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Log amplifier (https://goo.gl/RLYrxw) _

admin February 24, 2012 22 Comments

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Log amplifier.

Log amplifier is a linear circuit in which the output voltage will be a constant times the natural logarithm of the input. The basic output equation of a log amplifier is $V_{out} = K \ln (V_{in}/V_{ref})$; where V_{ref} is the constant of normalisation, and K is the scale factor. Log amplifier finds a lot of application in electronic fields like multiplication or division (they can be performed by the addition and subtraction of the logs of the operand), signal processing, computerised process control, compression, decompression, RMS value detection etc. Basically there are two log amp configurations: Opamp-diode log amplifier and Opamp-transistor log.

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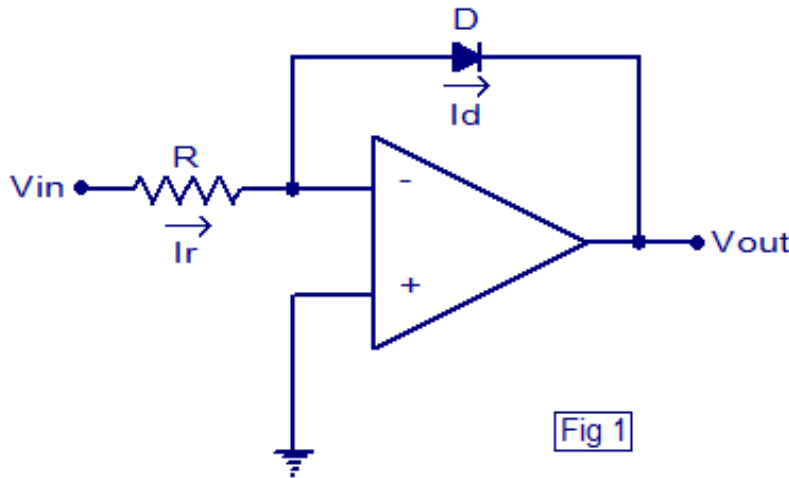
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Opamp-diode log amplifier.



Opamp - diode log amplifier

(<https://goo.gl/RLYrxw>).

Opamp-diode log amplifier

The schematic of a simple Opamp-diode log amplifier is shown above. This is nothing but an opamp wired in closed loop inverting configuration with a diode in the feedback path. The voltage across the diode will be always proportional to the log of the current through it and when a diode is placed in the feedback path of an opamp in inverting mode, the output voltage will be proportional to the negative log of the input current. Since the input current is proportional to the input voltage, we can say that the output voltage will be proportional to the negative log of the input voltage.

According to the PN junction diode equation, the relationship between current and voltage for a diode is

$$I_d = I_s (e^{(V_d/V_t)} - 1) \dots \dots \dots (1)$$

Where I_d is the diode current, I_s is the saturation current, V_d is the voltage across the diode and V_t is the thermal voltage.

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Since V_d the voltage across the diode is positive here and V_t the thermal voltage is a small quantity, the equation (1) can be approximated as

$$I_d = I_s e^{(V_d/V_t)} \dots\dots\dots(2)$$

Since an ideal opamp has infinite input resistance, the input current I_r has only one path, that is through the diode. That means the input current is equal to the diode current I_d .

$$\Rightarrow I_r = I_d \dots\dots\dots(3)$$

Since the inverting input pin of the opamp is virtually grounded, we can say that

$$I_r = V_{in}/R$$

Since $I_r = I_d$ (from equation (3))

$$V_{in}/R = I_d \dots\dots\dots(4)$$

Comparing equation (4) and (2) we have

$$V_{in}/R = I_s e^{(V_d/V_t)}$$

i.e. $V_{in} = I_s R e^{(V_d/V_t)} \dots\dots\dots(5)$

Considering that the negative of the voltage across diode is the output voltage V_{out} (see the circuit diagram (fig1)), we can rearrange the equation (5) to get

$$V_{out} = -V_t \ln(V_{in}/I_s R)$$

Opamp transistor log amplifier.

In this configuration a transistor is placed in the feedback path of an opamp wired in inverting mode. Collector of the transistor is connected to the inverting input of the opamp, emitter to output and base is grounded. The necessary

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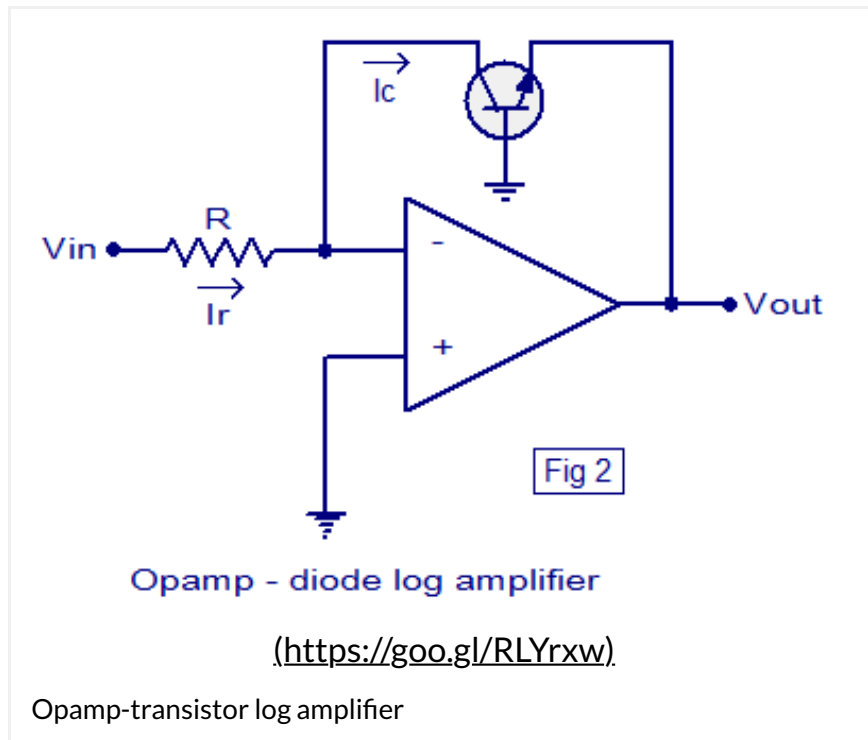
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condition for a log amp to work is that the input voltage must be always positive. Circuit diagram of an Opamp-transistor log amplifier is shown below.



From Fig 2 it is clear that base-emitter voltage of the transistor $V_{be} = -V_{out}$ (1)

We know that $I_c = I_{so} (e^{(V_{be}/V_t)} - 1)$ (2)

Where I_c is the collector current of the transistor, I_{so} the saturation current, V_{be} the base emitter voltage and V_t the thermal voltage.

Equation (1) can be approximated as $I_c = I_{so} e^{(V_{be}/V_t)}$ (3)

ie, $V_{be} = V_t \ln (I_c/I_{so})$ (4)

Since input pin of an ideal opamp has infinite input impedance, the only path for the input current I_r is through the transistor and that means $I_r = I_c$.

Since the inverting input of the opamp is virtually grounded $I_r = V_{in}/R$

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That means $I_c = V_{in}/R$ (5)

From equations (5) , (4) and (1) it is clear that

$V_{out} = -V_t \ln (V_{in}/I_{s0}R_1)$(6)

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COMMENTS

Hari

April 6, 2018

Purpose of hysteresis in a comparator?



Hari

April 6, 2018

How current characteristics of pn junction employed in a log amplifier?



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Charles.

November 17, 2017

In your article, saying that for Opamp-transistor log amplifier, "The necessary condition for a log amp to work is that the input voltage must be always positive." Is there any mistake? I feel the input voltage should be always negative, not positive. Please help me clarify this. Thank you.



R Va (<https://goo.gl/RLYrxw>)

October 30, 2017

What would happen if the input voltage is negative? On both cases.



Hailv

October 19, 2017

Why use it for measurement light?



Saroj Chaudhari

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May 1, 2017

Can you please tell me the limitations of basic log amplifier?



teo

October 8, 2016

what is aplication?



Juan Lizarazo

September 28, 2016

Aren't these circuits very temperature dependent?. Do you have an idea of how strong this dependence will be?



lingesh

July 30, 2016

How to convet the one value into log value

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bear woods

April 22, 2016

does equation five change if opamp is ideal.



bear woods

April 21, 2016

Does the formula change if I add a resistor just before the ground on the diode drawing. the resistor would be between the ground and the positive side of the op-amp



rohit mishra (<https://goo.gl/RLYrxw>)

February 27, 2015

which diode is use in log amplefier?



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January 30, 2016

Pn junction diode



SUNDAR

February 7, 2016

Well, any diode with normal thermal characteristics suffices. The Thermal Voltage for a standard diode comes to 26mV at room temperature of 30 degC



megala

September 23, 2016

PN junction diode is used.



T-Tech

January 20, 2015

Excuse me but how can a NPN transistor work when base is grounded?

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Mukesht

July 28, 2015

Because the transistor is in the common base configuration



Arjun Shrestha

October 19, 2013

Please make me clear about the final equation in diode model..Thank you..



Jaco

January 16, 2014

i.e. $V_{in} = I_s R e^{(V_d/V_t)}$

(5)

$e^{(V_d/V_t)} = V_{in}/(I_s R)$

$\ln[e^{(V_d/V_t)}] = \ln[V_{in}/(I_s R)]$

$V_d/V_t = \ln[V_{in}/(I_s R)]$

$V_d = V_t \ln[V_{in}/(I_s R)]$

Considering that the negative of the voltage across diode is the output voltage V_{out} (see the circuit diagram (fig1)), we can rearrange the equation (5) to get

$$V_{out} = -V_t \ln[V_{in}/(I_s R)]$$



Fady Mourad

March 24, 2012

please, i want more explanation about the transformation from equation 5 to the final form equation in the diode model
thnx in advance



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