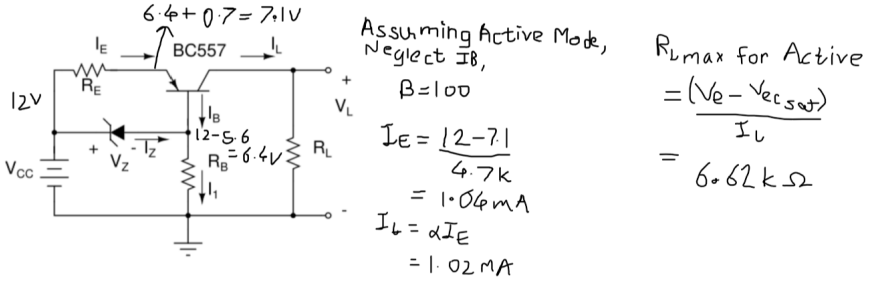
EE230 : Analog Circuits Lab

Mayur Ware | 19D070070, **Section 6**

Experiment 4 : Current Source, Current Mirror, and Differential Pair

August 21, 2021

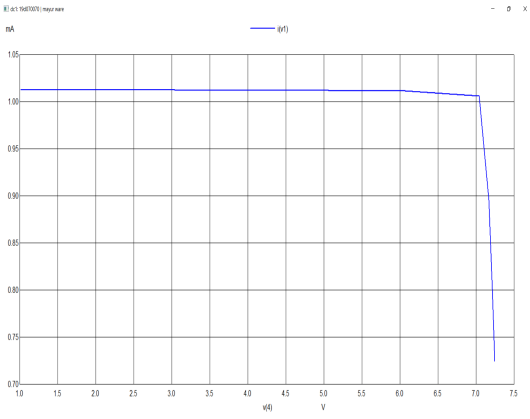
BJT Current Source




```
19D070070 | Mayur Ware
*Common-Emitter Amplifier: Biasing Circuit
.model bc557a NPN IS=10f BF=200 ISE=10.3f IKF=50m NE=1.3
+ BR=9.5 VAF=80 IKR=12m ISC=47p NC=2 VAR=10 RB=280 RE=1 RC=40
+ tr=0.3u tf=0.5n cje=12p vje=0.48 mje=0.5 cjc=6p vjc=0.7 mjc=0.33 kf=2f
Q1 4 3 2 bc557a
*Voltage Sources
Vin 1 GND 12
Vl 5 GND dc 0
Ve 6 2 dc 0
Vb 3 7 dc 0
X1 3 1 DI_1N4734A
*Resistors
Re 1 6 4.7k
Rb 7 GND 2.2k
Rl 4 5 1k
*Control Commands
.op
.control
run
print i(V2) i(V1) V(2) V(3) V(5)
.endc
.end
```

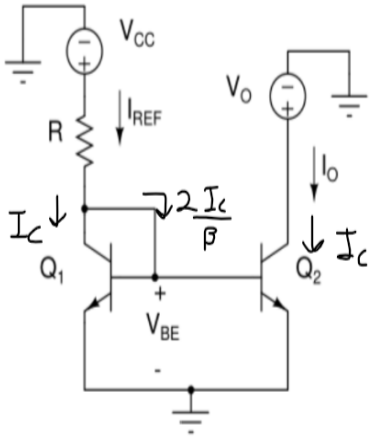
Simulation Results (Operating Point) :

i(ve) = 1.026180e-03 i(vb) = 2.961952e-03 i(vl) = 1.012825e-03 v(e) = 7.176954e+00 v(b) = 6.516294e+00 v(c) = 1.012825e+00



I learned use and benefits of Zener diode in pnp transistor circuit.

BJT Current Mirror based Current Source

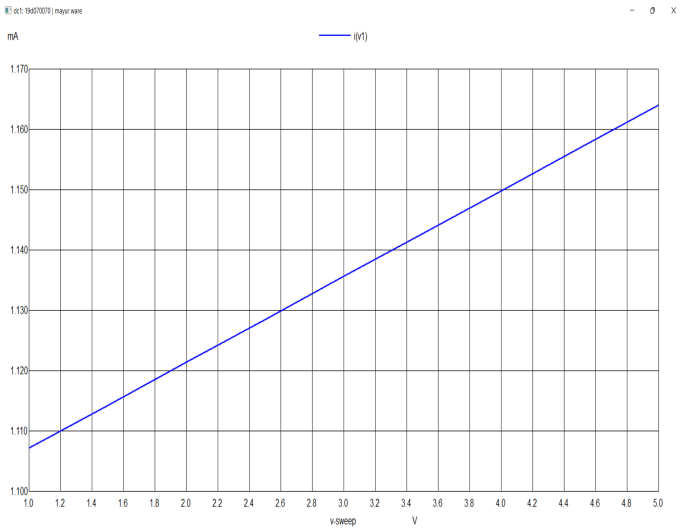


$$\Rightarrow I_{Ref} = I_c\left(1+\frac{2}{\beta}\right)$$

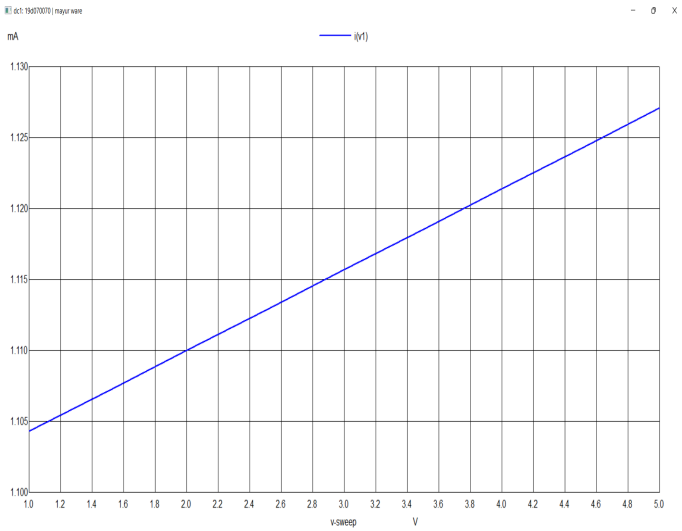
$$\frac{I_o}{I_{Ref}} = \frac{1}{\left(1+\frac{2}{\beta}\right)} \times \left(\frac{V_o - V_{BE}}{V_A}\right)$$

```
19D070070 | Mayur Ware
*BJT Current Mirror Circuit
.model bc547a NPN IS=10f BF=100 ISE=10.3f IKF=50m NE=1.3
+ BR=9.5 VAF=200 IKR=12m ISC=47p NC=2 VAR=10 RB=280 RE=1 RC=40
+ tr=0.3u tf=0.5n cje=12p vje=0.48 mje=0.5 cjc=6p vjc=0.7 mjc=0.33 kf=2f
*BJT
Q1 2 3 GND bc547a
Q2 5 3 GND bc547a
*Voltage Sources
Vcc 1 GND 12
Vo 4 GND 1
V1 4 5 dc 0
V2 2 3 dc 0
*Resistors
R 1 2 10k
*Control Commands
.dc Vo 1 5 0.5
.control
run
plot i(V1)
.endc
.end
```

Plots :



V_A = **80V**



V_A = **100V**

Observations :

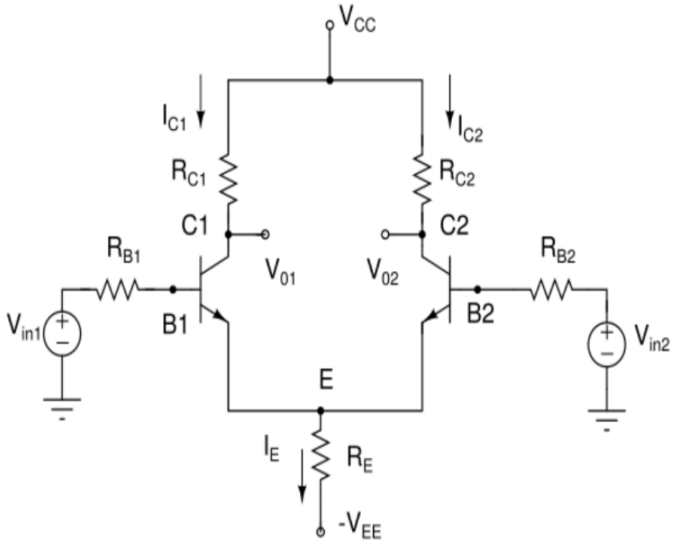
For both cases, plot of I_O is a straight line. But, for V_A = 100V, I_O values are slightly less than V_A = 80V

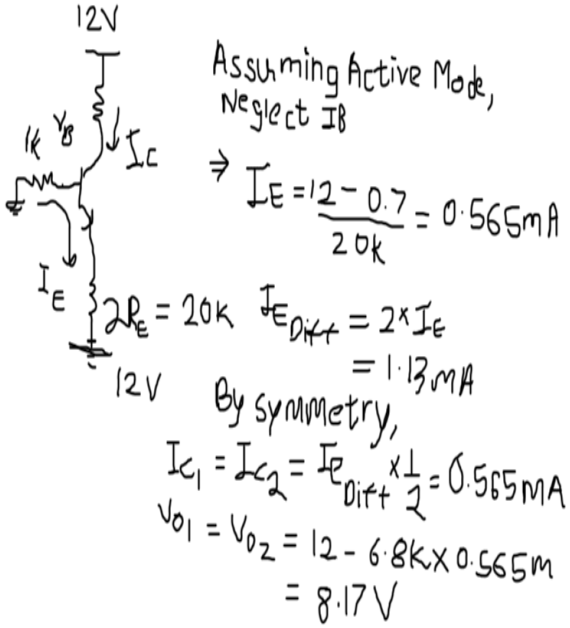
Learning :

I learned how to change V_A value in a transistor model.

Differential Pair

DC Operating Values






```
19D070070 | Mayur Ware
*BJT Differential Pair Circuit
.model bc547a NPN BF=400 NE=1.3 ISE=10.3F IKF=50M IS=10F VAF=80 ikr=12m
+ BR=9.5 NC=2 VAR=10 RB=280 RE=1 RC=40 VJE=.48 tr=.3u tf=.5n
+cje=12p vje=.48 mje=.5 cjc=6p vjc=.7 mjc:.33 isc=47p kf=2f
*BJT
Q1 C1 B1 E bc547a
Q2 C2 B2 E bc547a
*Voltage Sources
Vcc CC GND 12
V1 CC 1 dc 0
V2 CC 2 dc 0
Vee GND EE 12
*Resistors
Rc1 1 C1 6.8k
Rc2 2 C2 6.8k
Re E EE 10k
Rb1 B1 GND 1k
Rb2 B2 GND 1k
*Control Commands
.op
.control
run
set color0 = white
set color1 = black
set color2 = blue
set color3 = red
set xbrushwidth = 2
print -i(Vee) i(V1) i(V2) V(E) V(C1) V(C2)
.endc
.end
```

Simulation Results (Operating Point) :

-i(vee) = 1.135562e-03 i(v1) = 5.645243e-04

i(v2) = 5.645243e-04 v(e) = -6.44385e-01

v(c1) = 8.161234e+00 v(c2) = 8.161234e+00

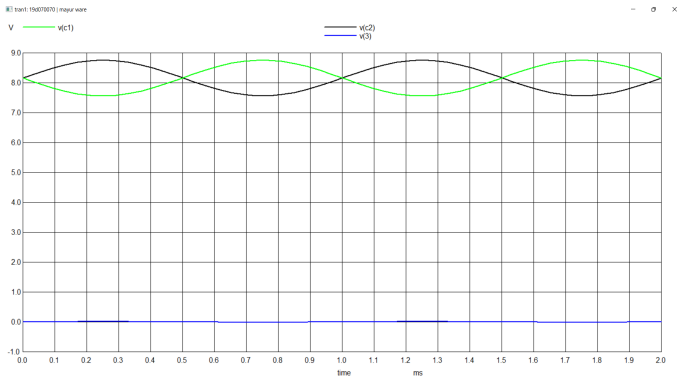
Learning :

Equal I_{C1} and I_{C2}, V_{C1} and V_{C2} due to circuit symmetry

Differential Amplifier

```
19D070070 | Mayur Ware
*BJT Differential Pair VTC Circuit
V 3 GND sin(0 10m 1k 0 0)
*Control Commands
.tran 0.1m 2m
.control
run
meas tran a pp V(C1)
meas tran b pp V(3)
print a/b
plot V(3) V(C1) V(C2)
.endc
.end
```

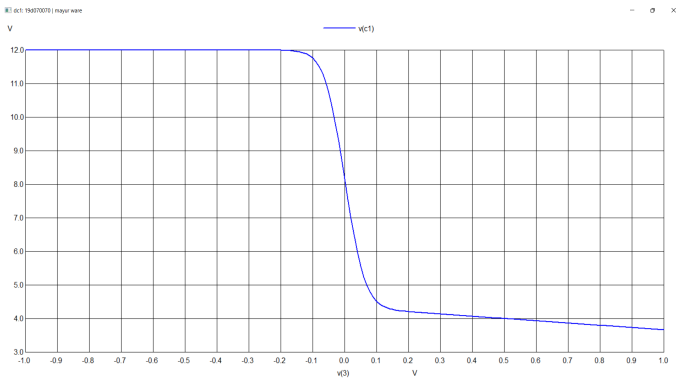
a = 1.196783e+00
b = 1.993003e-02
Gain = a/b = 6.004923e+01



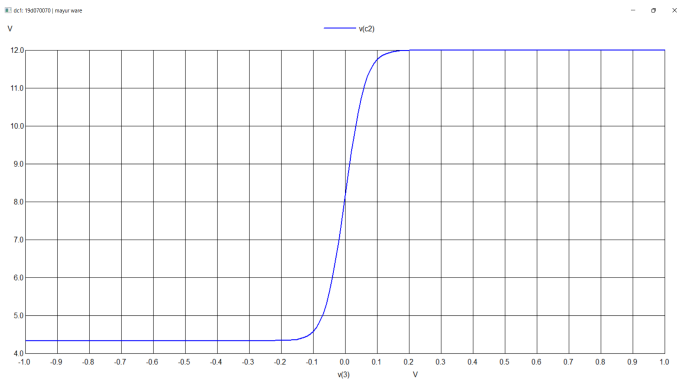
Large-Signal Characteristics (Voltage-Transfer Characteristics - VTC)

```
19D070070 | Mayur Ware
*BJT Differential Pair VTC Circuit
*Control Commands
.dc V3 -1 1 0.01
.control
run
plot V(C1) vs V(3)
plot V(C2) vs V(3)
.endc
.end
```

Plots :



V_{C1} **vs** V_{in1}



V_{C2} **vs** V_{in1}

Observations :
V_{C1} decreases as V_{in1} goes from it's negative peak to it's positive peak
V_{C2} increases as V_{in1} goes from it's negative peak to it's positive peak