RF and Digital-RF Component Test

Training Programme
by
Dream Catcher Consulting Sdn Bhd

05 - 07 Mar 19
Dream Catcher Consulting Sdn Bhd, Penang

303-4-5 & 303-4-6 Block B, Krystal Point
Jln Sultan Azlan Shah 11900 Sg Nibong Penang, Malaysia
http://dreamcatcher.asia
enquiry@dreamcatcher.asia
+604 640 7111 / 7112
+604 640 7110
**Synopsis**

**SBL-Khas 5739**

The aim of this course is to provide a basic working knowledge of RF and Digital-RF Component Test - usage and setting up of CW-RF and IQ-modulated RF instruments, measurement procedures, instrument limits, calibration methods, example measurements of different types of DUTs, and understanding the significance of the parameters being measured. Some of the Digital-RF test parameters covered in this course such as EVM and BER are also applicable for system-level tests.

Frequencies of interest to us fall within the 300MHz-6GHz range. Often it is a challenge to test these components at RF frequencies due to their unusual, difficult-to-access non-coaxial interfaces. We will look into traditional CW-RF parameters such as P1dB and OIP3 as well as more modern IQ-modulated parameters such as EVM and ACPR which are replacing the CW-RF parameters for wireless-standards testing, since these would more accurately reflect the actual performance of the component under those signal conditions hence the differentiation between RF and digital-RF.

**Course highlight**
The course reinforces learning through exercises and labs, so that the attendees are not just passive listeners - 30% of the course consists of worked-through exercises, and 20% comprises lab demonstrations and hands-on labs.

**What You Will Learn**

- RF connector and cable types and the function of various RF test accessories
- How to use the Vector Network Analyzer (VNA) to measure S-parameters and Gain Compression parameters such as P1dB and Psat, and as a TDR
- VNA calibration methods
- Test setups and measurement procedures for Power, Gain Compression, Efficiency and Linearity parameters such as P1dB, PAE, Harmonics and OIP3 using Signal Generators, Power Sensor and Spectrum Analyzer
- How to check instrument limits
- Digital-RF signal tests such as EVM, ACPR and BER and relation to analog impairments
- Noise Figure measurement methods and impact of test fixture
- Measurement of Phase Noise, Oscillator parameters and sensitivities

**Who Should Attend**

This course is suitable for factory, applications, marketing, sales or field staff who need to know the basics of how RF and Digital-RF components are checked and tested and the meaning of such tests. For factories, staff would be Technicians, Engineers, and Managers involved in component and product characterization and testing, quality assurance, test development, manufacturing, troubleshooting and repair.

**Prerequisite**

Diploma or Degree in any physical science or technology field, preferably in electrical or electronic engineering. Working experience in RF is not required. Although the course includes a review of fundamental RF concepts, attendees are assumed to have at least a theoretical
knowledge of RF concepts such as dB and dBm units, transmission lines, impedance matching, S-parameters, Smith Chart and reflections, and reflection measures such as reflection coefficient G, VSWR and Return Loss. If this knowledge is lacking, we recommend attending DreamCatcher's foundational-level RF course Essential RF Microwave Concepts - A Practical Approach, before attending this course.

**Course Methodology**

50% lecture, 30% exercise and 20% lab.

**Course Duration**

3 day(s), 9am - 5pm

**Course Structure**

**Day 1 - RF Fundamentals Review**

**01 Introduction**

- Component vs system level tests
- A typical DUT datasheet of a Power Amplifier
- Overview of component types - passive and active RF components
- Overview of component form factors - DUTs with coaxial connectors, and DUTs without coaxial connectors

**02 Signal & Spectrum**

- Wavelength, Speed, Frequency
- Fourier, Harmonics
- Time Domain and Frequency Domain
- dB, dBx

**03 Circuit Fundamentals**

- Ideal Capacitor, Inductor
- Bias-Tee
- Real-world L, C, R
- SRF, Parasitics Implications

**04 Transmission Lines**

- Lumped Element vs Transmission Line
- Characteristic Impedance
- Terminations: Load, Short, Open
- TDR
- Standing Wave, SWR
- Gamma, Return Loss
- Insertion Loss
- 75 ohm and 50 ohm cable
05 S-parameters

- S-parameters definition
- S-param for n-port
- Interpreting S-parameter values
- s2p file format

06 Smith Chart

- Smith Chart Introduction
- From Impedance to Smith Chart
- Use of Smith Chart
- Smith Chart Regions
- Constant Reflection Circles

Day 2 - RF Test and Measurement

07 RFMW Test Accessories

- Connectors, adapters and attenuators
- Bias tees
- DC block
- Power divider, splitter
- Filters - LPF, HPF, BPF
- Isolator
- Torque wrench
- RF Cables - characteristic impedance, cut-off frequency, phase velocity, losses
- Example Test Setup for IP3 Measurement

08 Spectrum Analyzer Measurements

- Superheterodyne receiver
- Resolution Bandwidth (RBW), Sweep Time, Mixer distortion, Attenuator test, Noise floor,
  Video Bandwidth (VBW), Detector
- General usage procedure
- Linearity: Harmonics, OIP3, IIP3
- Mixers: Conversion Gain/Loss, LO-to-IF/LO-to-RF Feedthrough

Lab08 Spectrum Analyzer Measurements

09 Digital-RF Signal Measurements

- IQ Diagram & Channel Capacity
- Modulation measurement setup, settings
- VSA Digital Demod: Tx-Rx Matched filters
- LAB DEMO-IQ constellation, EVM measurements
- Measurement parameters - OBW, channel power, spectrum emission mask, ACPR/ACLR,
  CCDF
- Transmitter tests
- EVM, AM-PM, modulation impairment examples, common constellation errors
- Receiver tests
- BER, loopback test, receiver sensitivity
10 Network Analyzer Measurements

- Network Analyzer (NA, VNA)
- Types of Network Analyzer
- 1-port and 2-port error models
- SOLT, SOLR
- Thru Response cal-measurement uncertainty
- In-Fixture measurement error correction
- Filter Measurements: Insertion Loss, Group Delay, Out-of-Band Rejection, Bandwidth, Q-factor, Reflection
- TDR option
- Power Sweep for Amplifier P1dB

Day 3 - RF Test and Measurement (cont)

Lab10 Network Analyzer Measurements

11 Power Measurements

- Power Measurement - Instrument Comparison
- Power Meter and Sensor
- Types of Power Measurement, types of power sensor, power sensor errors
- Power Amplifier Measurements
- P1dB, Psat, PAE

12 Noise Figure Measurements

- Thermal, shot, flicker noise
- SNR and Noise Figure
- Using and calibrating an NF meter/NFA
- Cascaded Noise Stages
- LAB DEMO/VIDEO - cascaded NF and impact of losses before and after the DUT
- Shield boxes to isolate DUT

13 Phase Noise Measurements

- VIDEO DEMO - phase noise and jitter
- Why is Phase Noise important?
- Phase Noise unit of measure
- Oscillator parameters - phase noise, output power, current, frequency pushing, frequency pulling etc
- Sensitivity of Phase Noise measurements
- Oscillator measurement methods
- Direct Spectrum Method
- Signal Source Analyzer

Course Instructor(s)

Dr Teoh Chin Soon

Education and Research Work
In 1992 Teoh Chin Soon received the B.Eng. degree in Electronic Engineering from the
University of Manchester, United Kingdom, graduating with high honors, and continued on to do a Ph.D. in Microwave Engineering, graduating in 1996. In his research he designed and demonstrated a novel 3- and 4-port broadband circulator using a nonreciprocal distributed-coupling phenomenon. During his PhD, he received for two consecutive years the IEEE MTT-S Graduate Fellowship Award. He has authored or co-authored 7 technical papers in international journals and conferences, and 2 local conference papers.

Industry Experience
From 1996-97 Teoh Chin Soon was with SCM Integrated Systems in Kuala Lumpur, where he was involved in the installation, alignment and maintenance of digital microwave radio links and site-testing of marine-radar systems operating at 3GHz and 10GHz bands. Subsequently he joined the Test and Measurement Division of Hewlett-Packard in 1997 (renamed Agilent Technologies in 1999) as an application engineer for RF/MW and wireless instrumentation and later on developed and supported test solutions for mobile wireless handsets. In 2002 he moved into RFIC design work with Avago Technologies, and successfully released a 0.5-6GHz low-noise amplifier into the market. During this time, he designed 2.4GHz and 5GHz baluns and filters for WLAN bands, initiated ESD improvement efforts and introduced new methodologies in ESD design for GaAs PHEMTs. In early 2007, he ventured out with some partners to found DreamCore Technologies Sdn Bhd to provide RF Design Services to the electronics industry particularly in the area of RF devices and components. In the past 5 years, through DreamCore he has designed and developed many GaAs/InGaP RFICs such as low-noise amplifiers, power amplifiers and RF switches, as well as RF test boards and fixtures for customers in Malaysia, USA and China.

Publications
Administrative Details

Programme Logistics

**Duration:** 3 day(s), 9am - 5pm  
**Date:** 05 - 07 Mar 19  
**Venue:** Dream Catcher Consulting Sdn Bhd, Penang

Morning break, lunch and tea break will be provided throughout the course duration. Course Manual and Certificate of Attendance will be provided.

Your Investment

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<tr>
<th>Condition</th>
<th>Price per Pax</th>
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<tr>
<td>Regular fee</td>
<td>RM3,640.00</td>
<td>RM218.40</td>
<td>RM3,858.40</td>
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<td>Early bird discount for registration before 05-Feb-2019. N/A for SBL KHAS</td>
<td>RM3,310.00</td>
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<td>Group discount for every 3 pax registered, receive 1 complimentary seat</td>
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Additional cost may incur for customization or extra material request. Course fee is 100% claimable from PSMB (SBL scheme) in accordance to PSMB guidelines.

3 Easy Steps to Register

- **Phone** +604 640 7111 / 7112  
- **Fax registration form** to +604 640 7110  
- **Email registration form** to register@dreamcatcher.asia
Method of Payment

Crossed cheque / bank draft made in favour of DREAM CATCHER CONSULTING SDN BHD.
Registration form
together with payment to be couriered to:

Dream Catcher Consulting Sdn Bhd
303-4-5 & 303-4-6
Block B, Krystal Point
Jln Sultan Azlan Shah
11900 Sg Nibong
Penang, Malaysia

Payment must be received no later than 10 working days before the course commences. An
undertaking may be accepted in cases where payment is delayed. However all payments must
be made before the course commences.

Closing registration date is 19-Feb-2019.

Refund and Cancellation

Fees will only be refunded in full for cancellation received in writing more than 10 working days
prior to the commencement date. Substitute attendee(s) will be accepted at no extra charge.

Disclaimer

Dream Catcher Consulting Sdn Bhd reserves the right to change the instructors, date and to
vary/cancel the programme should unavoidable circumstances arise. All effort will be taken to
inform participants of the changes. Upon sending the registration form, you are deemed to
have read and accepted the terms.

Enquiries

call us at +604 640 7111 / 7112 or email us at enquiry@dreamcatcher.asia
# Registration Form

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<th>No.</th>
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Total Amount

(Emails are required to ensure notification of any changes reach the participant)

Submitted by:

Company Name: ____________________________
Company Address: ____________________________
Contact Person: ____________________________ Designation: ____________________________
Dept: ____________________________ Phone: ____________________________
Email: ____________________________

Please complete this form with an authorised signature below and fax to fax registration form to +604 640 7110 or email to email registration form to register@dreamcatcher.asia. Call us at phone +604 640 7111 / 7112 for any enquiry.

Authorised Signature: ____________________________

* Please print full name (authorised signature) if you submit via email

Name: ____________________________ Designation: ____________________________
Dept: ____________________________ Date: ____________________________

This registration is invalid without a signature. Payment must be made no later than 10 working days before the course commences. An undertaking may be accepted in cases where payment is delayed. However all payment must be made before the course commences. Participants who registered but did not attend will be invoiced accordingly. Fees will only be refunded in full for cancellation received in writing more than 10 working days prior to the commencement date. Substitute attendee(s) will be accepted at no extra charge.

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Enclosed cheque/bank draft no ____________________________ made in favour of DREAM CATCHER CONSULTING SDN BHD