IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)
e-ISSN: 2278-2834, p-ISSN: 2278-8735
PP 56-59
www.iosrjournals.org

Effect of Component Tolerance on Performance of Difference Amplifier

Phatangare V.S.[1]&Gundal S.S.[2]
[1,2]*(E&TCDept,AVCOE Sangamner,SPP Univ.Pune(MS), India)*

Abstract : *The Integrated circuit operational amplifier (IC Opamp) is the most widely used for all linear circuits in production today. Opamps find applications in every analog area. Despite of this wide usage, many of the basic performance characteristics of the opamps are based on the external component used along with it. Care should be taken while choosing component for circuit design. One of the parameters , CMRR is considered here to check the performance of the circuit, which depends on external components also. In this paper, performance analysis of the difference amplifier using opamp is done for two sets of resistance values. In one set exactly matched values are considered and in another set different values are considered (this difference is due to tolerance of component) .In both the cases CMRR and output is calculated and result is compared. This shows that if the values of resistances are tightly matched then CMRR is very high and output is free from error voltage and performance of circuit is improved.*

Keywords *-Opamp, CMRR,* V_{CM}*(Common Mode Signal),* V_D*(Differential Mode Signal) ,*G_D*(Differential Gain),*G_{CM}*(Common Mode Gain).*

1. INTRODUCTION

Any signal processing (such as amplification, sampling, filtering) adds noise to a measurement. The difference amplifier is a circuit that requires two separate input voltages. The purpose of the circuit is to amplify the difference between two input voltages. The circuit also has the capability to effectively ignore the inputs when they are the same. This function is vital as all electronic circuits are exposed to interference. Often such interference will result in the input signals having the same voltage value. An ideal difference amplifier will reject all such interference and amplify only the difference between the two inputs. The key to the difference amplifier is an operational amplifier. While using opamp for difference amplifier ,we have to consider some parameters of it. One important parameter is CMRR.

2. COMMON MODE REJECTION RATIO (CMRR)

As opamp has ability to amplify differential signals. In fact the ideal op amp has an infinite gain for differential voltage signals. It is desired that signals that are common to both inputs “Common Mode (CM) Signals” be rejected by the amplifier. An ideal op amp has the ability to completely reject those CM signals; thus having infinite Common Mode Rejection (CMR) ability.

For an amplifier subjected to a differential voltage V_D and a common mode voltage V_{CM}, the output voltage is given by

$V_O = G_D V_D + G_{CM} V_{CM}$

Where G_D is the differential gain and G_{CM} is the common mode gain of the amplifier. In practice we would like to minimize G_{CM}. The ability of an amplifier to reject the CM signal is expressed by a parameter called the Common Mode Rejection Ratio (CMRR) which is defined as the ratio of the differential gain to common mode gain as follows.

$CMRR_{dB}$= 20 $\log_{10}$(Gain of Differential Signal/Gain of Common Mode Signal)

$CMRR_{dB} = 20 \log_{10} (G_D/G_{CM})$

In most of the applications opamps are used in closed loop configurations. . To guarantee the performance of the circuit, the designer must understand what factors can affect the value of CMRR The most basic factors are tolerance and temperature coefficient of resistance (TCR) .In real circuits, resistor mismatch limits the available CMRR .The resistors used in the circuit, marked R1 and R2, has a direct impact on the CMRR .

3. THEORATICAL CMRR ANALYSIS

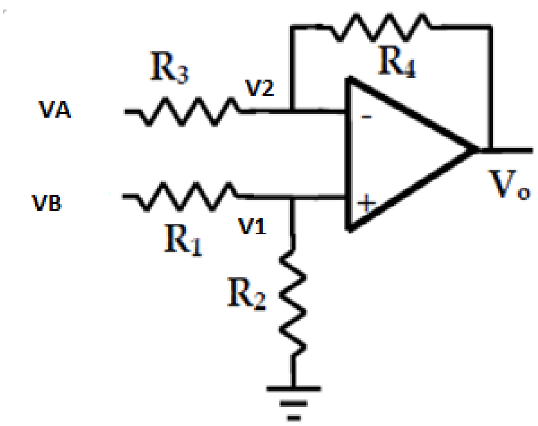

Fig.1 shows the circuit analyzed .It consists of opamp and four resistors.

By appling superposition theorem,

V_O={[1+(R4/R3)]*[R2/(R1+R2)]*VB}-[(R4/R3)]*VA.

V_O=[1+(R4/R3)]*[(R2/R1)/((R2+R1)/R1)]VB-[R4/R3]*VA (1)

Here, we define differential mode and common mode input components as

V_{DM}=VB-VA

V_{CM}=(VB+VA)/2

We can express the actual inputs in terms of the newly defined components:

VB=V_{CM}+V_{DM}/2

VA=V_{CM}-V_{DM}/2 (2)

Thus, we can draw the circuit as shown in fig. 2

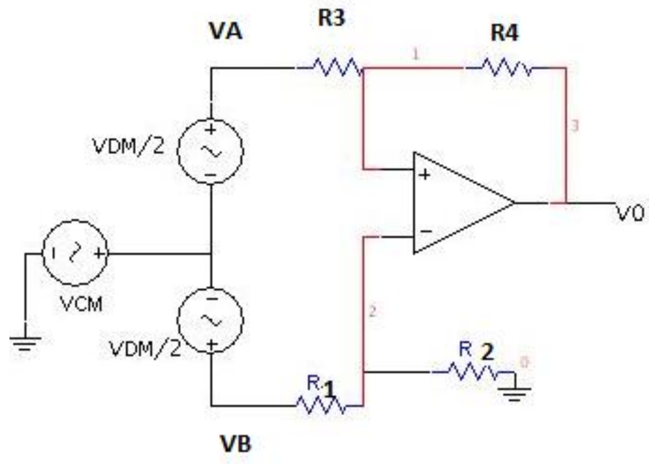

Fig. 2 Difference Amplifier with Common mode Signal and Differential Signal

$V_O=G_DV_{DM}+G_{CM}V_{CM}$ (3)

Take R1=R3=10kΩ

R2=100 kΩ&R4=110 kΩ(R4≠R2 ,due to tolerance)

Hence,

R2/R1=10 & R4/R3=11 (4)

Then, from equation (1) ,output voltage is given by

V_O={[11*(11/12)]*VB}-{[10*VA]}.

V_O=10.0833VB-10VA

From equation (2)

$V_O=10.0833(V_{CM}+V_{DM}/2)-10(V_{CM}-V_{DM}/2)$

$V_O=0.0833V_{CM}+10.042V_{DM}$. (5)

Comparing equations (3)&(5)

$G_{CM}=0.0833$ and $G_D=10.042$

$CMRR_{dB}=20\log_{10}(G_D/G_{CM})=41.6_{dB.}$

Now consider .

R1=R3=10kΩ

R2=R4=100 kΩ (R4=R2=exactly matched)

Hence

R2/R1= R4/R3=10

then from equation (1) ,output voltage is given by

$V_O=\{[11*(10/11)]*V_B\}-\{[10*V_A]\}$.

V_O=10VB-10VA

From equation (2)

$V0=10(V_{CM}+V_{DM}/2)-10(V_{CM}-V_{DM}/2)$

$V0=0-10V_{DM}$ (6)

Comparing equations (3)&(6)

$G_{CM}=0$ and $G_D=10$

$CMRR_{dB}=20 \log_{10} (G_D/G_{CM})=\infty$.

4. RESULTS

Sr No.	Resistance Values	CMRR	V_O
1	R1=R3=10kΩ, R2=R4=100 kΩ	∞	no error voltage (output due to only differential signal)
2	R1=R3=10kΩ, R2=100 kΩ R4=110 kΩ	41.6_{dB}	contains error voltage(output due to differential signal & common mode signal)

5. CONCLUSION

Ifvalues R2 and R4 are exactly equals ,then G_{CM} is zero and CMRR is infinite and output voltage is only due to differential signal. But if R2 and R4 are not same then G_{CM} is non zero and hence CMRR is having some finite value which gives output voltage more .That means if resistance values are not matched ,CMRR degrades and output contains error voltage.This error voltage is due to common mode signal present at input. To reject common mode signal ,we require high CMRR,and high CMRR can be achieved by selecting tightly matched resistances.

REFERENCE

[1] Hwang-Cherng Chow and Jia-Yu Wang "high CMRR instrumentation amplifier for biomedical application" IEEE 2007.

[2] J. Szynowski, "CMRR analysis of instrumentation amplifiers," Electron, Lett. , Vol. 19, No.14, pp. 547-549, 1983

[3] R.Pallas-Areny, "Interference – rejection characteristics of biopotentialamplifiers : A comparison," IEEE Trans. Biomed. Eng. , Vol. BME-35. Pp. 953-959. Nov. 1988.

[4] R.L.Schoenfeld, "Common-mode rejection ratio – Two definitions," IEEE Trans. Biomed. Eng., vol. BME-17, pp.73-74, 1970. Comments on BME-18, p. 251, 1971.

[5] Sergio Franco, "Design with Operational amplifiers & analogue integrated circuits, third edition," Tata McGraw-Hill, pp.73-74, 2002.