School of Electrical and Information Engineering
University of the Witwatersrand, Johannesburg
ELEN4001—High Frequency Techniques

Course Brief and Outline—2024

Academic Staff:

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1 Course Background

Antennas form a vital link between transmitters (receivers) and the propagation medium. As such they perform as electromagnetic transducers by converting current I, and voltage V into $\underset{\sim}{E}$, and $\underset{\sim}{H}$ fields and vice versa. (Forgetting this leads to the iPhone4 antenna fiasco! (iPhone12 not much better...))

The sudden interest in all things "Wireless" was first ushered in by the phenomenal success of GSM, which has evolved exponentially.

Although from a DataComms perspective, we are simply the "air-interface" it is a very misunderstood area: it is ultimately the antenna (system) that determines the interface to the medium.

The main aim of lectures is to convey some experience, insight and intuition as well as to stimulate discussion.

2 Course Objectives

Largely, High Frequency Techniques builds on the foundation laid by Electromagnetics to cover the Antenna Design aspects of the communications channel. However, any High Frequency (ie High Speed circuits) relies on the techniques developed in this course.

3 Course Outcomes

On successful completion of this course, the student is capable of:

1. understanding antenna terminology and fundamental characteristics.
2. using antenna simulation programs effectively.
3. designing and understanding the operation of some common antenna types.
4. performing basic electromagnetic derivations on simple antenna types.
5. performing some basic antenna measurements.

4 Course Content

Revision of Antenna Fundamentals Electromagnetic Spectrum, Radiation Basics, Polarization, Directivity and Gain, Reciprocity, Aperture, Radiation Resistance, Link Equation (Friis), Field and Power Flow, Modulation Schemes and Noise.

Thin Linear Antennas Fields from Potentials, Fields from Current carrying wires, The ideal dipole, Short Dipole, Short Monopole, Reactance of small antennas, Sinusoidal Dipole, Ohmic Losses, Matching, Baluns, Thickness Factor.

Array Theory Isotropic arrays, Pattern Multiplication, Binomial Arrays, Uniform Arrays, Interferometer, Multi-beam "Smart Antennas", Continuous Aperture distributions.

Common Antenna Types Travelling wave (HF) antennas, Small loop, and slot antennas, Normal mode helical, Axial mode helical, Reflector antennas, including the Corner Reflector, Yagi-Uda, LPDA.

Propagation Ionospheric propagation, Line of Sight, Penetration

EMC/I Electromagnetic Compatibility: Regulations, methods, compliance.

5 Prior Knowledge Assumed

A *strong* Electromagnetics background is assumed.

6 Assessment

All submissions must be in strict accordance with the guidelines contained in the *School's Blue Book* and the rules contained in the *School's Red Book.* No exceptions will be considered.

6.1 Formative Assessment

It is an "Honours" year!

6.2 Summative Assessment

Assessment Contributor	Duration (hours)	Component Yes/No	Method & Weight%	Calculator Type	Permitted Supporting Material
Lab	3	No	20%	3	N/A
Project	30	No	40%	3	N/A
Exam	2	No	40%	2	Note

Note:

- Dictionary permitted,
- Handwritten A4 formula sheet permitted[1].
- 2023 sees the introduction of two *University Diktat's*, both of which I disagree with on pedagogical grounds: 1) Examinations cannot exceed 40% weighting, and 2) the implementation of the thus-far-ignored Rule G7.10(b). I reproduce it from pg25 of the *2023 Rules and Syllabuses* here:

> **7.10 Sub-minimum rule**
> Unless specified otherwise in a course outline, a student will not be allowed to obtain credit for a course unless s/he achieves:
>
> a) a final mark of at least 50 percent for that course; and
> b) a sub-minimum of 35 percent in each of the components of that course as well as in the summative assessment for that course.
>
> Such a sub-minimum criterion applies only to components which contribute 25 percent or more towards a course, unless specified otherwise in the course outline.
>
> Summative assessment in this instance is assessment that regulates the progression of students by awarding marks at the conclusion of a course.

[1] All 6 sides may be used

The examination will cover *all* material covered in the course, and especially discussion topics in lectures.

6.3 Assessment Criteria

The student's understanding of the fundamental aspects of the course will be probed. Exam questions etc will need to be answered in order to answer the question: "WHY?" as opposed to the simplistic "HOW". I am not attempting to assess a simple methodology, I will assess fundamental understanding of concepts.

Note that the onus is upon the student to convey this understanding in an examination. A terse, correct "answer" may not necessarily attract marks! Please refer to my exam writing skills notes at `ytdp.eie.wits.ac.za/ExamWritingSkills.html`.

7 Satisfactory Performance (SP) Requirements

For the purpose of Rule G.13, *satisfactory performance in the work of the class* means attendance and completion of prescribed laboratory activities, attendance at tutorials designated as compulsory in this CB&O, submission of assignments, writing of scheduled tests unless excused in terms of due procedure.

8 Teaching and Learning Process

8.1 Teaching and Learning Approach

Covid-19 is not Covid-23: and thus we are fully back to Face-to-Face, not even Mask-to-Mask. But the (Hastily Assembled) material is still available on *Ulwazi*. Interaction is thus via lectures for those that wish to engage with real input. For those that eschew that, *Ulwazi* can work, but good luck to you :-)

A form of interaction is the ***Ulwazi Discussions*** which does support Mathematics (via MathJax). The advantage is that the ***Discussion*** is open to all in the class, and can be accessed at any time. I will thus also be using the ***Discussion asynchronously***, checking in several times per week. Please stick to using the Pinned *Generalised ChatRoom Facility*.

Please do not ***email*** me questions, as the rest of the class will not benefit: use ***Discussions***.

8.2 Information to Support the Course

There is a prescribed text for this course, the same as was used for the Electromagnetics course.

There are no notes handed out for this course.

In addition, there is a 122 page "Study Guide", by some obscure bloke:

- Clark A. R. (2004) "SuperNEC Study Guide for Electromagnetics and Antennas", Poynting Innovations, Wynberg, Sandton.

available from the Course Home Page. (See below).

Other References

- Kraus JD (1988) Antennas (2nd ed.) McGraw-Hill.
- Collins, RE (1985) Antennas and radiowave Propagation. McGraw-Hill.
- Jordan EC and Balmain KG (1968) Electromagnetic Waves and Radiating Systems. Prentice-Hall.
- Balanis CA(1982) Antenna Theory—Analysis and Design. Harper and Row
- Stutzman WL and Thiele GA, (1981) Antenna Theory and Design. John Wiley and Sons.

- Hall GL (ed) (yearly publication) The ARRL Antenna Book, American Radio Relay League.

8.3 Learning Activities and Arrangements

Lectures:

There will be two lectures per week. Students are expected to attend all lectures and to make their own notes.

I keep strictly to South African Standard Time (SAST). I respect your time, and will not drag on my lectures, and I expect you to respect my time, and that of your colleagues, by arriving on time, so that latecomer disruption is avoided.

Tutorials:

There will also be a tutorial by arrangement only.

Project:

In common with all fourth year courses in the "Honours" year, there will be a project—see handout, deadline as per 4th year schedule.

Laboratory:

There will be a laboratory associated with this course with a booking sheet posted later. The laboratory is felt to be an extremely important part of this course: hence the assessment rating. A thorough and properly presented report is expected. Students who cannot produce evidence of preparation will be asked to leave the laboratory.

School Policy states that there are no lab exemptions.

Consultation:

Via Ulwazi ***Discussions***.

It is generally convenient to grab me between and after lectures.

9 Course Home Page

For other information related to the course, please refer to the Course Home page at
`https://ytdp.eie.wits.ac.za/elen4001Home.html`

Some of the eTexts referred to in EM may be of use: Electromagnetics Course Home page at
`https://ytdp.eie.wits.ac.za/elen3000Home.html`

The online version is `https://ytdp.eie.wits.ac.za/elen4001outline.html`