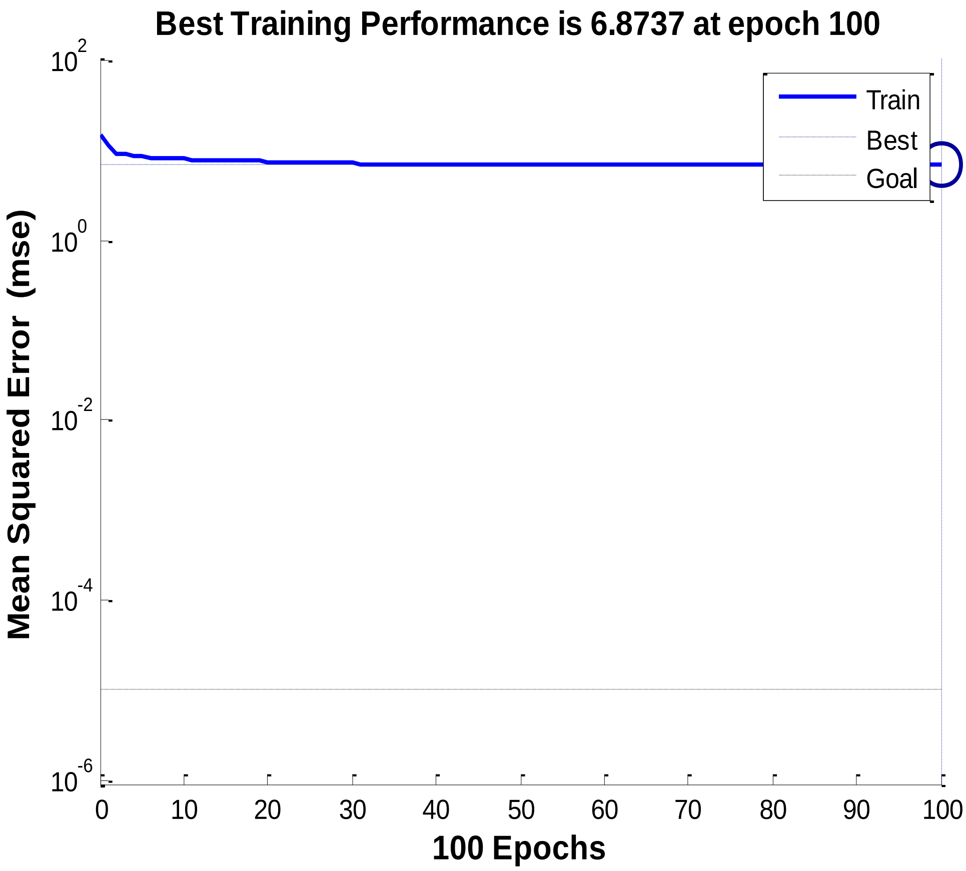


Fig.5: Training Performance Results of table II

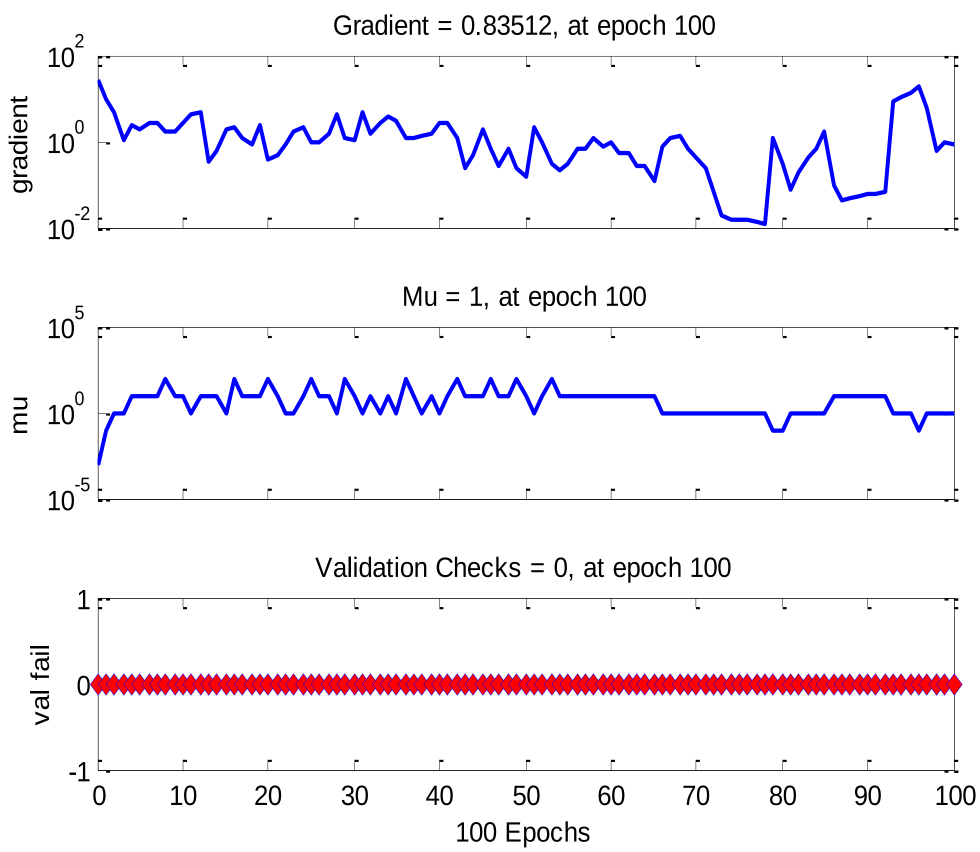


Fig.6 Training at gradient, mu, and fail values of Table II

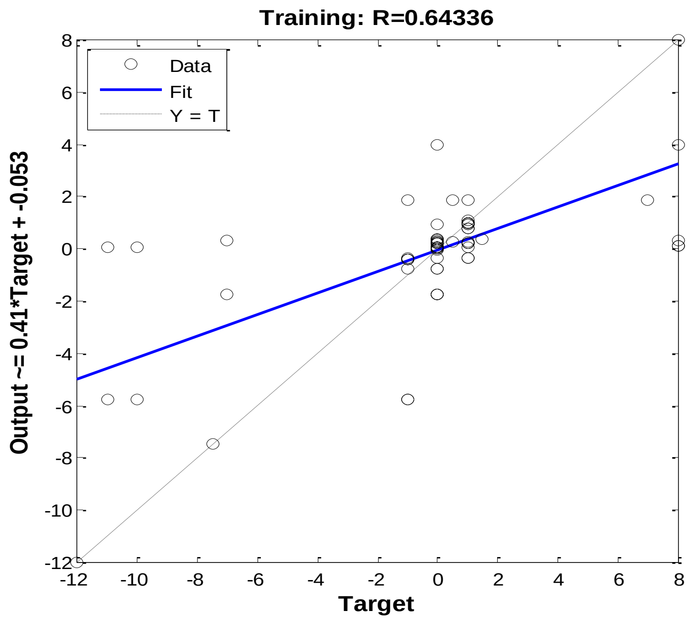


Fig.7: Training Target of Table II

III. CONCLUSIONS

The approach to analog fault diagnosis of state variable Biquad filters using CFOAs was presented here. The faults Diagnosis feature are extracted from feed forward neural network. The workability of the circuit has been verified by PSPICE simulation results. Their frequency response has been obtained. Through, Monte Carlo analysis fault dictionary and Histogram was derived which gives the detail of mean, sigma and Nominal values. A set of node voltage was obtained from the simulation results. Through the feed forward technique in neural network was trained for achieving targets. The workability of the circuit has been confirmed with Theoretical values. Next step, to use fuzzy logic systems to classify for crisp value for the faulty circuit elements

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