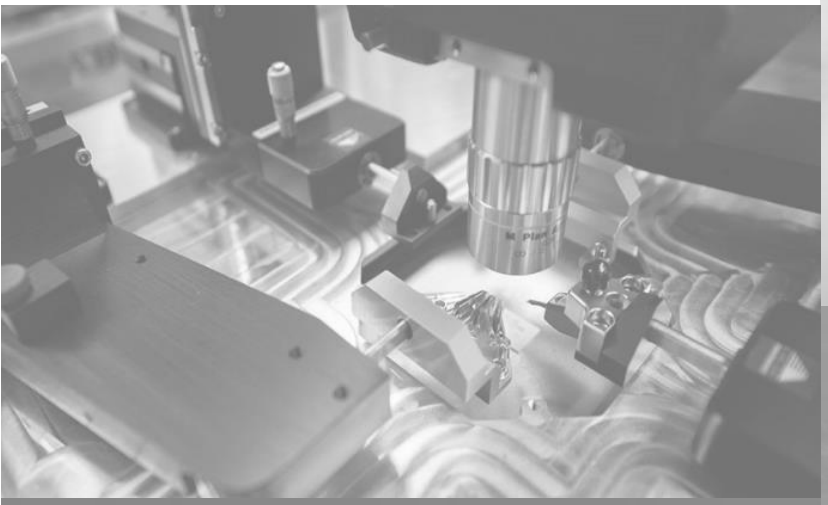
FILPAL

Empowering RF Innovations

TECHNICAL TRAINING



COURSE BROCHURE

www.filpal.com

MISSION

Strengthening RF talent pool to support industry growth.

OUR TRAINING PROGRAM

The program is divided into 4 levels

Level 1: RF fundamental and measurement basics (4 days),

Level 2: RF Sub-System Evaluation and Measurement (3 days),

Level 3: Advanced RF Characterization and Measurement (4 days), and

Level 4: Advanced RF and Microwave Design and Measurement (5 days).

The program aims to deliver the knowledge in RF and microwave fields starting from theory until the final product/prototype evaluation so that each participant, upon completion the program, would be ready to take challenges and work in the RF related industries.

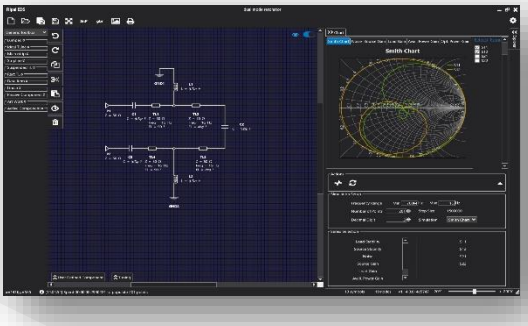
It is designed according to dedicated level with dedicated module(s) starting from basic to advanced. The coverage includes theory, mathematical calculations, design and simulation using software, and up until testing and measurement.

WHY WE DIFFER

The training is conducted by RF experts with easily digestible contents that make learning fun and effective. The content includes practical/experiential training with in-house RF software tools and prefabricated RF & microwave prototypes. We also provide customizable program to suit your specific needs.

Looking to upgrade your RF skillsets? Or you are

- *engineer,*
- *RF designer,*
- *sales engineer,*
- *project manager,*
- *lecturers,*
- *technician,*
- *government officer, or*
- *engineering student?*



RF INDUSTRY-READY TRAINING PROGRAM

Level 1

RF Fundamental and Measurement Basics
4 days, 5 modules (3 theory & 2 practical)
Practical lab work is 15 hours

Module 1: RF & microwave systems & RF engineering fundamentals
Module 2: Transmission lines and impedance matching techniques
Module 3: Passive and active RF & microwave components
Module 4: EDS HF[1] software
Module 5: VNA[2] practical lab works

Level 2

RF Sub-System Evaluation and Measurement
3 days, 5 modules (3 theory & 2 practical)
Practical lab work is 12 hours

Module 1: Introduction to microwave system level design
Module 2: Introduction to RF front-end design
Module 3: Time Domain Reflectometry (TDR)
Module 4: Link budget calculation and simulation
Module 5: Advanced VNA[2] measurement

Level 3

Advanced RF Characterization and Measurement
4 days, 6 modules (2 theory & 4 practical)
Practical lab work is 15 hours

Module 1: RF and microwave device design lifecycle
Module 2: Microwave network analysis
Module 3: Signal flow graphs
Module 4: Troubleshooting and calibration techniques
Module 5: Advanced test and measurement techniques
Module 6: Non-linear characterization and measurement

Level 4

Advanced RF and Microwave Design & Measurement
5 days, 7 modules (2 theory & 5 practical)
Practical lab work is 18 hours

Module 1: Microwave transmission line design considerations
Module 2: RF and microwave PCB[3] design
Module 3: Advanced impedance matching techniques
Module 4: RF and microwave filters
Module 5: Multi-port RF and microwave components
Module 6: Active RF component design
Module 7: Practical consideration of RF system level

1 **EDS HF**: Electronic Design Software – High Frequency
2 **VNA**: Vector Network Analyzer
3 **PCB**: Printed Circuit Board

LEVEL 1: RF FUNDAMENTAL AND MEASUREMENT BASICS

This level provides the understanding of RF and microwave engineering fundamental, knowledge on the most important parameters for the RF. You will learn most of the important terminologies and the network parameters used in RF and microwave engineering discipline. You will also gain the necessary knowledge of how to read, analyse and evaluate the datasheet and understand the requirements. The hands-on measurement of the prototypes which will contribute to the practical activities could accelerate the understand and improve the technical know-how of the participants.

Module 1 – RF and microwave systems and RF engineering fundamentals

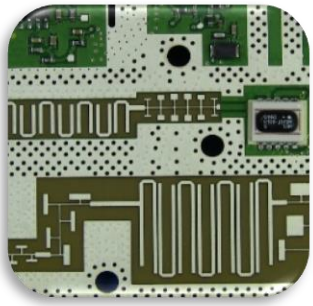
- Introduction to RF and microwave systems
- Introduction to transceiver architecture
- Basic radio and RF concepts
- RF engineering fundamentals
- Network parameters

Module 2 – Transmission lines and impedance matching techniques

- Transmission lines theory
- Smith chart & impedance matching
- Narrowband and broadband matching

Module 3 – Passive and active RF and Microwave components

- Understanding RF and microwave passive and active components
- Figure of merits for amplifier and oscillator
- Antenna introduction



Module 4 – EDS HF software

- FILPAL EDS HF software overview
- Simulation of S-parameter, Y-parameter, Z-parameter
- Simulation of Smith chart, and Linear chart
- Case study I: transmission line simulation and unitary condition
- Case study II: Microstrip resonator example.
- Case study III: Smith chart for impedance matching.

Module 5 – Vector Network Analyzer (VNA) practical lab works

- Impedance matching (practical lab work)
- Measurement of transmission line
- Transmission line case study (lab work)

LEVEL 2: RF SUB-SYSTEM EVALUATION & MEASUREMENT

This level covers the introduction to microwave system level and the introduction to RF front end design. The time domain reflectometry (TDR) and its applications will be included together with the link budget calculation which is one of the important skills in the RF system level evaluation, design, and planning. The Vector Network Analyzer (VNA) practical lab works in testing and measuring various types of RF and microwave devices and components will be a truly hands-on module that the participants find it very useful.

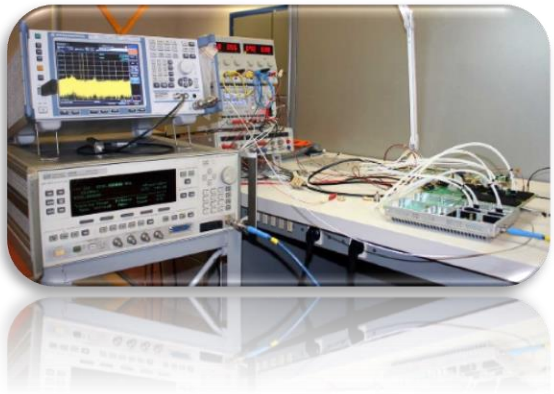
Module 1 – Introduction to microwave system level

- Introduction to microwave system level design
- Modulation-demodulation scheme and multiple access techniques
- Microwave system considerations

Module 2 – Introduction to RF front end design

- Operating principle of the RF receiver front end
- Factors that affect the performance of RF front end
- Typical GSM Mobile Handset RF Front End
- RF front end block diagram and analysis

Module 3 – Time Domain Reflectometry (TDR)



- Typical applications
- Introduction to echo technique
- Transmission line impedance profile
- A time domain reflectometer setup
- Locating mismatches

Module 4 – Link budget calculation and simulation

- Important parameters in wireless network.
- Free space path loss
- Choosing the correct antenna and antenna height
- Key term in outdoor wireless networks – fade margin
- Link budget calculations and simulation

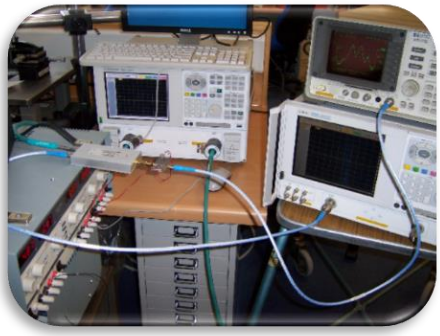
Module 5 – Advanced Vector Network Analyzer (VNA) measurement

- Overview of various type of measurement and RF instrument
- Calibration, measurement, and troubleshooting techniques
- Test and measurements of filter, coupler, amplifier, and other devices testing & measurement

LEVEL 3: ADVANCED RF CHARACTERIZATION & MEASUREMENT

This level introduces RF and microwave device design lifecycle including the rules of thumb, reference, and guide for RF instrumentation selection. This is part of process of decision making as an RF engineer or manger on the CAPEX investment. The coverage in this level includes the microwave network analysis together with signal flow graphs and the use case for the TRL calibration technique for VNA. The test and measurement of the prototypes which will contribute to the practical activities which could accelerate the understand and improve the technical know-how of the participants.

Module 1 – RF and microwave device design lifecycle.

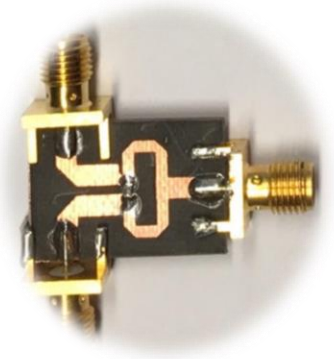


- Overview on RF engineering design process
- RF instrumentation selection
  (Rules of thumb/reference/guide)
- RF and microwave device design lifecycle

Module 2 – Microwave network analysis

- The concept of impedance
- Two-port network and theory
- Introduction to multiport microwave network

Module 3 – Signal flow graphs

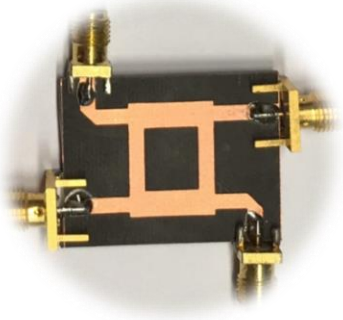


- Importance of signal flow graph
- Signal flow graph representation of a 2-port network
- Decomposition of signal flow graphs
- Use case TRL network analyzer calibration, (lab work)

Module 4 – Advanced tests and measurements

- Introduction to calibration, measurement, and troubleshooting techniques
- Test and measurements of filter, power divider and coupler
- Test and measurements of amplifier

Module 5 – Troubleshooting and calibration techniques



- Impedance matching (lab work)
- Measurement of transmission line
- Transmission line case study

Module 6 – Non-linear characterization and measurement

- The test accessories
- Measurement setup
- Use case IP3 two tones measurement

LEVEL 4: ADVANCED RF & MICROWAVE DESIGN & MEASUREMENT

This level focuses on the design of RF and microwave devices and components. The course starts from microwave transmission line to passive components and active components design until the test and measurement of those components. RF and microwave PCB design which is greatly important and very much relevant in electronic industry especially in the high-speed design. The module concludes with the practical consideration of RF system level.

Module 1 – Transmission line design considerations

- Transmission media characteristic
- Microwave transmission lines
- Line calculation (lab work)

Module 2 – RF and microwave PCB design

- Wavelength and guided wavelength in PCB
- Lumped-element equivalent model
- Conductor and skin depth
- Discontinuity and loss effects
- Multilayers, via-hole, keep out area
- RF PCB design (lab work)

Module 3 – Advanced impedance matching techniques

- L-section impedance matching network
- Quarter-wave transformer
- Narrowband and broadband matching
- Design cases I to III (lab work)

Module 4 – RF and microwave filters

- Applications of RF & microwave filters
- Ideal versus practical filters
- Effect of losses on band-pass filters
- TEM transmission line filters
- Design cases I to IV (lab work)

Module 5 – Multi-port RF and microwave components

- Figure of merits/Important parameters
- Three-port and four-port networks
- Wilkinson power divider.
- Branch-line and directional couplers.
- Design cases I to IV (lab work)

Module 6 – Active RF component design

- Figure of merits/Important parameters
- Amplifier stability and noise performance
- Various types of gains in for the amplifier
- Input and output matching
- Design cases I to III (lab work)

Module 7 – Practical consideration of RF system level

- System design process
- Effect of impedance mismatches on system gain
- Transmission line interconnections
- Noise factor and noise figure
- Overall noise figure of the system
- Nonlinearity in the signal path
- Second-order terms and intercept points
- Frequency conversion

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