Cascode Amplifier Design:

This sheet describes a Cascode Amplifier with calculation and graphs. The Cascode amplifier is typical used in circuit there need a high gain, its can be a high frequency amplifier or a audio amplifier.

Requirement:
Task 1:
Design a Cascode amplifier stage using bipolar transistors to drive a load resistance of 100 Ω. The amplifier output is to be a time varying signal of +/-600mV. The overall performance of the amplifier is specified as:

- Operation Current for collectors in transistor T1 and T2 are set to 1.2mA
- Overall gain -30 v/v (29,54dB)
- VCC 15V DC
- Input signal 20mVolt pike
- Load resistor of 100 Ω

Task 2:
Modify the Cascode amplifier to a Tuned Amplifier, with a frequency of 470 KHz and a Band width of 20 KHz.

Description of Cascode:

The basic Cascode amplifier consists of a Common-Emitter (CE) configuration, with a extra transistor connected between collector on transistor 1 and collector resistor (RC) and there are insert a extra resistor in the basis network. See the diagram in figure 1.

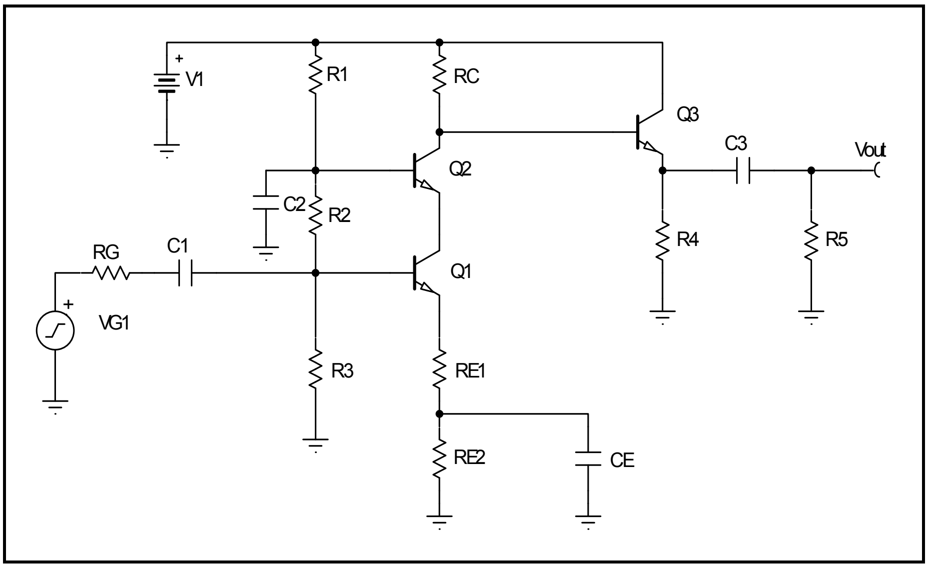

Figure 1 – Diagram over Cascode amplifier.

Calculation of the resistor value with DC:

The are Choose value for U_{RC} = 7.5V, U_{RE} = 1V
Transistor Data for a BC549B: HFE = 486;

Calculation of R_C:

$$R_C = \frac{U_{RC}}{I_C} \Rightarrow \frac{7.5V}{1.2mA} = 6.25K\Omega \approx \underline{\underline{6.2K\Omega_{E24}}}$$

Calculation of R_E:

$$R_E = \frac{U_{RE}}{I_C} = \frac{1V}{1.2mA} = 833.3\Omega \approx \underline{\underline{820\Omega_{E12}}}$$

Calculation of voltage Basis on Q1:

$$U_{Q1_B} = U_{RE} + U_{Q1_{BE}} = 1V + 0.7V = \underline{\underline{1.7Volt}}$$

Calculation of I_{Q1B}:

$$I_B = \frac{I_C}{HFE} \Rightarrow \frac{1.2mA}{486} = \underline{2.469\mu A}$$

Calculation of on current plus 10% an I_B:

$$I_{B\_on} = \frac{IB \cdot 100}{10} \Rightarrow \frac{2.469\mu A \cdot 100}{10} = \underline{24.69\mu A}$$

Calculation of R3, R2 & R1 for basis current and voltage:

$$R_3 = \frac{U_{R1}}{I_{B\_on}} \Rightarrow \frac{1.7V}{24.69\mu A} = 68.85K\Omega \approx \underline{\underline{68K\Omega_{E12}}}$$

$$R_2 = \frac{U_{R2}}{I_{B\_on}} \Rightarrow \frac{((VCC - U_{RC}) + U_{BE}) - U_{Q_{1B}}}{I_{B\_on}} \Rightarrow \frac{((15V - 7.5V) + 0.7V) - 1.7V}{24.69\mu A} = 264K\Omega \approx \underline{\underline{222K\Omega_{E12}}}$$

$$R_1 = \frac{U_{R1}}{I_{B\_on}} \Rightarrow \frac{VCC - (VCC - U_{RC}) + U_{BE})}{I_{B\_on}} \Rightarrow \frac{15V - ((15V - 7.5V) + 0.7V)}{24.69\mu A} = 275K\Omega \approx \underline{\underline{270K\Omega_{E12}}}$$

Circuit with ideal component value:

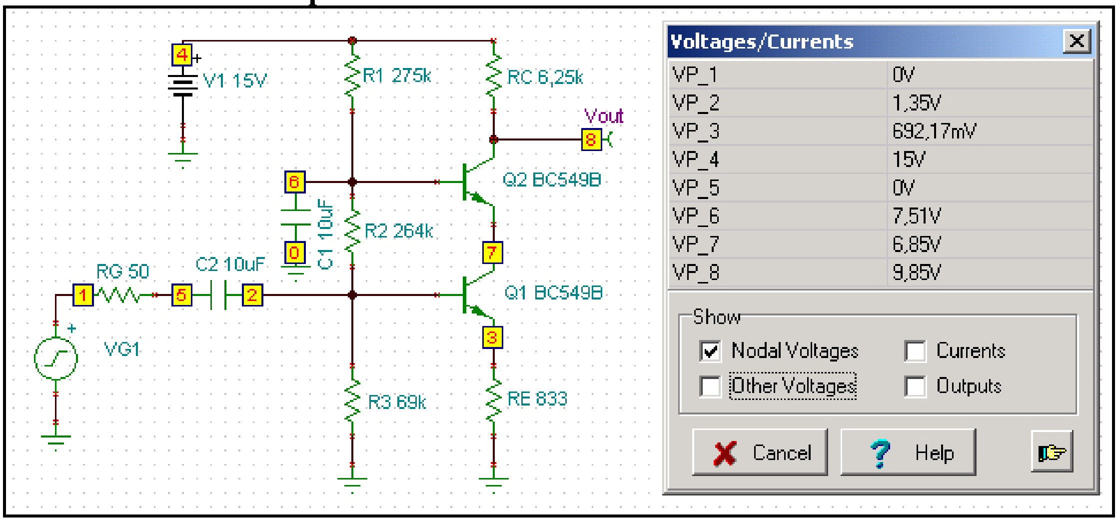

Figure 2 – Measurement a DC voltage in Tina

Calculation of AC condition:

Calculation on re:

$$re = \frac{1}{40 \cdot IE} \Rightarrow \frac{1}{40 \cdot 1.2mA} = \underline{\underline{20.83\Omega}}$$

Calculation on R_{E1} and R_{E2}:

$$R_{E1} = \frac{R_C}{A_V} - re \Rightarrow \frac{6.25K\Omega}{30} - 20.83\Omega = \underline{\underline{187.5\Omega}}$$

$$R_{E2} = R_E - R_{E1} \Rightarrow 833\Omega - 187.5\Omega = \underline{\underline{645.5K\Omega}}$$

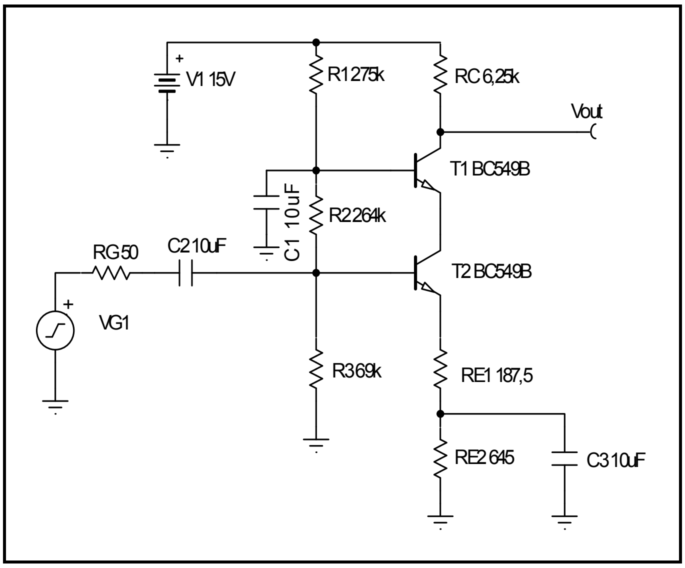

Figure 3 – Diagram with AC condition:

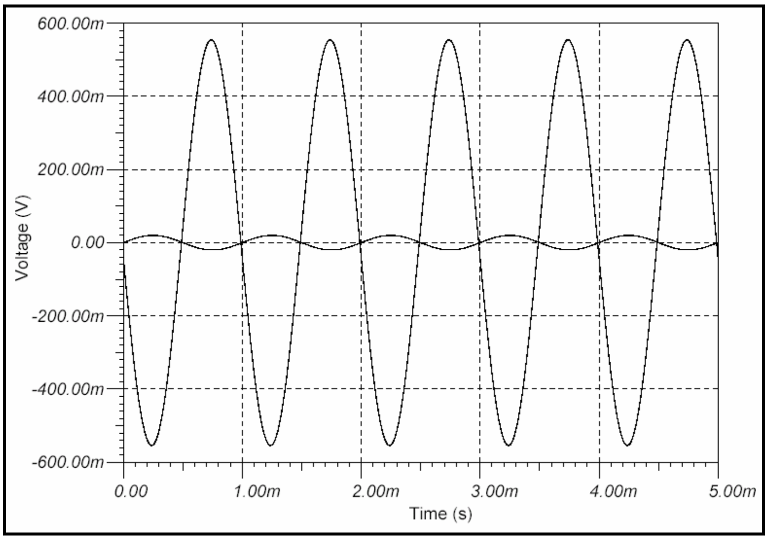

Figure 4 – Oscilloscope picture of gain for the circuit.

The gain is measurement to 554mVpp, but this circuit have no load and then well pull the signal to a lower one, so this gain is okay. Before the buffer circuit is added.

Calculation on Buffer circuit:

Calculation of the buffer circuit, with a load resistor on 100 Ω:

R4 is choose to 100KΩ

$$R_C' = \frac{U_{RC}}{I_C} \Rightarrow \frac{7.5V}{1.2mA} = 6.25K\Omega$$

$$new\_R_C = \frac{R_C' \cdot R_4}{R_4 - R_C'} \Rightarrow \frac{6.25K\Omega \cdot 100K\Omega}{100K\Omega - 6.25K\Omega} = \underline{\underline{6.667K\Omega}}$$

Control calculation:

$$R_C' = R_4 \,//\, new\_R_C \Rightarrow 100K\Omega \,//\, 6.667K\Omega = \underline{\underline{6.25K\Omega}}$$

Calculation of RL'

$$R_L' = R_C' \,//\, R_L \Rightarrow 5.25K\Omega \,//\, 100\Omega = \underline{98.4\Omega}$$

$$new\_R_{E1} = \frac{R_L'}{A_V} - re \Rightarrow \frac{98\Omega}{30} - 20.83\Omega = \underline{\underline{17.55\Omega}}$$

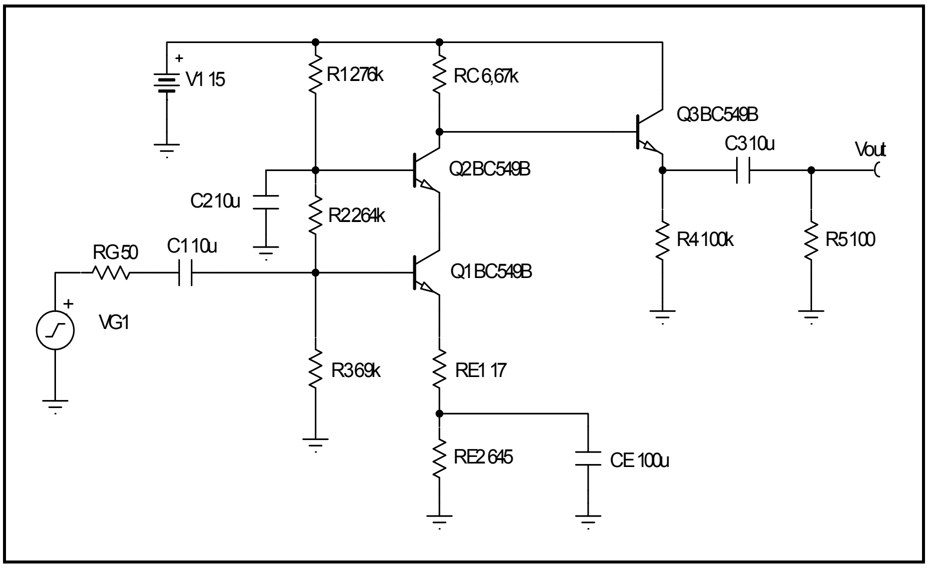

Figure 5 – Cascode amplifier with buffer.

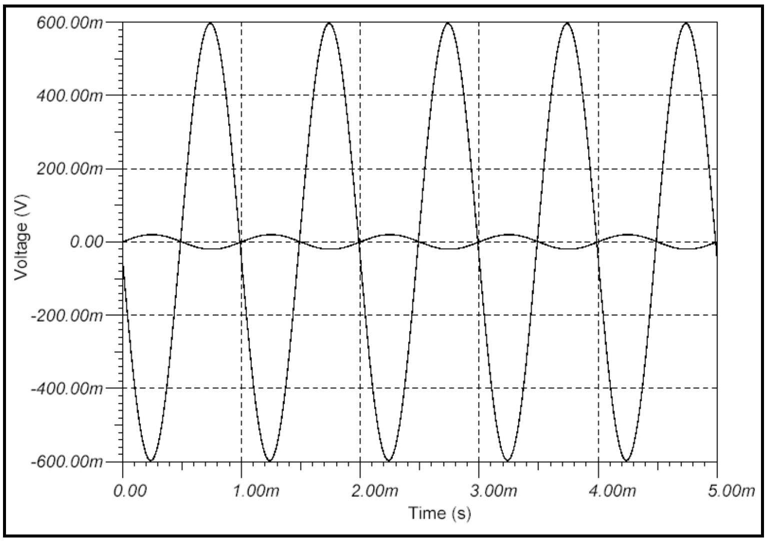

Figure 6 – Gain for the Cascode Amplifier with buffer circuit:

The gain is showed on figure 6, and this elucidate at the gain is 600mVpp.

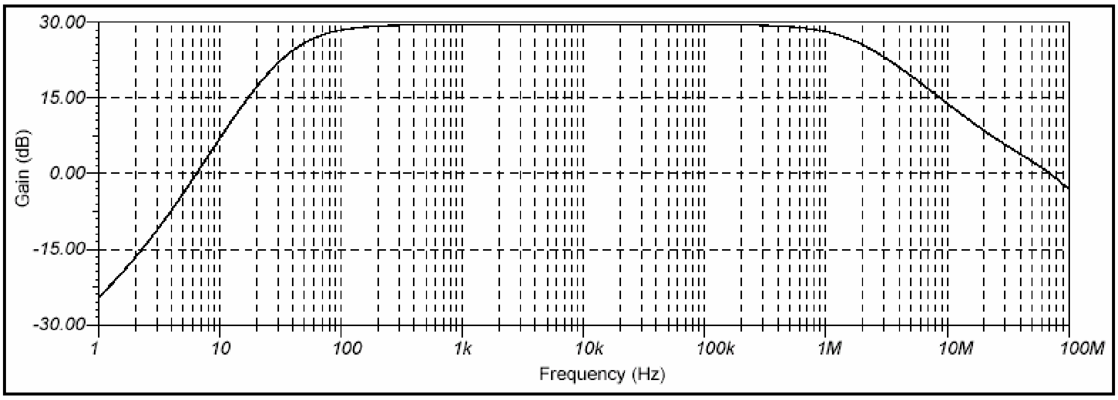

Figure 7 - Frequency characterize for the Cascode circuit.

Calculation on Tuned Amplifier:

The are used the same circuit for the Tuned Amplifier, the are just change a resistor R_C to a coil L_1 and a capacitor C_5 call a oscillatory circuit.

L is chosen to 1mH:

Calculation of Q:

$$Q = \frac{\omega L}{R_S} \Rightarrow \frac{f_C}{BW} \Rightarrow \frac{470KHz}{20KHz} = \underline{\underline{23.5}}$$

$$R_S = \frac{2\pi \cdot f \cdot L}{Q} \Rightarrow \frac{2\pi \cdot 470KHz \cdot 1mH}{23.5} = \underline{\underline{125.7\Omega}}$$

$$R_P = R_S \cdot (1 + QL^2) \Rightarrow 125.7\Omega \cdot (1 + 23.5^2) = 69.5K\Omega$$

$$C = \frac{Q}{2\pi \cdot f_C \cdot R_P} \Rightarrow \frac{23.5}{2\pi \cdot 470KHz \cdot 69.5K\Omega} = 114.5pF \approx \underline{\underline{100pF_{E6}}}$$

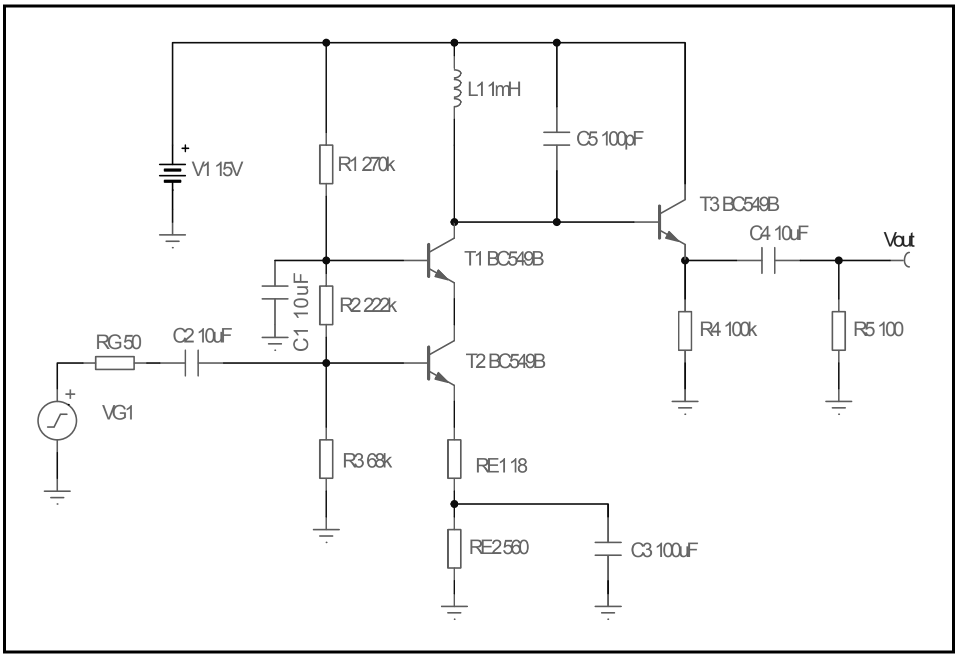

Figure 8 – Diagram for Tuned Amplifier:

This circuit is the same as Cascode amplifier, but they are adding an oscillatory. To make a frequency on 470 KHz, with a bandwidth on 20 KHz. See the graph on next page for this circuit.

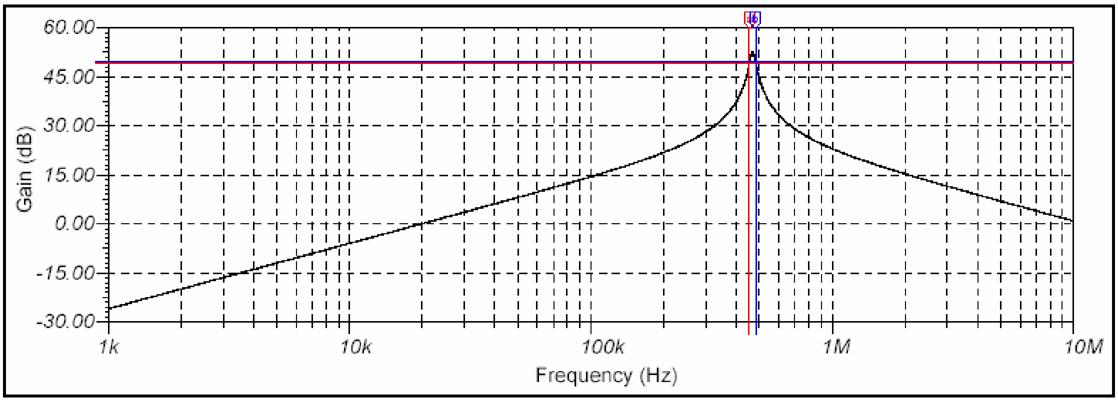

Figure 9 - Frequency characterize for the Tuned circuit.

This graph view the frequency characterize for the Tuned amplifier, with a bandwidth on 20 KHz and a frequency on 467.5 KHz, because the component is chosen to non ideal components from the E12 series.