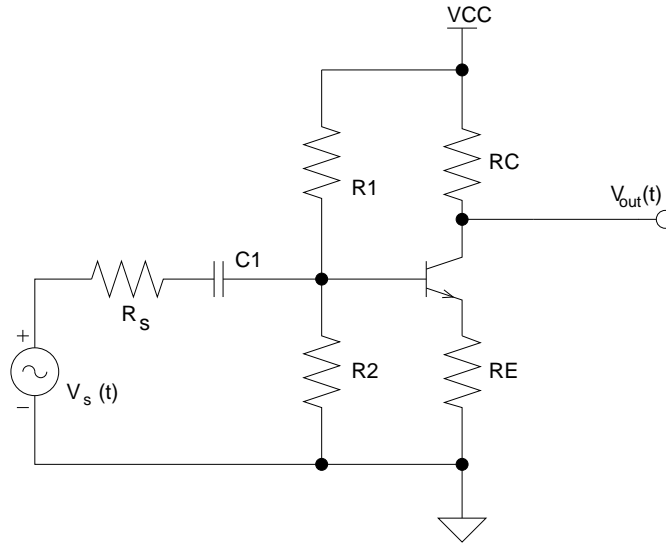


Physics 536 - Assignment #7 - Due March 28th

With a new, improved, model for the 2N3904 transistor!

1. Consider the following common emitter amplifier circuit:



- (a) If $V_{CC} = 10$ V, determine values for the components R_1 , R_2 , R_C and R_E that will result in a small signal voltage gain of $A = -5$, an output impedance of 1 k Ω and an input impedance of 10 k Ω . Assume $\beta = 100$, $V_{be} = 0.7$ V and choose a quiescent point such that $V_c = 5$ V.
- (b) If the impedance of the voltage source is $R_s = 10$ k Ω , what value of C_1 would result in a -3 db low-frequency cut-off of 1 kHz?

2. A 2N3904 NPN transistor can be modelled in SPICE using

```
.MODEL 2N3904 NPN(IS=4.639E-15 NF=0.9995 ISE=2.091E-14 NE=1.6 BF=160.1 IKF=0.12
+          VAF=98.69 NR=1.001 ISC=3.257E-12 NC=1.394 BR=5.944 IKR=0.06
+          VAR=19.29 RB=1 IRB=1E-6 RBM=1 RE=0.3614 RC=1.755 XTB=0
+          EG=1.11 XTI=3 CJE=5.631E-12 VJE=0.7002 MJE=0.3385
+          TF=3.001E-10 XTF=27 VTF=1.461 ITF=0.2723 PTF=0 CJC=4.949E-12
+          VJC=0.5969 MJC=0.1928 XCJC=0.864 TR=9.4E-8 CJS=0 VJS=0.75
+          MJS=0.333 FC=0.5582)
```

and

```
Q1 <C> <B> <E> 2N3904
```

where <C>, and <E> are the collector, base and emitter nodes, respectively.

(a) Design a current sink using a single 2N3904 transistor that will sink 5 mA of current, assuming that voltage sources of $V_{CC} = +10$ V and $V_{EE} = -10$ V are available. Design it such that the voltage at the emitter is -8 V and use a resistor divider to provide the voltage at the base with a Thevanin equivalent resistance of 5 k Ω . Assume that $\beta \approx 100$ and $V_{be} \approx 0.7$ V.

(b) Simulate the circuit by performing an operating point analysis and adjust the component values from the ones estimated in part (a) to achieve the desired current. Hand in the netlist and the output of the operating point analysis.