1.5 ANALYSIS OF FEEDBACK AMPLIFIER

CURRENT-SERIES (OR) SERIES-SERIES FEEDBACK AMPLIFIER

- Trans-conductance feedback amplifier provides an output current Io which is proportional to the input voltage V_s . The feedback signal is the voltage V_f , Here added to Vs at the input of the amplifier.

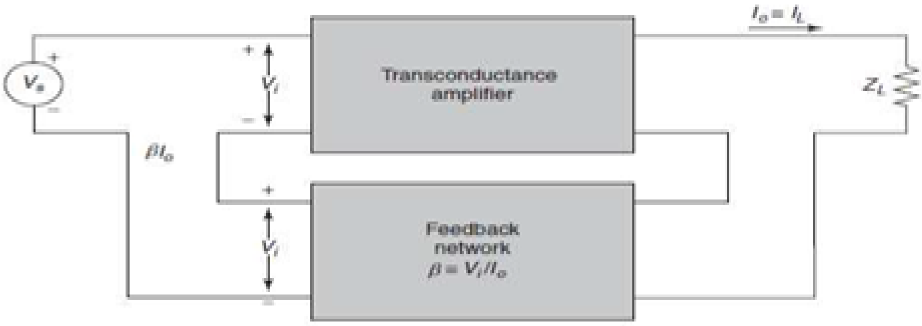

Fig.1.5.1 . Current – Series Amplifier

(Source: Microelectronics byJ. Millman and A. Grabel, , 2nd ed., Page-240)

Input & Output resistance:

Input resistance:

- Step 1:Draw the equivalent Circuit for Current Series amplifier

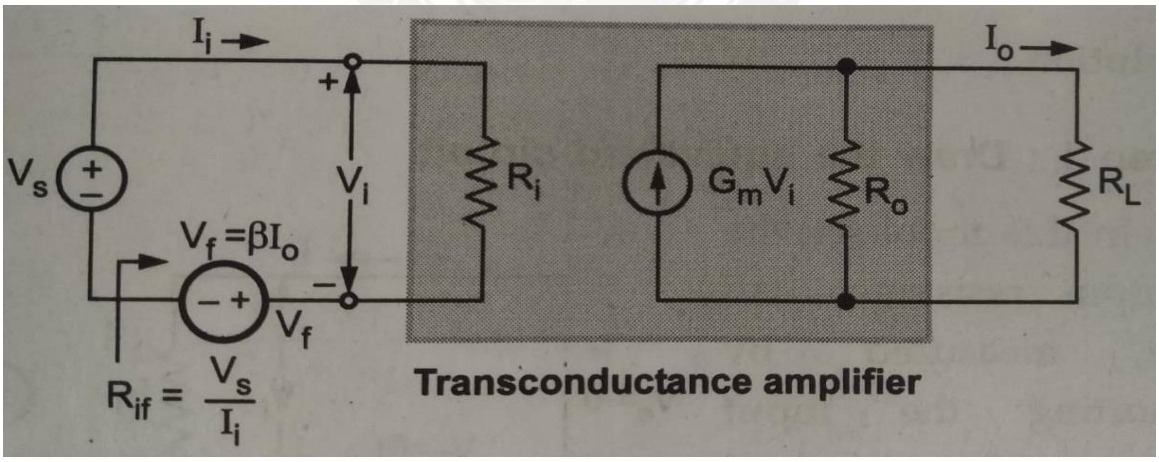

Fig.1.5.2 . Current – Series Amplifier-input resistance

(Source: Microelectronics by J. Millman and A. Grabel, , 2nd ed., Page-240)

Looking in fig1.5.2 the input resistance with feedback is given $R_{if} = V_s / I_i$

- Step 2:Obtain expression for V_s

Appling KVL to the input side,

$$V_s - I_i R_i - V_f = 0$$

$V_s = I_i R_i + V_f = I_i R_i + \beta I_o$ -------- (1)

- Step 3:Obtain expression for I_o in terms of V_i

  Output Current I_o is given by

  $I_o = G_m V_i R_o / (R_o + R_L)$

  where $G_M = G_m R_o / (R_o + R_L)$

  $I_o = = G_M V_i = G_M I_i R_i$ -------- (2)

  G_m is open Circuit Transconductance gain without feedback and G_M is Transconductance without feedback taking the load R_L into account

- Step 4: Obtain expression for R_{if}

  Sub value of I_o from eqn (2) in eqn (1)

  $V_s = I_i R_i + \beta G_M I_i R_i = I_i (R_i + \beta G_M R_i)$

  $R_{if} = Vs / Ii = R_i + \beta G_M R_i$

Output resistance:

- Step 1:Draw the equivalent Circuit

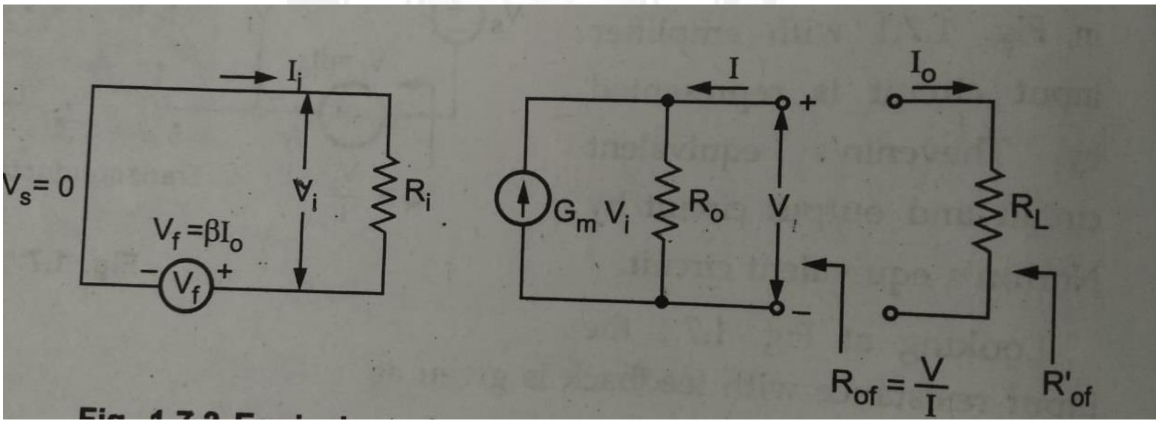

Fig.1.5.3 . Current – Series Amplifier-output resistance

(Source: Microelectronics by J. Millman and A. Grabel, , 2nd ed., Page-241)

Output resistance can be measured by shorting the input source $V_s = 0$ and looking into the output terminals with R_L disconnected

- Step 2: Obtain expression for I in terms of V

  Appling KCL to the output Node,

  $I = (V / R_o) – G_m V_i$ -------- (1)

  Input voltage is given by

  $V_i = - V_f = - \beta I_o$

  $V_i = \beta I$:; $I_o = -I$ -------- (2)

Sub value of V_i from eqn (2) in eqn (1)

$I = (V / R_o) – G_m \beta I$

$V / R_o = I + G_m \beta I = I (1+ G_m \beta)$

- Step 3: Obtain expression for R_{of}

$$R_{of} = V / I$$

$$R_{of}=R_o (1+ \beta G_m)$$

- Step 4: Obtain expression for R'_{of}

$$R'_{of} = R_{of} \parallel R_L = R_oR_L / (R_o + R_L + \beta A_v R_L)$$

Dividing num and den by $(R_o + R_L)$

$$R'_{of}=R'_o (1+ \beta G_m) / (1+ \beta G_M)$$

$$R'_o=R_o R_L / (R_o + R_L)$$

$$G_M= G_mR_o / (R_o + R_L)$$

Transistorized Analysis of feedback amplifiers:

1. Identify the type of feedback
2. Find input circuit
3. Find output circuit
4. Replace transistor by its h-parameter equivalent circuit.
5. Find open loop voltage gain
6. Indicate v_o and v_f and calculate β
7. Calculate D, A_{vf}, R_{if}, R_{of}, and R'_{of}

VOLTAGE-SHUNT (OR) SHUNT-SHUNT FEEDBACK AMPLIFIER

- The voltage-shunt or shunt-shunt feedback amplifier provides an output voltage V_o in proportion to the input current I_s. The input current I_i of the basic amplifier is the algebraic sum of I_s and the feedback current I_f.

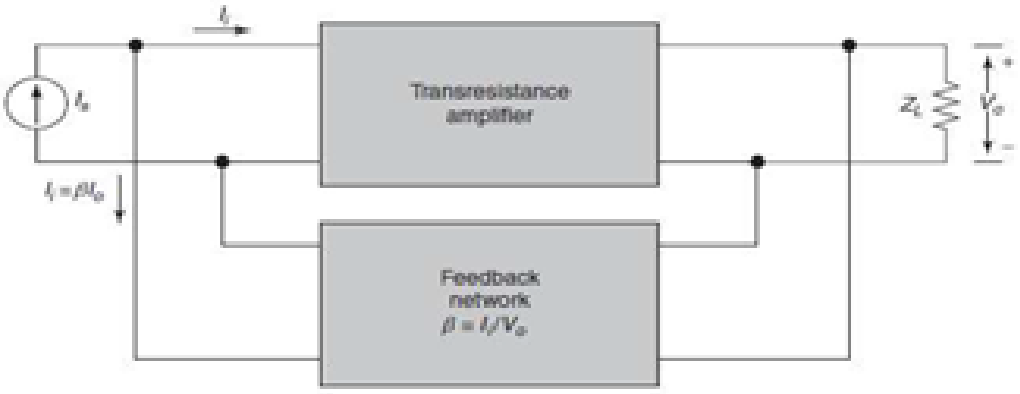

Fig 1.5.4.Voltage-Shunt Amplifier

(Source: Microelectronics by J. Millman and A. Grabel, , 2nd ed., Page-252)

Input Resistance:

- Step 1:Draw the equivalent Circuit for Voltage Shunt amplifier

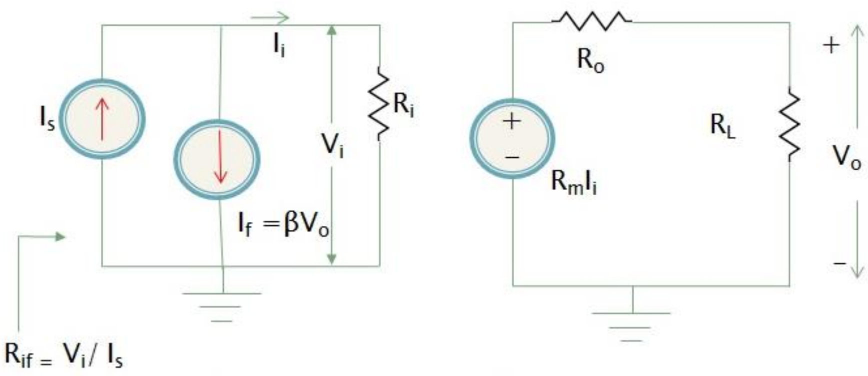

Fig 1.5.5.Voltage-Shunt Amplifier-input resistance

(Source: Microelectronics byJ. Millman and A. Grabel, , 2nd ed., Page-252)

Looking in fig 1.5.5 the input resistance with feedback is given $R_{if} = V_i / I_s$

- Step 2: Obtain expression for I_s

Appling KCL to the input node,

$I_s = I_i + I_f = I_i + \beta V_o$ ------- (1)

Expression for V_o in terms of I_i

Output Voltage V_o is given by

$V_o = R_m I_i R_o / (R_o + R_L)$

where $R_M = R_m R_o / (R_o + R_L)$

$V_o = R_M I_i$ -------- (2)

R_m is open Circuit Transresistance gain without feedback and R_M is Transresistance without feedback taking the load R_L into account

- Step 3: Obtain expression for R_{if}

Sub value of V_o from eqn (2) in eqn (1)

$$I_s = I_i + \beta R_M I_i = I_i (1 + \beta R_M)$$

$$R_{if} = V_i / I_s = V_i / I_i (1 + \beta R_M)$$

Output resistance:

- Step 1:Draw the equivalent Circuit

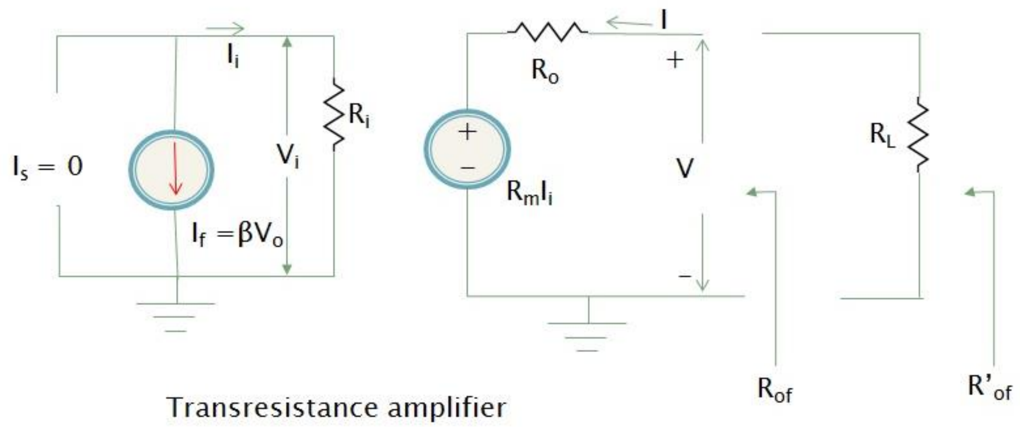

Fig 1.5.6.Voltage-Shunt Amplifier-output resistance

(Source: Microelectronics byJ. Millman and A. Grabel, , 2nd ed., Page-252)

Output resistance can be measured by opening the input source $I_s = 0$ and looking into the output terminals with R_L disconnected

- Step 2: Obtain expression for I in terms of V ,

Appling KVL to the output Side,

$$R_m I_i + I R_o - V = 0$$

$$I = (V - R_m I_i) / R_o \qquad \text{-------- (1)}$$

Input Current is given by

$$I_i = - I_f = - \beta V \qquad \text{-------- (2)}$$

Sub value of I_i from eqn (2) in eqn (1)

$$I = (V + R_m \beta V) / R_o$$

$$I = V (1 + R_m \beta) / R_o$$

- Step 3: Obtain expression for R_{of}

$$R_{of} = V / I \qquad R_{of} = R_o / (1 + \beta R_m)$$

- Step 3: Obtain expression for R'_{of}

$R'_{of} = R_{of} \parallel R_L = R_o R_L / (R_o + R_L (1 + \beta R_m))$

$R'_{of} = R'_o (1 + \beta R_M)$ $\quad\quad\quad$ $R'_o = R_{of} R_L / (R_{of} + R_L)$

Dividing num and denominator by $(R_o + R_L)$

$$R'_o = R_{of} R_L / (R_{of} + R_L)$$

Transistorized Analysis of feedback amplifiers:

1. Identify the type of feedback
2. Find input circuit
3. Find output circuit
4. Replace transistor by its h-parameter equivalent circuit.
5. Find open loop voltage gain
6. Indicate v_o and v_f and calculate β
7. Calculate D, A_{vf}, R_{if}, R_{of}, and R'_{of}

SHUNT-SERIES (OR) CURRENT-SHUNT FEEDBACK AMPLIFIER

- The current-shunt feedback amplifier, supplies an output current I_o which is proportional to the input current I_i . This makes it a current amplifier.
- The feedback signal is the current if the input current of the basic amplifier is $I_i = I_s + I_f$ and the output current is $I_o = I$

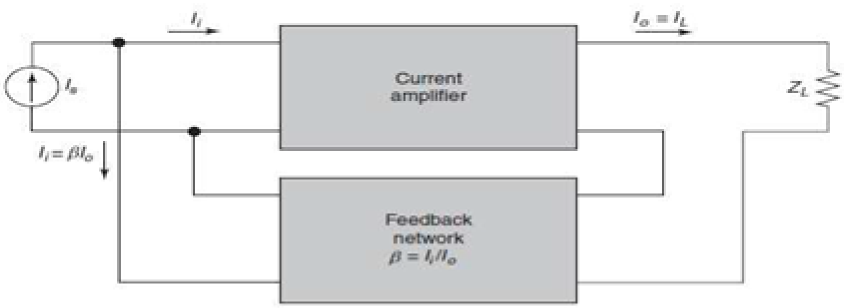

Fig: 1.5.7 Current -Shunt Amplifier

(Source: Microelectronics byJ. Millman and A. Grabel, , 2nd ed., Page-255)

Input & Output resistance:

Input resistance:

- Step 1:Draw the equivalent Ckt for Voltage Series Shunt amplifier

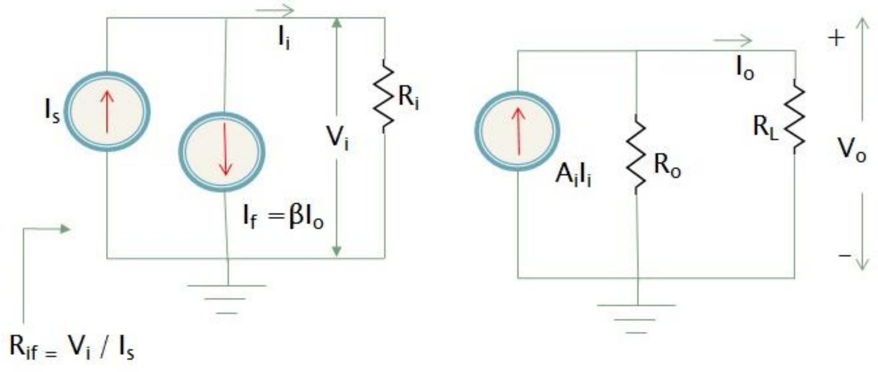

Fig: 1.5.8 Current -Shunt Amplifier-input resistance

(Source: Microelectronics byJ. Millman and A. Grabel, , 2nd ed., Page-256)

Looking in fig 1.5.8 the input resistance with feedback is given $R_{if} = V_i / I_s$

- Step 2:Obtain expression for I_s

  Appling KCL to the input node ,

  $Is = I_i + I_f = I_i + \beta I_o$ ------- (1)

- Step 3:Obtain expression for I_o in terms of I_i

  Output Current I_o is given by

  $I_o = A_i I_i R_o / (R_o + R_L)$

  Where $A_I = A_i R_o / (R_o + R_L)$

  $I_o = A_I I_i$ -------- (2)

A_i is open Circuit Current gain without feedback and A_I is Current gain without feedback taking the load R_L into account

- Step 3: Obtain expression for R_{if}

  Sub value of I_o from eqn (2) in eqn (1)

  $I_s = I_i + \beta A_I I_i = I_i (1 + \beta A_I)$

  $R_{if} = V_i / I_s = V_i / I_i (1 + \beta A_I)$

Output resistance:

- Step 1:Draw the equivalent Ckt

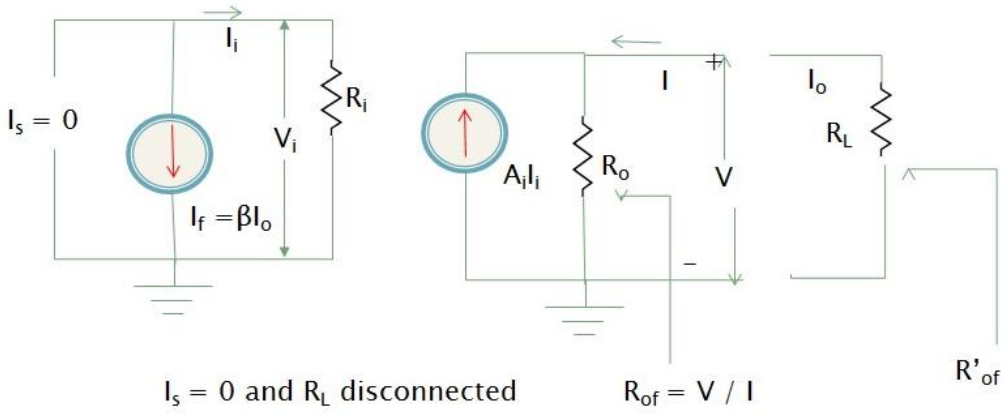

Fig: 1.5.9 Current -Shunt Amplifier-output resistance

(Source: Microelectronics byJ. Millman and A. Grabel, , 2nd ed., Page-256)

Output resistance can be measured by shorting the input source $I_s = 0$ and looking into the output terminals with R_L disconnected

- Step 2: Obtain expression for I in terms of V

Appling KCL to the output node,

$I = (V / R_o) – A_i I_i$ -------- (1)

Input Current is given by

$I_i = - I_f = - \beta I_o = \beta I$ -------- (2)

Sub value of I_i from eqn (2) in eqn (1)

$I = (V / R_o) – A_i \beta I$

$V / R_o = I + A_i \beta I = I (1 + \beta A_i)$

- Step 3: Obtain expression for R_{of}

$R_{of} = V / I$

$R_{of}=R_o (1+ \beta A_i)$

- Step 4: Obtain expression for R'_{of}

$R'_{of} = R_{of} \parallel R_L$

$R'_{of}=R'_o (1+ \beta A_i) / (1+ \beta A_I)$

Dividing num and den by $(R_o + R_L)$

$R'_o=R_o R_L / (R_o + R_L)$

Transistorized Analysis of feedback amplifiers:

1. Identify the type of feedback
2. Find input circuit

3. Find output circuit
4. Replace transistor by its h-parameter equivalent circuit.
5. Find open loop voltage gain
6. Indicate v_o and v_f and calculate β
7. Calculate D, A_{vf}, R_{if}, R_{of}, and R'_{of}