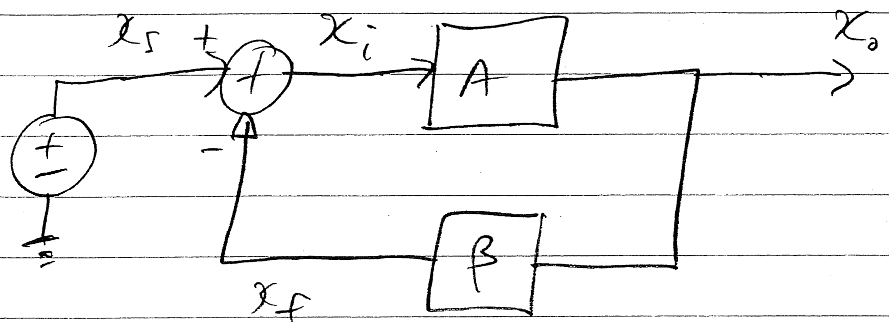
4 BASIC FEEDBACK STRUCTURES

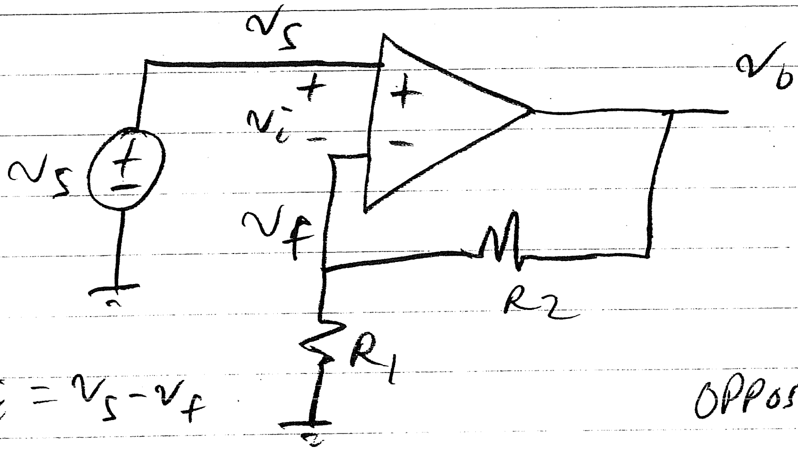


4 BASIC TYPES DEPENDING ON TYPES OF SIGNALS AT x_s, x_f, x_i + x_o

x_s, x_f, x_i	x_o	TYPE (INPUT/OUTPUT)
VOLTAGE	VOLTAGE	SERIES-SHUNT
CURRENT	VOLTAGE	SHUNT-SHUNT
CURRENT	CURRENT	SHUNT-SERIES
VOLTAGE	CURRENT	SERIES-SERIES

SO SERIES-SHUNT MEANS OUTPUT IS A VOLTAGE AND IS <u>SAMPLED</u> WITH A <u>SHUNT</u> NETWORK WHILE INPUT IS ALSO A VOLTAGE AND THE SUBTRACTION IS DONE WITH A <u>SERIES</u> NETWORK.

SERIES-SHUNT EXAMPLES

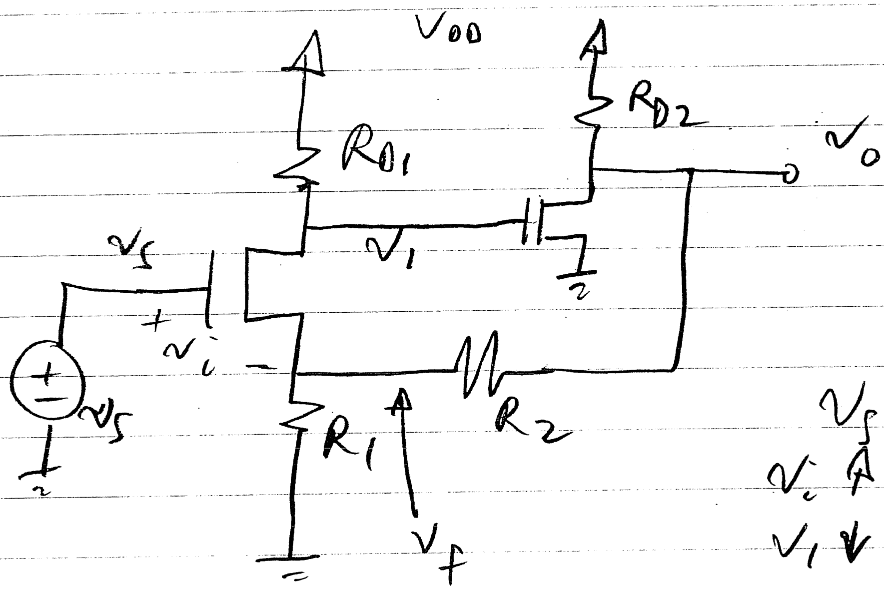


$v_i = v_S - v_f$

NEG FEEDBACK CHECK

$v_S \uparrow \Rightarrow v_i \uparrow$
$v_i \uparrow \Rightarrow v_o \uparrow$
$v_o \uparrow \Rightarrow v_f \uparrow$
$v_f \uparrow \Rightarrow \underline{v_i \downarrow}$ ✓

OPPOSITE OF ORIGINAL V_i CHANGE



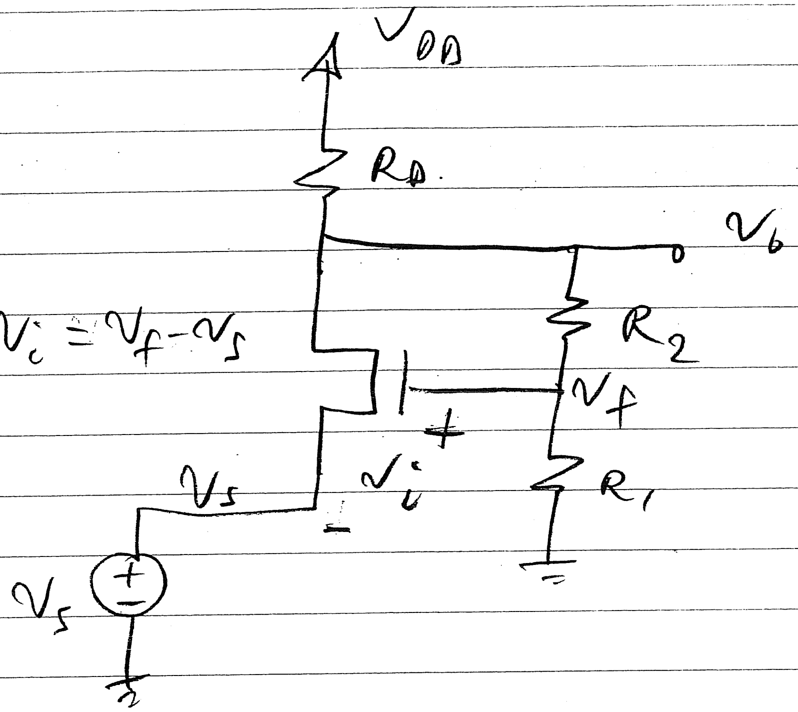
$v_i = v_S - v_f$

NEG FEEDBACK CHECK

$v_S \uparrow \Rightarrow v_i \uparrow$
$v_i \uparrow \Rightarrow v_1 \downarrow$
$v_1 \downarrow \Rightarrow v_o \uparrow$
$v_o \uparrow \Rightarrow v_f \uparrow$
$v_f \uparrow \Rightarrow \underline{v_i \downarrow}$ ✓

FF3

$v_i = v_f - v_s$



NEG FEEDBACK CHECK

$v_s \uparrow \Rightarrow v_i \downarrow$

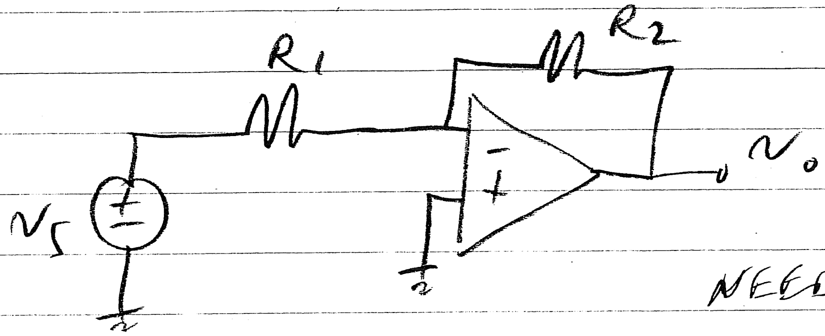
$v_i \downarrow \Rightarrow v_o \uparrow$

$v_o \uparrow \Rightarrow v_f \uparrow$

$v_o \uparrow \Rightarrow \underline{\underline{v_i \uparrow}}$ ✓ OPPOSITE OF ORIGINAL v_i CHANGE

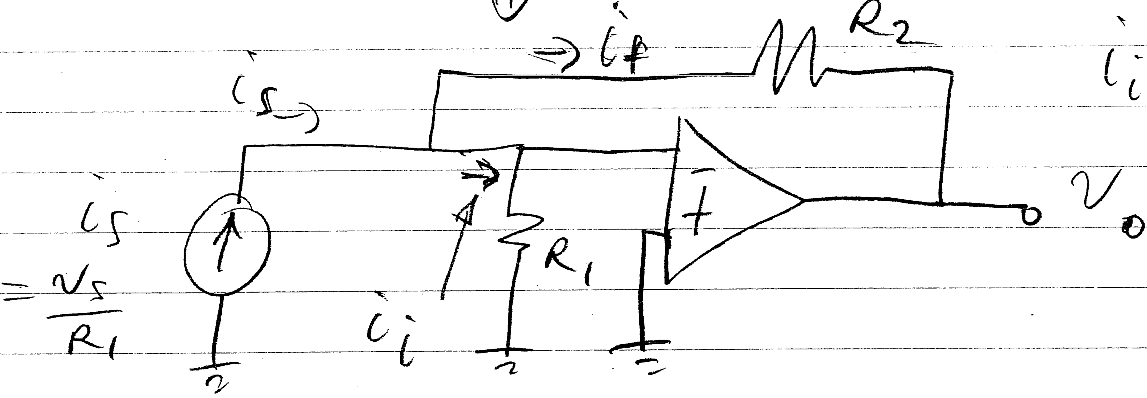
FF4

SHUNT - SHUNT EXAMPLES



NEEDS MODIFICATION

⇓



$i_i = i_s - i_f$

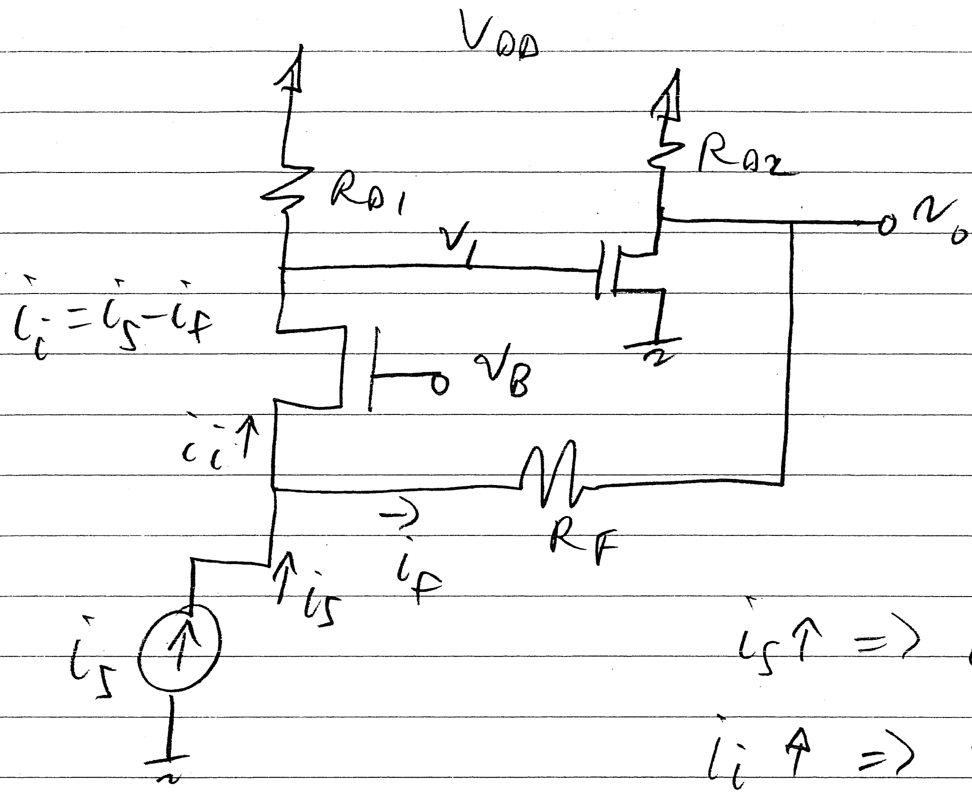
$i_s \uparrow \Rightarrow i_i \uparrow$

$i_i \uparrow \Rightarrow v_o \downarrow$ (SINCE $v_- \uparrow$ DUE TO $i_i \uparrow$ $v_o = A(v_+ - v_-)$)

$v_o \downarrow \Rightarrow i_f \uparrow$

$i_f \uparrow \Rightarrow i_i \downarrow$ ✓

FF5



$i_s \uparrow \Rightarrow i_i \uparrow$

$i_i \uparrow \Rightarrow v_1 \uparrow$

$v_1 \uparrow \Rightarrow v_o \downarrow$

$v_o \downarrow \Rightarrow i_f \uparrow$

$i_f \uparrow \Rightarrow i_i \downarrow$ ✓

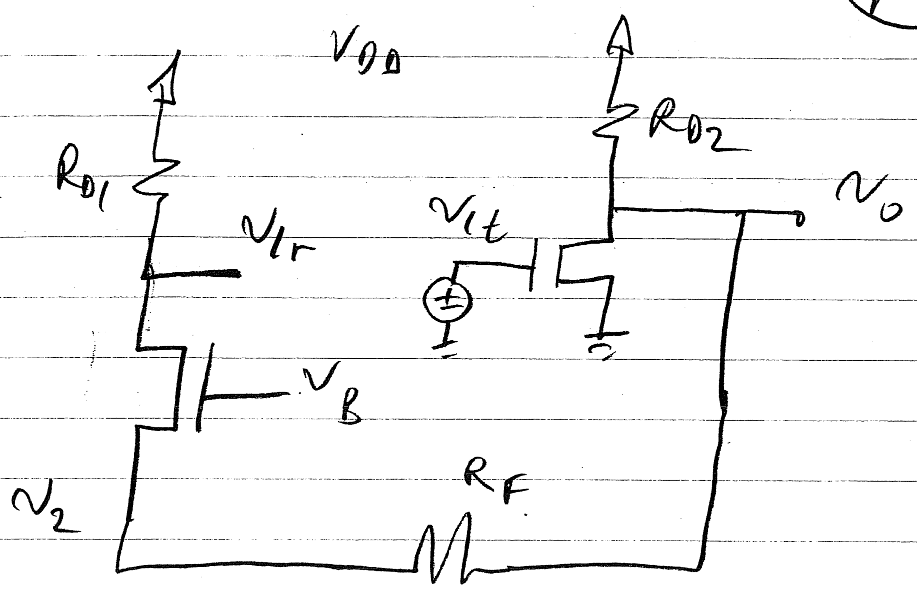
A BIT MORE DIFFICULT TO SEE NEG FEEDBACK HERE. EASIER TO LOOK AROUND LOOP AT v_1 WITH $i_s = 0$ (OPEN)

BREAK LOOP AT v_1

INSERT TEST VOLTAGE v_{1t} + FIND RETURN SIGNAL v_{1r}

IF $v_{1t} \uparrow$ THEN $v_{1r} \downarrow$

FF6



$v_{1t} \uparrow \Rightarrow v_o \downarrow$

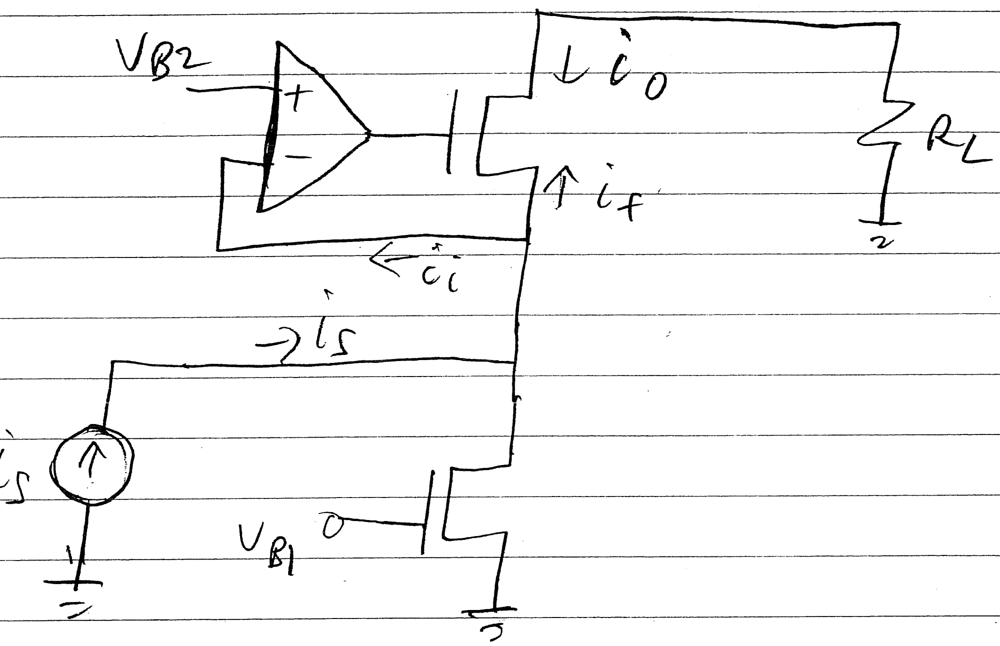
$v_o \downarrow \Rightarrow v_2 \downarrow$

$v_2 \downarrow \Rightarrow v_{1r} \downarrow$ ✓

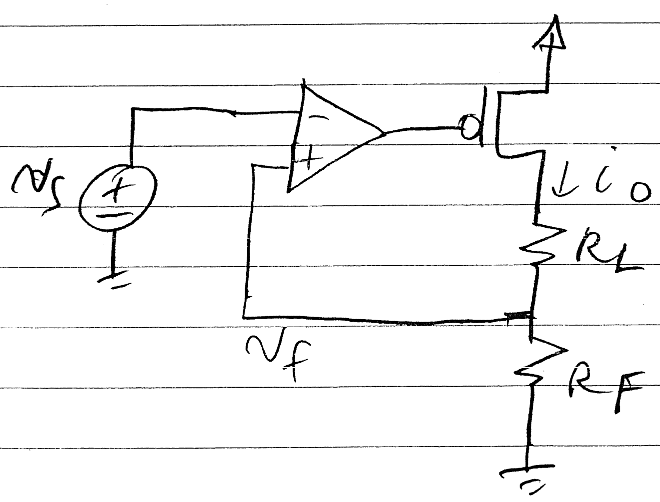
OPPOSITE OF v_{1t}

FF7

SHUNT-SERIES EXAMPLE



SERIES-SERIES EXAMPLE



- IN GENERAL, TYPE OF FEEDBACK IS DETERMINED BY WHERE INPUT IS APPLIED AND WHAT IS CONSIDERED TO BE THE OUTPUT.

- THIS MAKES 4 FEEDBACK APPROACH DIFFICULT TO USE & PRONE TO ERRORS

- WE SHALL <u>DEVIATE</u> FROM TEXTBOOK HERE AND USE THE <u>LOOP GAIN ANALYSIS APPROACH</u>

- IT IS DESCRIBED IN THE 5'TH EDITION OF "ANALYSIS AND DESIGN OF ANALOG INTEGRATED CIRCUITS" BY GRAY/HURST/LEWIS/MEYER, 2009

- ANOTHER ISSUE WITH 4 FEEDBACK APPROACH IS THAT $A\beta$ DEPENDS ON INPUT APPLIED + OUTPUT TAKEN ESPECIALLY WHEN β IS <u>NOT</u> <u>UNIDIRECTIONAL</u>

- THE <u>LOOP GAIN</u> IS UNCHANGED IN THE RETURN-RATIO APPROACH

- LOOP GAIN DETERMINES STABILITY OF A CIRCUIT.