RFL- RFT

RF Circuit Trainer

AKADEMIKA

- Frequency Range up to 2 GHz
- Dedicated Boards for both active and passive microstrip components
- Analysis of Discontinuities in Microwave Circuits
- Analysis of Impedance Matching Networks
- Analysis of Lumped Filters characterization
- Analysis of BJT & Power Amplifiers
- Good Power handling capacity
- Gold plated PCB
- On Board Power Supply to drive Active Devices

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RFL-RFT - RF Circuit Training System consist of 3 individual boards to introduce the concept of Transmission Line Circuits , RF Microwave Network Analysis ,Impedance Transformation, impedance Matching along with Active RF devices like BJT Amplifier,MOSFET Amplifier, LNA. etc.The trainer kit boosts the learning curve & visualization towards critical impedance theory along with application circuit.
The design frequency range of component is up to 2GHz.The Trainer kits contains gold plated components in accurate, robust and integrated board platform.

Discontinuities in Microwave Circuits

Designing high-frequency microwave circuits and, with increasing frequency, millimeter-wave frequencies require for the most part laying out carefully conceived transmission lines to carry those high-frequency signals across a printed-circuit board (PCB). Of course, if the task of fabricating the PCB was simply a matter of adding circuit elements, such as resistors, capacitors, and inductors, to create the necessary frequency-domain/time-domain response for the PCB, it might go somewhat easier. But every PCB with high-frequency transmission lines must also manage any number of circuit discontinuities and junctions as part of that design—these are those locations where signals must pass some change in the transmission-line path, such as a transition in the width of a transmission line, a gap between sections of transmission line, even an abrupt change in direction for the transmission line. In all cases, a high-frequency signal that has been propagating along a straight and consistent transmission line must now navigate some form of obstruction, such as an abrupt change in direction, a difference in transmission-line width.

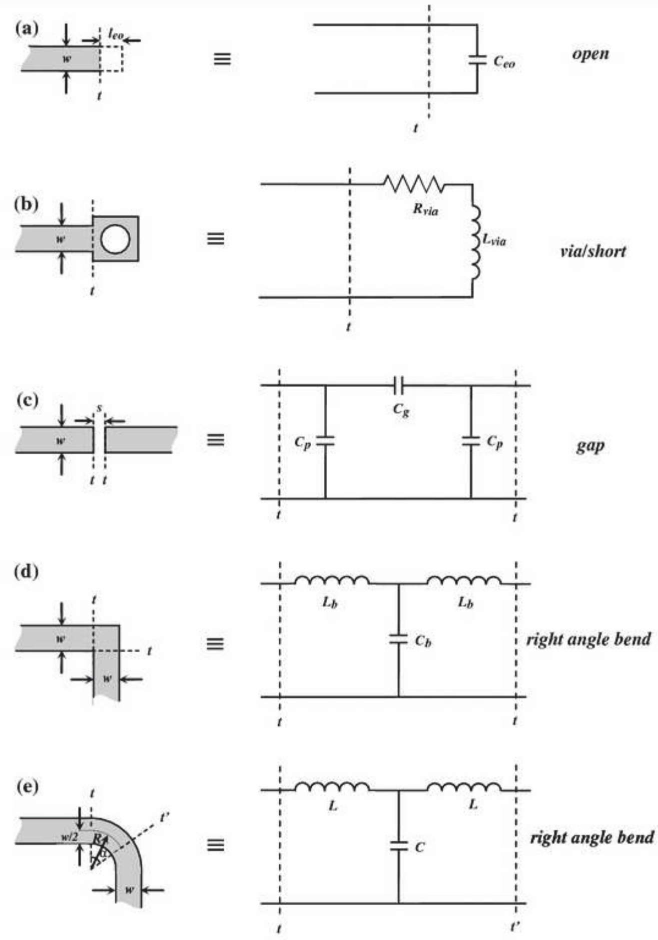

Fig.Some Common Microwave Discontinuty

A discontinuity will introduce a shift in impedance, it is hoped that the PCB substrate will provide the most stable basis for a circuit design's target impedance, usually 50 .

Impedance Matching

An impedance vector consists of a real part (resistance, R) and an imaginary part (reactance, X).Impedance can be expressed using the rectangular-coordinate form: $Z = R + jX$

The main role in any Impedance Matching scheme is to force a load impedance to “look like” the complex conjugate of the source impedance, and maximum power can be transferred to the load. When a source termination is matched to a load with passive lossless two-port network, the source is conjugated matched to the input of the network, and also the load is conjugate matched to the output of the network.

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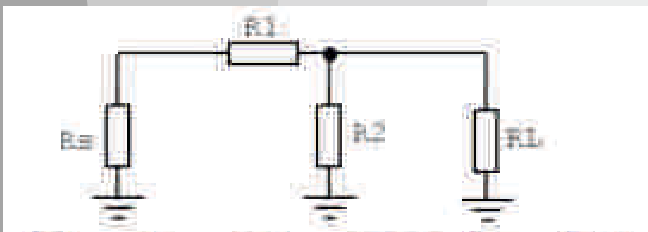
1.Impedance Matching using Resistor Networks

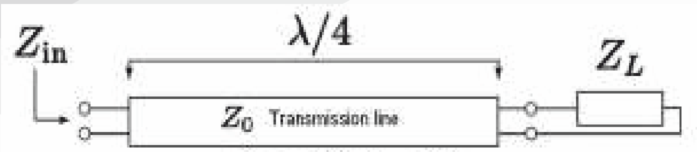
Using a resistive network can match simultaneous input and output, but create more loss



$$R1 = R_S - (R_L \times R2) / (R_L + R2)$$
$$R2 = R_L - \sqrt{[(R_S) / (R_S - R_L)]}$$

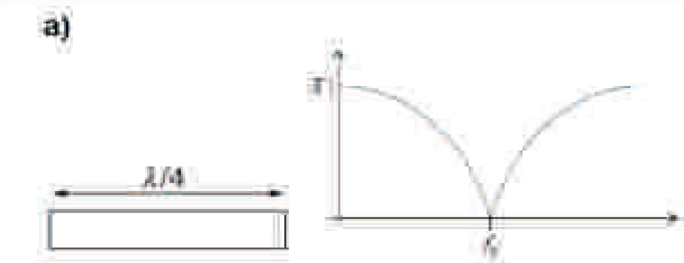
2.Impedance Matching using Quarter-Wave (λ/4) Transmission Lines

A quarter-wave impedance transformer is a component used in RF engineering consisting of a length of transmission line one quarter of a wavelength (λ/4) long and terminated in some known impedance ZL



$$Zo = \sqrt{(Z_{in} \times Z_L)}$$

The characteristic impedance of the quarter-wave line is the geometric average of Zin and ZL.

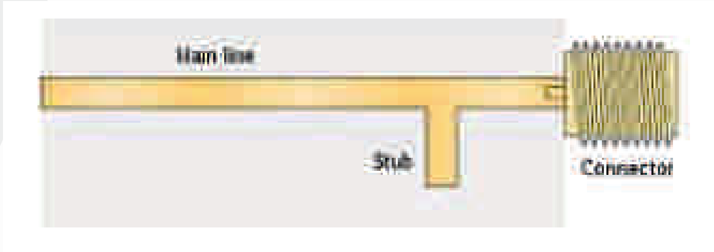


A quarter-wave /4 transformer provides a perfect match at only one frequency

A broadband design may be obtained by a cascade of λ/4 line sections of gradually varying their characteristic impedance

3.Impedance Matching using Stub

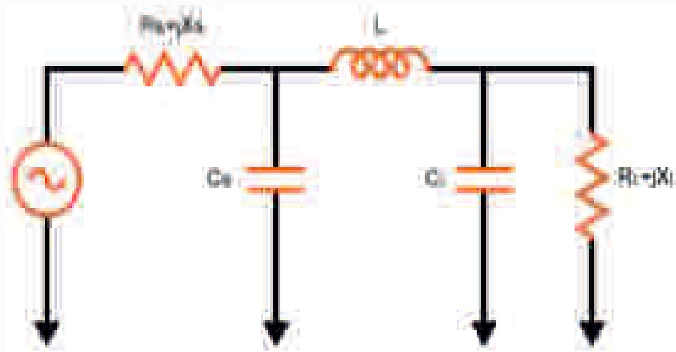
The shorted stub can be constructed which can produce reactance of any value. This can act as impedance matching device which cancels reactive part of complex impedance.



Stubs can be used to match a load impedance to the transmission line characteristic impedance. The stub is positioned a distance from the load. This distance is chosen so that at that point the resistive part of the load impedance is made equal to the resistive part of the characteristic impedance by impedance transformer action of the length of the main line. The length of the stub is chosen so that it exactly cancels the reactive part of the presented impedance.

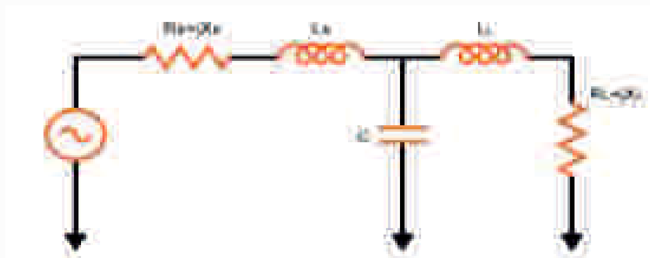
4.Impedance Matching Using Pi-Network

The basic π-network's primary application is to match a high impedance source to lower value to load impedance. It can also be used in reverse to match a low impedance to a higher impedance



5.Impedance Matching Using L-Network

The T-match impedance matching circuit is one of the circuits used to match the impedance between two points, usually a source and a load. The circuit got its name because the inductor and the capacitor form a T-shape



Low-Noise Amplifiers (LNAs)

A low-noise amplifier (LNA) is an electronic amplifier that amplifies a very low-power signal without significantly degrading its signal-to-noise ratio. An amplifier will increase the power of both the signal and the noise present at its input, but the amplifier will also introduce some additional noise. LNAs are designed to minimize that additional noise. Designers can minimize additional noise by choosing low-noise components, operating points, and circuit topologies. Minimizing additional noise must balance with other design goals such as power gain and impedance matching

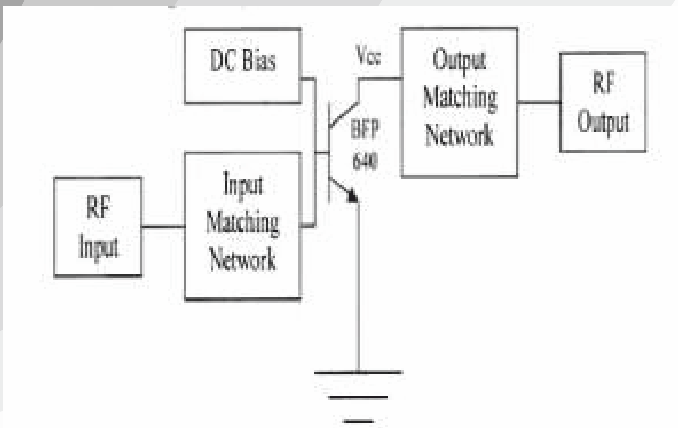


Fig. Block diagram of typical LNA

Frequency Multiplier

A low- In electronics, a frequency multiplier is an electronic circuit that generates an output signal whose output frequency is a harmonic (multiple) of its input frequency. Frequency multipliers consist of a nonlinear circuit that distorts the input signal and consequently generates harmonics of the input signal. A subsequent band pass filter selects the desired harmonic frequency and removes the unwanted fundamental and other harmonics from the output

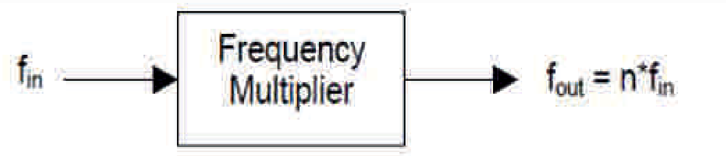


Fig. Block diagram of Frequency Multiplier

A frequency multiplier has the property that the frequency of the output signal has an integer multiple of the input frequency.

Phase-Locked Loop (PLL)

A phase-locked loop or phase lock loop (PLL) is a control system that generates an output signal whose phase is related to the phase of an input signal. There are several different types; the simplest is an electronic circuit consisting of a variable frequency oscillator and a phase detector in a feedback loop. The oscillator generates a periodic signal, and the phase detector compares the phase of that signal with the phase of the input periodic signal, adjusting the oscillator to keep the phases matched.

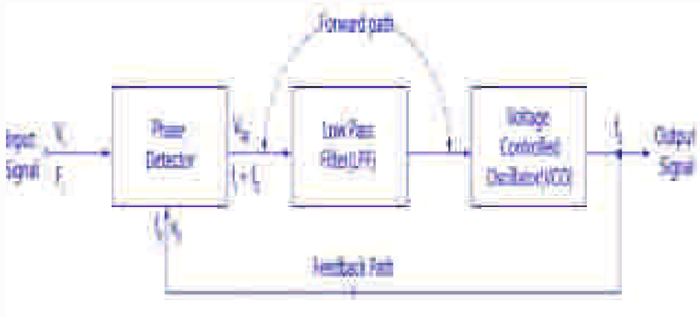
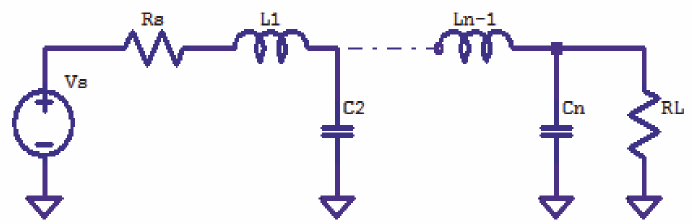


Fig. Block diagram of PLL

Keeping the input and output phase in lock step also implies keeping the input and output frequencies the same. Consequently, in addition to synchronizing signals, a phase-locked loop can track an input frequency, or it can generate a frequency that is a multiple of the input frequency. These properties are used for computer clock synchronization, demodulation, and frequency synthesis.

LC Butterworth Filter

Physical synthesis of a Butterworth filter requires components which can be interconnected to form complex poles (dampened harmonic oscillators). A passive arrangement of resistors and capacitors can form arbitrary real valued poles and zeros; however a passive RC network cannot synthesize complex poles. The natural choice for passive components which can synthesize oscillators, are inductors and capacitors. An immediate benefit of choosing an LC network for synthesis, is that the network in the ideal case is lossless. Allowing for low insertion-loss in the pass-band, and maximizing power transfer from source to load.



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KEY MEASUREMENT PARAMETERS

1. Insertion Loss (S_{21})

Fig.Insertion Loss of Microstrip Line

Graph shows insertion loss of T-Matching circuit. We infer that there is very less insertion loss at 411 MHz

3. S-Parameters (S_{12})

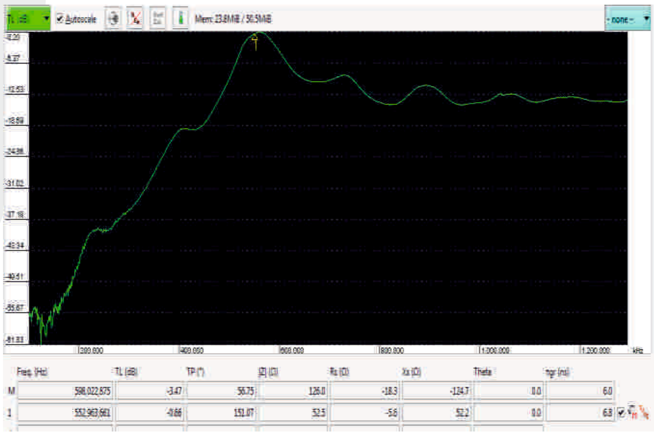

Fig.S_{12} of PI Matching Network

Graph shows the S_{12} parameters of PI matching network and we infer that the Q- Factor of PI matching is very high with good selectivity

2. Isolation (S_{31})

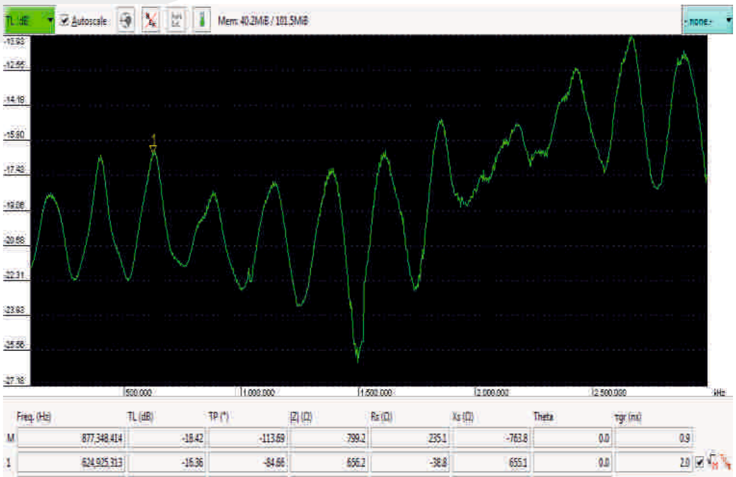

Fig. Isolation of Microstrip Coupled Line

Graph shows isolation of Microstrip Coupled Line. It shows very high isolation at 500 MHz.

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4. S-Parameters (S_{11})

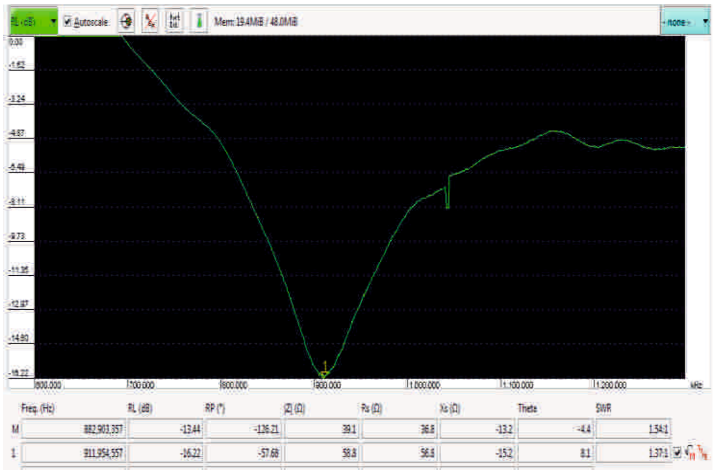

Fig. S-Parameters of Stub Matching Circuit

Graph shows S-Parameter S_{11} of stub matching network. It shows S_{11}= -15.2 dB.From this we infer that there is very good impedance matching observed at 900 MHz.

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TECHNICAL SPECIFICATION

BOARD 1: TRANSMISSION CHANNEL & MICROSTRIP DISCONTINUITIES

Open air transmission
- Frequency : 0.9GHz to 3GHz
- Power : 0dBm to -20dBm
- Load : Matched Antenna

Co-axial cable transmission
- Frequency : 0.1GHz to 3GHz
- Power : 0dBm to -20dBm
- Load : Open, short

Microstrip transmission line
- Frequency : 0.9GHz to 3GHz
- Power : 0dBm to 20dBm
- Load condition : Open, short

CPW transmission line
- Frequency : 0.9GHz to 3GHz
- Power : 0dBm to -20dBm
- Load condition : Open, short

Slot line
- Frequency : 0.9GHz to 3GHz
- Power : 0dBm to -20dBm
- Load condition : Open, short

CPW transmission line with ground
- Frequency : 0.9GHz to 3GHz
- Power : 0dBm to -20dBm
- Load condition : Open, short,

Coupled line microstrip transmission line
- Frequency : 0.9GHz to 3GHz
- Power : 0dBm to -20dBm
- Load condition : Balanced load,

Open discontinuity
- Frequency : 0.9GHz to 3 GHz
- Power : 0dBm to -20dBm

Short discontinuity
- Frequency : 0.9GHz to 1.3GHz
- Power : 0dBm to -20dBm

GAP discontinuity
- Frequency : 0.9GHz to 1.3GHz
- Power : 0dBm to -20dBm
- Load condition : Matched

Bend discontinuity
- Frequency : 0.9GHz to 1.3GHz
- Power : 0dBm to -20dB

Step discontinuity
- Frequency : 0.9GHz to 1.3GHz
- Power : 0dBm to -20dBm
- Load condition : Matched

Tee discontinuity
- Frequency : 0.9GHz to 1.3GHz
- Load condition : Matched

BOARD-2 : RF CIRCUITS & MATCHING ARCHITECTURE

RF Lump Element
- Frequency : 0.3GHz to 1GHz
- Type : Capacitive, Inductive
- Load condition : Matched

High frequency effect on Lump Element
- Frequency : 0.01GHz to 3GHz
- Power : 0dBm to -20dBm

Inductive Resonance Circuit
- Frequency : 0.3GHz to 1GHz
- Power : 0dBm to -20dBm
- Load condition : Matched

Capacitive Resonance Circuit
- Frequency : 0.3GHz to 1GHz
- Power : 0dBm to -20dBm
- Load condition : Matched

RLC Resonance Circuit
- Frequency : 0.3GHz to 1GHz
- Power : 0dBm to -20dBm
- Load condition : Matched

Tunable Resonance Circuit
- Frequency : 0.3GHz to 1GHz
- Power : 0dBm to -20dBm
- Load condition : Matched

BALUN
- Frequency : 0.3GHz to 2GHz
- Power : 0dBm to -20dBm
- Load condition : Matched

DC Bias TEE
- Frequency : 0.3GHz to 1.3GHz
- Power : 0dBm to -20dBm
- Isolation : 25dB

Microstrip Bias TEE
- Frequency : 0.7GHz to 1.3 GHz
- Power : 0dBm to -20dBm
- Load condition : Matched load

Single stub matching
- Frequency : 0.8GHz to 2.0 GHz
- Load condition : Variable load

Quarter wave transformer
- Frequency : 0.8GHz to 2.0 GHz
- Power : 0dBm to -20dBm

Binomial Quarter transformer
- Frequency : 0.5GHz to 2.0 GHz
- Power : 0dBm to -20dBm

L Matching for resistive load
- Frequency : 0.3GHz to 1.0GHz
- Load condition : Resistive load

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L Matching for complex load
- Frequency : 0.3GHz to 1.0GHz
- Load condition : Complex load

T Matching
- Frequency : 0.3GHz to 1.0GHz
- Load condition : high load impedance

PI Matching
- Frequency : 0.3GHz to 1.0GHz
- Load condition : low load impedance

BOARD-3 : RF ACTIVE COMPONENT & ITS APPLICATION CIRCUITS

RF BJT Amplifier
- Frequency Range : 0.3GHz to 0.8GHz
- Gain : 9dB
- Reverse Isolation : < - 10 dB

Low Noise Amplifier
- Frequency Range : 0.3GHz to 0.8GHz
- Gain : 10dB
- Noise Figure (NF) : < 2.5dB

RF Power Amplifier
- Frequency Range : 0.3GHz to 1GHz
- Gain : 10dB
- Maximum Output Power : 20dBm

RF MOSFET Amplifier
- Frequency Range : 0.1GHz to 0.5GHz
- Gain : 10dB
- Reverse Isolation : < - 10 dB

RF Gain Equalizer
- Frequency : 0.5GHz to 0.8GHz
- Impedance : 50 ohm
- Load condition : Matched

RF LC Oscillator
- Frequency : 30 MHz (±25 MHz)
- Power level : - 27 dBm

Phase-locked loop
- Input Frequency : 500 KHz – 5 MHz
- VCO Locked Freq : 1.3MHz (± 500 KHz)

RF Frequency Multiplier
- Input Frequency Range : 10-500MHz
- Output Frequency Range : 20-1000MHz
- Impedance : 50 ohm

Lumped LPF Filter
- Cut Frequency : 450 MHz (+/- 50 MHz)
- Filter order : 7
- Return Loss : < -10 dB

Lumped HPF Filter
- Cut Frequency : 450 MHz (+/- 50 MHz)
- Filter order : 7
- Return Loss : < -10 dB

Lumped BPF Filter
- Center Frequency : 350 MHz (+/- 70 MHz)
- Filter order : 5
- Bandwidth : ~ 150 MHz @ 3 dB

Power Supply
- +24V, +12V, + 5 V, GND on board to drive the Active Devices

DELIVERABLES
- Transmission Channel & Microstrip Discontinuities Module: 01nos
- RF Circuits & Matching Architecture Module: 01nos
- RF Active Component and Its Application Circuits Module: 01nos
- SMA (M) to SMA (M) 50 ohm RG316 cable 50cm: 02nos
- SMB (Plug) to Crocodile clips DC supply cable: 02nos
- 50-ohm Terminations: 02nos
- Manual: 01nos

RECOMMENDED EQUIPMENTS
- SA3600TG: Spectrum Analyzer with Tracking Gen.
- VNA-3000: Vector Network Analyzer

***Note: not supplied along with module**

TUTORIALS
- Measurement of Insertion loss (S21) for different devices.
- Study of Load condition over transmission line channel.
- Study of Phase characterization of channel.
- Measurement of frequency BW response.
- Study Z parameter of stub matching circuits.
- Study and calculation of Smith chart over a wide band.
- Measurement of S11 / VSWR for different devices.
- Measurement of Q Factor for different devices.
- Measurement of Resonance over BW.
- Study of Match & Unmatched circuits.
- Measurement of transmission & reflection Characteristic of lumped LPF, HPF,BPF filters
- Study network analysis of different RF Active circuits like BJT, MOSFET and LNA Amplifiers.
- Measurement of Gain Flatness.
- Study of RF Gain equalizer circuit and its measurement.
- Study of RF LC Oscillator.
- Study RF Frequency Multiplier Circuits.
- Study of Phase-Locked Loop (PLL) Circuits.

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