# CARLETON UNIVERSITY

Final
**EXAMINATION**
Dec 11, 1998

**DURATION:** 3 **HOURS** No. of Students: 70

Department Name & Course Number: Electronics, 97.455
Course Instructor(s) C. Plett

**AUTHORIZED MEMORANDA**
Calculators Only. Page 5 is a formula sheet.

Students **MUST** count the number of pages in this examination question paper **before** beginning to write, and report any discrepancy immediately to a proctor. This question paper has 5 pages.

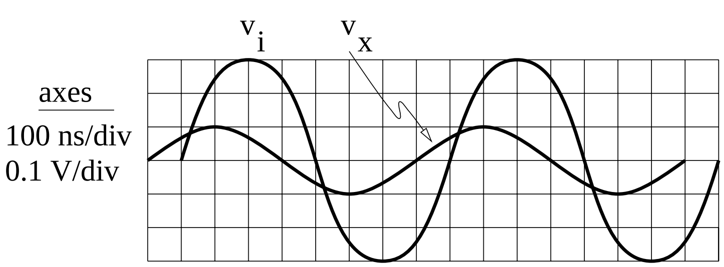
This examination question paper may be taken from the examination room.

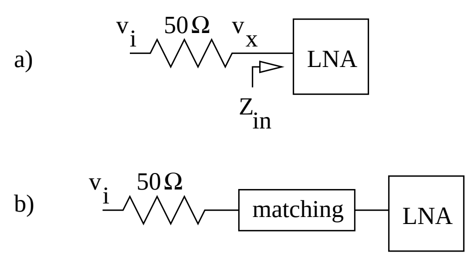
## 1. Tuned Amplifiers [20 marks total]

The following waveforms represent an oscilloscope trace of the voltage across a 50Ω test resistor placed at the input of an LNA.

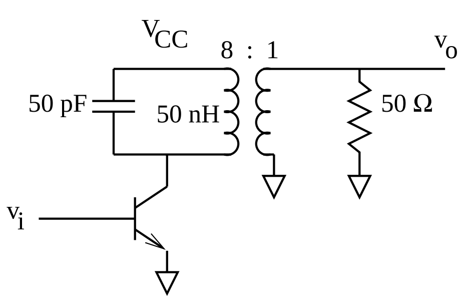
a) Calculate the input impedance $Z_{in}$ of the LNA.

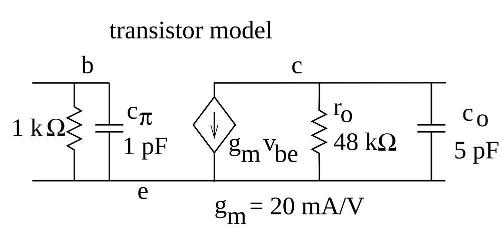
b) Calculate the components for input impedance matching to be placed between the LNA and the 50Ω resistor. Use L and C, no transformers.




c) For the following simple tuned amplifier with a transformer coupled output, calculate the gain $v_o/v_i$, the centre frequency and the bandwidth. Assume the transistor has a model as shown and the secondary inductance of the transformer may be ignored.

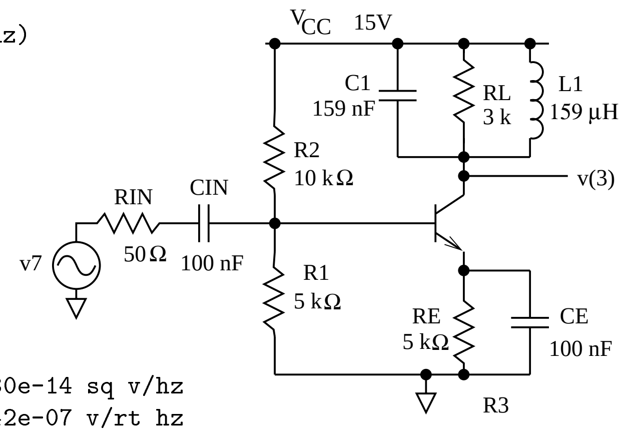


## 2. Noise Figure [5 marks total]

The following SPICE output file shows noise components for a tuned amplifier. Calculate the noise figure in dB at 1 Mhz.

```
****** H S P I C E --  95.2 (950213)   10:01:58  97/09/19    sun4 ******
tuned amplifier as a spice example * with comments *
 ******  noise analysis                tnom=  25.000 temp=  25.000 ******

    frequency = 1.000e+06  hz

**** resistor squared noise voltages (sq v/hz)

element    0:RL        0:R1        0:R2        0:RE        0:RIN
   total 4.709e-17   7.623e-17   3.811e-17   7.952e-20   7.615e-15
      rx 2.929e+03   4.811e+03   4.811e+03   1.554e+02   4.808e+03

**** transistor squared noise voltages (sq v/hz)

element    0:q1
      rb 1.050e-14
      rc 7.401e-24
      re 4.033e-17
      ib 1.583e-16
      ic 2.323e-15
      fn   0.
   total 1.302e-14

**** total output noise voltage          = 2.080e-14 sq v/hz
                                         = 1.442e-07 v/rt hz
     transfer function value:
       v(3)/v7                           = 9.617e+01
     equivalent input noise at v7        = 1.499e-09 /rt hz
```

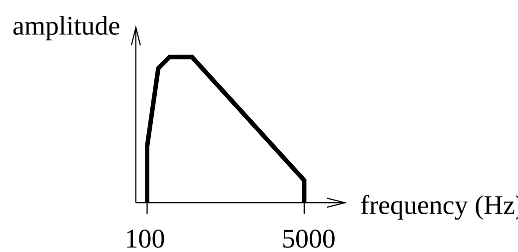



## 3. Up-Conversion Mixer [5 marks total]

My voice has the spectrum as shown. It is being modulated up to 1 GHz. Sketch the amplitude spectrum around 1 GHz for the following modulation types.

a) AM
b) DSBSC
c) narrowband FM
d) SSB.

Which one(s) have the narrowest bandwidth?




## 4. FM Demodulators [4 marks total]

List two ways to demodulate FM showing block diagrams where appropriate.

## 5. <u>Receiver Design</u> [20 marks]

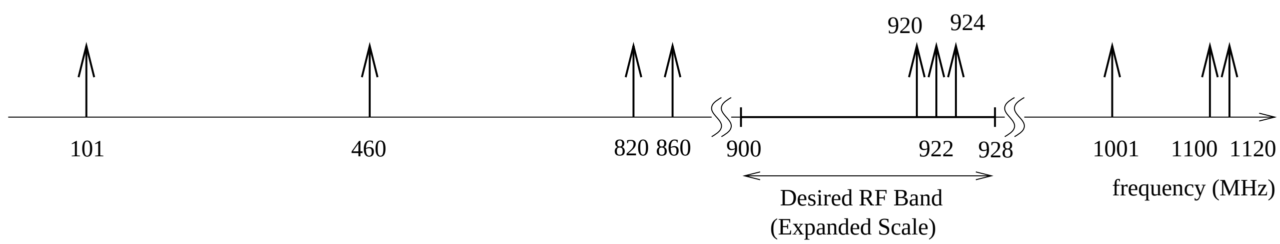
A communication receiver is required for which the RF channels are between 902 and 928 MHz with a channel spacing of 2 MHz (and a bandwidth each of 2 MHz). The IF is at 100 MHz. Assume for this problem that you are trying to receive the channel at 920 Mhz.

a) Sketch a block diagram of the communication receiver from antenna to IF showing frequencies at each stage and approximate bandwidths of the filter(s). If two possible local oscillator frequencies are found, use the highest one.

b) The following input spectrum, is received at the antenna. Identify the wanted and unwanted components, including adjacent channels and image frequencies.

c) Identify where and how in your receiver, adjacent channels and image frequencies are removed.

d) If part of the receiver is nonlinear, additional components can appear due to harmonic distortion and intermodulation. In the following spectrum, which input components are of most concern for nonlinearity, and how does one combat this problem?




## 6. <u>Colpitts Oscillator</u> [10 marks]

For the Colpitts oscillator circuit shown:

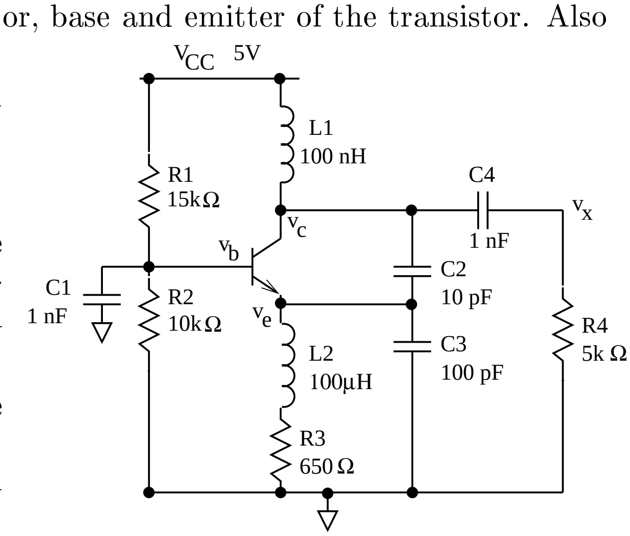
a) Determine the DC voltages on the collector, base and emitter of the transistor. Also determine the collector current.

b) Identify the main components which determine the oscillator frequency.

c) Estimate the oscillator frequency in Hertz.

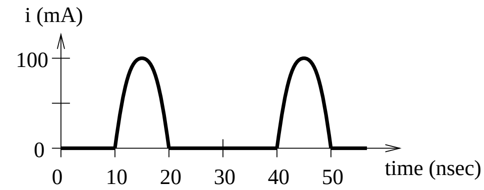
d) Describe briefly how one might simulate the open loop performance of this oscillator. What would one hope to learn from an open-loop analysis?

e) Describe how this oscillator could be made voltage controllable. (What component(s) would need to be added, and where would they go?)



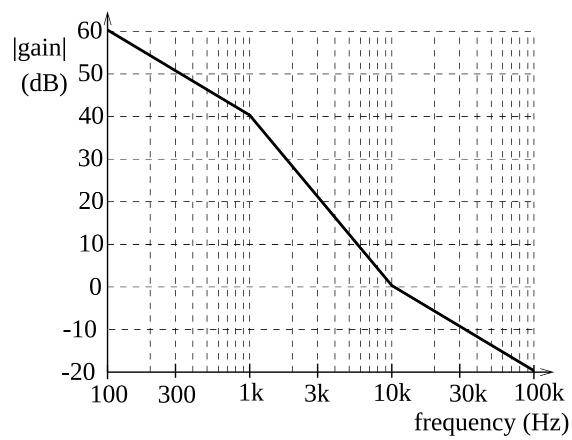
7. **Class C Amplifier** [10 marks]

At the right is shown the collector current of a class C amplifier. Calculate the efficiency. Assume the Class C amplifier has a power supply of 10V, and a (non-optimal) load resistor of 200 $\Omega$.




8. **Phase-Locked Loop** [**20 marks total**]

On the right is shown the open-loop gain for a PLL which has a phase detector with constant $K_{phase} = 1$ V/rad. and a VCO with constant $K_{VCO} = 10^6$ rad/sec/V.




a) What type of loop filter is being used? Determine its time constants and its transfer function.

b) Now determine the parameters of the closed-loop PLL including $K$, $\omega_n$ and $\zeta$.

c) Sketch the phase corresponding to the above magnitude plot. Explain the stability or lack of stability of the circuit.

d) **Note** This part is not for the same PLL as parts a), b), c). For a PLL which uses as loop filter an integrator with phase-lead correction, with a natural frequency of 1 kHz, damping constant of 0.707, and an exclusive-or gate phase detector, estimate the maximum frequency step which can be applied to the loop without losing lock during this step. Also, estimate the settling time during such a transient.

9. **Television Question** [**6 marks**]

a) Describe briefly the use of the following forms of modulation in the context of television:
   - i) amplitude modulation
   - ii) frequency modulation
   - iii) phase modulation

b) Describe how phase demodulation can be accomplished in a TV. Include simple block diagrams.