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Analog Electronics Lab #2 - Common Collector Amplifier, Darlington pair, Bootstrap configuration

# **Objectives**

Design the provided circuit on LT Spice and calculate the following parameters

- 1. Voltage gain
- 2. Input Resistance
- 3. Output Resistance
- 4. Input voltage and current
- 5. Output voltage and current
- 6. Show input and output waveform

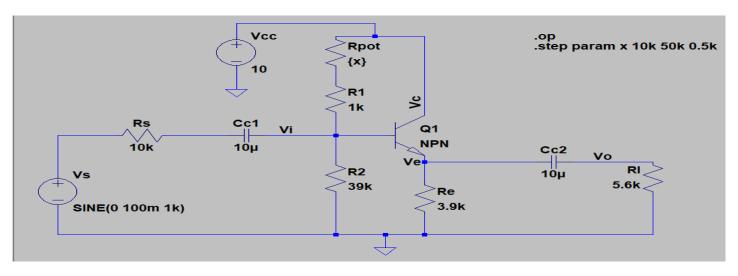
for the following three configurations:

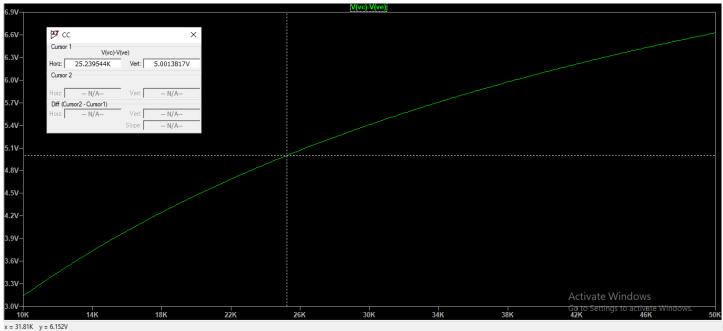
- a) Common collector,
- b) Darlington pair,
- c) Bootstrap configuration.

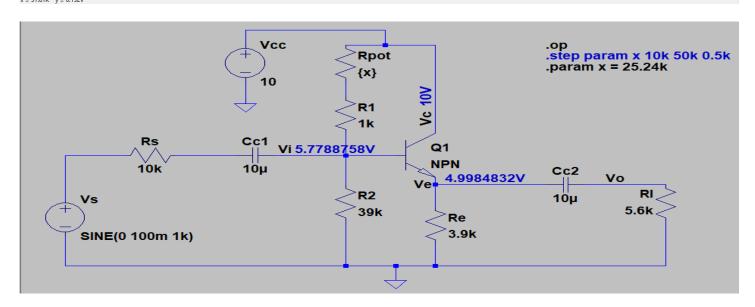
at an operating point Vce = Vcc/2. Also, record observations and write conclusions for each amplifier configuration.

# Common Collector

# Finding the value of potentiometer resistance







DC analysis using .op gives Rpot = 25.24 k $\Omega$  (total = 26.24 k $\Omega$ ) for Vce = 5V.

# AC analysis to find voltage gain, Iin, Iout, Vin, Vout at f = 1kHz (.ac lin 1 1k 1k)

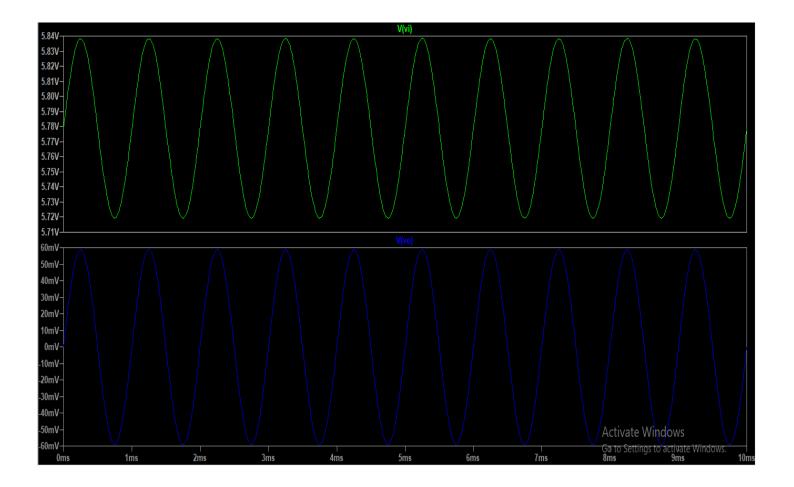
 $\frac{Gain = V(vo)/V(vi) = 0.0589986/0.0595167 = 0.9913 = -0.076 \text{ dB}}{Gain \text{ (Ai)} = Ie(Q1)/Ib(Q1) = 25.6633uA/0.254092uA = 101 = 40.1 \text{ dB}}$ 

A	C Analys	is			
frequency:	1000	Hz			
V(vc):	mag:	0 phase:	0°	voltage	
V(vi):	mag:	0.0595167 phase: 0	.0352325°	voltage	
√(ve):	mag:	0.0589988 phase: 0	.0346508°	voltage	
V(n001):	mag:	0.0572485 phase: 0	.0352325°	voltage	
√(vo):	mag:	0.0589986 phase:	0.197488°	voltage	
V(n003):	mag:	0.0595167 phase: -0	.0267943°	voltage	
V(n002):	mag:	0.1 phase:	0°	voltage	
Ic(Q1):	mag: 2	2.54092e-005 phase:	0.1015°	device_current	
Ib(Q1):	mag: 2	2.54092e-007 phase:	0.1015°	device_current	
Ιe(Q1):	mag: 2	2.56633e-005 phase:	-179.899°	device_current	
I (Cc1) :	mag: 4	1.04833e-006 phase:	-179.961°	device_current	
I (Cc2) :	mag: 1	1.05355e-005 phase:	-179.803°	device current	
I (Rs) :	mag: 4	1.04833e-006 phase:	-179.961°	device_current	
I(Rl):	mag: 1	1.05355e-005 phase:	-179.803°	device_current	
I(Re):	mag: 1	L.51279e-005 phase:	0.0346508°	device_current	
I (R2):	mag: 1	L.52607e-006 phase:	0.0352325°	device current	
I (Rpot):	mag: 2	2.26817e-006 phase:	-179.965°	device_current	
I(R1):	mag: 2	2.26817e-006 phase:	-179.965°	device_current	
I (Vcc) :	mag: 2	2.31411e-005 phase:	-179.892°	device_current	
I (Vs) :	magr. /	1.04833e-006 phase:	-179.961°	device current	

# Other parameters:

 $Vin = 0.0595167 \ V \not \triangleq 0.0352325^{\circ}$   $Iin = 4.04833 \ \mu A \not \triangleq -179.961^{\circ}$   $Vout = 0.0589986 \ V \not \triangleq 0.197488^{\circ}$   $Iout = 10.5355 \ \mu A \not \triangleq -179.803^{\circ}$ 

# Input and Output waveforms (.tran 10m)



# Input resistance (R<sub>in</sub>)

**DC** input resistance: infinite (as input capacitor blocks all dc voltage)

### AC input resistance:

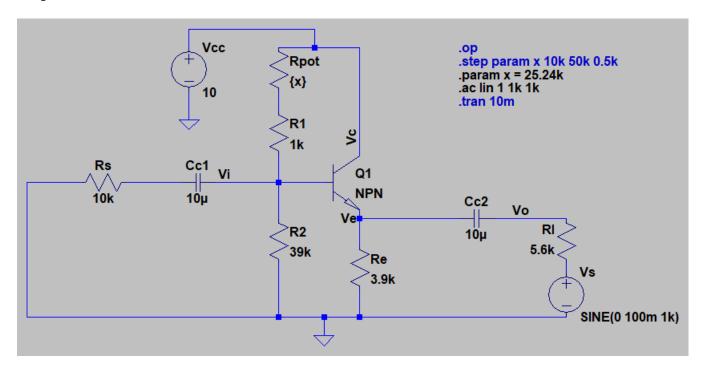
```
* D:\BITS\BITS SEM 6\INSTR F341 (AnE)\Lab2\CC\CC.asc
                                                                                ×
       --- AC Analysis ---
frequency:
               1000
                              Ηz
V(vc):
                             0 phase:
              mag:
                                                            voltage
V(vi):
              maq:
                     0.0595167 phase:
                                       0.0352325°
                                                            voltage
                     0.0589988 phase:
                                        0.0346508°
V(ve):
              mag:
                                                            voltage
                     0.0572485 phase:
V(n001):
              mag:
                                        0.0352325°
                                                            voltage
                     0.0589986 phase:
V(vo):
              maq:
                                         0.197488°
                                                            voltage
                     0.0595167 phase: -0.0267943°
V(n003):
              mag:
                                                            voltage
                           0.1 phase:
V(n002):
              mag:
                                                            voltage
              mag: 2.54092e-005 phase:
Ic(Q1):
                                             0.1015°
                                                            device current
              mag: 2.54092e-007 phase:
                                                            device current
Ib (Q1):
                                             0.1015°
              mag: 2.56633e-005 phase:
                                           -179.899°
Ie(Q1):
                                                            device current
              mag: 4.04833e-006 phase:
                                           -179.961°
                                                            device current
I(Cc1):
              mag: 1.05355e-005 phase:
I(Cc2):
                                           -179.803°
                                                            device current
I(Rs):
              mag: 4.04833e-006 phase:
                                           -179.961°
                                                            device current
              mag: 1.05355e-005 phase:
                                           -179.803°
I(Rl):
                                                            device current
I(Re):
              mag: 1.51279e-005 phase:
                                          0.0346508°
                                                            device current
              mag: 1.52607e-006 phase:
I(R2):
                                          0.0352325°
                                                            device current
I(Rpot):
              mag: 2.26817e-006 phase:
                                           -179.965°
                                                            device current
              mag: 2.26817e-006 phase:
                                           -179.965°
I(R1):
                                                            device current
I(Vcc):
              mag: 2.31411e-005 phase:
                                           -179.892°
                                                            device current
              mag: 4.04833e-006 phase:
                                           -179.961°
                                                            device current
I(Vs):
```

$$R_{in} = \frac{V_{in}}{I_{in}} = \frac{V(vi)}{I(Vs)} = \frac{0.0595167}{4.04833 \times 10^{-6}} = 14.7 \text{ k}\Omega$$

# Output resistance (R<sub>out</sub>)

**DC** output resistance:  $5.6 \text{ k}\Omega$ 

### AC output resistance:

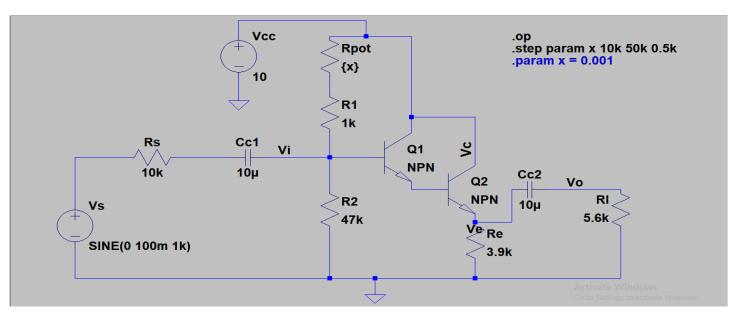


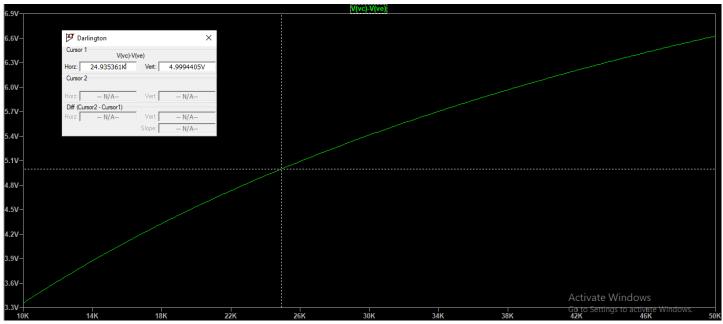
```
* D:\BITS\BITS SEM 6\INSTR F341 (AnE)\Lab2\CC\CC.asc
                                                                                ×
       --- AC Analysis ---
               1000
frequency:
                              Ηz
V(vc):
                             0 phase:
              mag:
                                                            voltage
V(vi):
              mag: 0.00104312 phase:
                                         0.106299°
                                                            voltage
              mag: 0.00139127 phase:
                                         0.120234°
V(ve):
                                                            voltage
V(n001):
              mag: 0.00100336 phase:
                                         0.106299°
                                                            voltage
V(n003):
                           0.1 phase:
                                                0°
                                                            voltage
              mag:
V(vo):
              mag: 0.00141941 phase:
                                         -11.2671°
                                                            voltage
V(n002):
              mag: 0.00104311 phase:
                                         0.197488°
                                                            voltage
              mag: 1.70811e-005 phase:
Ic(Q1):
                                           -179.838°
                                                            device current
              mag: 1.70811e-007 phase:
Ib(Q1):
                                           -179.838°
                                                            device current
              mag: 1.72519e-005 phase:
                                           0.161987°
                                                            device_current
Ie(Q1):
              mag: 1.04311e-007 phase:
                                           0.197488°
I(Cc1):
                                                            device_current
              mag: 1.76086e-005 phase:
I(Cc2):
                                           0.161141°
                                                            device_current
              mag: 1.04311e-007 phase:
I(Rs):
                                           0.197488°
                                                            device_current
              mag: 1.76086e-005 phase:
I(R1):
                                           0.161141°
                                                            device_current
              mag: 3.56736e-007 phase:
I(Re):
                                           0.120234°
                                                            device_current
              mag: 2.67466e-008 phase:
                                           0.106299°
I(R2):
                                                            device current
              mag: 3.97529e-008 phase:
I(Rpot):
                                           -179.894°
                                                            device current
              mag: 3.97529e-008 phase:
I(R1):
                                           -179.894°
                                                            device current
              mag: 1.71208e-005 phase:
I(Vcc):
                                           0.161857°
                                                            device current
              mag: 1.76086e-005 phase:
I(Vs):
                                           -179.839°
                                                            device current
```

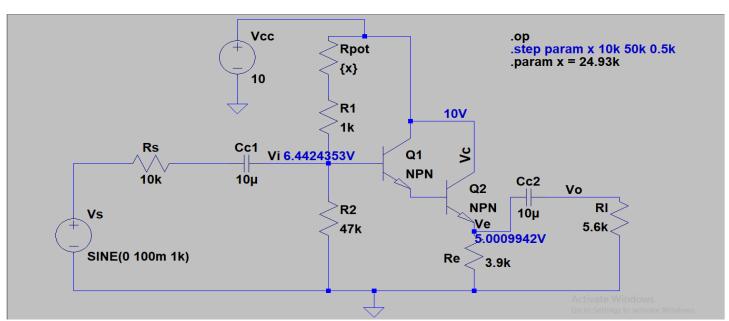
$$R_{out} = \frac{V_{out}}{I_{out}} = \frac{V(vo)}{I(Vs)} = \frac{0.00141941}{1.76086 \times 10^{-5}} = 80.61 \ \Omega$$

# Darlington Pair

# Finding the value of potentiometer resistance







DC analysis using .op gives Rpot =  $24.93 \text{ k}\Omega$  (total =  $25.93 \text{ k}\Omega$ ) for Vce = 5V.

# AC analysis to find voltage gain, Iin, Iout, Vin, Vout at f = 1kHz (.ac lin 1 1k 1k)

 $\frac{Gain (Av) = V(vo)/V(vi) = 0.0614665/0.0625454 = 0.983 = -0.151 dB}{Gain (Ai) = Ie(Q2)/Ib(Q1) = 26.7369uA/2.62107nA = 10200.76 = 80.17 dB}$ 

\* D:\BITS\BITS SEM 6\INSTR F341 (AnE)\Lab2\Darlington\Darlington.asc

--- AC Analysis --frequency: 1000 V(vc): mag: 0 phase: voltage V(vi): mag: 0.0625454 phase: 0.0341373° voltage V(n004):0.0620061 phase: 0.0335659° voltage mag: V(n001):mag: 0.0601333 phase: 0.0341373° voltage V(ve): mag: 0.0614668 phase: 0.0329845° voltage V(vo): mag: 0.0614665 phase: 0.195822° voltage V(n003): mag: 0.0625454 phase: -0.0204702° voltage 0° 0.1 phase: V(n002): voltage mag: Ic(Q2): mag: 2.64721e-005 phase: 0.0998332° device current mag: 2.64721e-007 phase: Ib(Q2): 0.0998332° device current Ie(Q2): mag: 2.67369e-005 phase: -179.9° device current Ic(Q1): mag: 2.621e-007 phase: 0.0998332° device current Ib(Q1): mag: 2.62107e-009 phase: 0.0998317° device current mag: 2.64721e-007 phase: -179.9° Ie(Q1): device current mag: 3.74546e-006 phase: -179.966° device current I(Cc1): mag: 1.09762e-005 phase: I(Cc2): -179.804° device current mag: 3.74546e-006 phase: I(Rs): -179.966° device current I(Rl): mag: 1.09762e-005 phase: -179.804° device current I(Re): mag: 1.57607e-005 phase: 0.0329845° device current mag: 1.33075e-006 phase: I(R2): 0.0341373° device current mag: 2.41209e-006 phase: I(Rpot): -179.966° device current mag: 2.41209e-006 phase: -179.966° I(R1): device current I(Vcc): mag: 2.43222e-005 phase: -179.894° device current I(Vs): mag: 3.74546e-006 phase: -179.966° device current

### Other parameters:

Vin = 0.0625454 V \$\rm 0.0341373°

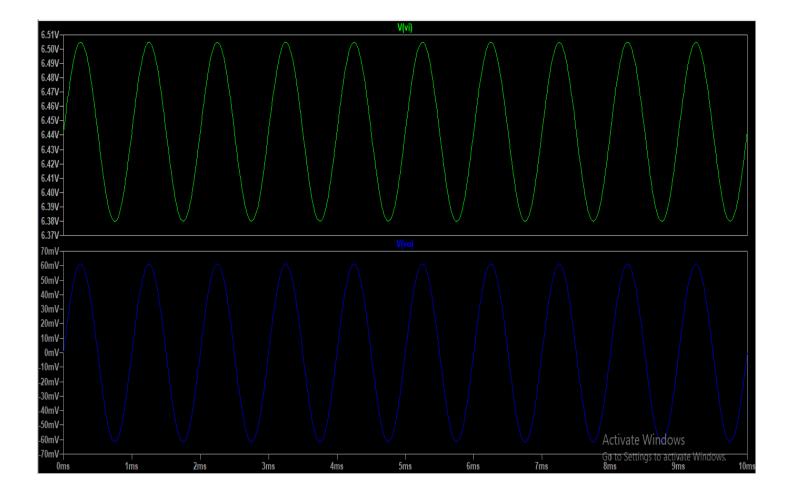
Iin = 3.74546 μA \$\rm -179.966°

Vout = 0.0614665 V \$\rm 0.195822°

Iout = 10.9762 μA \$\rm -179.804°

×

# Input and Output waveforms (.tran 10m)



# Input resistance (R<sub>in</sub>)

DC input resistance: infinite (as input capacitor blocks all dc voltage)

AC input resistance:

```
* D:\BITS\BITS SEM 6\INSTR F341 (AnE)\Lab2\Darlington\Darlington.asc
```

--- AC Analysis ---1000 frequency: HzV(vc): 0 phase: voltage mag: V(vi): 0.0625454 phase: 0.0341373° voltage mag: V(n004):0.0620061 phase: 0.0335659° mag: voltage V(n001): 0.0601333 phase: 0.0341373° voltage mag: 0.0614668 phase: 0.0329845° V(ve): voltage mag: 0.0614665 phase: 0.195822° V(vo): voltage mag: V(n003): 0.0625454 phase: -0.0204702° voltage mag: 0° 0.1 phase: V(n002): voltage mag: Ic(Q2): mag: 2.64721e-005 phase: 0.0998332° device current mag: 2.64721e-007 phase: Ib(Q2):0.0998332° device current mag: 2.67369e-005 phase: Ie(Q2): -179.9° device current mag: 2.621e-007 phase: 0.0998332° Ic(Q1): device current Ib(Q1): mag: 2.62107e-009 phase: 0.0998317° device current mag: 2.64721e-007 phase: -179.9° device current Ie(Q1): I(Cc1): mag: 3.74546e-006 phase: -179.966° device current mag: 1.09762e-005 phase: I(Cc2): -179.804° device current I(Rs): mag: 3.74546e-006 phase: -179.966° device current mag: 1.09762e-005 phase: -179.804° I(Rl): device current I(Re): mag: 1.57607e-005 phase: 0.0329845° device current mag: 1.33075e-006 phase: I(R2): 0.0341373° device current -179.966° I(Rpot): mag: 2.41209e-006 phase: device current mag: 2.41209e-006 phase: -179.966° I(R1): device current I(Vcc): mag: 2.43222e-005 phase: -179.894° device current I(Vs): mag: 3.74546e-006 phase: -179.966° device current

$$R_{in} = \frac{V_{in}}{I_{in}} = \frac{V(vi)}{I(Vs)} = \frac{0.0625454}{3.74546 \times 10^{-6}} = 16.7 \text{ k}\Omega$$

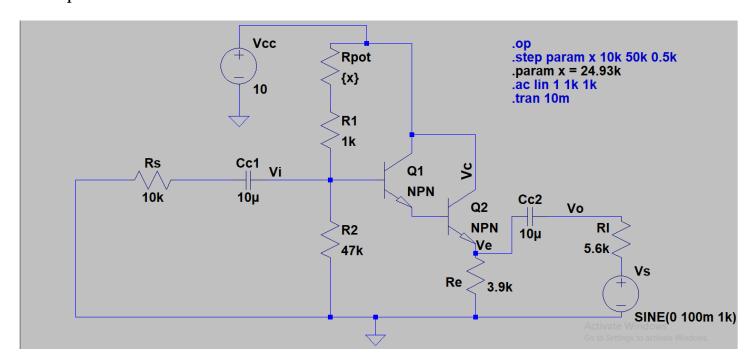
×

# Output resistance (R<sub>out</sub>)

**DC** output resistance:  $5.6 \text{ k}\Omega$ 

### AC output resistance:

I(Vs):



X

\* D:\BITS\BITS SEM 6\INSTR F341 (AnE)\Lab2\Darlington\Darlington.asc

mag: 1.77288e-005 phase:

```
--- AC Analysis ---
frequency:
               1000
                             Hz
V(vc):
                             0 phase:
                                                0°
                                                            voltage
              mag:
V(vi):
              mag: 1.07599e-005 phase:
                                           0.104633°
                                                            voltage
V(n003):
              mag: 0.000364645 phase:
                                          0.159999°
                                                            voltage
V(n001):
              mag: 1.03449e-005 phase:
                                           0.104633°
                                                            voltage
              mag: 0.000718529 phase:
                                          0.160828°
V(ve):
                                                            voltage
              mag:
                                                            voltage
V(n004):
                           0.1 phase:
                                                o°
              mag: 0.000771949 phase:
                                          -21.2787°
V(vo):
                                                            voltage
              mag: 1.07599e-005 phase:
                                           0.195822°
V(n002):
                                                            voltage
Ic(Q2):
              mag: 1.73708e-005 phase:
                                           -179.838°
                                                            device current
Ib(Q2):
              mag: 1.73708e-007 phase:
                                           -179.838°
                                                            device current
Ie(Q2):
              mag: 1.75445e-005 phase:
                                           0.161682°
                                                            device current
              mag: 1.71988e-007 phase:
Ic(Q1):
                                           -179.838°
                                                            device current
              mag: 1.71988e-009 phase:
                                           -179.838°
                                                            device current
Ib(Q1):
              mag: 1.73708e-007 phase:
                                           0.161682°
                                                            device current
Ie(Q1):
                                           0.195822°
              mag: 1.07599e-009 phase:
                                                            device current
I(Cc1):
              mag: 1.77288e-005 phase:
                                                            device current
I(Cc2):
                                           0.161673°
I(Rs):
              mag: 1.07599e-009 phase:
                                           0.195822°
                                                            device current
I(Rl):
              mag: 1.77288e-005 phase:
                                           0.161673°
                                                            device current
              mag: 1.84238e-007 phase:
I(Re):
                                           0.160828°
                                                            device current
I(R2):
              mag: 2.28934e-010 phase:
                                           0.104633°
                                                            device current
              mag: 4.1496e-010 phase:
                                          -179.895°
                                                            device current
I(Rpot):
              mag: 4.1496e-010 phase:
I(R1):
                                          -179.895°
                                                            device current
              mag: 1.75432e-005 phase:
                                           0.161681°
I(Vcc):
                                                            device current
```

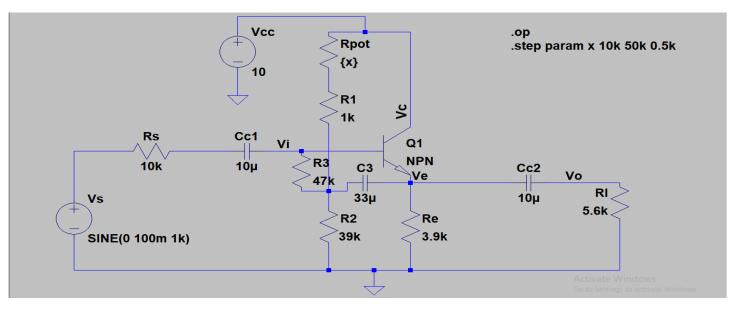
$$R_{out} = \frac{V_{out}}{I_{out}} = \frac{V(vo)}{I(Vs)} = \frac{0.000771949}{1.77288 \times 10^{-5}} = 43.54 \Omega$$

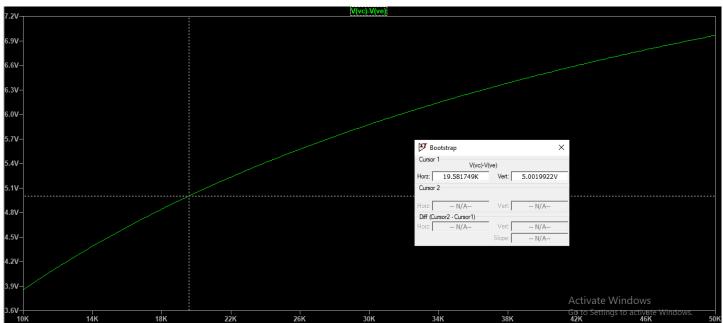
-179.838°

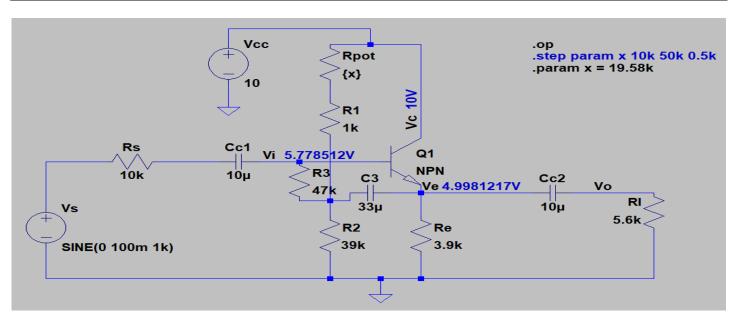
device current

# Bootstrap Configuration

# Finding the value of potentiometer resistance







DC analysis using .op gives Rpot =  $19.58 \text{ k}\Omega$  (total =  $20.58 \text{ k}\Omega$ ) for Vce = 5V.

# AC analysis to find voltage gain, Iin, Iout, Vin, Vout at f = 1kHz (.ac lin 1 1k 1k)

 $\underline{\text{Gain}} = V(\text{vo})/V(\text{vi}) = 0.0940859/0.0950528 = 0.9898 = -0.089 \text{ dB}$  $\underline{\text{Gain}} \text{ (Ai)} = \text{Ie}(Q1)/\text{Ib}(Q1) = 47.8894\text{uA}/0.474152\text{uA} = 101 = 40.1 \text{ dB}$ 

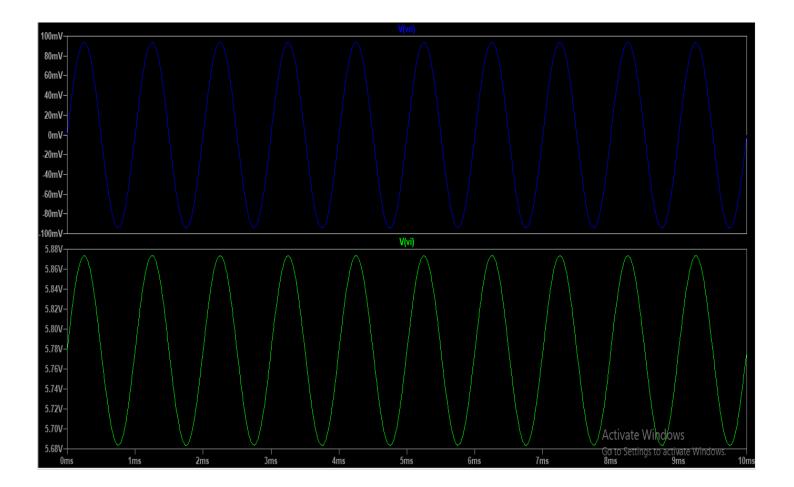
\* D:\BITS\BITS SEM 6\INSTR F341 (AnE)\Lab2\Bootstrap\Bootstrap.asc

--- AC Analysis --frequency: 1000 Ηz V(vc): 0 phase: voltage mag: V(vi): 0.0950528 phase: 0.00562132° mag: voltage 0.0940863 phase: 0.00500168° V(ve): mag: voltage V(n001): 0.0895146 phase: 0.0254538° voltage mag: V(n004):0.0940863 phase: 0.0254538° mag: voltage 0.0940859 phase: 0.167839° V(vo): mag: voltage V(n003): 0.0950528 phase: 0.000875256° voltage mag: V(n002): 0.1 phase: 0° voltage mag: mag: 4.74152e-005 phase: 0.0659414° Ic(Q1): device current mag: 4.74152e-007 phase: 0.0659414° Ib(Q1): device current Ie(Q1): mag: 4.78894e-005 phase: -179.934° device current mag: 6.96364e-006 phase: 0.0312136° device current I(C3): mag: 4.94716e-007 phase: 179.983° I(Cc1): device\_current mag: 1.68011e-005 phase: I(Cc2): -179.832° device current mag: 2.05761e-008 phase: device current -1.92423° I(R3): mag: 4.94716e-007 phase: I(Rs): 179.983° device current mag: 1.68011e-005 phase: -179.832° I(Rl): device current I(Re): mag: 2.41247e-005 phase: 0.00500168° device current I(R2): mag: 2.41247e-006 phase: 0.0254538° device current mag: 4.57174e-006 phase: -179.975° I(Rpot): device current mag: 4.57174e-006 phase: I(R1): -179.975° device current mag: 4.28435e-005 phase: I(Vcc): -179.93° device current mag: 4.94716e-007 phase: 179.983° I(Vs): device current

### Other parameters:

Vin = 0.0950528 V \$\neq\$ 0.00562132° Iin = 0.494716 μA \$\neq\$ 179.983° Vout = 0.0940859 V \$\neq\$ 0.167839° Iout = 16.8011 μA \$\neq\$ -179.832° ×

# Input and Output waveforms (.tran 10m)



# Input resistance (R<sub>in</sub>)

**DC** input resistance: infinite (as input capacitor blocks all dc voltage)

AC input resistance:

```
* D:\BITS\BITS SEM 6\INSTR F341 (AnE)\Lab2\Bootstrap\Bootstrap.asc
```

```
--- AC Analysis ---
              1000
frequency:
                            Ηz
                            0 phase:
V(vc):
              mag:
                                                         voltage
                    0.0950528 phase: 0.00562132°
V(vi):
              mag:
                                                         voltage
V(ve):
              mag:
                    0.0940863 phase: 0.00500168°
                                                         voltage
                    0.0895146 phase: 0.0254538°
V(n001):
              maq:
                                                         voltage
V(n004):
              mag:
                    0.0940863 phase:
                                      0.0254538°
                                                         voltage
                    0.0940859 phase:
                                       0.167839°
V(vo):
              mag:
                                                         voltage
V(n003):
              mag: 0.0950528 phase: 0.000875256°
                                                         voltage
                          0.1 phase:
                                              0°
V(n002):
                                                         voltage
              maq:
Ic(Q1):
              mag: 4.74152e-005 phase: 0.0659414°
                                                         device current
              mag: 4.74152e-007 phase:
Ib(Q1):
                                        0.0659414°
                                                         device current
Ie(Q1):
              mag: 4.78894e-005 phase:
                                        -179.934°
                                                         device current
              mag: 6.96364e-006 phase:
                                        0.0312136°
I(C3):
                                                         device_current
I(Cc1):
              mag: 4.94716e-007 phase:
                                        179.983°
                                                         device current
              mag: 1.68011e-005 phase:
                                         -179.832°
                                                         device current
I(Cc2):
I(R3):
              mag: 2.05761e-008 phase:
                                         -1.92423°
                                                         device current
              mag: 4.94716e-007 phase: 179.983°
I(Rs):
                                                         device current
I(Rl):
              mag: 1.68011e-005 phase: -179.832°
                                                         device current
              mag: 2.41247e-005 phase: 0.00500168°
I(Re):
                                                         device current
              mag: 2.41247e-006 phase: 0.0254538°
I(R2):
                                                         device current
              mag: 4.57174e-006 phase:
                                         -179.975°
                                                         device current
I(Rpot):
I(R1):
              mag: 4.57174e-006 phase:
                                         -179.975°
                                                         device current
              mag: 4.28435e-005 phase:
I(Vcc):
                                          -179.93°
                                                         device current
              mag: 4.94716e-007 phase:
I(Vs):
                                          179.983°
                                                         device current
```

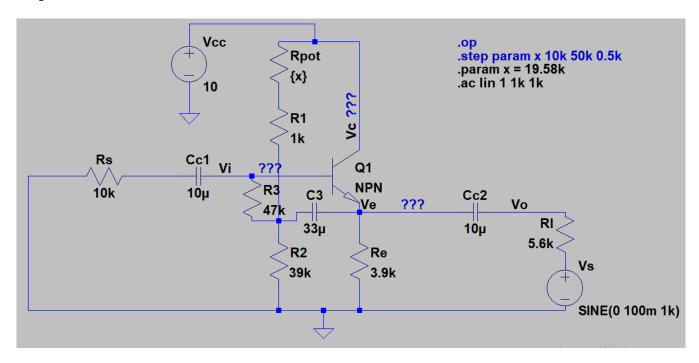
$$R_{in} = \frac{V_{in}}{I_{in}} = \frac{V(vi)}{I(Vs)} = \frac{0.0950528}{4.94716 \times 10^{-7}} = 192.136 \text{ k}\Omega$$

Х

## Output resistance (R<sub>out</sub>)

**DC** output resistance:  $5.6 \text{ k}\Omega$ 

### AC output resistance:



```
* D:\BITS\BITS SEM 6\INSTR F341 (AnE)\Lab2\Bootstrap\Bootstrap.asc
                                                                                ×
       --- AC Analysis ---
               1000
frequency:
                              Ηz
                              0 phase:
V(vc):
               mag:
                                                            voltage
V(vi):
               mag: 0.00173487 phase:
                                        0.0777356°
                                                            voltage
∇(ve):
               mag: 0.00207381 phase:
                                        0.0917466°
                                                            voltage
               mag: 0.00197304 phase:
V(n001):
                                          0.11322°
                                                            voltage
V(n003):
               mag: 0.00207381 phase:
                                          0.11322°
                                                            voltage
V(n004):
                                                            voltage
                           0.1 phase:
                                                O۰
               mag:
V(vo):
               mag: 0.00209274 phase:
                                         -7.55058°
                                                            voltage
V(n002):
               mag: 0.00173487 phase:
                                         0.168925°
                                                            voltage
                                           -179.837°
Ic(Q1):
               mag: 1.66276e-005 phase:
                                                            device current
               mag: 1.66276e-007 phase:
Ib(Q1):
                                           -179.837°
                                                            device current
               mag: 1.67938e-005 phase:
Ie(Q1):
                                           0.163463°
                                                            device current
               mag: 1.61154e-007 phase:
                                                            device_current
I(C3):
                                           0.121348°
               mag: 1.73487e-007 phase:
                                           0.168925°
I(Cc1):
                                                            device current
               mag: 1.74867e-005 phase:
                                                            device current
I(Cc2):
                                           0.160894°
I(R3):
               mag: 7.21147e-009 phase:
                                           -179.705°
                                                            device current
               mag: 1.73487e-007 phase:
I(Rs):
                                           0.168925°
                                                            device current
I(R1):
               mag: 1.74867e-005 phase:
                                           0.160894°
                                                            device current
I(Re):
               mag: 5.31746e-007 phase:
                                          0.0917466°
                                                            device current
I(R2):
               mag: 5.31746e-008 phase:
                                            0.11322°
                                                            device current
I(Rpot):
               mag: 1.00768e-007 phase:
                                           -179.887°
                                                            device_current
               mag: 1.00768e-007 phase:
I(R1):
                                           -179.887°
                                                            device_current
               mag: 1.67283e-005 phase:
                                                            device_current
I(Vcc):
                                           0.163161°
I(Vs):
               mag: 1.74867e-005 phase:
                                           -179.839°
                                                            device_current
```

$$R_{\text{out}} = \frac{V_{\text{out}}}{I_{\text{out}}} = \frac{V(\text{vo})}{I(\text{Vs})} = \frac{0.00209274}{1.74867 \times 10^{-5}} = 119.676 \ \Omega$$

## **Observations and Conclusions**

- 1. The common collector configuration approximately gives the same amplitude of output waveform as the input waveform, shifted by a DC offset. Hence, it is also called emitter follower and acts as level shifter.
- 2. The main advantage of Darlington pair over Common collector topology is that it gives a higher current gain because of cascading of two BJTs, which multiplies their h<sub>FE</sub> (or β-value).
- 3. Bootstrap configuration is used to get high input impedance as the input impedance of the other two configurations contribute to loading effects which can be seen in their waveforms (120 mV peak-to-peak). The Bootstrap configuration however has a much higher input resistance and gives nearly the same waveform as the source voltage (gives 190 mV peak-to-peak while source has 200 mV peak-to-peak).
- 4. The output resistance of all the three configurations is low which is a desired characteristic of an amplifier.
- 5. The purpose of all the three amplifiers is to shift the DC offset of input while keeping the amplitude same at input and output terminals.
- 6. The best amplifier for voltage level shift is the bootstrap configuration since the source voltage is least attenuated due to loading at BJT input.
- 7. The best amplifier for high current gain is Darlington configuration due to two cascaded BJTs.