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Theory of non inverting amplifier

Aim To design and simulate Summing and Averaging Amplifier circuits using 741. Components Name EDWin Components Used Description Number of components required RES RC05 Resistor 6 COMPARATOR LM358 Comparator 1 VDC VDC Dc voltage source 5 GND SPL0 Ground 7* Theory An operational amplifier is a direct coupled high gain amplifier consisting of one or more differential amplifiers and usually followed by a level translator and an output stage which is usually a push-pull or push-pull complementary symmetry pair. An operational amplifier can be used to amplify ac as well as dc input signals and was originally designed for computing such mathematical functions as addition, subtraction, multiplication and integration. An opamp can be configured in either the inverting or in the non-inverting mode. The circuit shown below is called a non-inverting amplifier, since the input voltage sources and resistors are connected to the non-inverting terminal of the op-amp. The circuit can be used either as a summing or an averaging amplifier through the selection of appropriate values of resistors, R1 and RF. The input resistance RiF of the non-inverting amplifier is very large and is given by In order to verify the functions of the circuit, the expression for the output voltage can be obtained as follows. Applying the superposition theorem, the voltage V1 at the non-inverting terminal is Hence the output voltage Vo is Summing Amplifier The Summing Amplifier produced using 741 is the circuit that sums up all the input voltages. As evident from equation 4 if the gain is equal to the number of inputs, the output voltage becomes equal to the sum of all input voltages. That is, if , then . Hence the circuit is called a non-inverting summing amplifier. Averaging Amplifier The output of the non-inverting amplifier as obtained from equation 4 is equal to the average of all the input voltages times the gain of the circuit, hence the name averaging amplifier. Depending on the application requirement the gain can be set to a specific value. If the gain is 1 then the output voltage will be equal to the average of all input voltages. One special feature to be noted is that the non- inverting input voltage V1 is the average of all the inputs. Procedure EDWinXP-> Schematic Editor: The circuit diagram is drawn by loading components from the library. Wiring and proper net assignment has been made. The values are assigned for relevant components. EDWinXP-> Mixed Mode Simulator: The circuit is preprocessed. Waveform markers are placed in input and output of the circuit. GND net is set as reference net. The Transient Analysis parameters have been set. The Transient Analysis is executed and output waveform is observed in the Waveform Viewer. Result The output waveform may be observed in the waveform viewer. The two major classifications of operational amplifiers are the inverting and non-inverting amplifier. The crucial difference between inverting and non-inverting amplifier is that an inverting amplifier is the one that produces an amplified output signal which is out of phase to the applied input. As against, a non-inverting amplifier that amplifies the input signal level without changing the phase of the signal at the output. What is Op-amp? Operational amplifiers are considered as the fundamental component of analog electronic circuits. It is a linear device that is used for amplification of the DC signal. Thus, is used in signal conditioning, filtering, and performing operations like addition, subtraction, integration, etc. The various components like resistor, capacitor, etc. present between the input and output terminals of the amplifier and are used for amplifying the voltage level of the applied signal. It is a three-terminal device that has two inputs and one output terminal. Out of the two input terminals, one is an inverting terminal while the other is non-inverting. This article will provide the idea regarding the various differentiating factors between the inverting and non-inverting amplifiers. Content: Inverting Vs Non-Inverting Amplifier Comparison Chart Definition Key Differences Conclusion Comparison Chart Basis of ComparisonInverting AmplifierNon-Inverting Amplifier BasicIt provides an amplified signal which is out of phase with the applied input.It is designed to provide an amplified signal which is in phase with the signal present at the input. Phase difference between input and output180°0° InputApplied at negative input terminalProvided at positive input terminal Achieved outputInverted in natureNon-inverted in nature Expressed asNegative polarityPositive polarity Gain of AmplifierRatio of resistances.Summation of 1 with the ratio of resistances. Ground connectionThe positive input terminal is groundedThe negative input terminal is grounded Gain PolarityNegativePositive Definition of Inverting Amplifier A type of op-amp that is designed to generate a signal at the output which is 180° out of phase with the applied input is known as an inverting amplifier. This implies that if the phase of the applied input signal is positive then the amplified signal will be in a negative phase. In a similar way for a signal with a negative phase, the phase of the output will be positive. It is regarded as one of the simplest and widely used configurations of the op-amp. The figure below represents the circuit of inverting amplifier: Here from the above figure, it is clear that the feedback is provided to the op-amp so as to have the closed-loop operation of the circuit. To have the accurate operation of the circuit, negative feedback is provided to it. Thus, to have a closed-loop circuit, the input, as well as the feedback signal from the output, is provided at the inverting terminal of the op-amp. For, the above-given network, the gain is given as: Definition of Non-Inverting Amplifier An amplifier that produces an amplified signal at the output, having a similar phase as that of the applied input is known as the non-inverting amplifier. This simply means that for an input signal with a positive phase, the output will also be positive. Also, the same goes for input with the negative phase. The figure below represents the circuit of the non-inverting amplifier: In this case, to have an output of the same phase as input, the input signal is applied at the non-inverting terminal of the amplifier. But here also negative feedback is to be provided, thus, the fed-back signal is provided to the inverting terminal of the op-amp. The closed-loop gain of the non-inverting amplifier is given as: It is to be noted here that an amplifier with an inverting configuration can be converted into a non-inverting one, just be altering the provided input connections. The key factor of differentiation between inverting and non-inverting amplifier is done on the basis of phase relationship existing between input and output. In the case of the inverting amplifier, the output is out of phase wrt input. Whereas for the non-inverting amplifier, both input and output are in the same phase. The input signal in the inverting amplifier is applied at the negative terminal of the op-amp. On the contrary, the input in the case of a non-inverting amplifier is provided at the positive terminal. The gain provided by the inverting amplifier is the ratio of the resistances. As against, the gain of the non-inverting amplifier is the summation of 1 and the ratio of the resistances. In the inverting amplifier, the non-inverting terminal is grounded. Whereas in the non-inverting amplifier, the inverting terminal of the op-amp is grounded. The achieved gain of the inverting amplifier is negative thus it provides inverted output. But for a non-inverting amplifier, the gain is positive and hence the achieved output is non-inverted in nature. Conclusion The above discussion about the inverting and non-inverting amplifier concludes that in both inverting and non-inverting amplifiers negative feedback is used that helps to provide the controllable gain of the amplifier. Operational amplifiers can be used in two basic configurations to create amplifier circuits. One is the inverting amplifier where the output is the inverse or 180° out of phase with the input, and the other is the non-inverting amplifier where the output is in the same sense or in phase with the input. Non-Inverting Amplifier Circuit Basic: The basic non-inverting amplifier circuit using an op-amp is shown below. In this circuit the signal is applied to the non-inverting input of the amplifier. However the feedback is taken from the output via a resistor to the inverting input of the operational amplifier where another resistor is taken to ground. It is the value of these two resistors that govern the gain of the operational amplifier circuit. Non-Inverting Amplifier Circuit The gain of the non-inverting amplifier circuit for the operational amplifier is easy to determine. The calculation hinges around the fact that the voltage at both inputs is the same. This arises from the fact that the gain of the amplifier is exceedingly high. If the output of the circuit remains within the supply rails of the amplifier, then the output voltage divided by the gain means that there is virtually no difference between the two inputs. As the input to the op-amp draws no current this means that the current flowing in the resistors R1 and R2 is the same. The voltage at the inverting input is formed from a potential divider consisting of R1 and R2, and as the voltage at both inputs is the same, the voltage at the inverting input must be the same as that at the non-inverting input. This means that Vin = Vout x R1 / (R1 + R2). Hence the voltage gain of the circuit Av can be taken as: Non-inverting Operational Amplifier Configuration: In the previous Inverting Amplifier tutorial, we said that for an ideal op-amp “No current flows into the input terminal” of the amplifier and that “V1 always equals V2”. This was because the junction of the input and feedback signal (V1) are at the same potential. In other words the junction is a “virtual earth” summing point. Because of this virtual earth node the resistors, Rƒ and R2 form a simple potential divider network across the non-inverting amplifier with the voltage gain of the circuit being determined by the ratios of R2 and Rƒ as shown below. Equivalent Potential Divider Network: Then using the formula to calculate the output voltage of a potential divider network, we can calculate the closed-loop voltage gain (A V) of the Non-inverting Amplifier as follows: Then the closed loop voltage gain of a Non-inverting Operational Amplifier will be given as: We can see from the equation above, that the overall closed-loop gain of a non-inverting amplifier will always be greater but never less than one (unity), it is positive in nature and is determined by the ratio of the values of Rƒ and R2. If the value of the feedback resistor Rƒ is zero, the gain of the amplifier will be exactly equal to one (unity). If resistor R2 is zero the gain will approach infinity, but in practice it will be limited to the operational amplifiers open-loop differential gain, (Ao). We can easily convert an inverting operational amplifier configuration into a non-inverting amplifier configuration by simply changing the input connections as shown. non-inverting amplifier Input- impedance of non-inverting amplifier: It is often necessary to know the input impedance of a circuit. The input impedance of this non-inverting amplifier circuit is very high, and may typically be well in excess of 10^7 ohms. For most circuit applications this can be completely ignored. This is a significant difference to the inverting configuration of an operational amplifier circuit which provided only a relatively low impedance dependent upon the value of the input resistor. AC coupling the non-inverting op-amp circuit: In most cases, it is possible to DC couple the circuit. However. in this case it is necessary to ensure that the non-inverting has a DC path to earth for the very small input current that is needed. This can be achieved by inserting a high-value resistor, R3 in the diagram, to ground as shown below. The value of this may typically be 100 k ohms or more. If this resistor is not inserted the output of the operational amplifier will be driven into one of the voltage rails. Basic non-inverting operational amplifier circuit with capacitor coupled input When inserting a resistor in this manner it should be remembered that the capacitor-resistor combination forms a high-pass filter with a cut-off frequency. The cut-off point occurs at a frequency where the capacitive reactance is equal to the resistance. Op amp as a voltage follower: A non-inverting amplifier using an op amp forms an ideal voltage follower. The very high gain of the op-amp enables it to present a very high impedance to the signal source whilst being able to accurately follow the voltage waveform. An op amp is configured in its non-inverting amplifier format, linking the output directly to the inverting input and applying the input signal to the non-inverting input. From the gain equation. it is possible to see that the voltage gain of this circuit is unity. Av = 1 + R2 / R1. R2 is zero and R1 is infinity, so the term R2/R1 is zero and this means that Av = 1. Non-inverting amplifier used as a voltage follower Non-inverting amplifier using single supply: Normally op amps are configured to use dual supplies – the chips are intended for use in this way. However, this is not always feasible if only one rail is present. To enable the op amp to run with just one power rail, the positive and negative rails have to be simulated by operating the amplifier half way between the rail and ground, and ensuring the decoupling is sufficient in all the required areas. This is often referred to as a virtual ground technique. To create the virtual ground, two resistors form a voltage divider so that the half the rail voltage, Vcc/2 appears at the non-inverting input of the op-amp. Non-inverting amplifier using a single voltage rail 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 typically chosen because they determine the input impedance. To incoming signals they are in parallel with each other and the input impedance of the op-amp itself is normally much higher and is often ignored – although check for the given op amp. Assuming this and each resistor being 100 kΩ, then the resistance in parallel is 50Ω Capacitor C2 value: The value of this capacitor must be chosen to give a low impedance at low frequencies. It is typically chosen to be equal in impedance to R1 at the lowest frequency required – this will give a -3dB fall at this frequency. Capacitor C2 type: It is important that this capacitor must be a low leakage type. If not the leakage could cause the output to hit the voltage rail if there is some gain in the circuit. Typically ceramic or tantalum types are best. Electrolytic types have a higher leakage and may not be suitable. Operating range: Dependent upon the requirements for the non-inverting amplifier, 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. This type of circuit is often very useful when only one supply line is available. Often it is more convenient to adopt this approach that provide an additional supply rail. Feedback is important to us.

what is the non inverting amplifier

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