

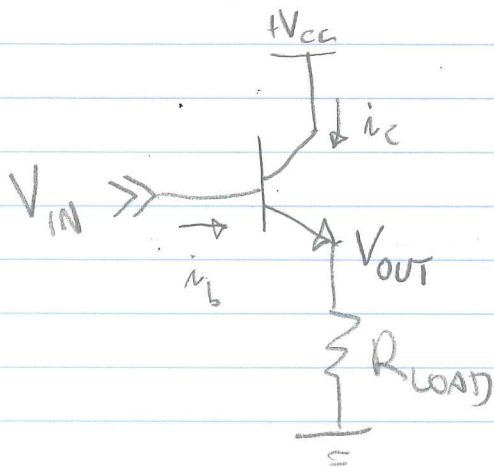
## TODAY'S LECTURE

FOR THE PROJECT, YOU HAVE AN ACTIVE FILTER THAT CANNOT SUPPLY THE CURRENT (A FEW HUNDRED mA) NEEDED TO POWER THE MIRROR ACTUATOR. WE'LL THEREFORE DISCUSS POWER AMPLIFIERS TODAY.

WE'LL ALSO GO OVER ONE WAY OF GENERATING FRAMES FOR YOUR LASER LIGHT SHOW ANIMATION.

(2)

AN "EMITTER FOLLOWER" — THE SIMPLEST CURRENT BOOSTER,  
(SINGLE-ENDED, UNITY GAIN AMPLIFIER)



$$V_{OUT} = V_{IN} - 0.7V$$

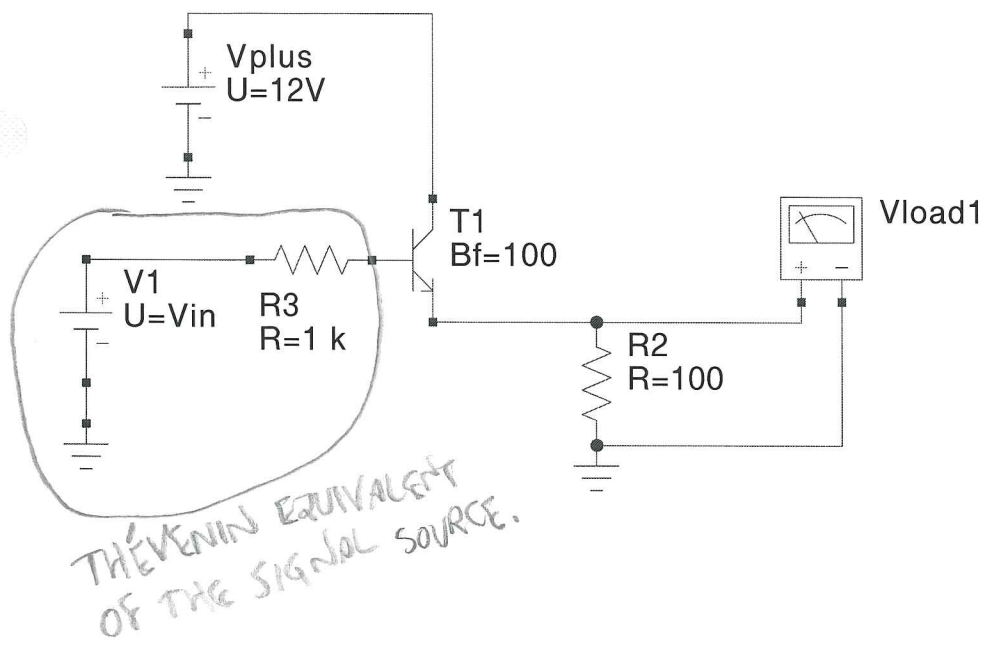
SO WHAT?

$$i_c = \beta i_b$$

SO  $V_{CC}$  TAKES MOST OF THE LOAD.

THIS IS A CRUDE VOLTAGE FOLLOWER.  
IT'S JUST OFF BY A BIT.

Q: WHAT ARE THE LIMITATIONS  
OF THIS CIRCUIT?



dc simulation

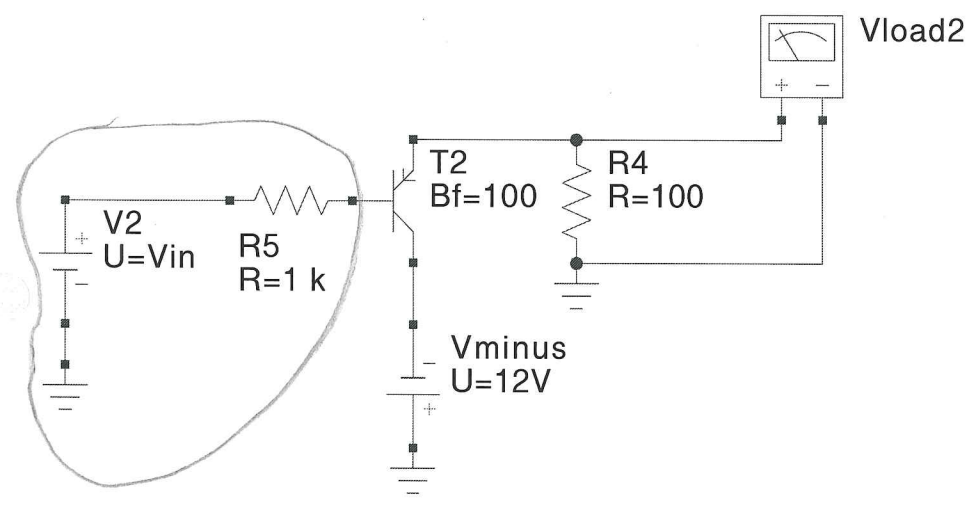
DC1

Parameter sweep

SW1  
 Sim=DC1  
 Type=lin  
 Param=Vin  
 Start=-20V  
 Stop=20V  
 Points=401

Equation

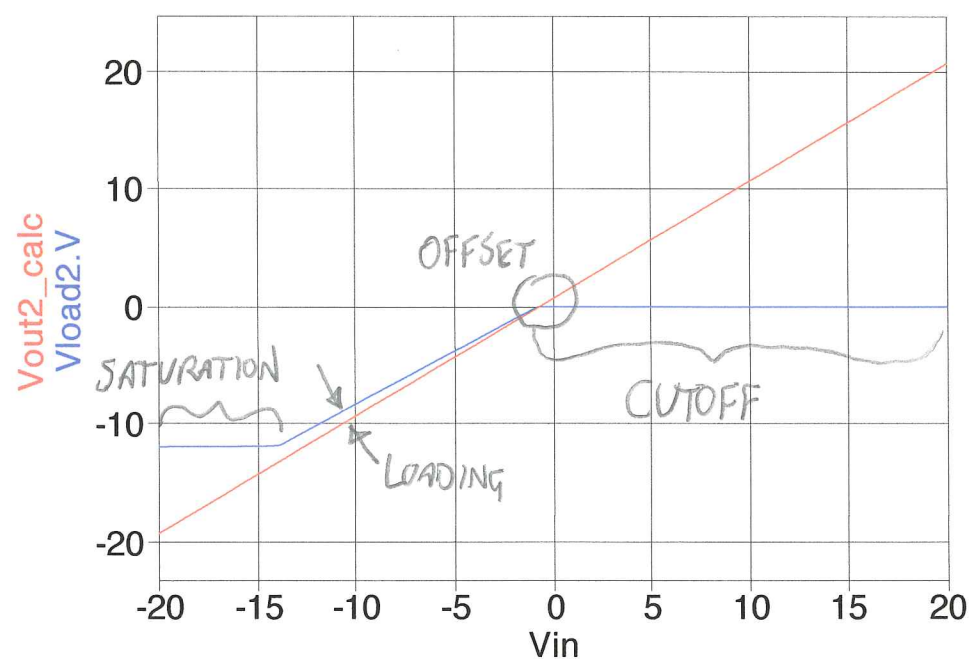
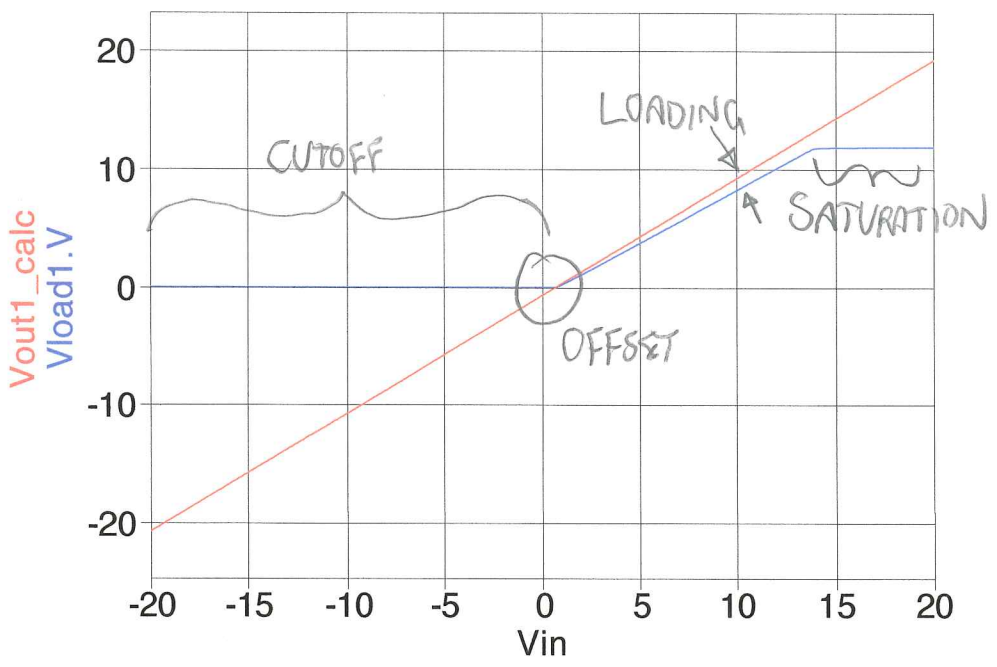
Eqn1  
 $V_{out1\_calc} = V_{in} - 0.7$



Equation

Eqn2  
 $V_{out2\_calc} = V_{in} + 0.7$

- I'VE ADDED IMPEDANCE OF  $1k$  TO THE SIGNAL  $V_{in}$ . (WHY ELSE WOULD WE NEED A FOLLOWER?)
- SECOND CIRCUIT IS PNP VERSION:  
 $V_{out} = V_{in} + 0.7V$

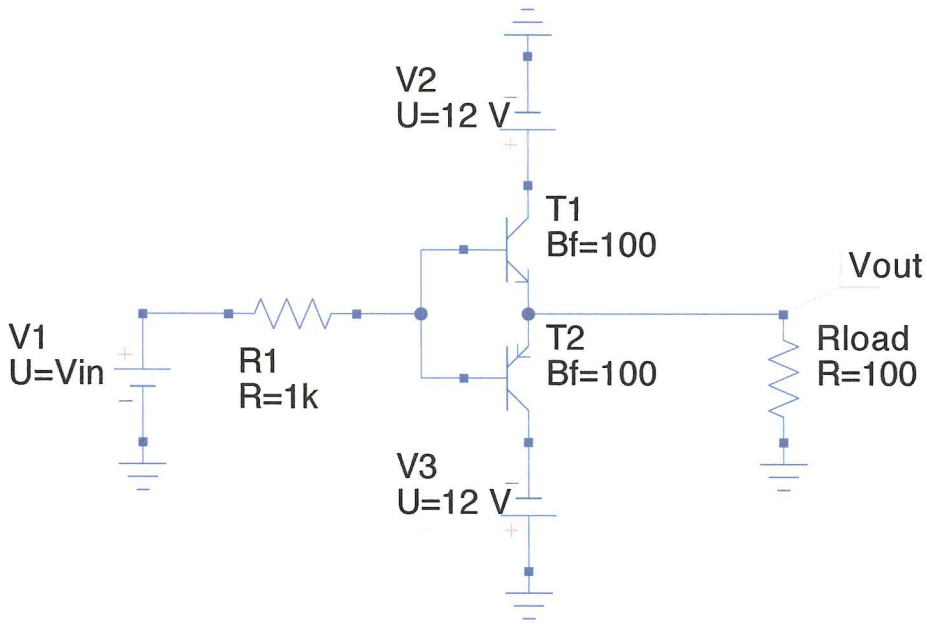


WHAT WE WOULD LIKE TO FIX:

- CUTOFF
- OFFSET
- LOADING

# The Push-Pull.

Combine NPN and PNP single-ended amps.  
Can we reach both rails?



dc simulation

DC1

Parameter sweep

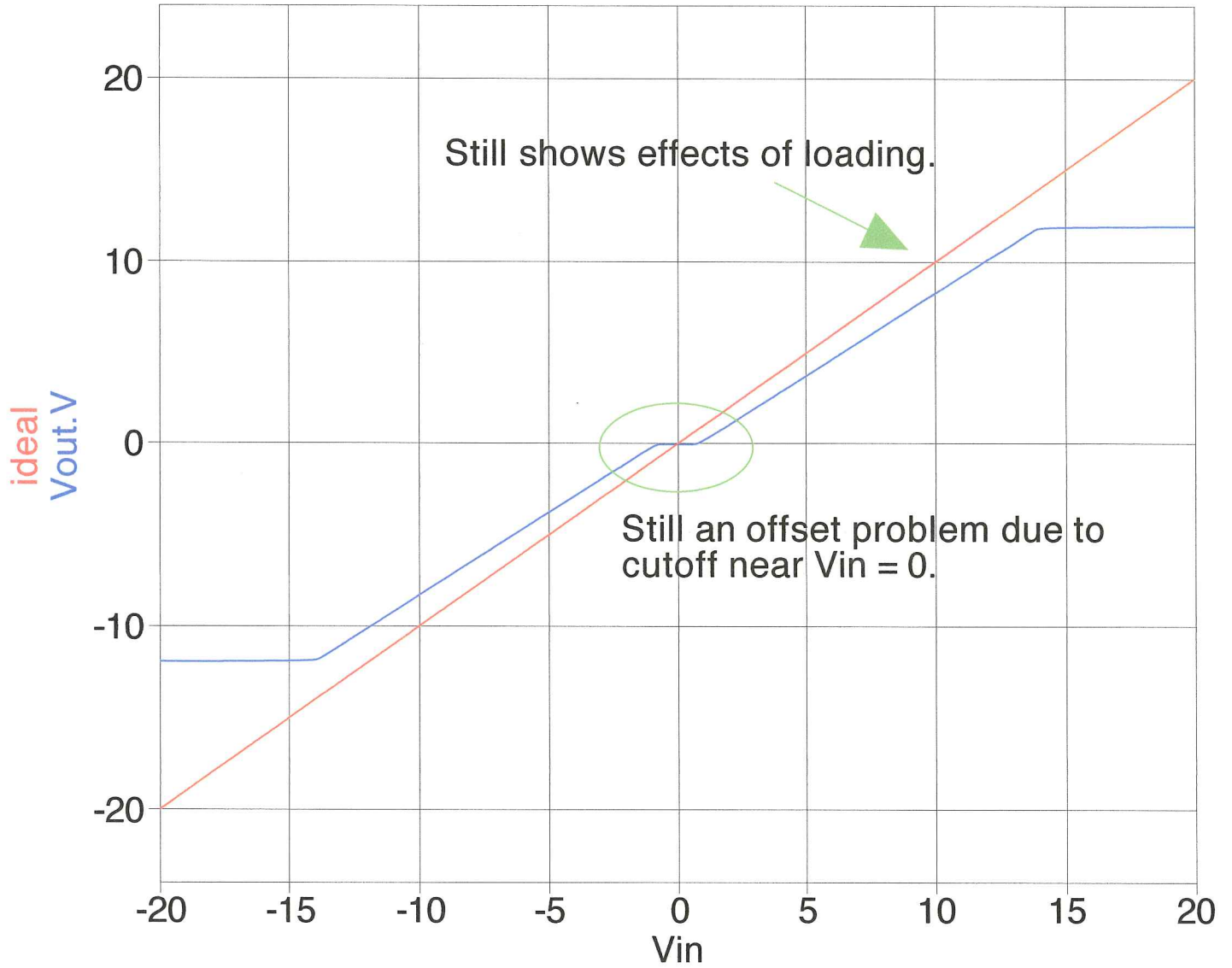
SW1  
Sim=DC1  
Type=lin  
Param=Vin  
Start=-20V  
Stop=20V  
Points=401

Equation

Eqn1  
ideal=Vin

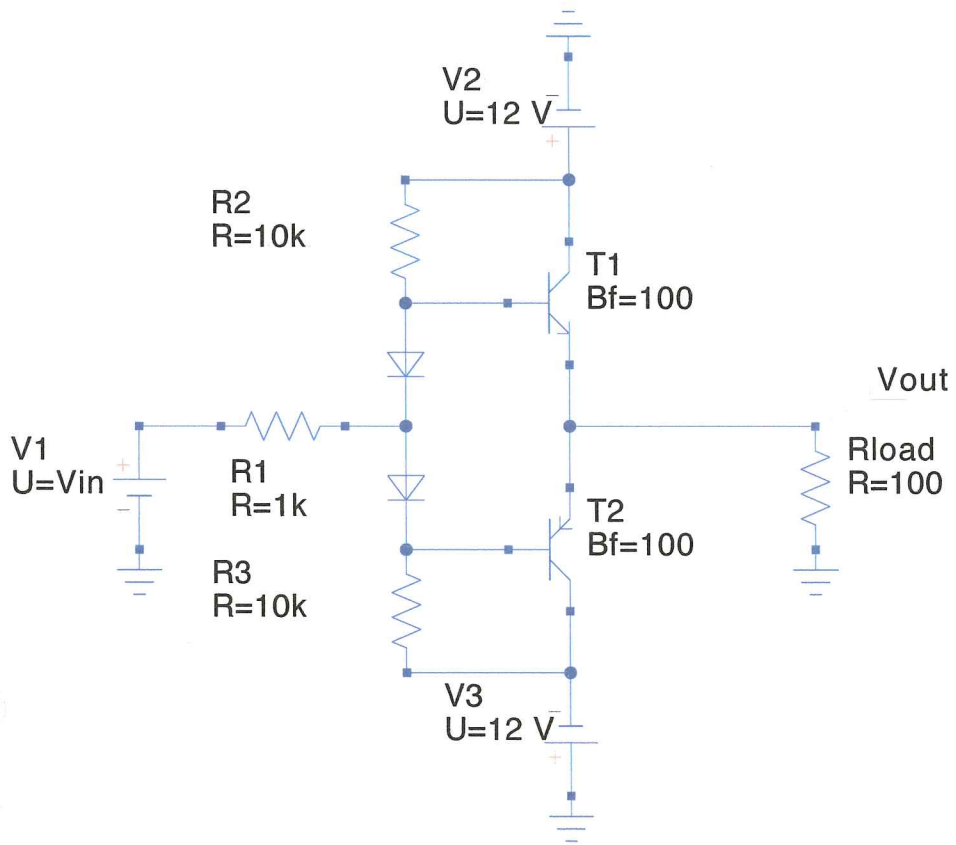
# The Push-Pull.

Unlike the single-ended amp, it can sink or source current and go to both rails.



# Diode Bias.

A popular way to fix the offsets. Diodes produce signals  $V_{in} + 0.7V$  and  $V_{in} - 0.7V$ .



dc simulation

DC1

Parameter sweep

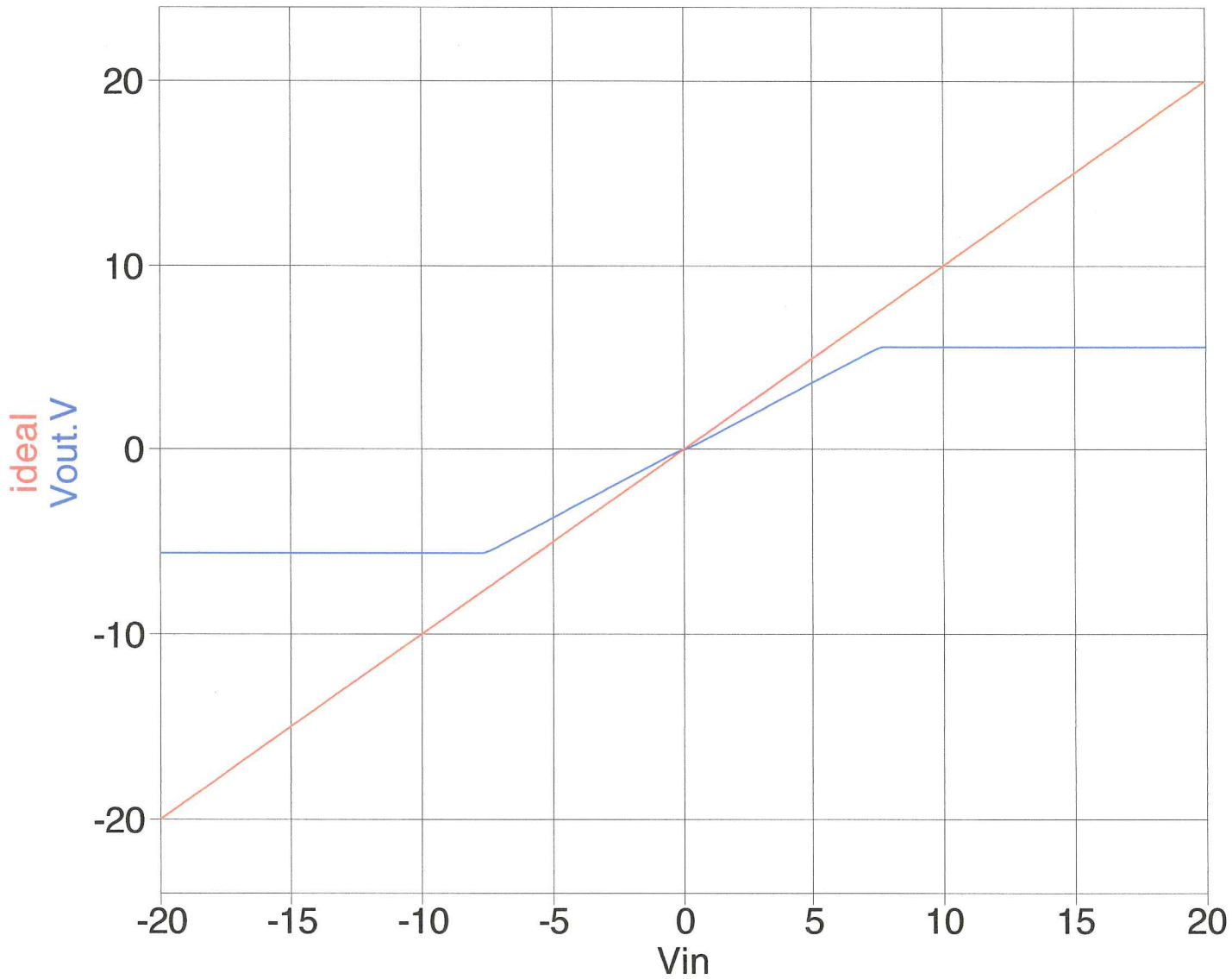
SW1  
Sim=DC1  
Type=lin  
Param=Vin  
Start=-20V  
Stop=20V  
Points=401

Equation

Eqn1  
ideal=Vin

# Diode Bias.

- Eliminates offset (provided the diode drop matches the BJT junction voltage).
- Worsens loading (larger bias resistors help)
- Can't reach rail-to-rail (smaller bias resistors help)
- If impedance on  $V_{in}$  is removed, the last 2 problems are fixed. But then we wouldn't need an amp at all!

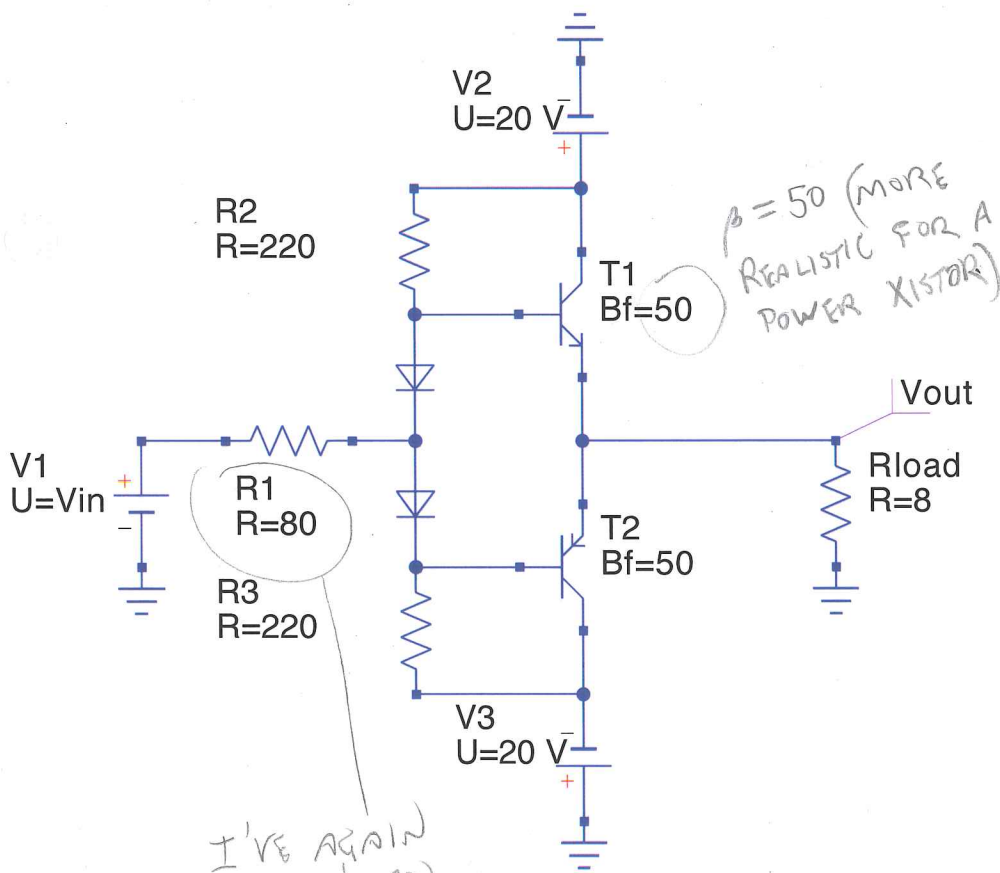




I WONDERED WHETHER I HAD MISSED SOMETHING — IS THE DIODE BIASED PUSH-PULL REALLY THAT BAD? SO I TRIED REPLICATING THE EXAMPLE DISCUSSED BY H&H.

## Diode Bias.

Modeled on the example described on P.92 of Horowitz & Hill (2ed).



I'VE AGAIN CHOSEN AN IMPEDANCE THAT IS 10 X THE RAIL

$\beta = 50$  (MORE REALISTIC FOR A POWER XISTOR)

### dc simulation

DC1

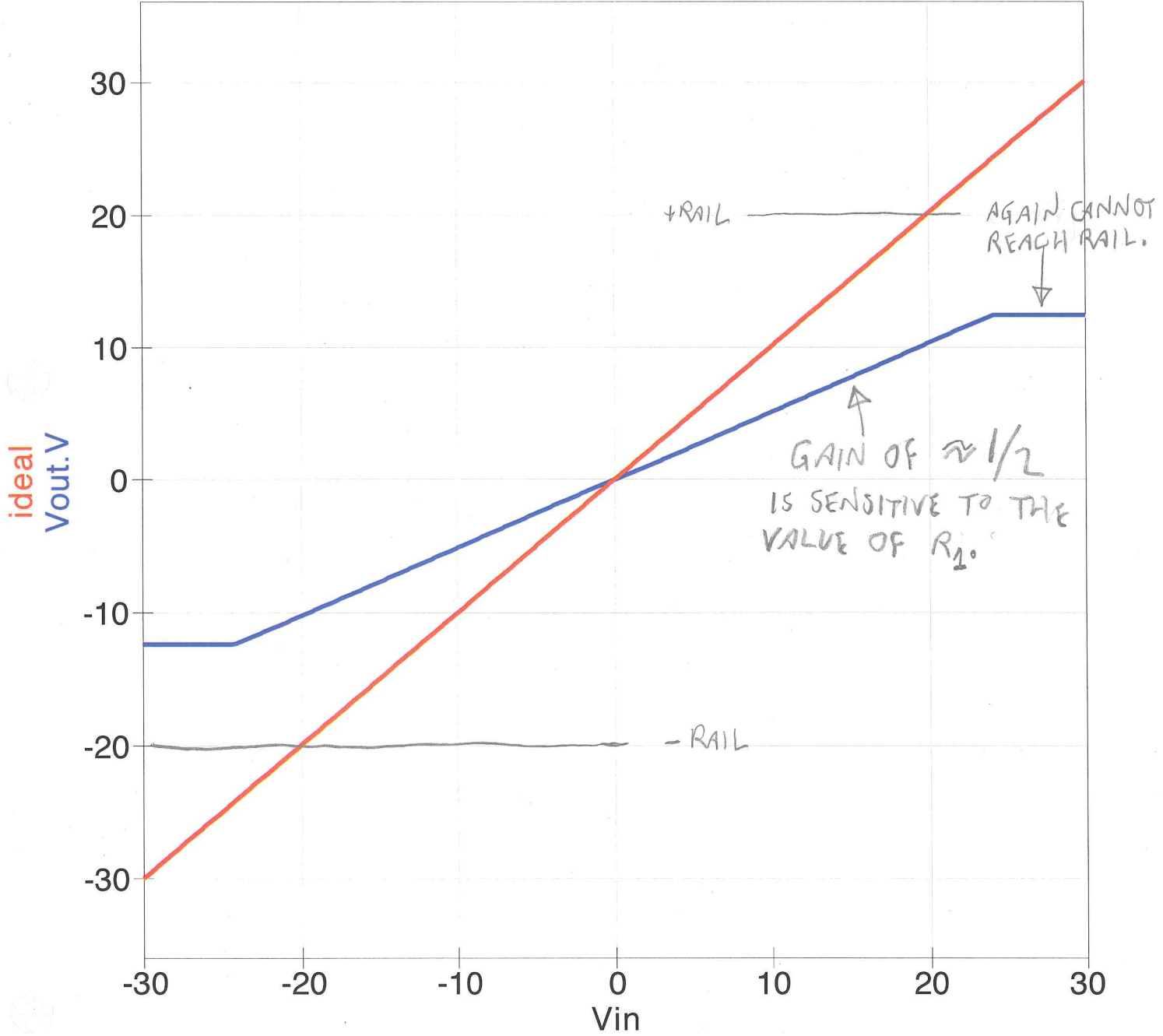
### Parameter sweep

SW1  
Sim=DC1  
Type=lin  
Param=Vin  
Start=-30V  
Stop=30V  
Points=601

### Equation

Eqn1  
ideal=Vin

Diode biased push-pull powers an 8Ω speaker. Parameters based on H&H p.92 (2ed).



Can negative feedback solve the issues with a push-pull?

dc simulation

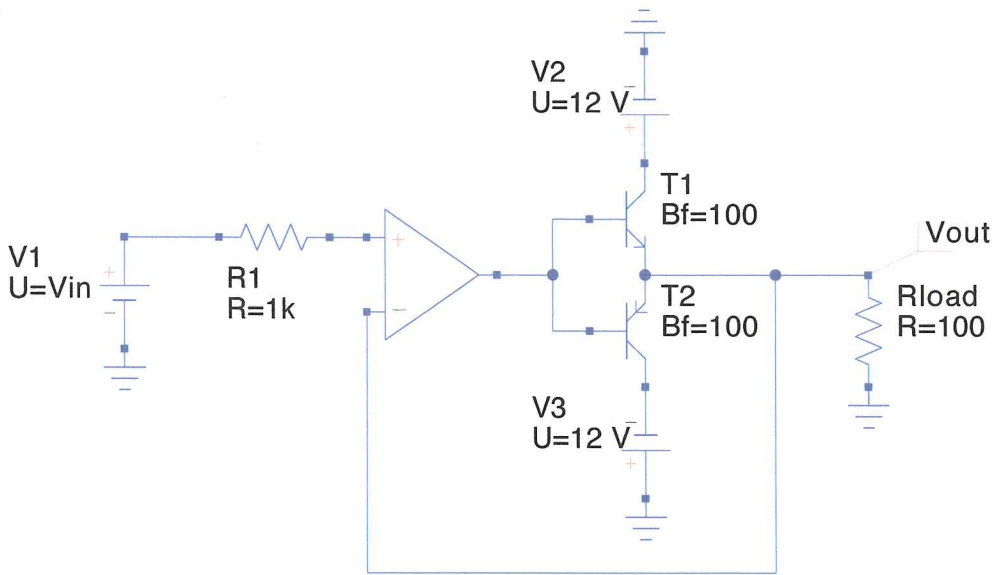
DC1

Parameter sweep

SW1  
Sim=DC1  
Type=lin  
Param=Vin  
Start=-20V  
Stop=20V  
Points=401

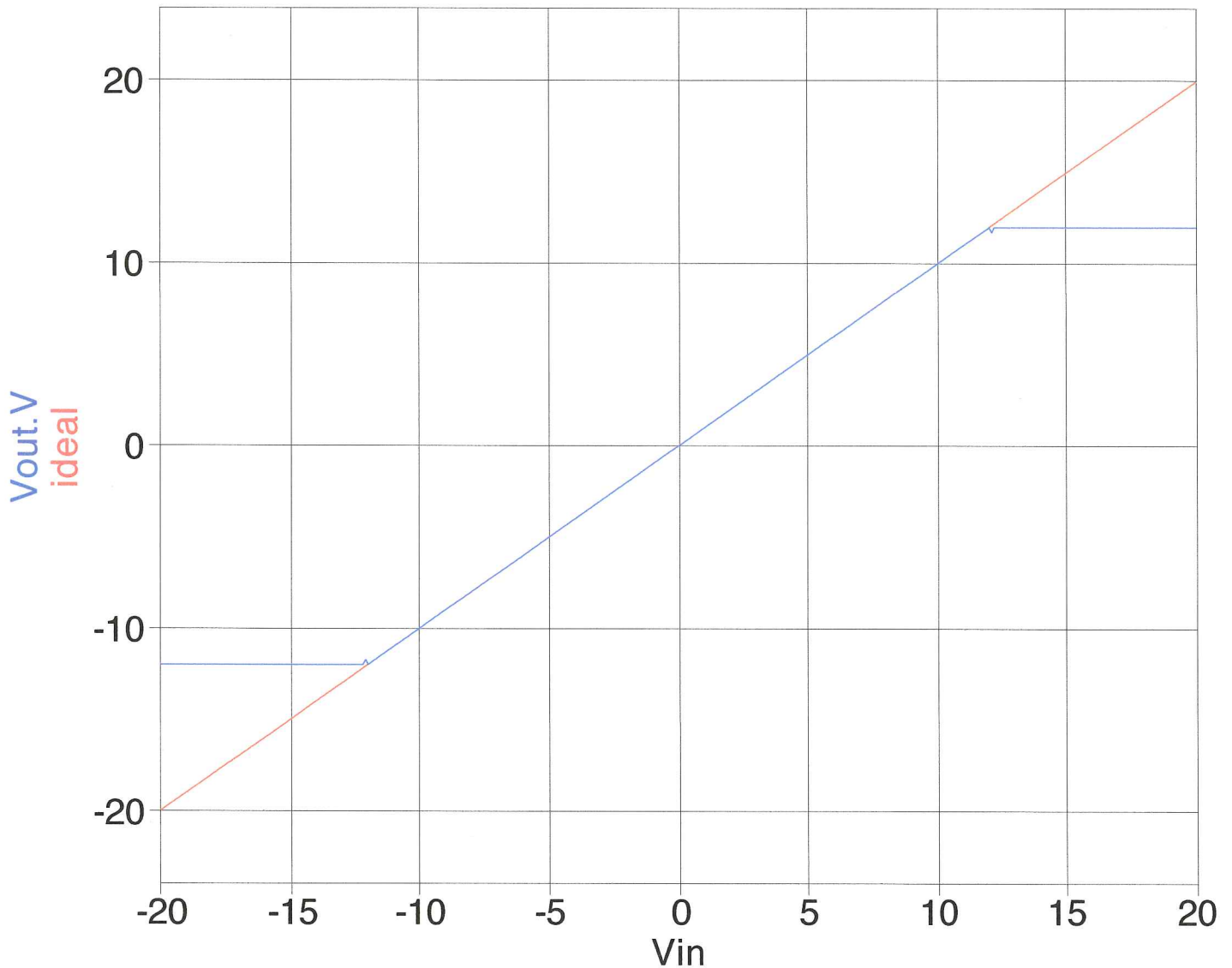
Equation

Eqn1  
ideal=Vin



Push-pull controlled by op amp with negative feedback.

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VICTORY!

Q: WHAT ARE THE LIMITATIONS OF THIS CIRCUIT?

(HINT: WHAT IF  $V_{IN}$  IS CHANGING RAPIDLY AS IT CROSSES ZERO?)