EE4011 Continuous Assessment 2007/8

Simulation of a Power Amplifier (PA) Circuit in Microwave Office

Background

The purpose of this assignment is to develop familiarity with an industry standard simulation tool for RF design by simulating a sample Power Amplifier (PA) circuit. The simulation tool is Microwave Office (MWO) from AWR for which 20 licenses are available for use in the CAD laboratory of The Electrical & Electronic Engineering Department, UCC.

Documentation and the Power Amplifier Circuit

The network directory \\Denovo\public\EE_4011\MWO contains extensive documentation for Microwave Office including a users guide (MWO_AO_2007UserGuide[1].pdf) and a "getting started" guide (GettingStarted[1].pdf). The simulator setup for a particular simulation or graph can be found by consulting these pdf files. Most simulation approaches for power amplifiers are described in Chapter 6 of the getting started guide "Using The Nonlinear Simulator" but some analysis and graphical options will require other sections of the getting started, the users guide, or the other guides to be consulted. The circuit to be used for this assignment is the BJT power amplifier circuit with input and output matching networks as described on page 6-20 and onwards in the getting started guide.

Although power amplifiers have not been specifically discussed in class, this circuit is a single-transistor amplifier and it behaves like the amplifiers seen in class. Some of the matching elements are based on transmission line segments instead of the lumped-element matching networks studied in class but these can be treated as "black box" elements for this assignment. The simulation of the power amplifier circuit relies heavily on a simulation approach known as harmonic balance. This is an efficient simulation technique for the analysis of circuits under steady-state periodic excitation. Again, although harmonic balance has not been discussed in class, it is a very common simulation approach for the analysis of non-linear RF circuits and can also be treated as a "black box" simulation engine for the purposes of this assignment.

Assignment Elements

1. Work through every step of chapter 6 of the getting started guide in the order presented and save the resulting schematics and simulation graphs. It is important not to skip any part of chapter 6 because the elements of the amplifier are added one by one from start to finish in this chapter.
2. By consulting the available documentation perform the following extra analyses on the power amplifier circuit:
    - (i) For a single tone input with frequency 2.2GHz show the output spectrum at port 2 and the voltage waveforms at the base and collector terminals of the transistor, if the input power is set to -10dBm.
    - (ii) Repeat (i) for input powers of 0dBm and 25dBm.
    - (iii) Determine the P1dB point of the circuit using an appropriate single tone input power sweep for an input frequency of 2.2GHz.
    - (iv) Determine the efficiency of the amplifier circuit for the same input conditions as in (iii).

(v) Use the "tuner" tool to determine the influence of a +/- 150mV variation of the DC base bias on the circuit performance.

(vi) Use the "optimizer" tool to determine the optimum base bias voltage to give the best efficiency for an input frequency of 2.2 GHz for power levels between -10dBm and 10dBm.

(vii) Consult any of the RF texts mentioned in class or elsewhere to identify an alternative RF amplifier architecture to the one used here, implement this in Microwave Office and perform basic simulations of the circuit operation.

3. Prepare a report of 15 to 20 pages (using 11 or 12 point font) summarising the simulations performed with appropriate graphs and comments on how you interpret the results of the simulations and how these relate to what has been covered in class. Indicate the total time you needed to complete these tasks. Finally, comment on what you have learned through this assignment and give your opinion of Microwave Office and the assignment in general, with suggestions for improvement. While grading will be performed on the printed reports, students are also asked to submit an electronic copy of the reports and the simulator files used to generate the simulations by email to Dr. McCarthy.
4. Deadline: Wednesday 19th March, 2008, 12pm. Hand in to Ralph O'Flaherty's Office (Room 1.21).

Notes:
Students may co-operate to build up familiarity with Microwave Office and to get the basic PA circuit schematic simulating properly. However, each student is required to develop an individual competence for using Microwave Office and is expected to write and submit an individual report, which is to be written by the student on their own and in the student's own words. Students are encouraged to consult textbooks or other sources for further information on PA design. Such sources of information should be clearly referenced. Students are reminded of UCC's policy on plagiarism as outlined in the Examinations and Student Records document:
http://www.ucc.ie/en/SupportandAdministration/PoliciesandProcedures/ExaminationsandStudentRecords/StudentRecordsRegistration/UCCPlagiarismPolicy/

Past students who have used Microwave Office have stressed the importance of taking time to go through the Getting Started Guide and returning to it if problems are encountered. They have also stressed that for some simulations it is necessary to consult the Users Guide.

Past students have commented on the fact that Microwave Office generates many windows so be sure to look in the full workspace of Microwave Office when you are trying to find a simulation result. They have also indicated that the Microwave Office help menus are indeed very helpful.

In previous years, most students have reported that it has taken between 4 and 6 hours to complete the simulation aspects of the assignment and this has been followed by 4 to 6 hours writing the report. But the times have varied widely from student to student so it is important to start the assignment as soon as possible to complete it by the due date.

There are 25 students registered to take EE4011 in 2007/8, but there are only 20 licences for Microwave Office in the CAD laboratory. It is therefore important to spread the work out over a few days rather than rely on one marathon session on the day before the deadline.

	Excellent >70%	Very Good 60-69%	Good 50-59%	Satisfactory 40-49%	Unsatisfactory <40%
Report Organization and Presentation (20% weighting)	Professional-style report with excellent organisation, readability and graphics.	Same as good but with even better clarity and organisation including references, table of contents, etc.	Same as satisfactory but with clear introduction, body, & conclusion and flows well from one section to another.	Between the suggested length with clear graphs, text and page numbers.	Report not submitted or very short. Poor quality graphs. Poor structure.
Circuit Simulations/ Knowledge of MWO (30% weighting)	Extensive range of simulations incorporating but extending beyond the core requirements indicating a deep working knowledge of MWO.	Same as good but with additional simulations demonstrating deeper knowledge of MWO and the PA.	All of the required simulations have been performed and discussed indicating a good working knowledge of MWO	Most of the required simulations have been performed and discussed.	Most of the required simulations have not been performed or presented in graphical form indicating a weak working knowledge of MWO.
Comments on simulations and relationship to lectures (30% weighting)	Comments indicate a deep understanding of the links between the circuit operation and the simulation results and a strong link is established between the assignment and the lectures.	A very good understanding of the circuits and related simulations is apparent and a clear effort has been made to link the discussion to the lecture material.	Comments indicate good understanding of the characteristics being simulated and a link to the lectures is recognized.	Short comments indicating the student understands what is being simulated.	No comments or only very short comments are provided.
Appraisal/ Reflection (20% weighting)	A comprehensive appraisal of the assignment and MWO is presented. Learning achievements are clearly acknowledged and a range of suggestions for improvement are made.	Clear opinions about the assignment and MWO are presented. Learning outcomes are recognized and some suggestions for improvement are presented.	The appraisal gives clear opinions about the assignment and MWO and recognizes what has been learned by doing the assignment.	A short appraisal is presented outlining what has been learned.	No appraisal or reflection is presented.

Dr. Kevin McCarthy,
Department of Electrical and Electronic Engineering,
UCC,
27/2/2008