

Common Emitter Configuration

Analog Electronics Lab Experiment -1

Submitted by : Jash Shah

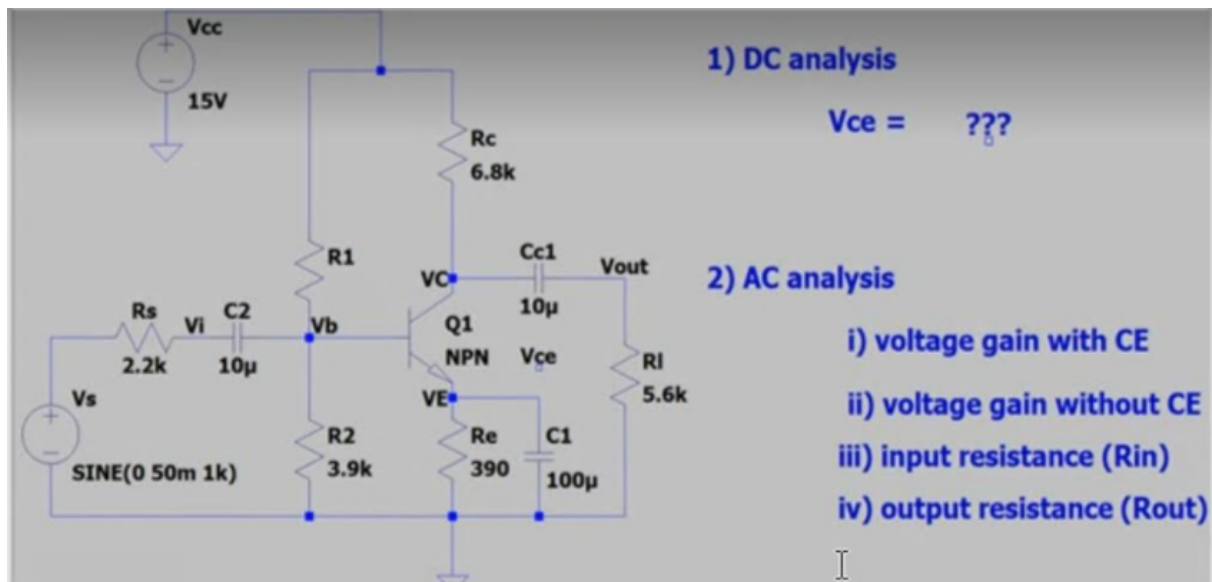
BITS Id : 2018A8PS0507P

Lab Section: P5

Submitted to : Sambhavi Shukla, Teena Gakhar

Date : 22/1/21

1. Objective



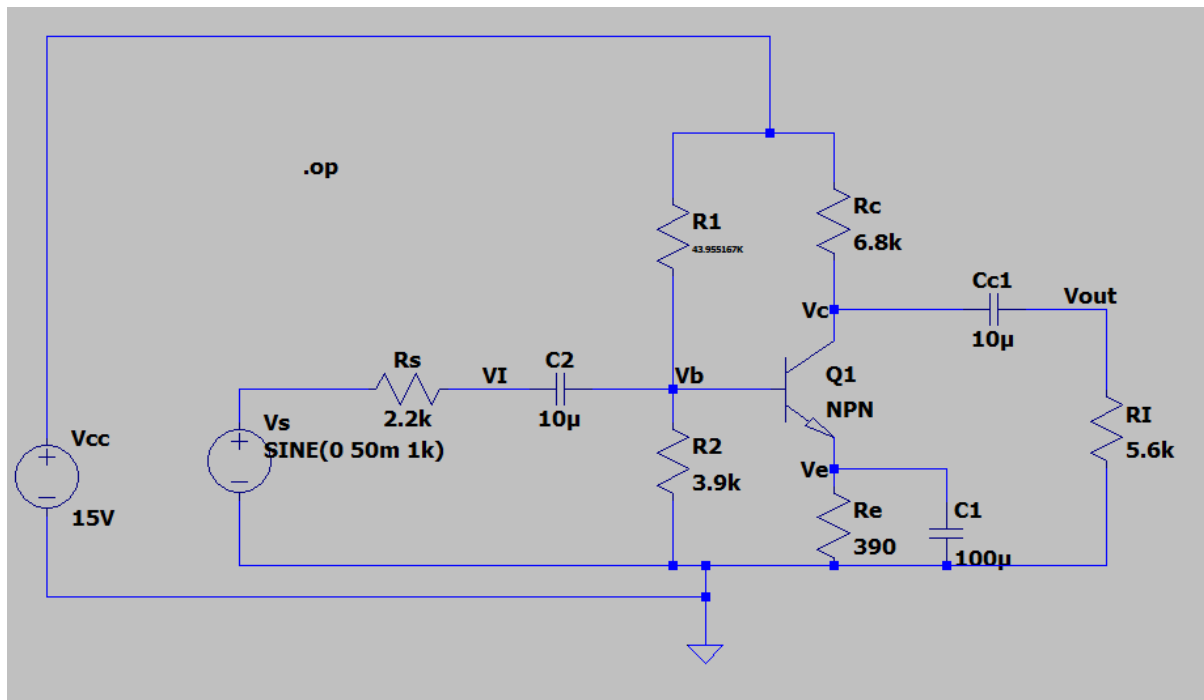
Design the provided circuit on LT-Spice and calculate the following parameters

- 1) Voltage Gain
 - a) With emitter capacitor
 - b) Without emitter capacitor
- 2) Input Resistance
- 3) Output Resistance
- 4) Show the waveforms for input and output voltages

Given Information - DC Operating point(Q-point) of transistor = 7.5V

Components provided – BJT, Capacitor, Resistor, Voltage Source AC and DC. wires

2. Schematic



The DC Operating Points are as follows

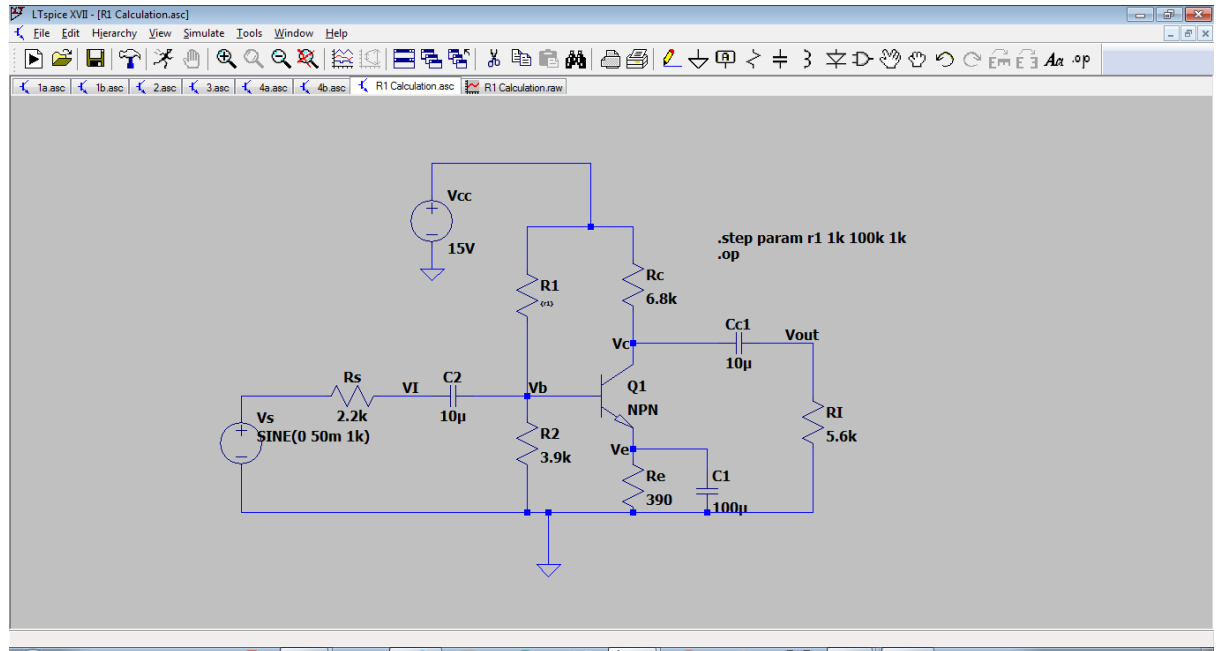
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--- Operating Point ---

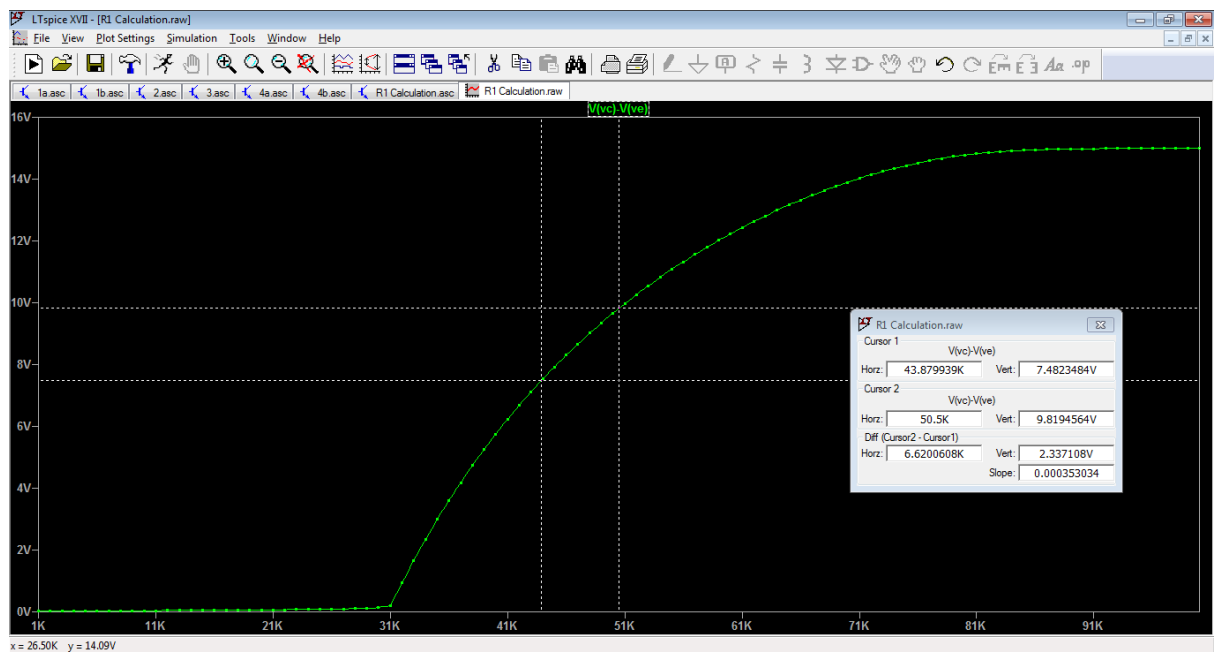
V(vc):          7.92378      voltage
V(vb):          1.18516      voltage
V(ve):          0.409901     voltage
V(vout):         4.43732e-13  voltage
V(n001):        15          voltage
V(vi):          2.60736e-14   voltage
V(n002):        0           voltage
Ic(Q1):         0.00104062    device_current
Ib(Q1):         1.04062e-05    device_current
Ie(Q1):        -0.00105103    device_current
I(C2):          1.18516e-17    device_current
I(C1):          4.09901e-17    device_current
I(Cc1):         7.92378e-17    device_current
I(R2):          0.000303888    device_current
I(Re):          0.00105103    device_current
I(R1):          0.000314294    device_current
I(Rs):          1.18516e-17    device_current
I(Rc):          0.00104062    device_current
I(Ri):          7.92378e-17    device_current
I(Vs):          1.18516e-17    device_current
I(Vcc):        -0.00135491    device_current
  
```

3. Procedure

Given that the Q-point is 7.5V, the first step was to find the value of unknown resistance R1. This was done by using .step param method for sweeping the values of R1 from 1k to 100k and selecting the value that corresponds to $V_c - V_e = 7.5V$



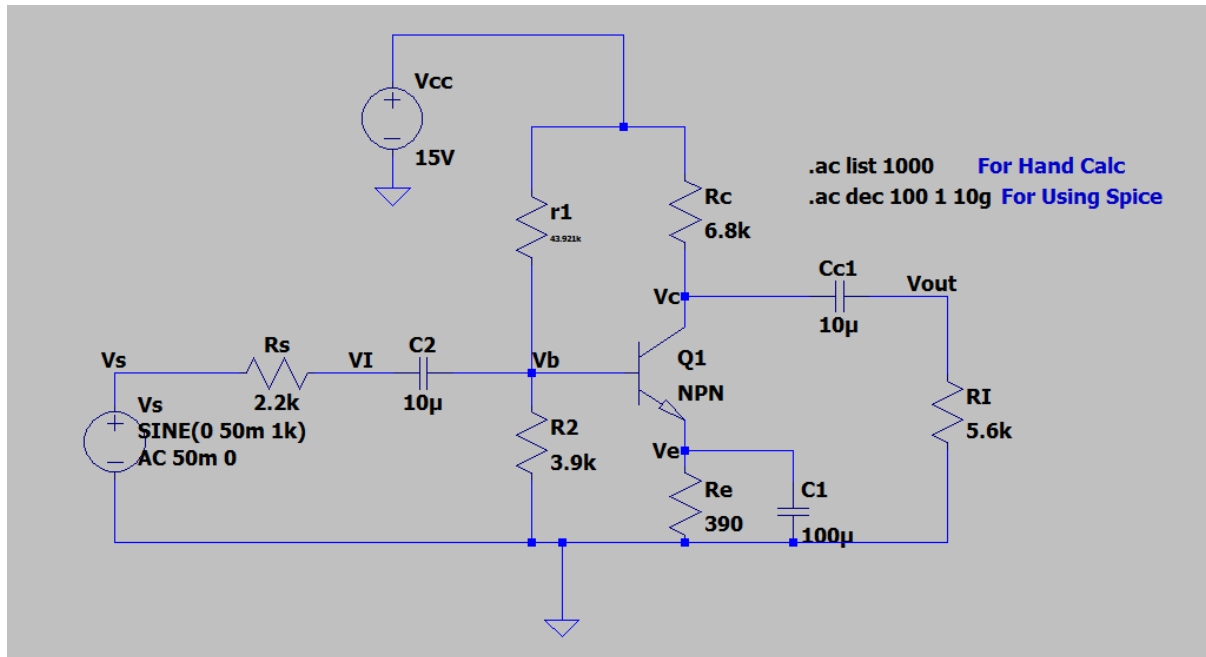
The resultant plot obtained was as follows.



The value of resistance thus found was 43.955167K ohms.

1. Voltage Gain

a. With Emitter Capacitor



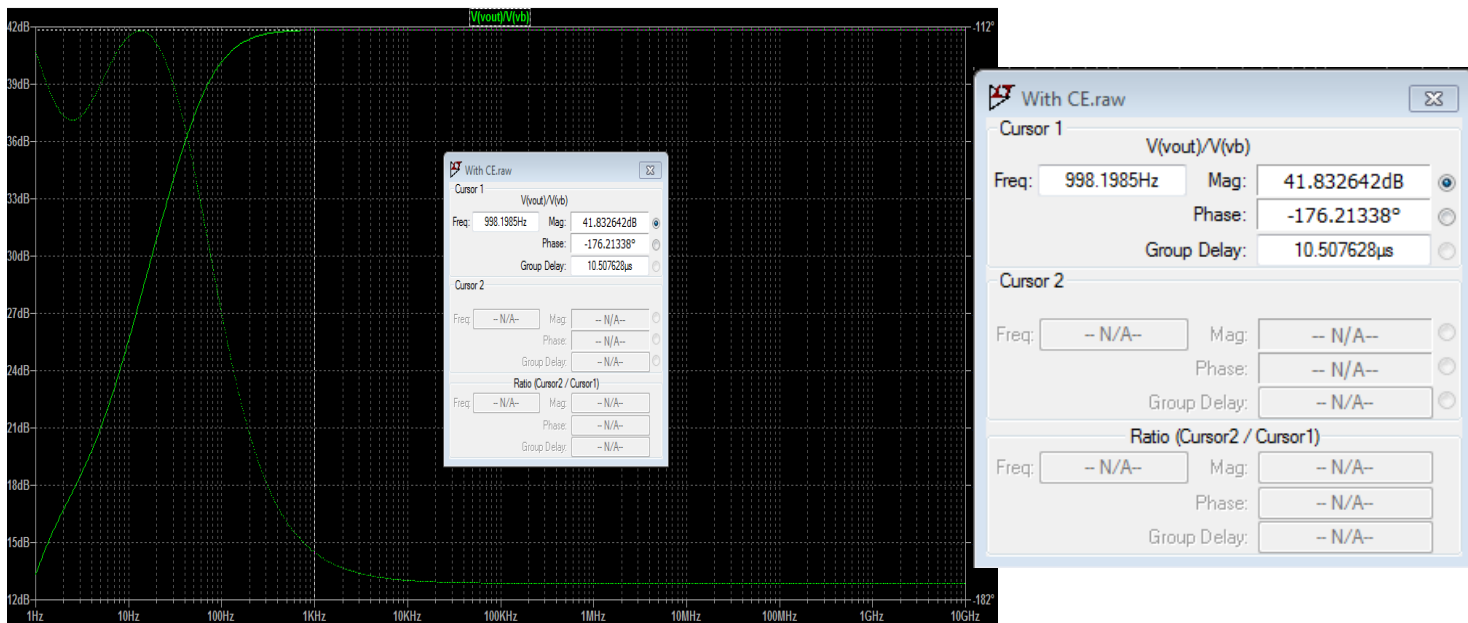
Using Hand calculations, I used the command .ac list 1k to perform AC analysis and got the following results

--- AC Analysis ---				
frequency:	1000	Hz		
V(vc):	mag: 2.47195	phase: -177.447°	voltage	
V(vb):	mag: 0.0200171	phase: -1.06334°	voltage	
V(ve):	mag: 0.0012939	phase: -87.1234°	voltage	
V(vout):	mag: 2.47194	phase: -177.284°	voltage	
V(n001):	mag: 0	phase: 0°	voltage	
V(vi):	mag: 0.0200266	phase: -1.68357°	voltage	
V(vs):	mag: 0.05	phase: 0°	voltage	
Ic(Q1):	mag: 0.000804938	phase: 2.64279°	device_current	
Ib(Q1):	mag: 8.04939e-06	phase: 2.64279°	device_current	
Ie(Q1):	mag: 0.000812988	phase: -177.357°	device_current	
I(C2):	mag: 1.36308e-05	phase: -178.876°	device_current	
I(C1):	mag: 0.000812981	phase: 2.87661°	device_current	
I(Cc1):	mag: 0.000441418	phase: -177.284°	device_current	
I(R2):	mag: 5.1326e-06	phase: -1.06334°	device_current	
I(Re):	mag: 3.31769e-06	phase: -87.1234°	device_current	
I(R1):	mag: 4.55753e-07	phase: 178.937°	device_current	
I(Rs):	mag: 1.36308e-05	phase: -178.876°	device_current	
I(Rc):	mag: 0.000363522	phase: 2.55349°	device_current	
I(Ri):	mag: 0.000441418	phase: -177.284°	device_current	
I(Vs):	mag: 1.36308e-05	phase: -178.876°	device_current	
I(Vcc):	mag: 0.000363067	phase: -177.442°	device_current	

From this, Gain (A_v) =
 $|V_{out}/V_b| = |2.4719/0.02| = 123.491$

Converting this to decibels,
 $20\log(123.4) = 41.83 \text{ dB}$

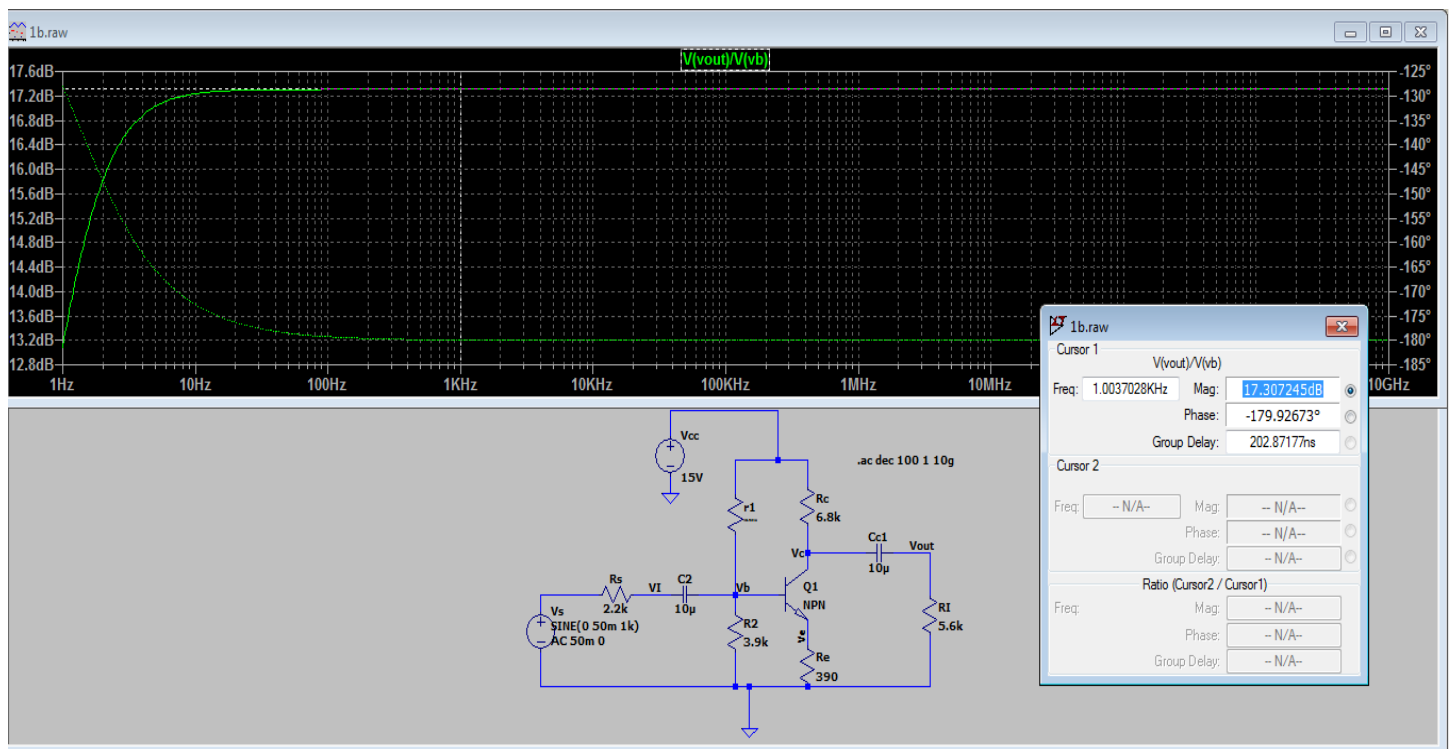
Performing the same experiment **using LTSpice**, I used .ac dec 100 1 10g to sweep the frequencies from 1Hz to 10 GHz.



Voltage gain obtained from the above plot = 41.83 dB

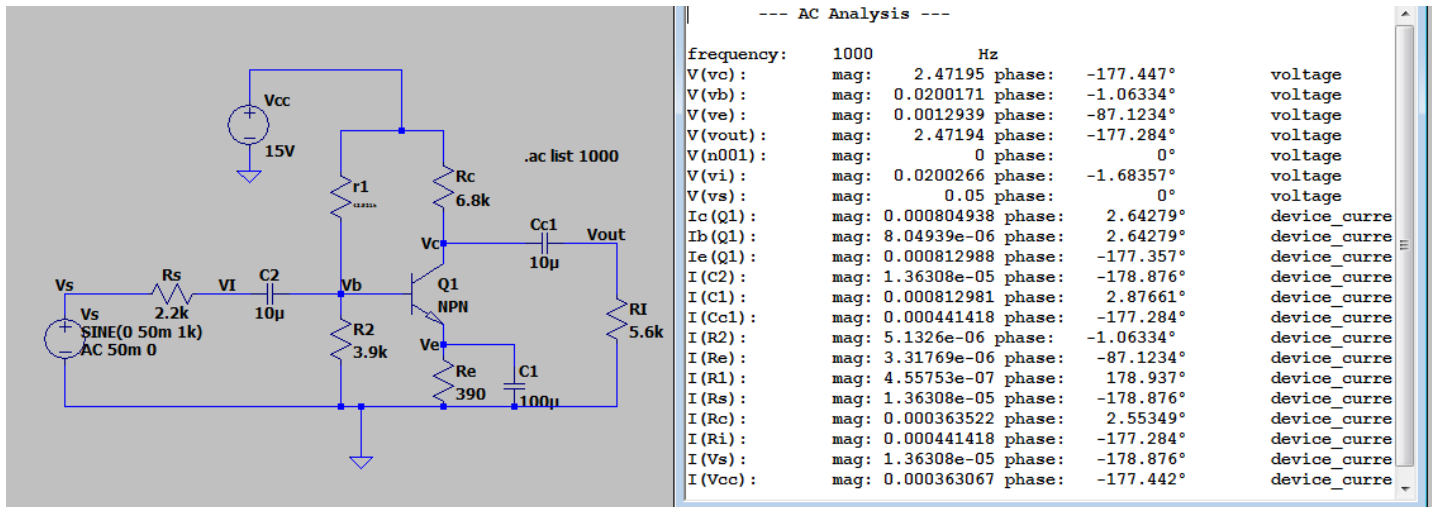
b. Without Emitter Capacitor

A similar procedure was followed with the following circuit



The gain obtained = 17.307 dB (Using Spice)
 17.29 dB (Using Hand Calculation)

2. Input Resistance

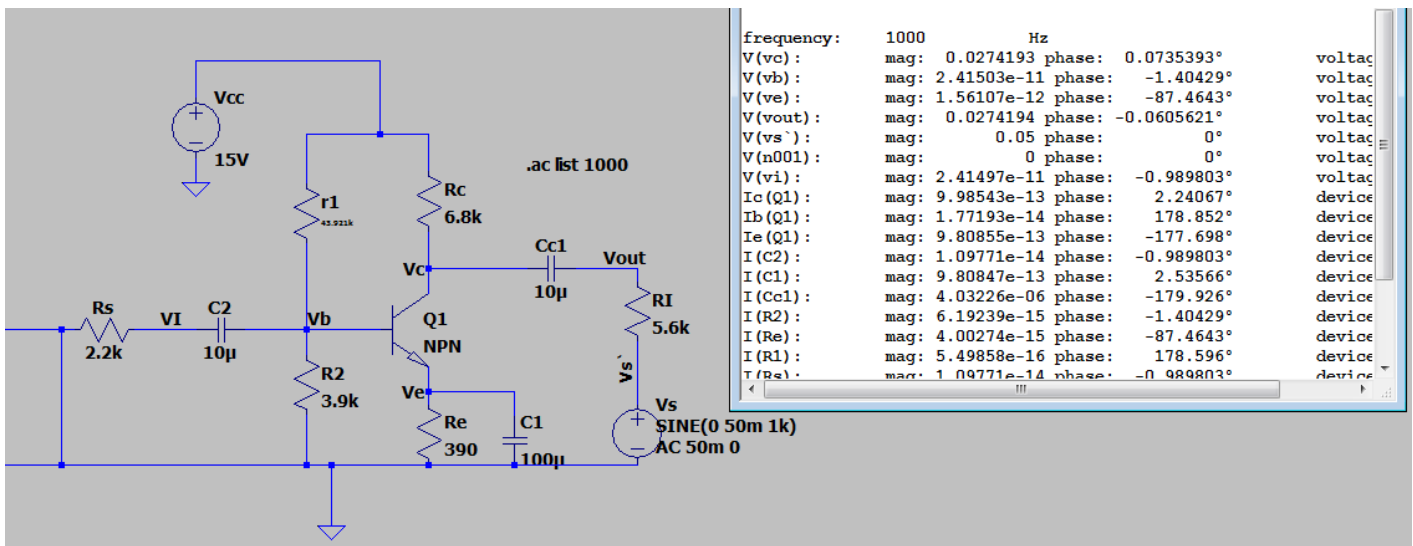


Using the results obtained, the Input resistance,

Calculation: $I(v_i) = V_s - V_i/R_s = 0.05 - 0.02/2.2k = 1.36e-005$ Amp

$R_{in} = V(v_i)/I(v_i) = 0.02/1.36e-005 = 1.467k$ ohms

3. Output Resistance



Calculation –

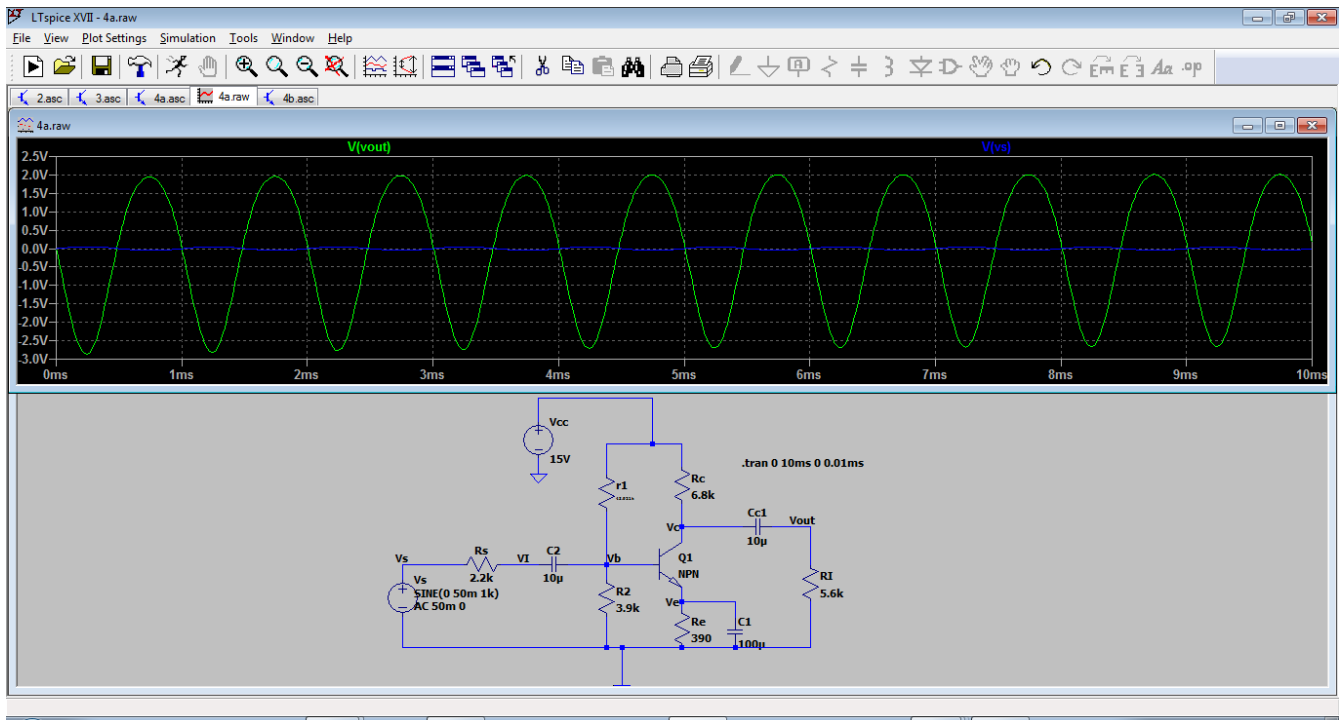
$I_{out} = (V(v_{s'}) - V(v_{out}))/R_L = (0.05 - 0.0274194)/5.6k = 4.032e-6$ Amp

$R_{out} = V(v_{out})/I_{out} = 0.0274/4.032e-6 = 6.795k$ ohms

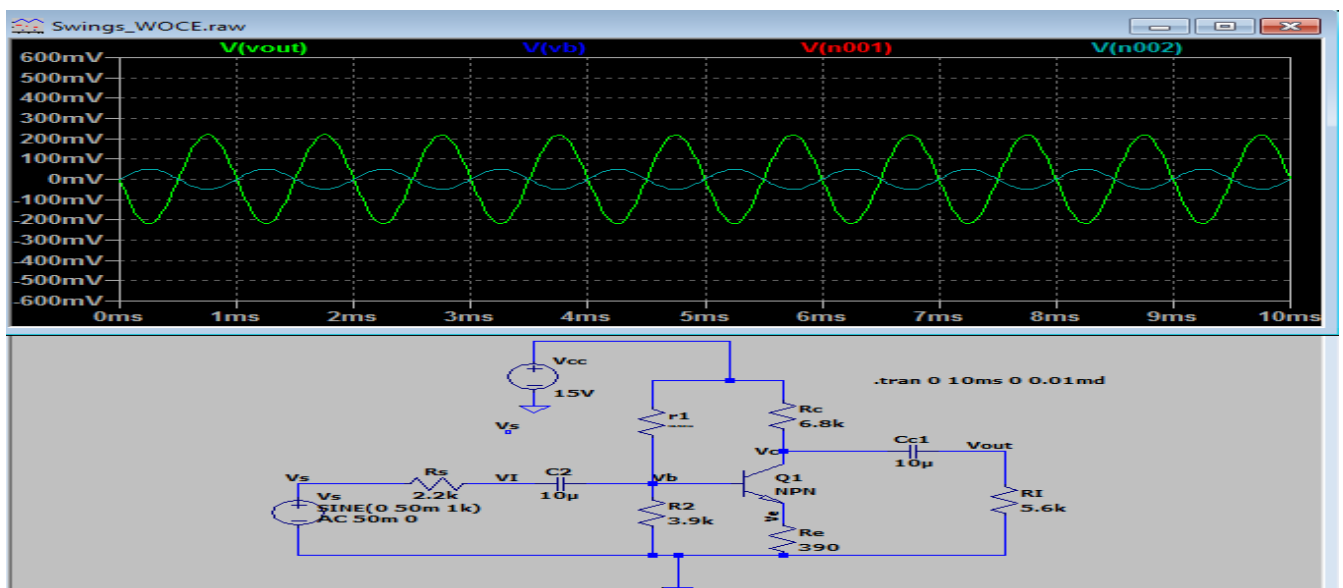
4. Input and Output Voltage Swings

For getting the swings, I used transient analysis by using
.tran 0 10ms 0 0.01ms command

With Capacitor



Without Capacitor



4. Results

- 1) There is phase reversal in amplification.
- 2) We obtained very high Voltage gains.
- 3) Voltage Gain increased with C_e (emitter capacitor).
- 4) All the parameters are summarized in the table below

Parameter	Value Obtained
Unknown Resistance	43.95k Ohms
Input Impedance	1.467k Ohms
Output Impedance	6.795k Ohms
Voltage gain (C_e present)	41.83 dB with 180 phase diff
Voltage gain (C_e absent)	17.3 dB with 180 phase diff

5. LTSpice Net lists

These are the netlists of the LTSpice models developed. Only the main files are present here. For example, the file for finding gain with C_e present has been attached below, but have not attached the equivalent file with C_e absent.

Complete set of files is available in the official lab drive folder maintained by Lab Instructors
<https://drive.google.com/file/d/1vwR0k77ZjiFtjd2cXuhUyrkCeGe10ePN/view?usp=sharing>

a. R_unkown calculation

```
Version 4
SHEET 1 880 680
WIRE 176 -192 -544 -192
WIRE 176 -96 176 -192
WIRE 176 -96 80 -96
WIRE 240 -96 176 -96
WIRE 240 -48 240 -96
WIRE 80 -32 80 -96
WIRE 240 80 240 32
WIRE 368 80 240 80
WIRE 496 80 432 80
WIRE 512 80 496 80
WIRE 240 112 240 80
WIRE -224 160 -352 160
WIRE -96 160 -144 160
```


WIRE -64 160 -96 160
WIRE 80 160 80 48
WIRE 80 160 0 160
WIRE 176 160 80 160
WIRE 512 160 512 80
WIRE -352 192 -352 160
WIRE 80 192 80 160
WIRE -544 208 -544 -192
WIRE 240 240 240 208
WIRE 352 240 240 240
WIRE 240 256 240 240
WIRE 352 272 352 240
WIRE -352 336 -352 272
WIRE 80 336 80 272
WIRE 80 336 -352 336
WIRE 112 336 80 336
WIRE 240 336 112 336
WIRE 352 336 240 336
WIRE 512 336 512 240
WIRE 512 336 352 336
WIRE -544 368 -544 288
WIRE 112 368 112 336
WIRE 112 368 -544 368
WIRE 112 416 112 368
FLAG 112 416 0
FLAG -96 160 VI
FLAG 240 240 Ve
FLAG 240 80 Vc
FLAG 80 160 Vb
FLAG 496 80 Vout
SYMBOL npn 176 112 R0
SYMATTR InstName Q1
SYMBOL cap 368 96 R270
WINDOW 0 32 32 VTop 2
WINDOW 3 0 32 VBottom 2
SYMATTR InstName Cc1
SYMATTR Value 10μ
SYMBOL res 496 144 R0
SYMATTR InstName RI
SYMATTR Value 5.6k
SYMBOL res 224 -64 R0
SYMATTR InstName Rc
SYMATTR Value 6.8k
SYMBOL cap 336 272 R0
SYMATTR InstName C1
SYMATTR Value 100μ
SYMBOL cap 0 144 R90
WINDOW 0 0 32 VBottom 2

```

WINDOW 3 32 32 VTop 2
SYMATTR InstName C2
SYMATTR Value 10μ
SYMBOL res -128 144 R90
WINDOW 0 0 56 VBottom 2
WINDOW 3 32 56 VTop 2
SYMATTR InstName Rs
SYMATTR Value 2.2k
SYMBOL voltage -544 192 R0
SYMATTR InstName Vcc
SYMATTR Value 15V
SYMBOL res 64 -48 R0
WINDOW 3 36 68 Left 0
SYMATTR InstName R1
SYMBOL res 224 240 R0
SYMATTR InstName Re
SYMATTR Value 390
SYMBOL res 64 176 R0
SYMATTR InstName R2
SYMATTR Value 3.9k
SYMBOL voltage -352 176 R0
WINDOW 3 24 44 Left 2
WINDOW 123 0 0 Left 0
WINDOW 39 0 0 Left 0
SYMATTR Value SINE(0 50m 1k)
SYMATTR InstName Vs
TEXT -288 -64 Left 2 !.op
TEXT -336 -40 Left 2 !.step param r 1k 100k 1k

```

b. Input and Output Swings

```

Version 4
SHEET 1 880 680
WIRE 176 -192 -64 -192
WIRE -64 -144 -64 -192
WIRE 176 -96 176 -192
WIRE 176 -96 80 -96
WIRE 240 -96 176 -96
WIRE 240 -48 240 -96
WIRE -64 -32 -64 -64
WIRE 80 -32 80 -96
WIRE 240 80 240 32
WIRE 368 80 240 80
WIRE 496 80 432 80
WIRE 512 80 496 80
WIRE 240 112 240 80
WIRE -224 160 -352 160
WIRE -96 160 -144 160

```

WIRE -64 160 -96 160
WIRE 80 160 80 48
WIRE 80 160 0 160
WIRE 176 160 80 160
WIRE 512 160 512 80
WIRE -352 192 -352 160
WIRE 80 192 80 160
WIRE 240 240 240 208
WIRE 352 240 240 240
WIRE 240 256 240 240
WIRE 352 272 352 240
WIRE -352 336 -352 272
WIRE 80 336 80 272
WIRE 80 336 -352 336
WIRE 112 336 80 336
WIRE 240 336 112 336
WIRE 352 336 240 336
WIRE 512 336 512 240
WIRE 512 336 352 336
WIRE 112 416 112 336
FLAG -64 -32 0
FLAG 112 416 0
FLAG -96 160 VI
FLAG 240 240 Ve
FLAG 240 80 Vc
FLAG 80 160 Vb
FLAG 496 80 Vout
FLAG -352 160 Vs
SYMBOL npn 176 112 R0
SYMATTR InstName Q1
SYMBOL cap 368 96 R270
WINDOW 0 32 32 VTop 2
WINDOW 3 0 32 VBottom 2
SYMATTR InstName Cc1
SYMATTR Value 10μ
SYMBOL res 496 144 R0
SYMATTR InstName RI
SYMATTR Value 5.6k
SYMBOL res 224 -64 R0
SYMATTR InstName Rc
SYMATTR Value 6.8k
SYMBOL cap 336 272 R0
SYMATTR InstName C1
SYMATTR Value 100μ
SYMBOL cap 0 144 R90
WINDOW 0 0 32 VBottom 2
WINDOW 3 32 32 VTop 2
SYMATTR InstName C2

```

SYMATTR Value 10μ
SYMBOL res -128 144 R90
WINDOW 0 0 56 VBottom 2
WINDOW 3 32 56 VTop 2
SYMATTR InstName Rs
SYMATTR Value 2.2k
SYMBOL voltage -64 -160 R0
SYMATTR InstName Vcc
SYMATTR Value 15V
SYMBOL res 64 -48 R0
WINDOW 3 36 68 Left 0
SYMATTR Value 43.921k
SYMATTR InstName r1
SYMBOL res 224 240 R0
SYMATTR InstName Re
SYMATTR Value 390
SYMBOL res 64 176 R0
SYMATTR InstName R2
SYMATTR Value 3.9k
SYMBOL voltage -352 176 R0
WINDOW 3 24 44 Left 2
WINDOW 123 24 72 Left 2
WINDOW 39 0 0 Left 0
SYMATTR Value SINE(0 50m 1k)
SYMATTR Value2 AC 50m 0
SYMATTR InstName Vs
TEXT 368 -56 Left 2 !.tran 0 10ms 0 0.01ms

```

c. Gain Calculation

```

Version 4
SHEET 1 880 680
WIRE 176 -192 -64 -192
WIRE -64 -144 -64 -192
WIRE 176 -96 176 -192
WIRE 176 -96 80 -96
WIRE 240 -96 176 -96
WIRE 240 -48 240 -96
WIRE -64 -32 -64 -64
WIRE 80 -32 80 -96
WIRE 240 80 240 32
WIRE 368 80 240 80
WIRE 496 80 432 80
WIRE 512 80 496 80
WIRE 240 112 240 80
WIRE -224 160 -352 160
WIRE -96 160 -144 160

```

```

WIRE -64 160 -96 160
WIRE 80 160 80 48
WIRE 80 160 0 160
WIRE 176 160 80 160
WIRE 512 160 512 80
WIRE -352 192 -352 160
WIRE 80 192 80 160
WIRE 240 240 240 208
WIRE 352 240 240 240
WIRE 240 256 240 240
WIRE 352 272 352 240
WIRE -352 336 -352 272
WIRE 80 336 80 272
WIRE 80 336 -352 336
WIRE 112 336 80 336
WIRE 240 336 112 336
WIRE 352 336 240 336
WIRE 512 336 512 240
WIRE 512 336 352 336
WIRE 112 416 112 336
FLAG -64 -32 0
FLAG 112 416 0
FLAG -96 160 VI
FLAG 240 240 Ve
FLAG 240 80 Vc
FLAG 80 160 Vb
FLAG 496 80 Vout
FLAG -352 160 Vs
SYMBOL npn 176 112 R0
SYMATTR InstName Q1
SYMBOL cap 368 96 R270
WINDOW 0 32 32 VTop 2
WINDOW 3 0 32 VBottom 2
SYMATTR InstName Cc1
SYMATTR Value 10µ
SYMBOL res 496 144 R0
SYMATTR InstName RI
SYMATTR Value 5.6k
SYMBOL res 224 -64 R0
SYMATTR InstName Rc
SYMATTR Value 6.8k
SYMBOL cap 336 272 R0
SYMATTR InstName C1
SYMATTR Value 100µ
SYMBOL cap 0 144 R90
WINDOW 0 0 32 VBottom 2
WINDOW 3 32 32 VTop 2
SYMATTR InstName C2

```

```

SYMATTR Value 10µ
SYMBOL res -128 144 R90
WINDOW 0 0 56 VBottom 2
WINDOW 3 32 56 VTop 2
SYMATTR InstName Rs
SYMATTR Value 2.2k
SYMBOL voltage -64 -160 R0
SYMATTR InstName Vcc
SYMATTR Value 15V
SYMBOL res 64 -48 R0
WINDOW 3 36 68 Left 0
SYMATTR Value 43.921k
SYMATTR InstName r1
SYMBOL res 224 240 R0
SYMATTR InstName Re
SYMATTR Value 390
SYMBOL res 64 176 R0
SYMATTR InstName R2
SYMATTR Value 3.9k
SYMBOL voltage -352 176 R0
WINDOW 3 24 44 Left 2
WINDOW 123 24 72 Left 2
WINDOW 39 0 0 Left 0
SYMATTR Value SINE(0 50m 1k)
SYMATTR Value2 AC 50m 0
SYMATTR InstName Vs
TEXT 368 -56 Left 2 !.ac list 1000
TEXT 544 -56 Left 2 ;For Hand Calc
TEXT 368 -24 Left 2 !.ac dec 100 1 10g
TEXT 568 -24 Left 2 ;For Using Spice

```

d. R_in Calculation

```

Version 4
SHEET 1 880 680
WIRE 176 -192 -64 -192
WIRE -64 -144 -64 -192
WIRE 176 -96 176 -192
WIRE 176 -96 80 -96
WIRE 240 -96 176 -96
WIRE 240 -48 240 -96
WIRE -64 -32 -64 -64
WIRE 80 -32 80 -96
WIRE 240 80 240 32
WIRE 368 80 240 80
WIRE 496 80 432 80
WIRE 512 80 496 80

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WIRE 240 112 240 80
WIRE -224 160 -352 160
WIRE -96 160 -144 160
WIRE -64 160 -96 160
WIRE 80 160 80 48
WIRE 80 160 0 160
WIRE 176 160 80 160
WIRE 512 160 512 80
WIRE -352 192 -352 160
WIRE 80 192 80 160
WIRE 240 240 240 208
WIRE 352 240 240 240
WIRE 240 256 240 240
WIRE 352 272 352 240
WIRE -352 336 -352 272
WIRE 80 336 80 272
WIRE 80 336 -352 336
WIRE 112 336 80 336
WIRE 240 336 112 336
WIRE 352 336 240 336
WIRE 512 336 512 240
WIRE 512 336 352 336
WIRE 112 416 112 336
FLAG -64 -32 0
FLAG 112 416 0
FLAG -96 160 VI
FLAG 240 240 Ve
FLAG 240 80 Vc
FLAG 80 160 Vb
FLAG 496 80 Vout
FLAG -352 160 Vs
SYMBOL npn 176 112 R0
SYMATTR InstName Q1
SYMBOL cap 368 96 R270
WINDOW 0 32 32 VTop 2
WINDOW 3 0 32 VBottom 2
SYMATTR InstName Cc1
SYMATTR Value 10µ
SYMBOL res 496 144 R0
SYMATTR InstName RI
SYMATTR Value 5.6k
SYMBOL res 224 -64 R0
SYMATTR InstName Rc
SYMATTR Value 6.8k
SYMBOL cap 336 272 R0
SYMATTR InstName C1
SYMATTR Value 100µ
SYMBOL cap 0 144 R90

```

WINDOW 0 0 32 VBottom 2
WINDOW 3 32 32 VTop 2
SYMATTR InstName C2
SYMATTR Value 10µ
SYMBOL res -128 144 R90
WINDOW 0 0 56 VBottom 2
WINDOW 3 32 56 VTop 2
SYMATTR InstName Rs
SYMATTR Value 2.2k
SYMBOL voltage -64 -160 R0
SYMATTR InstName Vcc
SYMATTR Value 15V
SYMBOL res 64 -48 R0
WINDOW 3 36 68 Left 0
SYMATTR Value 43.921k
SYMATTR InstName r1
SYMBOL res 224 240 R0
SYMATTR InstName Re
SYMATTR Value 390
SYMBOL res 64 176 R0
SYMATTR InstName R2
SYMATTR Value 3.9k
SYMBOL voltage -352 176 R0
WINDOW 3 24 44 Left 2
WINDOW 123 24 72 Left 2
WINDOW 39 0 0 Left 0
SYMATTR Value SINE(0 50m 1k)
SYMATTR Value2 AC 50m 0
SYMATTR InstName Vs
TEXT 368 -56 Left 2 !.ac list 1000