DTT421/ETK521
DE:3A & 3T Lp1 1999/00

SIMULATION: Antennas design and measurement- 5 points, Level C

Course co-ordinator :
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The study plan was reviewed by the study programme committee for the computer/electrical engineering programmes on 1 March 1999.
The study plan was confirmed by the board of the department of technology at the University of Kalmar on 11 March 1999.
The course is included in the subject COMPUTER ENGINEERING/ELECTRICAL ENGINEERING at level C (advanced) and belongs to the subject area of Engineering. The course is part of the computer engineering programme and the electrical engineering programme, telecommunications specialisation.

Aims

The course aims to provide theoretical and practical knowledge concerning measurement of aerials.

Prerequisites

Knowledge equivalent to the contents of DTT221/ETK361 SIGNALS AND SYSTEMS, 5 points and DOT192/ETK192 TELECOMMUNICATIONS, 4 points.

Course content

The course consists of a theoretical component and a project component, where the project is carried out at an industrial measuring bench.
Theoretical component
Antenna theory, with emphasis on dipoles. Transmission lines. Electromagnetic fields
Principles of measurement. Traceability. Uncertainty estimation.
Laborative work: Calibration of voltmeter.

Project component

Measurement of E and H plane fields around dipoles in space.

Tuition and examination

The course consists of lectures, one laborative exercise and one project
The final mark of 3 (three) is based on a pass mark for the laborative work and a pass mark for the project report. For a final mark of 4 (four) or 5 (five) a pass mark for a written examination is also required.

Required reading

The required reading was reviewed by the study programme committee for the computer/electrical engineering programmes on 1 March 1999.
Confirmed by the board of the department of technology at the University of Kalmar on 11 March 1999.

Required reading

University of Kalmar, Depart. of Technology; stencilled material.
Collection of articles.

Literature for project work

University of Kalmar, Depart. of Technology; stencilled material.
Manuals available on web pages
Reference literature
Balanis, Constantine A; Antenna Theory, Analysis and Design, John Wiley & Son. Inc. ISBN 0-471-59268-4.
Course co-ordinator: Wlodek Kulesza

Sections of the course

Examination code	**Name**	**Points**	**Compulsory tests**	**Scale of marks**
9901	Examination	3	X	F/3/4/5
9902	Project and lab.	2	X	F/P

Other literature

1. Kildal, P.-S.: *Antennas*, Chalmers University
2. Johanson, R.C.: Antenna Engineering Handbook, McGraw
3. Balanis, Constantine A; *Antenna Theory, Analysis and Design,* John Wiley & Son. Inc.
4. Stutzman, W.L., Thiele, G.A.: *Antenna Theory and Design,*
5. *IEEE Standard Test Procedure for Antennas.*
6. Liang Chi Shen, Jin Au Kong: *Applied Electromagnetism,* PWS Publishing Company.
7. Guru, B.S., Hiziroglu, H.R.: *Electromagnetic Fields Theory Fundamentals*, PWS Publishing Company
8. Young, P.H.: *Electronic Communication Techniques*, Prentice Hall.
9. Grant, I.S., Phillis, W.R.: *Electromagnetism,* John Wiley & Son. Inc.

Contents

Examples of possible examination problems:

Vectors

1. The current along a conductor is a function of the distance z and is given by
   $I(z) = j21.2\cos(kz)$ amperes
   The frequency is 100 MHz. What is the current as a function of z and t?
2. Calculate $\boldsymbol{A} \bullet \boldsymbol{B}$**,** given $A = \hat{x} + j2\hat{y}$ and $A = 2\hat{x} + j\hat{y}$. Are $\boldsymbol{A}(t)$ and $\boldsymbol{B}(t)$ perpendicular at all times?
3. Let $\boldsymbol{A} = \hat{y}\sin x$, $\phi = \sin(x)\sin(2y)$. Find $\nabla \times \boldsymbol{A}$, $\nabla \bullet \boldsymbol{A}$, and $\nabla\phi$
4. Express the following vectors in the rectangular coordinate system:
   a) $\hat{\boldsymbol{F}} = \rho\sin\phi\hat{\rho} - \rho\cos\phi\hat{\phi}$ b) $\hat{\boldsymbol{H}} = \frac{1}{\rho}\hat{\rho}$

Elektromagnetiska fält och polarisation:

5. Beskriv ett **E**-fält som en vektor i rektangulära koordinater. Hur är **H**-fältet relaterat till **E**-fältet?
6. Låt **E**-fältet vara polariserat i x-led och utbreda sig i z-led. Hur kan man skriva detta **E**-fält? Vad är krysspolarisationen?
7. Beskriv hur man med hjälp av två dipoler kan få ett cirkulärt polariserat **E**-fält (två sätt). Hur kan polarisationsvektorn se ut?
8. Energin i ett elektromagnetiskt fält beskrivs av pointingvektorn, skriv ner ett uttryck för pointingvektorn.
9. Skriv ner ett uttryck för effekttätheten **W** för att elektromagnetiskt fält.

Dipol:

1. Rita upp en dipol. Skissa upp strömfördelningen för en liten dipol och en infinitesimal dipol.
2. Skissa upp strålningsdiagrammet för en halvvågsdipol i **E**-planet och **H**-planet.
3. Skissa upp en dipol som du vill mäta, med en likadan dipol, och visa hur du tänker dig att mäta strålningsdiagram för copolarisation och krysspolarisation. Välj att mäta i **H**-planet.
4. Vad menas med en isotrop strålare? Hur stor är direktiviteten för en liten dipol mätt mot en isotrop strålare?
5. En halvågsdipol ska användas vid 2GHz. Hur lång blir denna dipol? Hur långt bort från denna bör man vara för att mäta upp dess fjärrfält?
6. Halvvågsdipolen har runt 75Ω. Om jag ansluter denna dipol till en Koaxialkabel på 50Ω, hur stor blir då reflektionskoefficienten och effektivitetskoefficienten e_r?
7. Skriv upp en formel för strömfördelningen för en infinitesimal dipol och räkna ut direktiviteten för denna. Om den totala effektiviteten för antennsystemet är e=0.79, vad blir då gain?
8. Hur kan jag bygga upp en dipol av infinitesimala dipoler? Skriv ner ett uttryck i vektorform.
9. Från detta uttryck, skriv ner en x-polariserad halvvågsdipol.

Strålningsfunktion - strålningsintensitet:

1. Skriv ner ett uttryck för strålningsintensitet **U** och uttryck strålningsfunktionen **G** i **U**.
2. Ett sätt att modellera ett strålningsdiagram är att försöka anpassa funktionen $G(\theta,\varphi) = \cos^n(\theta/2)$ till det uppmätta diagrammet. Räkna ut direktiviteten för $G(\theta,\varphi) = \cos^n(\theta/2)$, använd sfäriska koordinater.

Transmission line

1. Two coaxial lines have equal characteristic impedances: 50Ω. Both are air-filled. The first line has a power capacity of 1 MW., and the second line's capacity is 1 kW. Find the ratios a_1/a_2 and b_1/b_2. Consider only the breakdown E field.

2. A transmission line is short-circuited (Z_L=0).
   a) Find the expressions for $|V(z)|$ and $|I(z)|$ as a function of kz, Z_0, and V_+.
   b) Sketch $|V(z)|$ and $|I(z)|$.
   c) Find VSWR on the line
3. A transmission line is terminated with a normalized impedance Z_{Ln}=2+j2. The incident V_+=1.0, and the characteristic impedance of the line is 1.0. Show that V_{max}=I_{max}=1.62, $|V(0)| = 1.57$, $|V(-0.219\lambda)| = 0.78$, V_{min}=I_{min}=0.38, $|I(0)| = 0.55$, $|I(-0.219\lambda)| = 1.46$.

Antenna in systems and antenna measurement

1. A transmitting antenna is not matched to the impedance of a connecting transmission line. The radiation intensity or equivalently the power density at a specified distance is reduced from the perfect impedance match case. Compute this reduction in decibels for mismatch situations that produce VSWR values on the transmission line of 1.01, 1.2, 2 and 10.
2. Explain the reciprocity for antennas.
3. Categorize antenna ranges. Describe limitations associated with each range category.
4. In a compact antenna test range, reflected and diffracted rays from reflector cause error. Show methods that reduce the error.
5. Instrumentation for typical antenna-range measuring system.
6. Gain measurement methods.