

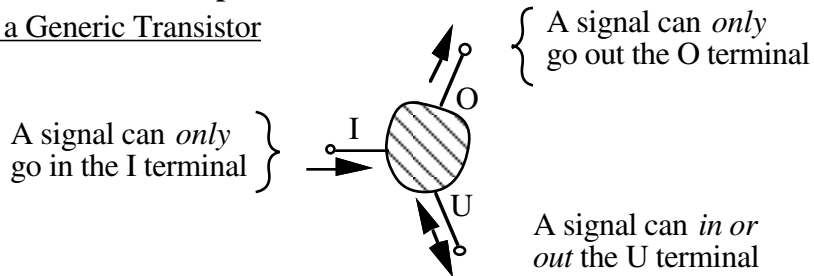
## ANALYSIS OF TRANSISTOR FEEDBACK AMPLIFIERS

### Steps In Analyzing Transistor Feedback Amplifiers

1. Identify the topology.
2. Determine whether the feedback is positive or negative.
3. Open the loop and calculate  $A$ ,  $\beta$ ,  $R_i$ , and  $R_o$ .
4. Use the Table to find  $A_f$ ,  $R_{if}$  and  $R_{of}$  or  $A_{F}$ ,  $R_{iF}$ , and  $R_{oF}$ .
5. Use the information in 4.) to find whatever is required ( $v_{out}/v_{in}$ ,  $R_{in}$ ,  $R_{out}$ , etc.)

### Generic Transistor Concept

#### Properties of a Generic Transistor

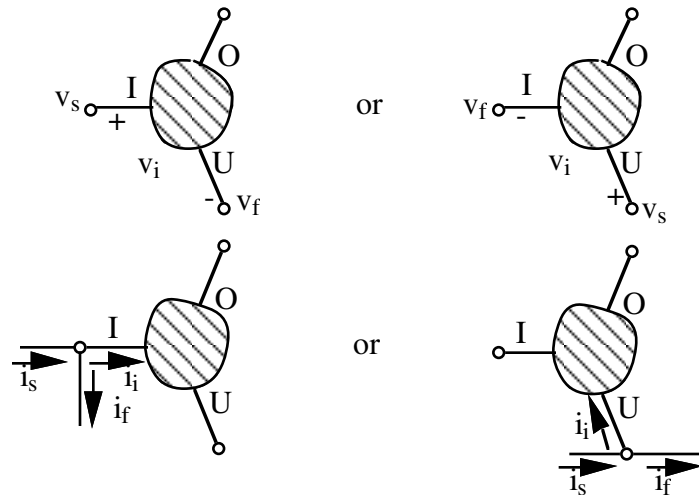


### Identification of the Feedback Topology

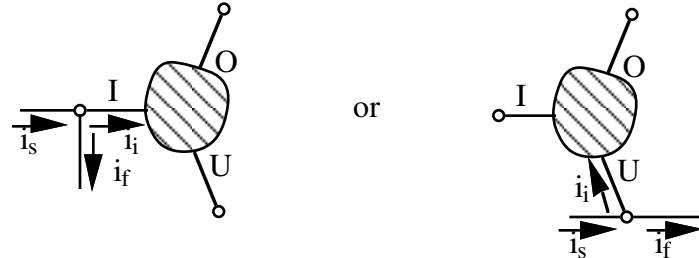
Isolate the input and output transistor(s) and apply the following identification.

#### Input

Series:

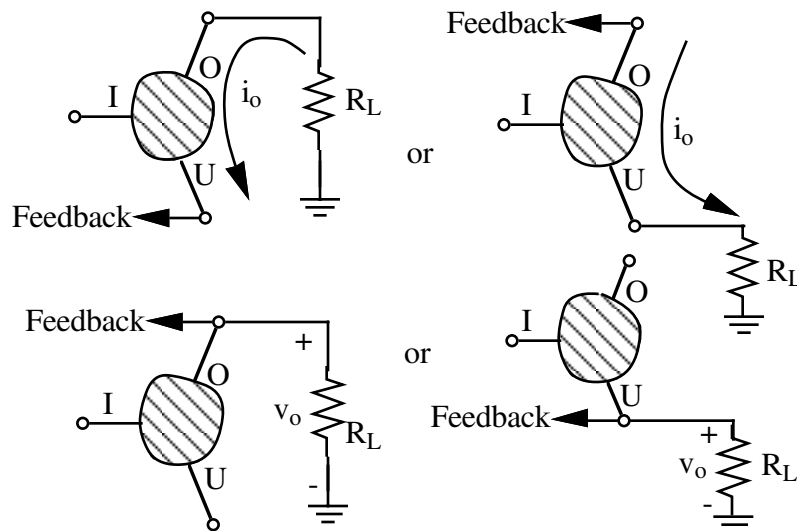


Shunt:

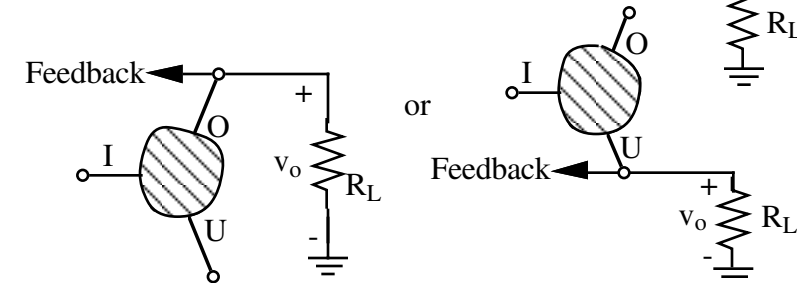


#### Output

Series:



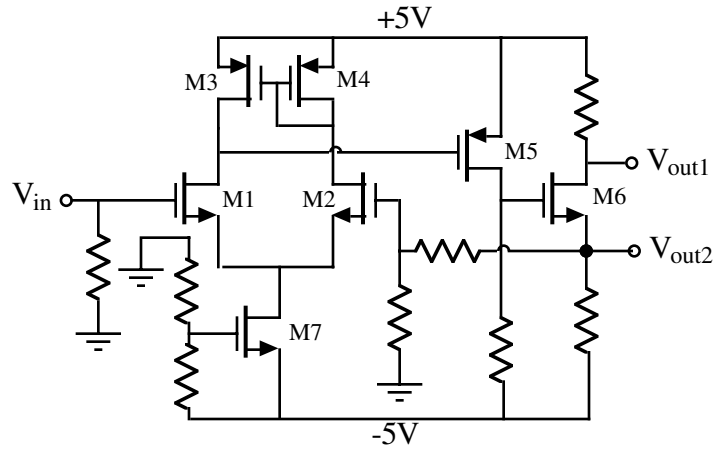
Shunt:



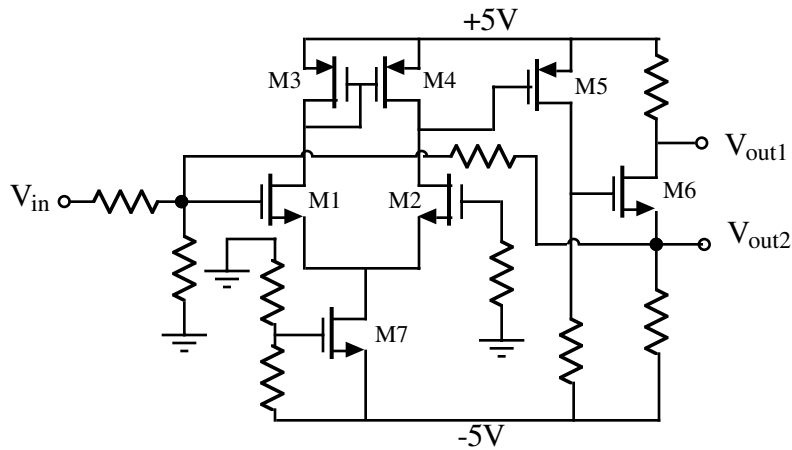
### EXAMPLE OF FEEDBACK TOPOLOGY IDENTIFICATION

Use the rules of identifying feedback topologies to identify the four different topologies for the circuits shown below.

#### Circuits 1 and 2



#### Circuits 3 and 4



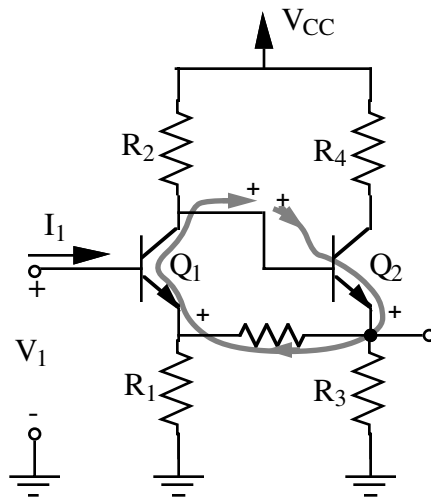
## RULES FOR IDENTIFYING POSITIVE AND NEGATIVE FEEDBACK

1. Identify the feedback loop by tracing its path on the diagram. If there are alternate paths, always choose the path with the highest loop gain. (Remember that a signal can go in the "I" or "U" terminal of a transistor and can only come out the "O" or "U" terminal.)

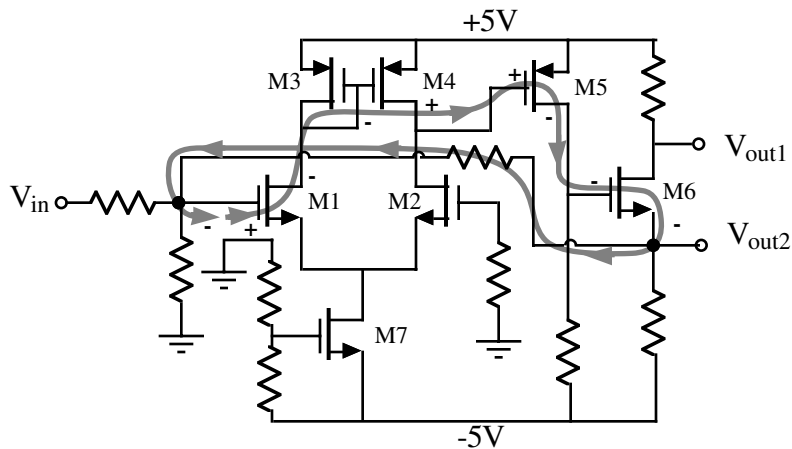
2. At any point on the feedback loop, assume the signal is positive and put a "+" mark at that point. Trace the signal around the loop remembering that the signal only inverts when it goes in a "I" terminal and out the "O" terminal of a transistor. All other paths through a transistor do not invert (i.e., "I" to "U" and "U" to "O").

3. When you have traced the polarity of the signal around the feedback loop back to the point where you placed the "+", the feedback is negative if the signal polarity is "-" and positive if the signal polarity is "+".

### Example 1



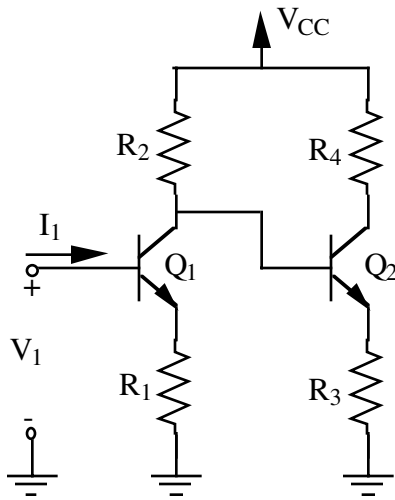
### Example 2



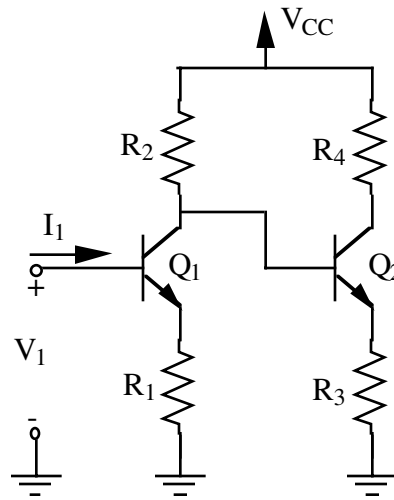
### EXAMPLE OF FEEDBACK TOPOLOGY IDENTIFICATION

Use the rules of identifying feedback topologies to create the four different negative feedback topologies using the identical starting structure.

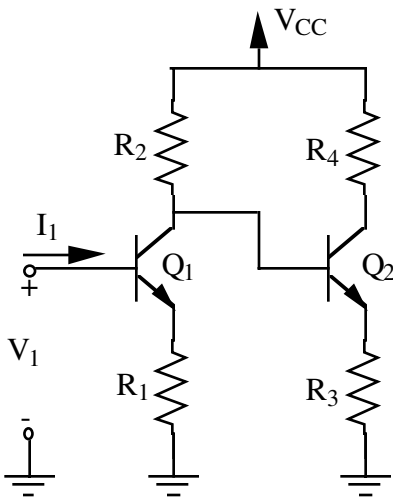
1. Voltage-Voltage (Series-Shunt)



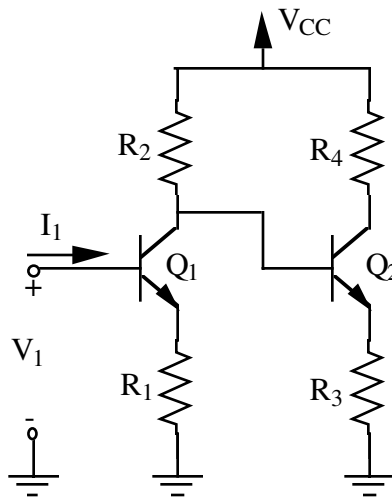
2. Current-Voltage (Shunt-Shunt)



3. Voltage-Current (Series-Series)

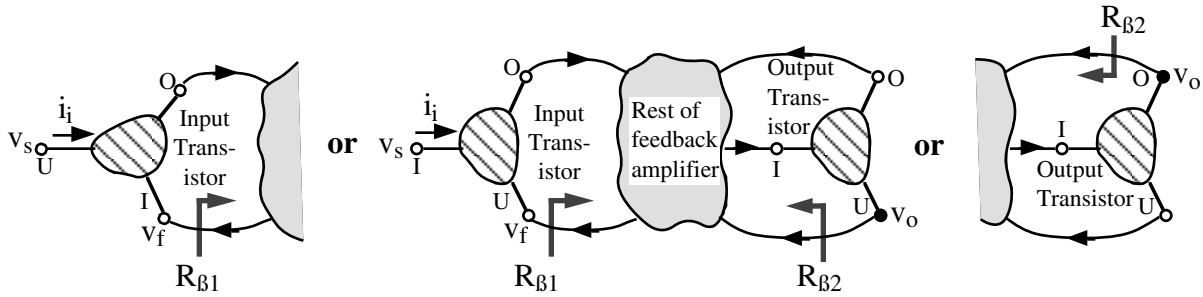


4. Current-Current (Shunt-Series)



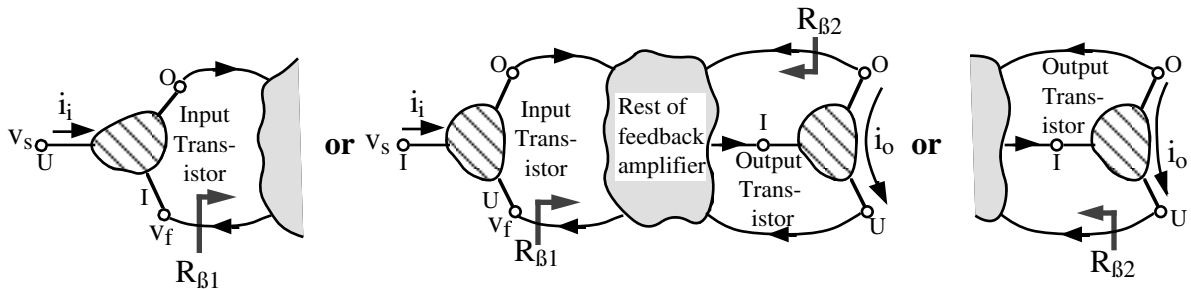
**RULES FOR ANALYSIS OF TRANSISTOR FEEDBACK AMPLIFIERS**

**Series-Shunt**



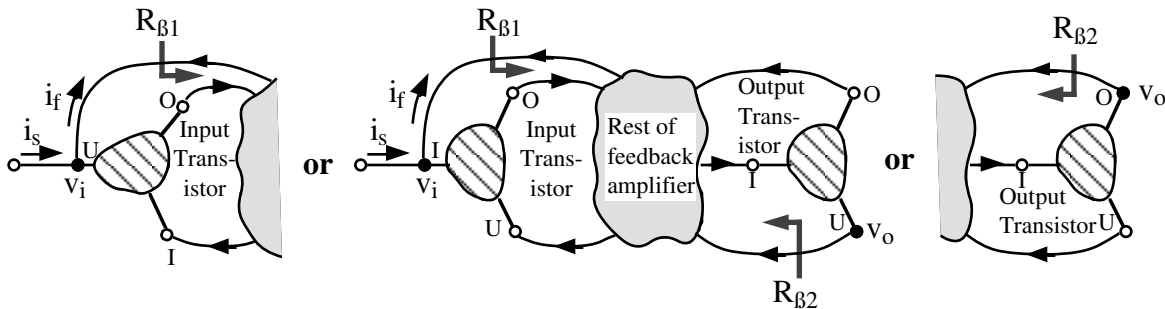
$R_{\beta 1}$  = Resistance seen looking out the I or U terminal of the input transistor with  $v_o = 0$ .  
 $R_{\beta 2}$  = Resistance seen looking out the O or U terminal of the output transistor with  $i_i = 0$ .

**Series-Series**



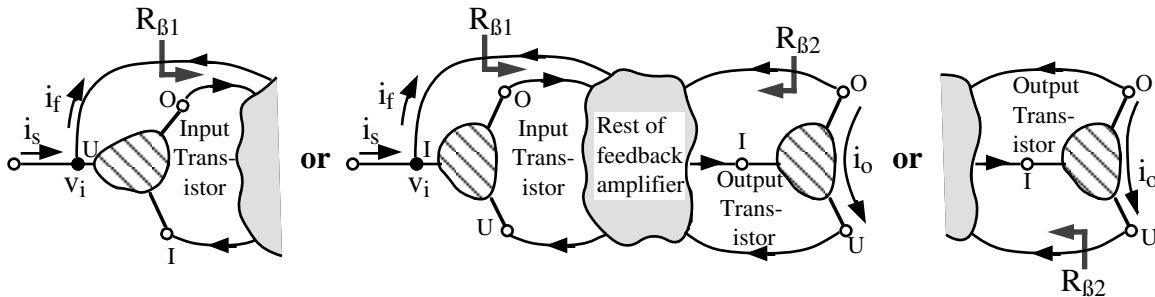
$R_{\beta 1}$  = Resistance seen looking out the I or U terminal of the input transistor with  $i_o = 0$ .  
 $R_{\beta 2}$  = Resistance seen looking out the O or U terminal of the output transistor with  $i_i = 0$ .

**Shunt-Shunt**



$R_{\beta 1}$  = Resistance seen looking out the I or U terminal of the input transistor with  $v_o = 0$ .  
 $R_{\beta 2}$  = Resistance seen looking out the O or U terminal of the output transistor with  $v_i = 0$ .

**Shunt-Series**



$R_{\beta 1}$  = Resistance seen looking out the I or U terminal of the input transistor with  $i_o = 0$ .  
 $R_{\beta 2}$  = Resistance seen looking out the O or U terminal of the output transistor with  $v_i = 0$ .

**Summary of the Important Relationships of Open-loop and Closed-loop Feedback Amplifiers.**

Quantity	Voltage Amplifier	Transconductance Amplifier	Transresistance Amplifier	Current Amplifier
Input-output variable	Voltage-voltage	Voltage-current	Current-voltage	Current-current
Small Signal Model				
Small Signal Amplifier with Source & Load				
Ideal RS	$R_S = 0$ or $R_S \ll R_i$	$R_S = 0$ or $R_S \ll R_i$	$R_S = \infty$ or $R_S \gg R_i$	$R_S = \infty$ or $R_S \gg R_i$
Ideal RL	$R_L = \infty$ or $R_L \gg R_o$	$R_L = 0$ or $R_L \ll R_o$	$R_L = \infty$ or $R_L \gg R_o$	$R_L = 0$ or $R_L \ll R_o$
Overall Forward Gain	$A_V = \frac{R_i R_L A_{vf}}{(R_S + R_i)(R_L + R_o)}$	$G_M = \frac{R_i R_o G_{mf}}{(R_S + R_i)(R_L + R_o)}$	$R_M = \frac{R_S R_L R_{mf}}{(R_S + R_i)(R_L + R_o)}$	$A_I = \frac{R_S R_o A_{if}}{(R_S + R_i)(R_L + R_o)}$
Feedback Topology	Series-shunt	Series-series	Shunt-shunt	Shunt-series
Ideal $\beta$ , finite $R_S$ and $R_L$ Feedback Small Signal Models				
Closed-Loop Gain (Ideal $R_S$ and $R_L$ )	$A_{vF} = \frac{A_{vf}}{(1 + A_{vf}\beta_v)}$	$G_{mF} = \frac{G_{mf}}{(1 + G_{mf}\beta_g)}$	$R_{mF} = \frac{R_{mf}}{(1 + R_{mf}\beta_r)}$	$A_{iF} = \frac{A_{if}}{(1 + A_{if}\beta_i)}$
Closed-Loop Input Resistance (Ideal $R_S$ and $R_L$ )	$R_{iF} = R_i(1 + A_{vf}\beta_v)$	$R_{iF} = R_i(1 + G_{mf}\beta_g)$	$R_{iF} = \frac{R_i}{1 + R_{mf}\beta_r}$	$R_{iF} = \frac{R_i}{1 + A_{if}\beta_i}$
Closed-Loop Output Resistance (Ideal $R_S$ and $R_L$ )	$R_{oF} = \frac{R_o}{1 + A_{vf}\beta_v}$	$R_{oF} = R_o(1 + R_{mf}\beta_g)$	$R_{oF} = \frac{R_o}{1 + R_{mf}\beta_r}$	$R_{oF} = R_o(1 + A_{if}\beta_i)$
Closed-Loop Gain	$A_{VF} = \frac{AV}{(1 + A_V\beta_v)}$	$G_{MF} = \frac{GM}{(1 + G_M\beta_g)}$	$R_{MF} = \frac{RM}{(1 + R_M\beta_r)}$	$A_{IF} = \frac{AI}{(1 + A_I\beta_i)}$
Closed-Loop Input Resistance	$R_{iF} = \frac{R_i R_S}{(R_i + R_S)(1 + A_V\beta_v)}$	$R_{iF} = \frac{R_i R_S}{(R_i + R_S)(1 + G_M\beta_g)}$	$R_{iF} = \frac{R_i R_S}{1 + R_M\beta_r}$	$R_{iF} = \frac{R_i R_S}{1 + A_I\beta_i}$
Closed-Loop Output Resistance	$R_{oF} = \frac{R_o R_L}{R_o + R_L + A_V\beta_v R_o R_L}$	$R_{oF} = \frac{R_o R_L}{(R_o + R_L)(1 + G_M\beta_g)}$	$R_{oF} = \frac{R_o R_L}{R_o + R_L + R_M\beta_r R_o R_L}$	$R_{oF} = \frac{R_o R_L}{(R_o + R_L)(1 + A_I\beta_i)}$
Output Resistance of Series Output Fb. Ckt	$R_{OUT} = R_{oF}$	$R_{OUT} = \frac{R_L}{R_{oF}}(R_{oF} - R_L)$	$R_{OUT} = R_{oF}$	$R_{OUT} = \frac{R_L}{R_{oF}}(R_{oF} - R_L)$