Microwave measurements

Finalità
A basic course in microwave measurements and measurement techniques from RF through microwave. Topics include characteristics of microwave generators, passive devices and detection systems; power, frequency, swept frequency network and spectrum analysis, time domain reflectometry and noise measurement. Techniques, precautions for each measurement type, and required instrumentation configurations are stressed.
Lecture and lab.

Programma
Diode detectors: general theory, noise, main characteristics. Homodyne and heterodyne detection.
Thermal detectors: thermocouple and bolometers. Mixer, attenuators, couplers, bridges. (4 hours)

Impedance and admittance relationships, matching, Smith Charts. Scattering parameters and signal flowgraphs. Topographical and analytical resolution of signal flowgraphs. Error analysis using signal flowgraphs (4 hours)

Time-domain reflectometry: general principles, fault location in transmission lines, evaluating cable loss, measurement of parasitic capacitance and inductance, time-domain from frequency-domain measurements.
(2 hours)

Attenuation measurements (2 hours)
Noise temperature and noise figure measurements: the Y-factor measurement technique, noise measurement by spectrum analyser. Gain and noise-figure optimisation. (1 hours)

Power measurements: expression for power (average, pulse, and peak envelope power). Power-head elements. Uncertainty due to DC-RF substitution error, efficiency, and multiple reflections. The microcalorimeter. (3 hours)

Network analysers: block diagram of the vector network analyser (microwave test sets, signal detection, synchronous detection, computer control). Scalar network analyser. The six-port network analyser. Calibration techniques (12 parameters, TRL). Applications. (6 hours)

Frequency measurement. Theory of phase noise measurement, phase-lock detection, frequency fluctuation and Allan variance, direct measurement of two-sided power spectral density. Microwave counters: transfer oscillators, heterodyne down converters. (2 hours)

Spectrum analyser: the traditional super-heterodyne architecture (tuning equation, frequency resolution and sweep time, display smoothing, multi-heterodyne, harmonic mixing). Amplitude and frequency accuracy, frequency resolution, noise and distortion, dynamic range. Modern performance spectrum analysers (digital IF section, swept and FFT analysis, compensation of the effects of phase noise and thermal noise). Applications (tracking generator, time-gating). (6 hours)

RF and microwave synthesiser: Direct Digital Synthesisers, fractional-N synthesisers. Comparison with unsynthesised generators. (4 hours)

Attività d'esercitazione
14 hours with approximately 4 laboratory assignments.

Modalità d'esame
Homework (not graded), Monthly Quizzes, Final Exam, Laboratory Reports

Propedeuticità
Transmission line theory - Theory of wave propagation in waveguide (Propagazione guidata)

Testi consigliati
G.H. Bryant: Principles of microwave measurements. Peter Peregrinus Ltd.
A. E. Bailey: Microwave measurements, 2nd ed., Peter Peregrinus Ltd.