Classroom

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Electronics & Communication Engineering

Analog Circuits Part-1

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1. A full wave rectifier has load resistance of 500 Ω and the used diodes has internal resistance of 50 Ω. If turn ratio from primary to half of secondary of transformer is 5:1 and primary winding voltage is 240 V rms, 50 Hz then calculate:

(i) dc and ac output current

(ii) dc and ac output voltage

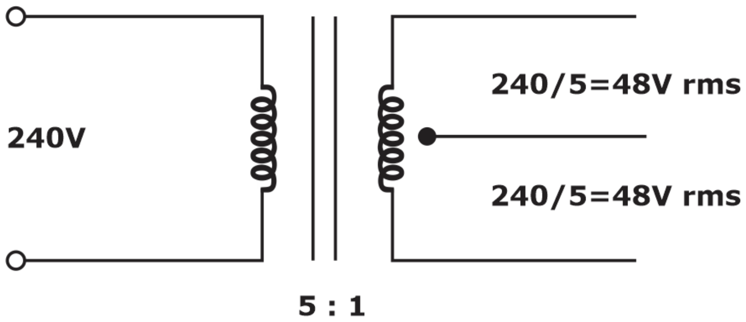
(iii) dc diode voltage and current

(iv) efficiency and regulation factor

(v) PIV and ripple frequency

(vi) RMS output current

Sol.



R_L = 500 Ω, R_f = 50 Ω

Rms secondary voltage $= \frac{V_m}{\sqrt{2}} = 48$

$\Rightarrow V_m = 48\sqrt{2} = 67.88V$

$\therefore I_m = \frac{V_m}{R_f + R_L} = \frac{67.88}{550} = 123\,mA$

(i) $I_{DC} = \frac{2I_m}{\pi} = \frac{2 \times 123}{\pi} = 78.3$ mA

AC output current I'_{rsm} ,

So, I'_{rms} = r × I_{DC} = 0.483 × 78.3

I'_{rms} = 37.82 mA

(ii) V_{DC} = I_{DC}, R_L = 78.3 × 10^{-3} × 500 = 39.15 V

AC output voltage V'_{rms} = r . V_{DC}

= 0.483 × 39.15

V'_{rms} = 18.9 V

(iii) $V_{diode,DC} = -\frac{2V_m}{\pi} = -\frac{2 \times 67.88}{\pi} = -43.16V$

$I_{diode,\,DC} = \frac{I_m}{\pi} = 39.15$ mA

(iv) $\%\eta = 81 \times \frac{R_L}{R_f \times R_L} = 81 \times \frac{500}{550}\%$

$\%\eta = 73.63\%$

$\%\text{Regulation} = \frac{R}{R_L} \times 100\% = \frac{50}{500} \times 100\% = 10\%$

(v) PIV = V_m

= 2 × 67.88 = 135.76 V

Ripple frequency = 2 f_0 = 100 Hz

(vi) RMS output current

$I_{rms} = \frac{I_m}{\sqrt{2}} = \frac{123}{\sqrt{2}} mA$

$\Rightarrow I_{rms} = 86.97$ mA

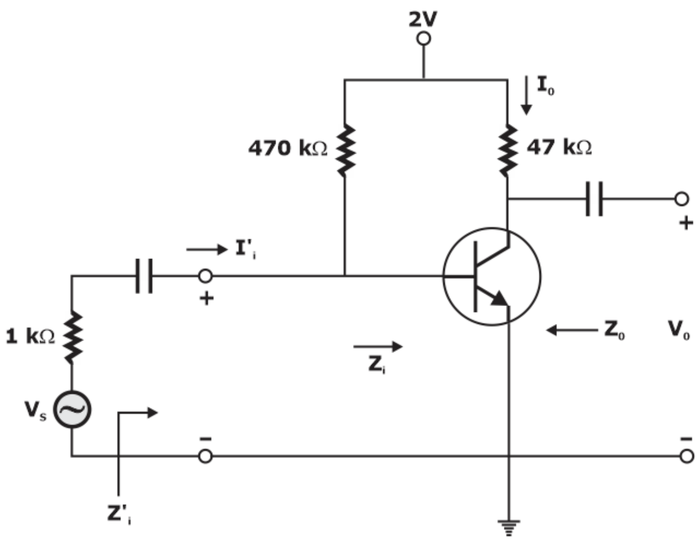
2. For the network shown below, determine the value of following parameters by using complete hybrid-equivalent model.

A. Z_i and Z'_i

B. A_V

C. $A_i = \frac{I_o}{I_i}$ and $A_i' = \frac{I_o}{I_i'}$

D. Z_o

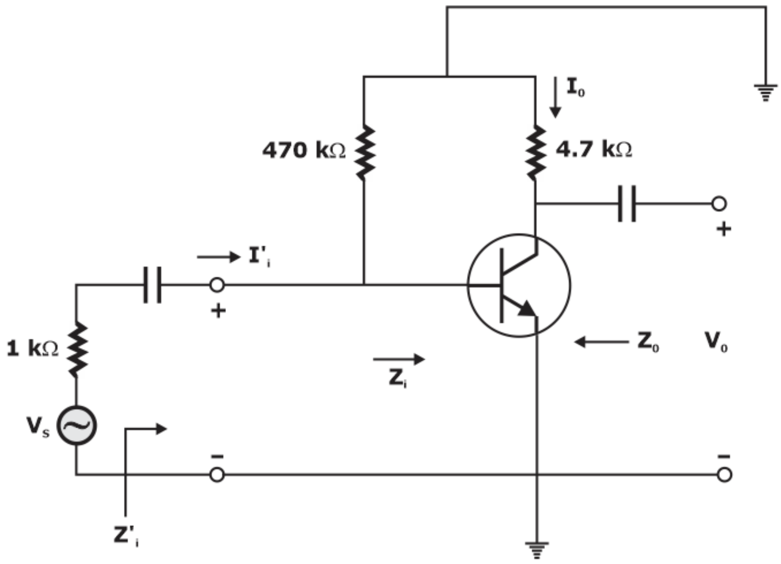


The h-parameters of the transistor are:

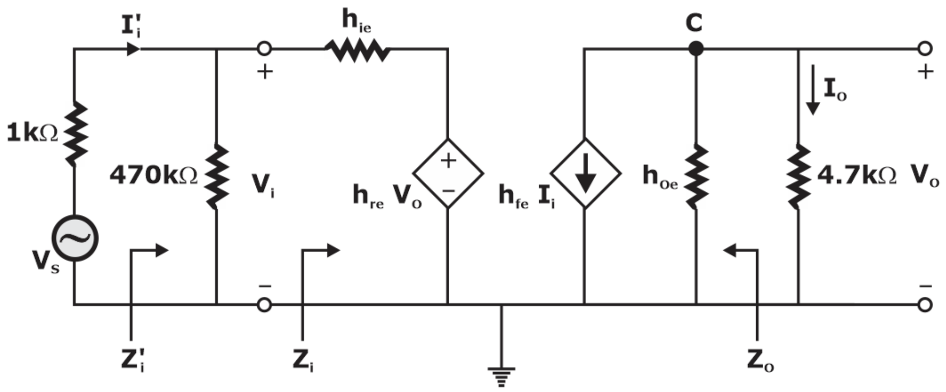
h_{fe} = 110 ; h_{ie} = 1.6 kΩ

$h_{fe} = 2 \times 10^{-4}$; h_{oe} = 20 μ℧

Sol. Redrawing the AC equivalent circuit



Substituting h-parameter equivalent circuit:



Current gain (A_i):

$$I_o \frac{+h_{fe} I_i \frac{1}{h_o}}{\frac{1}{h_{oe}} + 4.7\,k\,\Omega}$$

$$\Rightarrow \frac{I_o}{I_i} = A_i \frac{+h_{fe}}{1 + h_{oe} \times 4.7k\Omega} = \frac{+110}{1 + 20 \times 10^{-6} \times 4.7 \times 10^{3}}$$

$$\Rightarrow A_i = \frac{110}{1 + 0.094} = 100.548$$

Input impedance (Z_i):

Applying KVL in input loop

$$V_i = h_i I_i + h_{re} V_o = h_{re} V_o = h_i I_i + h_{re} \times (I_0 \times 4.7k\Omega)$$
$$= h_i I_i - h_{re} (+4.7k\Omega) A_i I_i$$

$$\frac{V_i}{I_i} = Z_i = h_i - h_{re} \times 4.7 \times 10^3 \times 100.548$$

$$= 1600 - 2 \times 10^{-4} \times 4.7 \times 10^3 \times 100.548$$

Z_i = 1.5 k Ω

Voltage gain (A_v):

$$A_v = \frac{V_o}{V_i} = \frac{I_o \times 4.7}{V_i} = \frac{A_i I_i \times 4.7}{V_i}$$

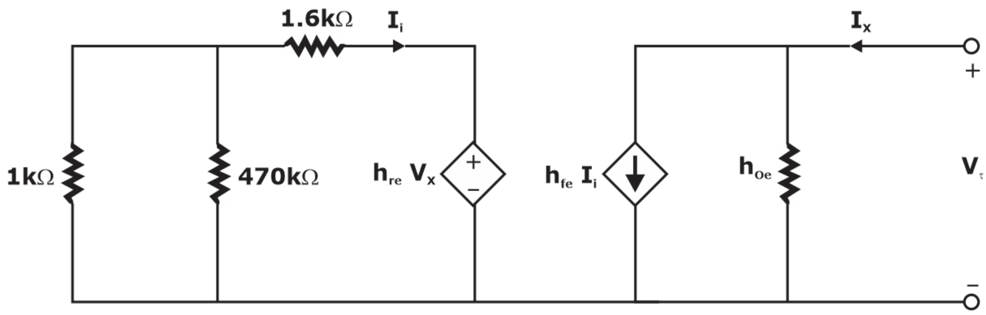
$$= \frac{A_i \times 4.7}{Z_i} = \frac{100.548 \times 4.7}{1.5}$$

Output impedance (Z_o):

Step 1: Disable external sources present in the input.

Step 2: Disconnect load resistance R_L form output circuit.

Step 3 : Assume that voltage V_x is applied at output port and current I_x is flowing into output node then R_o is calculated as V_x / I_x.



KCL at output node

$I_x = h_o V_x + h_f I_i$

$$\Rightarrow \frac{I_x}{V_x} = h_o + h_f . \frac{I_i}{V_x}$$

$$\frac{1}{Z_o} = \frac{I_x}{V_x} = h_o + h_f . \frac{I_i}{V_x} \quad ....(i)$$

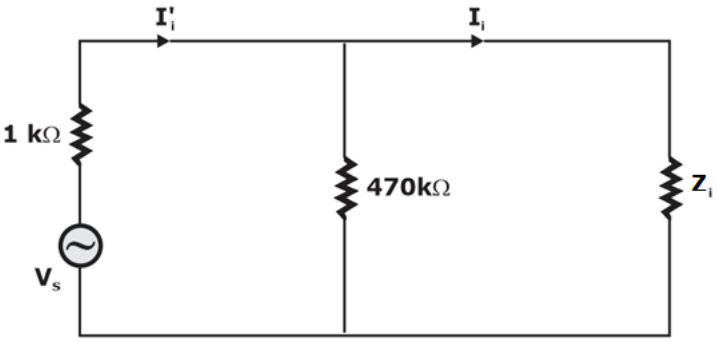
KVL in input loop

I_i (1kΩ || 470 kΩ) + 1.6 kΩ I_i + $h_r V_x$ = 0

→ 0.9978 I_i + 1.6 I_i = $h_r V_x$

$$\Rightarrow \frac{I_i}{V_x} = \frac{2}{2.56k\Omega} = \frac{2 \times 10^{-4}}{2.56 \times 10^3}$$

Now $\frac{1}{Z_o} = 20 \times 10^{-6} + 110 \times \frac{2 \times 10^{-4}}{2.56 \times 10^3}$



$$\frac{1}{Z_o} = 2.86 \times 10^{-5}$$

$$\therefore Z_o = 34.97\,k\Omega \simeq 35k\Omega$$

$$Z_i' : Z_i' = 470\ k\Omega \,||\, Z_i = \frac{470 \times 1.5}{470 + 1.5} = 1.495k\Omega$$

$$A_i' : A_i' = \frac{I_0}{I_i'} = \frac{I_o}{I_i} \cdot \frac{I_i}{I_i'} = A_i \frac{I_i}{I_i'}$$

$$I_i = I_i' \frac{470k\Omega}{Z_i + 470k\Omega}$$

$$\Rightarrow \frac{I_i}{I_i'} = \frac{470k\Omega}{1.5k\Omega + 470k\Omega} = 0.9968$$

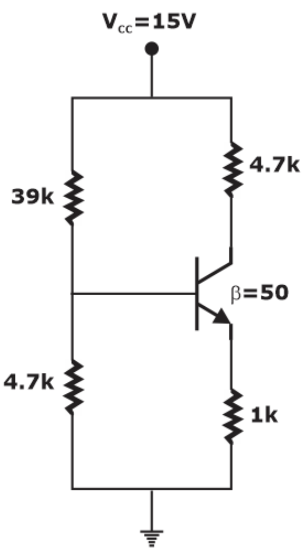
$\therefore A'_i = 100.548 \times 0.9968$

$A'_i = 100.226$

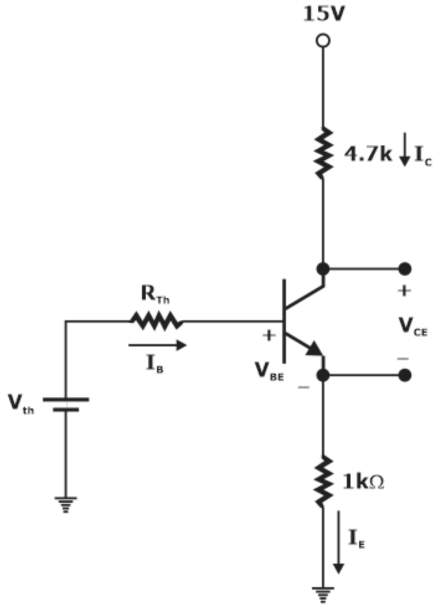
3. For the circuit shown in figure,

(i) Determine the operating point

(ii) Find the stability factor. Given: V_{BE} = 0.6 V, β = 50



Sol. Thevenin equivalent of the given circuit:



$$V_{Th} = \frac{47k\Omega \times 15V}{39k\Omega + 47k\Omega} = 1.61327\,V \text{ ....(1)}$$

R_{Th} = 4.7 kΩ || 39 kΩ = 4.1945 kΩ .....(2)

(i) Step (1): KVL for input section

V_{TH} – I_B R_{Th} – V_{BE} – (I_E × 1 k Ω)= 0.......(3)

$$\rightarrow (I_B \times 4.195k\Omega) + ((1+\beta) I_B \times 1k\Omega) - 1.61327V - 0.6V \text{ ....(4)}$$

$$\Rightarrow I_B = \frac{1.01327V}{4.1945k + 5K} = \frac{1.01327V}{55.1945k} \text{ ....(5)}$$

∴ I_{CQ} = β I_B = 50 × 0.018358 mA

= 0.1979 mA ....(6)

Step (2): KVL for output section

$$15V - (4.7k\Omega \times I_c) - V_{CE} - (1k\Omega \times I_E) = 0 \text{ ....(7)}$$

$$V_{CE} = 15V - (4.7k\Omega \times 0.9179\,mA) - 1k\Omega\left(\frac{1+\beta}{\beta}\right) I_c \text{ ...(8)}$$

= 15V – 4.31413V – 0.936258V ....(9)

∴ V_{CEQ} = 9.7496 V ....(10)

∴ Q = (9.7496 V, 9.9176 mA).....(11)

(ii) Stability factor, $S = \frac{\partial I_C}{\partial I_{C_0}}$

In self bias arrangement, stability factor,

$$S = \frac{1+\beta}{1+\beta\left[\frac{R_E}{R_E + R_{Th}}\right]} \text{ ....(1)}$$

$$\Rightarrow S = \frac{1+50}{1+50\left(\frac{1K}{1K+4.1945k}\right)} \quad \text{.........(2)}$$

$$= \frac{51}{1+50(0.1925)} = \frac{51}{1+9.625}$$

$\therefore$ S = 4.8 ......(3)

$$V_{Th} = \frac{R_2 V_{CC}}{R_1 + R_2} = \frac{5k\Omega \times 3V}{5k\Omega + 5k\Omega} = 1.5V \text{ .....(1)}$$

R_{Th} = $R_1||R_2$ = 5 kΩ || 5 kΩ = 2.5 kΩ ......(2)

Step (1): KVL for base-emitter loop

V_{th} – I_B R_{th} – V_{BE} – (1 + β) I_B × 1 k Ω = 0 ....(3)

$$I_B = \frac{1.5V - 0.7V}{2.5k\Omega + (5 \times 1k\Omega)} = \frac{0.8V}{47.5k\Omega} = 0.016842mA \text{ ....(4)}$$

$\therefore$ I_{CQ} = βI_B = 0.741 mA ....(5)

Step (2): KVL for output section

3V – V_{CEQ} – (I_E × 1k Ω) = 0 ....(6)

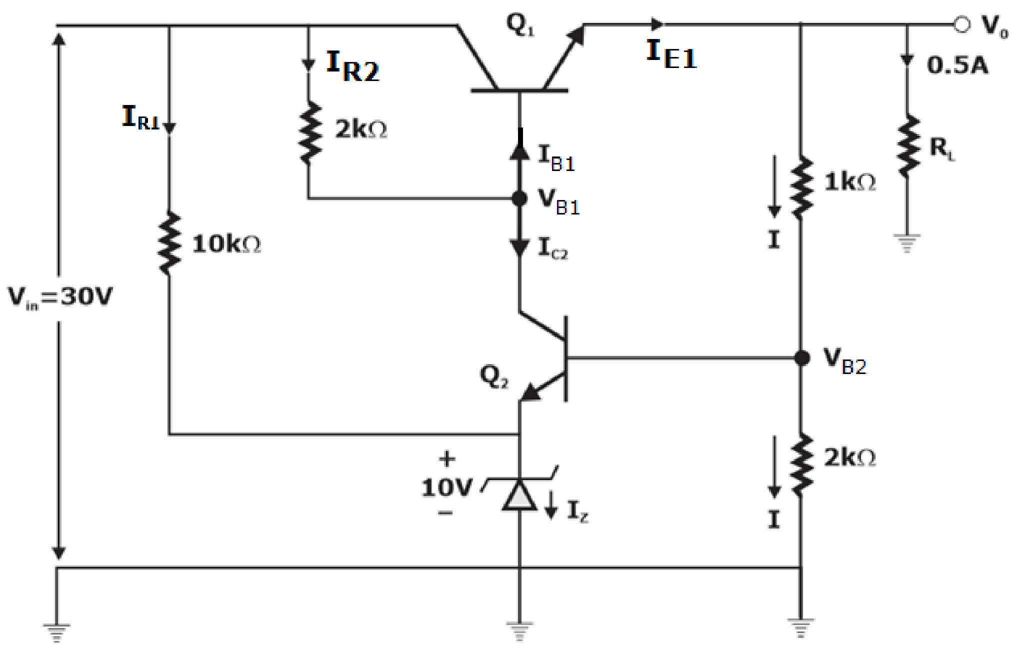
V_{CEO} = 3V – (1 + β) I_B × 1 k Ω ....(7)

= 3V – 0.75789 V ......(8)

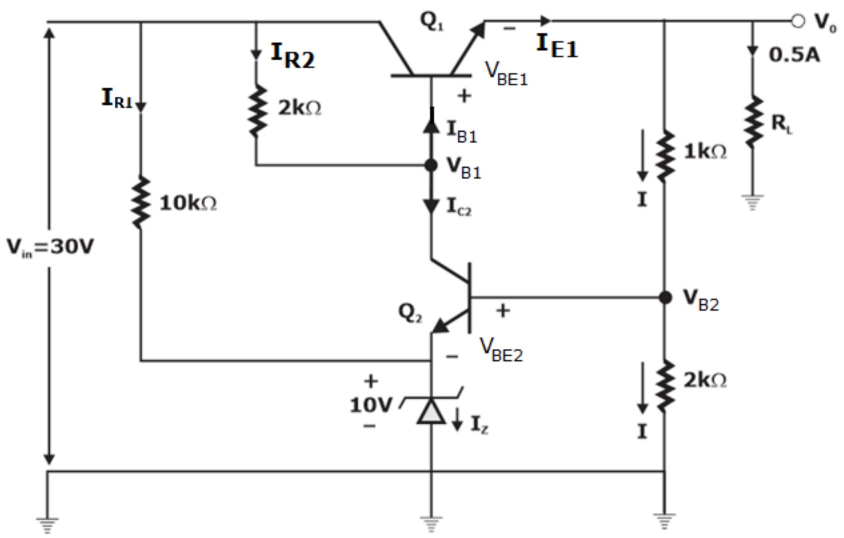
$\therefore$ V_{CEO} = 2.24211 V ......(9)

$\therefore$ Q = [2.24211V, 0.741 mA] ......(10)

4. Find the various voltages and current in the regulator circuit. Find the power dissipation in the Zener and transistor Q_1



Sol.



Form the figure it is clear that

$V_{B_2} = V_Z + V_{BE_2} = 10V + 0.7 = 10.7V$

$\therefore I = \frac{V_{B_2}}{2k} = \frac{10.7}{2k} = 5.35 \text{ mA}$

Here the β is not given. Assume high value of β that implies base current can almost be neglected

$\therefore$ I = 5.35 mA

$\therefore$ V_0 = I ×[1k + 2k] = 3k × 5.35 m = 16.05V

$\therefore R_L = \frac{16.05}{0.5} = 32.1\Omega$

From the fig

$V_{B_1} = V_0 + V_{BE_1}$

= 16.05 + 0.7 = 16.75 V

$\therefore I_{R_2} = \frac{V_{in} - V_{B_1}}{2k}$

$= \frac{30 - 16.75}{2k}$

$= \frac{13.25}{2k} = 6.625 \text{mA}$

$I_{R_1} = \frac{V_{in} - V_Z}{10k}$

$= \frac{30 - 10}{10k} = \frac{20}{10k} = 2\text{mA}$

As β is very high

$I_{B_1} \approx 0A$

$I_{C_2} = I_{R_2} = 6.625\,mA$

$\therefore I_{C_2} = I_{E_2} = 6.25\,mA$

$\therefore I_Z = I_{E_2} + I_{R_1} = 2mA + 6.625\,mA$

= 8.625 mA

From the figure, KCL at output node

$I_{E_1} = I + I_L = 5.35mA + 0.5A$

= 0.50535 A

β is very high

$I_{B_1} \approx 0 \Rightarrow I_{E_1} = I_{C_1} = 0.50535A$

Power dissipation in the zener diode:

$P = V_Z \times I_Z$

P = 10 × 8.625 mA

P = 86.25 Mw

Power dissipation in the transistor Q_1:

$P = V_{CE1} \times I_{C1}$

$P = \left(V_{C_1} - V_{E_1}\right) \times I_{C_1}$

P = (30 – 16.05) × 0.50535

P = 7.049 W

5. What is meant by feedback. Write a short note on negative feedback & mention it's advantages & disadvantages.

Sol. Introduction to feedback

Feedback is used in virtually all amplifier systems. Harold black, an electronics engineer with the Western Electric company, invented the feedback amplifier in 1928 while searching for methods to stabilize the gain of amplifiers for use in telephone repeaters.

In a feedback system, a signal that is proportional to the output is fed back to the input and combined with the input signal to produced a desired system response. As we will see, external feedback is used deliberately to achieve particular undesired system response may be produced.

Feedback can be either negative or positive. In negative feedback, a portion of the output signal is subtracted from the input signal; in positive feedback, a portion of the output signal is added to the input signal. Negative feedback, for example tends to maintain a constant value of amplifier voltage gain against variations in transistor parameters, supply Voltage and temperature. Positive feedback is used in the design of oscillators and in a number of other applications.

Advantages and Disadvantages of Negative feedback

Advantages

1. Gain sensitivity: Variations in the circuit transfer function (gain) as a result of changes in transistor parameters are reduced by feedback. This reduction in sensitivity is one of the most attractive features of negative feedback.

2. Bandwidth extension: The bandwidth of a circuit that incorporates negative feedback is larger than of the basic amplifier.

3. Noise sensitivity: Negative feedback may increase the signal-to -noise ratio if noise is generated within the feedback loop.

4. Reduction of nonlinear distortion: Since transistors have nonlinear characteristics, distortion may appear in the input signals, especially at large signal levels, Negative feedback reduces this distortion.

5. Control of impedance level: The input an output impedances can be increased or decreased with the proper type of negative feedback.

Disadvantages

1. Circuit gain: The overall amplifier gain, with negative feedback, is reduced compared to the basic amplifier used in the circuit.

2. Stability: There is a possibility that the feedback circuit may become unstable (oscillate) at high frequencies.

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