ENEL434 Electronics 2 - Assignment 2008

Introduction

In groups of two (2), you will design and build a UHF amplifier that operates at a designated centre frequency. Each group will be given a designated centre frequency and port return loss.

Specifications:

Transistor:	BFR92A
Centre frequency:	Value allocated to each group
Bandwidth*:	5 - 30 %
Gain:	Minimum gain specified for each group
Supply voltage:	< 18 V
Generator and load impedance:	50 + j 0 Ω
Input and output connectors:	BNC and RG58 cable
PCB:	1.6 mm FR4 or similar (Measured ε_r = 4.38)

*Bandwidth is the narrower of the gain and input and output reflection coefficient bandwidths, where the gain bandwidth is determined from the 3 dB points of the gain response, and the reflection coefficient bandwidth is where the reflection coefficient is less than -10 dB.

CAD Tools:

- AWR Microwave Office 2006 or AWR Microwave Office 2007 (MWO) will be used to simulate and layout the amplifier.
- Circuit simulation examples and guidelines will be available on the W drive to ease you into MWO.
- A MWO file containing a large-signal model of the BFR92A transistor will be provided on the W drive. This can be used to predict bias, small-signal response and large-signal response of the transistor.

Important Dates:

1. **18 July 2008:** Form your group (of 2) and email your group list to Dr Kim Eccleston **with CC to your group partner**. If you are unable to find a partner, email Dr Eccleston and a partner will be assigned to you.
2. **8 August 2008**: Submission by email to Dr Kim Eccleston a MWO file containing the amplifier schematic (layout not required but can be included). The purpose of this submission is to check that you are heading in the right direction and you will be advised accordingly if a change of direction is required.
3. **22 August 2008**: Submission by email to Dr Kim Eccleston a MWO file containing the final circuit and layout, and a CorelDraw file containing the pcb layout. It is important that the layout is error free because RF layout errors cannot be corrected with jumpers etc.
4. **8 September 2008 (possibly earlier):** Boards will be available for collection.
5. **10 October 2008:** Each group to demonstrate their amplifier.
6. **16 October 2008**: Submission of a group report. Each group shall submit one report. The report should contain design calculations / method, complete set of simulations, and test data. Only a hardcopy will be accepted.

Assessment Criteria:

You will be assessed against the following criteria of approximately equal weight:

1. Design calculations: to be supported by clear schematics.
2. Simulations: ability to effectively use MWO to simulate your circuit including presentation of graphs. To be supported by clear schematics and graphs.
3. Outcomes: simulation results, layout, construction and test results.

GROUP Report:

The group report will be used to assess the extent to which you meet the above assessment criteria. The following are important points to consider when writing the report:

1. Complete but concise.
2. Demonstrate understanding.
3. Include circuit diagrams that are clear and unambiguous.
4. Symbols in text need to be consistent with that in circuits diagrams and graphs.
5. Do NOT place important material in the appendices.
6. Important amplifier simulation results: Magnitudes of S11, S21 and S22 in dB.

Your **report** should demonstrate that you have performed the design in a systematic, valid and complete manner. **NB. a good design along with questionable design method will not score well.**

Email correspondence:

- Email correspondence - please adhere to the following rules and conventions:

  CC to your partner

  Subject line: ENEL434_ASSIGN_GP_XX [where XX is your TWO digit group number]

  File name: ENEL434_ASSIGN_GP_XX.yyy [where yyy is the relevant file extension]

  You and your partner's names must appear in the body.

  NB. Subject line and file name must follow exactly that given above. Latest file overwrites previous file.

Important PCB Artwork Attributes:

Identification:
Include the text: "ENEL434 2008 Group XX"

Artwork (CorelDraw file):
All metal (tracks, text, guidelines) to be BLACK filled.

Cut-out border:
You need to show the border of pcb - this defines the pcb edges. Use "L: shaped tracks to do this. Make sure that they are at least 10 mm away from RF tracks.

Transistor pads:
Make sure that the solder pads for the transistor appear on the layout. It is a serious error if they do not appear.

Input and Output Ports:
The input and output microstrips should come to the edge of the board. This is where the coaxial cable will be soldered. See photo of circuit board in Section 1 lecture notes. Be aware that the soldering of the coaxial cables to these microstrips will be critical to success.

RF Microstrip Tracks:
Be aware that the fields along RF tracks fringe about 3h on either side, where h is the pcb thickness. You do not want to disturb the fields so it is important that RF tracks have a clearance of 3h with respect to text, other tracks and edges of pcb. Failure to consider this could lead to a circuit that oscillates.

Vias:
You will make them by drilling a hole, threading tinned wire through and soldering both sides. Make sure that holes appear in the layout. Otherwise the drill will slip and break. Do not make the holes too large - otherwise you will be left with a hole and not a via. Use the same hole size as you would for a resistor lead etc (eg. about 0.5 mm).

Notes:

- Transistor data and other relevant resource materials will be on the W drive.
- The transistor S-parameters are bias and frequency dependent. So the S-parameters used in calculations should be for the bias point you have chosen and your allocated centre frequency.
- For **small-signal RF simulation**: The outcome of this simulation will be small-signal parameters such as: S-parameters, gain, K stability factor of the amplifier (or any 2-port circuit).
- Aim for a common-emitter configuration.
- It is important the amplifier is stable at ALL frequencies and not just within the pass-band.
- It is important to carefully consider the bias circuitry. Bias circuitry is notorious for causing amplifier instability.
- You will use RG58 coaxial cable with BNC connectors on one end to connect to the input and output ports.
- You may use microstrip transmission line and lumped components.
- PCB layout:
    - Layout of the RF sections is critical. A PCB interconnect will be behave as an inductance or a transmission line and may have a significant effect on circuit behaviour. The behaviour of an ordinary interconnect is difficult to predict.
    - It is best to use microstriplines to connect various components as the behaviour of microstrip is predictable and effects can be accounted for in the simulations. Microstripline will therefore require a ground plane on the bottom of the PCB. This simply means that you will use double sided PCB material, etch one side but leave the other side intact. All components are mounted (surface mount) on the etched side.
    - The BFR92A transistor is designed for surface mount.
    - It is recommended that you choose surface mount (0805 case style) capacitors and resistors that will “see” RF.
    - Meander long microstriplines to conserve PCB area - Use the “MTRACE2” element.
    - You should perform a final simulation that includes all layout and parasitic artefacts. The level of comprehensiveness to which this is done will determine how closely your simulations match the test results of the fabricated amplifier.
- Circuits are to be assembled within the departmental facilities.
- Each group will be given ONE and only ONE chance to demonstrate a working amplifier. Therefore it is imperative that the amplifier is completely assembled prior to the demonstration.
- Apart from bias operating point testing, only limited opportunities, if any, exist for RF testing prior to the demonstration. That is, it is expected to ensure that your simulations are complete, comprehensive and valid so that the circuit works as predicted and does NOT rely on post-tuning.
- You should obtain S-parameter frequency responses for all amplifier S-parameters and amplifier transducer gain. How will you obtain the transducer gain? You should provide at least two frequency spans: (i) dc to 1.5 GHz, and (ii) twice bandwidth of the amplifier centred on the amplifier centre frequency. For all spans it is important that you have at least 200 frequency data points.
- Choose appropriate vertical scales for plots. The automatic vertical scaling is rarely good for dB scales. eg. a scale from -100 dB to 50 dB is often inappropriate. A scale from -20 dB to 20 dB is a lot better.
- You are invited to perform large-signal simulations of your amplifier depicting load power versus input power. However**, credit for this is subject to completing the rest of the design and simulation to a high standard**.