

INVERTING AMPLIFIER With Its Design Considerations And Uses

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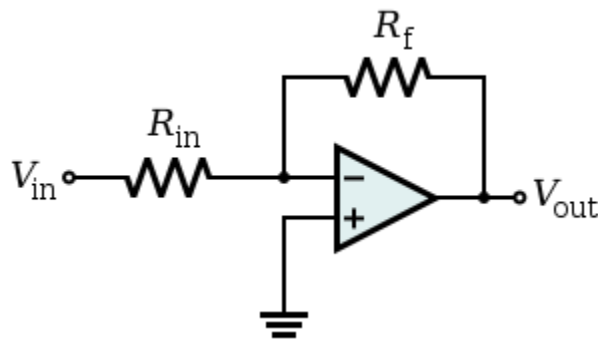
Abstract- The inverting amplifier using an op-amp is one of the most widely used operation amplifier circuits especially as it can be used as summing amplifier or virtual earth mixer. Unlike a non-inverting OP-amplifier which has a minimum possible gain of 1, an inverting Op-amp can be used as an attenuator with a gain less than 1. It has many advantages over non-inverting amplifier.

I. INTRODUCTION

An inverting amplifier is a special case of the differential amplifier in which that circuit's non-inverting input V_2 is grounded, and inverting input V_1 is identified with V_{in}

. The closed-loop gain is R_f/R_{in} , hence

$$V_{out} = - V_{in} * R_f / R_{in}$$



Figure(a): inverting amplifier

The simplified circuit above is like the differential amplifier in the limit of R_2 and R_g very small. In this case, though, the circuit will be susceptible to input bias current drift because of the mismatch between R_f and R_{in} .

To intuitively see the gain equation above, calculate the current in R_{in} :

$$i_{in} = V_{in} / R_{in}$$

then recall that this same current must be passing through, R_f therefore (because $V - = V + = 0$):

$$V_{out} = - i_{in} R_f$$

A mechanical analogy is a seesaw, with the $V -$ node (between R_{in} and R_f) as the fulcrum, at ground potential. V_{in} is at a length R_{in} from the fulcrum; V_{out} is at a length R_f . When V_{in} descends "below ground", the output V_{out} rises proportionately to balance the seesaw, and viceversa.

One key consideration when designing an inverting amplifier is the input impedance. This governs many of the requirements in terms of coupling between stages, particularly when they are AC coupled.

Using the diagram it is easy to determine the input impedance. As the inverting input to the amplifier is at earth potential, the input impedance is simply the value of R_{in} .

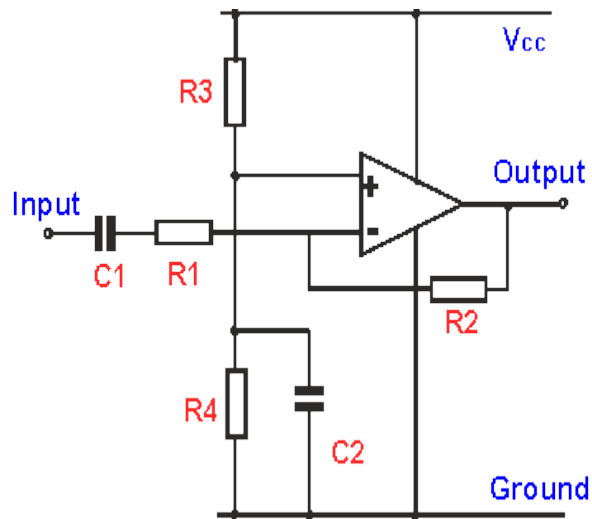
$$\text{Input impedance} = R_{in}$$

II. SINGLE SUPPLY INVERTING AMPLIFIER

Normally op amps use dual supply rails, e.g. $\pm 15V$. This enables the chips to operate using a signal related directly to ground without the need to as much coupling, if any.

This system works well in many applications, but it is not always viable to use dual supplies and in these circumstances it is necessary to change the inverting amplifier topology slightly to enable a single supply rail to be used.

This can be achieved by biasing the input of the op amp at half the rail voltage and then having decoupling to ground where necessary and inter-stage coupling to remove any DC voltages.



Figure(b): Inverting amplifier using a single rail supply

The Single rail inverting amplifier circuit is relatively Straight forward. The operating point is set by the two resistors R3 and R4. C4 provides the decoupling to earth or ground and should offer a low impedance at the lowest frequency of operation.

This circuit works well, but when using it a few design issues must be remembered:

-Resistors R3 & R4: These two resistors form the bias for the non-inverting amplifier, setting the input voltage and operating point. Typically they are set to provide half the supply voltage and therefore they will be equal in value.

Values of around 100kΩ are often chosen because they determine the input impedance.

-Capacitor C2 value: The value of this capacitor must be chosen to give a low impedance at low frequencies. It will help to reduce any noise from the power supply that may be present.

-Operating range: Dependent upon the requirements for the inverting amplifier circuit, it may be necessary to choose an op amp that is able to operate with its output voltage close to either voltage rail. In this way the maximum output

voltage swing can be obtained.

III. INVERTING AMPLIFIER DESIGN CONSIDERATIONS

There are a number of design considerations and tips to be kept in mind when designing an inverting amplifier circuit using an op amp.

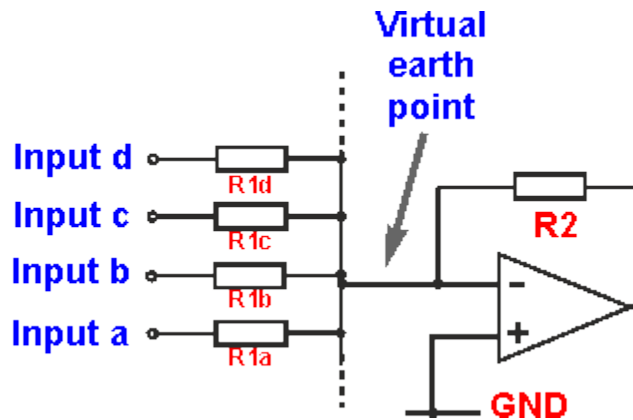
-Bandwidth product: It is worth mentioning at this point that for high levels of gain, the gain bandwidth product of the basic op amp itself may become a problem. With levels of gain of 100, the bandwidth of some operational amplifier ICs may only be around 3 kHz.

-Input impedance: With the value of R1, the input resistor being lower than the feedback resistor R2, care has to be taken when designing the circuit to ensure the input resistance is not too low for any given application. Often values of 10kΩ are used as this provides a reasonable load resistance for many circuits. However the exact requirements need to be determined for each application.

-Range of values for R1 and R2: When designing an inverting amplifier it is necessary to ensure that the values of the resistor used remain within 'sensible' bounds. If the input resistor is made too low, then the circuit may load the previous circuit too much. If high gain levels are required, then this may mean that the feedback resistor, R2 must be higher. Even though the input impedance of the integrated circuit itself may be high, using a high value of feedback resistor is not advisable as results may become a little unpredictable. As a very broad rule of thumb values for R2 of up to 100kΩ or a little more should be fine. Values above this should be used with a little caution, as the circuit may produce some unexpected effects, although in many instances they may work acceptably well.

IV. SUMMING AMPLIFIER / VIRTUAL EARTH MIXER

The fact that the inverting input to the amplifier is virtually at earth potential provides some significant possibilities for audio mixer applications.



Figure(c): Summing amplifier / virtual earth mixer

This form of virtual earth mixer, or summing amplifier adds several different signals in a linear or additive fashion. It is not the form of multiplier mixer used in RF circuits where a non-linear action is used.

Op amp summing amplifier / virtual earth mixer

There is almost no limit to the number of inputs that can be added. The gain for each leg being $R2 / R1y$ where $R1y$ is the input resistor for that particular channel.

V. ADVANTAGES

1) Unlike a non-inverting OP-amplifier which has a minimum possible gain of 1, an inverting Op-amp can be used as an attenuator with a gain less than 1 as well. Another advantage is that the input impedance of non-inverting op-amp is infinite while that of Inverting op-amp it is equal to the resistance between the input and the inverting terminal, so a better impedance matching can be obtained.

2) Slew rate of inverting amplifier is more and cmrr is more compared to non inverting amplifier.

3) Inverting op-amps provide more stability to the system than non-inverting op-amp. In case of inverting op-amp negative feedback is used that is always desirable for a stable system.

4) Speed of the opamp depends inversely on gain bandwidth product. This product is less for inverting

compared to non inverting hence output rise time is less for inverting but in non inverting topology this product is same as open loop opamp.

VI. CONCLUSION

This review summarizes the inverting amplifier its uses as summing amplifier or virtual earth mixer. Inverting amplifier has many advantages over non inverting amplifier. An inverting amplifier is a special case of the differential amplifier in which that circuit's non-inverting input V_2 is grounded, and inverting input V_1 is identified with V_{in} . Inverting amplifier has many advantages over non inverting amplifier.

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