EE 6601
Topics in Radio Frequency and Microwave Techniques
Course Aim and Intended Learning Outcomes (CILOs)

Course Aims

To provide students with selected topics for designing an analogue electronic circuit at intermediate frequency, radio frequency and microwave stages. This course is devoted to passive circuit elements, covering specialty topics in passive circuit design.

Course Intended Learning Outcomes (CILOs)

<table>
<thead>
<tr>
<th>No</th>
<th>CILOs</th>
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<tbody>
<tr>
<td>1</td>
<td>Describe the general characteristics of passive circuits at radio frequency</td>
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<tr>
<td>2</td>
<td>Describe the circuits being fabricated on a printed circuit board of microstrip lines</td>
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<td>3</td>
<td>Describe and analyze n-port networks</td>
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<td>4</td>
<td>Apply impedance transformers, power dividers, circulators, hybrids, filters, and couplers in RF circuit design</td>
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Assessment

Continuous Assessment: 40%
Examination: 60%

A two-hour examination will take place on completion of the course.
The 40% coursework will be based on assignments (20%) and 1 midterm exam (20%).

Text

Lecture Notes

Teaching Mode

3-hour lecture per week

Background Knowledge

Basic knowledge of the transmission equation is essential
Course Syllabus

**Discrete Components**
Wave propagation in lossy media, dielectric loss, loss tangent;
Wave penetration in conducting materials, depth of penetration, skin depth, surface resistance;
Behavior of ordinary discrete components at radio and microwave frequencies;
Lumped components for radio and microwave frequencies.

**Guided Waves**
Compare and contrast typical guided wave configurations: coaxial lines, parallel plates, balanced striplines, microstrip lines, and waveguides;
Equivalent circuit parameters: capacitance, self and mutual inductances, direct-current and radio frequency resistance;
Wave propagation in lossy lines, quality factor, dispersion-free propagation;
Multi-port network analysis: cascading networks, scattering matrix, conversion between different network representations, measurement of S-parameters.
Course Syllabus (continued)

Microstrip Lines
Pros and cons of using microstrip lines;
Dielectric and conductor losses, surface waves, characteristic impedance;
Effects due to a substrate of finite thickness, effective dielectric constant, phase velocity;
Corrections for conductors of finite thickness, finite ground planes, step discontinuity, T-junction, corners, gaps, and open-end;
Microstrip line designs.

Microstrip Line Devices
Impedance transformers, multi-section transformers, tapered lines, circulators, quadrature hybrids, ring hybrids, directional couplers, multi-section couplers;
Wilkinson power dividers, attenuators, admittance inverters, and phase shifters.
Course Syllabus (continued)

Microstrip Line Filters
Characteristics of a terminated transmission line, commensurate lines; Butterworth, Chebyshev, linear-phase, and elliptical filters; Low-pass, high-pass, band-pass and band-stop filters; Filter designs, Richard’s transformation, Kuroda’s identities.

Coupled-Line Devices
Coupled-line theory; Coupled-line couplers, multi-section couplers; Coupled-line filters, multi-section filters.
The Best Equipped Facilities in the Region
High-Pass Filter

8.5GHz

10.5GHz
Wave Propagation Through the Filter

Generated 2nd Harmonic From The Active Device

-6 dB @ 2 GHz

<-15 dB @ 2 GHz

-34 dB @ 3.5 GHz

<-48 dB @ 3.5 GHz

Pass band

Stop band
Surface Waves On a Dielectric Slab

@5GHz the field due to a point source (horizontal dipole) located on the interface.
The plane wave in the dielectric. Total reflection will happen at the interface of the air and dielectric. Surface wave in the transvers direction is standing wave and decays exponentially in the air away from the interface.

The plane wave is examined because the wave generated by the point source can be expanded into plane waves.
@5GHz
Wave propagation in a microstrip line
Surface wave is generated.
Waveguide T-Junction

Excite port 1 with port 2 matched and port 3 shorted

Excite port 2 with ports 3 matched and port 1 shorted

Excite port 1 and ports 3, see the output in port 1,2,3 (power combiner)
Microstrip Line Design and Matching

S11 of Dual Band Stub / SCMRC

S21 of Dual Band Stub / SCMRC

[S11 and S21 plots showing frequency response in dB against frequency (GHz) with design parameters and matching values]

[Microstrip line design models showing current densities with color coding for different regions]
For More Details