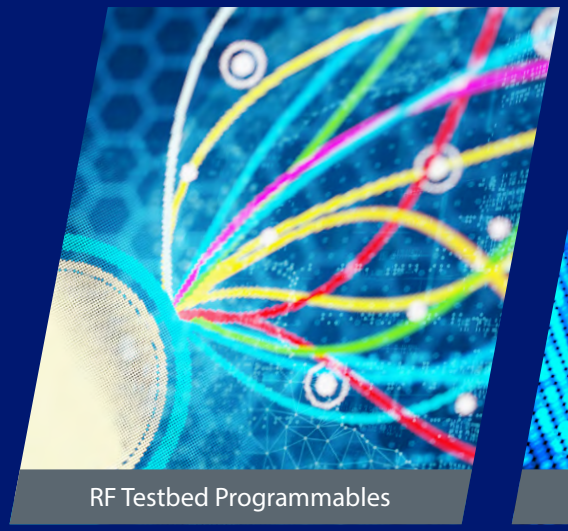
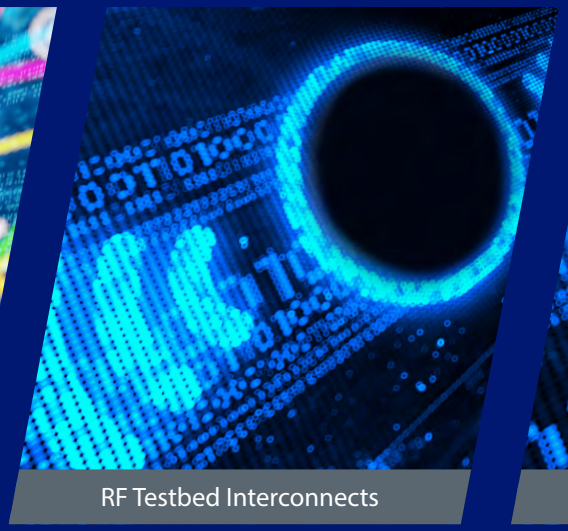
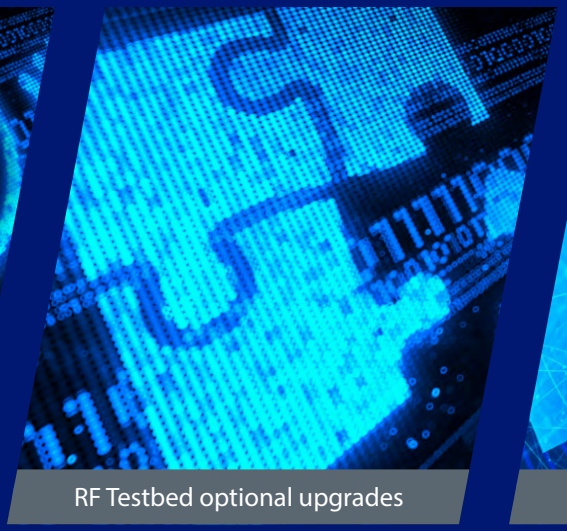
Cookbook For RF Testbed Design

Ensuring you have the right tools to drive your newest tech development

Components to build a conductive RF Testbed for 5G and Wi-Fi 6E


RF Testbed Programmables


RF Testbed Interconnects


RF Testbed optional upgrades


Building an RF Testbed

Introduction

Dear Reader,

Cables may become artifacts of the past as the products we use in our everyday lives adopts new 5G and Wi-Fi 6/6E wireless connectivity. These newest wireless network standards provide improvements in speed, coverage, and reliability. The primary focus and reason for needing the current wireless upgrade is to support the growing number of devices that demand internet access. Current legacy wireless approaches simply don't cut it anymore.

5G and Wi-Fi 6/6E use different kinds of antennas, operate on different radio spectrum frequencies, connect many more devices to the internet, minimizes delays, and delivers ultrafast speeds. RF Lab measurement systems now must support frequencies from DC to 75 GHz, the forthcoming 28 and 39 GHz bands for 5G, and new Wi-Fi bands 57 to 66 GHz defined for WLAN IEEE 802.11ad, plus frequencies greater than 66 GHz for WLAN IEEE 802.11ay.

There has been strides in developing extremely compact conductive connector heads and surface/edge-mount coaxial connector ports for modern RF devices. Ensuring RF testbed platform compatibility is essential.

RF Lab Testbed measurements are an essential part of performance evaluation and certification of network elements and the wireless devices using a network, by measuring the transmit power and receiver sensitivity performance. Conductive connectorized testing of radio hardware is considered to be the primary test method for performance and conformance testing throughout a wireless device design and production phases. Conductive testing enables extremely precise measurements that are highly controlled, repeatable, and reliable.

The quality of coaxial conductive testing is partially due to the much lower loss and lower interference conductive medium of using conductive coaxial transmission lines instead of an air-link. With a conductive RF Testbed system, the energy within even a complex multi-port device can be accurately be measured at each port. This enables accurate characterization of the network element or device's behaviour.

Our conductive RF Testbed enables testing of individual sub-circuits, components, or even individual devices within a complex radio system. Non-destructive conductive testing can even be done using probes, solderable test connectors or test ports built into the RF board. Given that test signals are intrinsically shielded within the APITech RF Lab, external shielding during testing is not usually required, and a very small test footprint can be achieved.

In this RF cookbook, we have selected a portfolio of APITech componets & subsystems and looked at how to build a Wi-Fi or 5G RF Testbed to meet the testing needs of new radio technologies considering what and how tests are performed.

To dive deeper into RF testing for 5G or Wi-Fi networks, please reach out to me.

David J Swift
Global Director of Telecom Sales, APITech

What's driving the need for new RF Testbed Labs in terms of bandwidth, spectrum and latency?

5G up to 100 times faster than 4G.

The result?

Downloading a high-definition film over a 4G network takes 50 minutes on average, on 5G, it takes just nine minutes.

Today an operator might have 100 MHz of spectrum in use for all their customers on a network. This will increase to around a 1,000 MHz with 5G.

The result?

Data will be transferred in real time.

With 4G, the latency rate is 200 milliseconds, not far off the 250 milliseconds it takes for humans to react to visual stimuli. The target 5G latency rate is significantly lower: at just 1 millisecond.

For consumers it will make things seem faster, for industry it makes it possible to remotely control machinery over long distances.

RF Testbed's play a key part in the verification of these important KPI factors.

Network performance / QoS **49%**

Speed / simplicity of deployment **49%**

Application performance **45%**

Data sovereignty / privacy **43%**

Source: Cap Gemini's global enterprise 5G survey

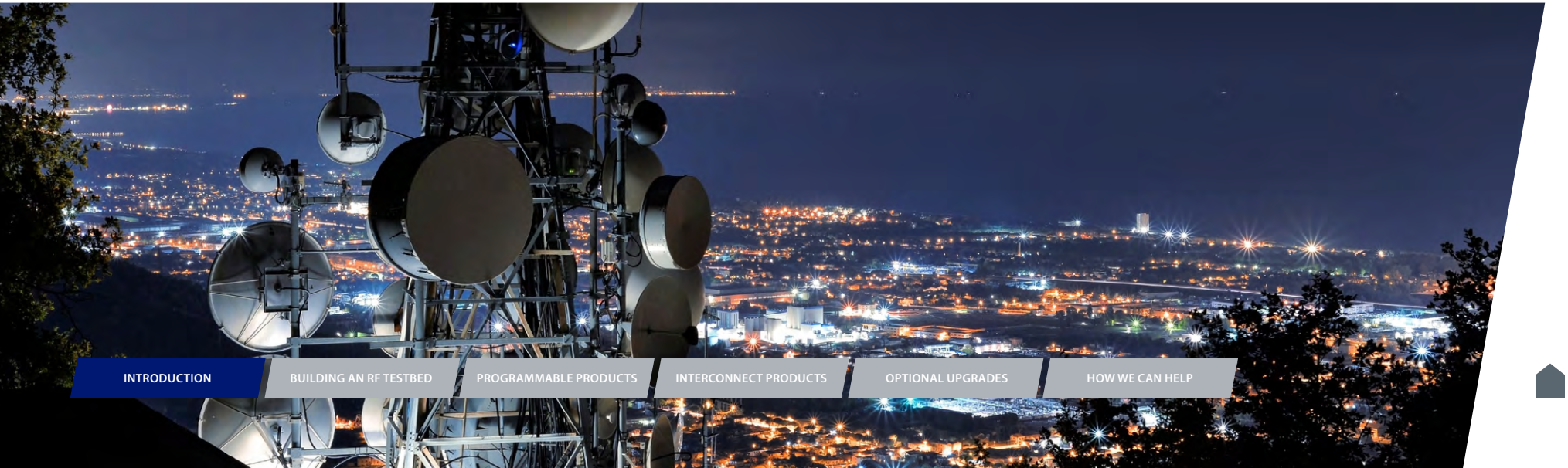
Where do APITech and 5G / Wi-Fi Meet?

APITech has over 60 years of wireless device and system innovation/development/design heritage, developed through several business units, which are now joined as one to offer the most comprehensive wireless test and measurement systems development organization.

APITech has expertize in developing essential wireless communications components, accessories, assemblies/modules, and even entire systems. With the expanding use of wireless communications technology in various test subsytems, operators and wireless systems manufacturers need knowledgeable and skilled engineers able to meet the challenges of the latest wireless communications generations. Wi-Fi 6E and 5G in particular, are presenting a new realm of testing and system design challenges, and APITech is uniquely positioned to help.

The four chapters of this cookbook are:

1. **Building an RF Testbed** – The complexity of traditional RF testing environments has steadily grown over time. APITech shares RF Testbed configurations to simulate, explore, and test with a Low PIM RF Testbed.
2. **RF Testbed Lab Programmables** – Learn about our programmable product portfolio designed for Lab and production test environment.
3. **RF Testbed Lab Connectors and Adapters** – products will influence test results in various and sometimes unpredictable ways. Find out about our product portfolio specifically designed with low PIM for RF Testbeds.
4. **RF Testbed Lab Optional Upgrades** – to handle specific use-cases or better device management.



How Can We Help You Conquer Your Commercial Wireless Strategy?

Making the most of RF technology is at the heart of this telecommunications revolution.

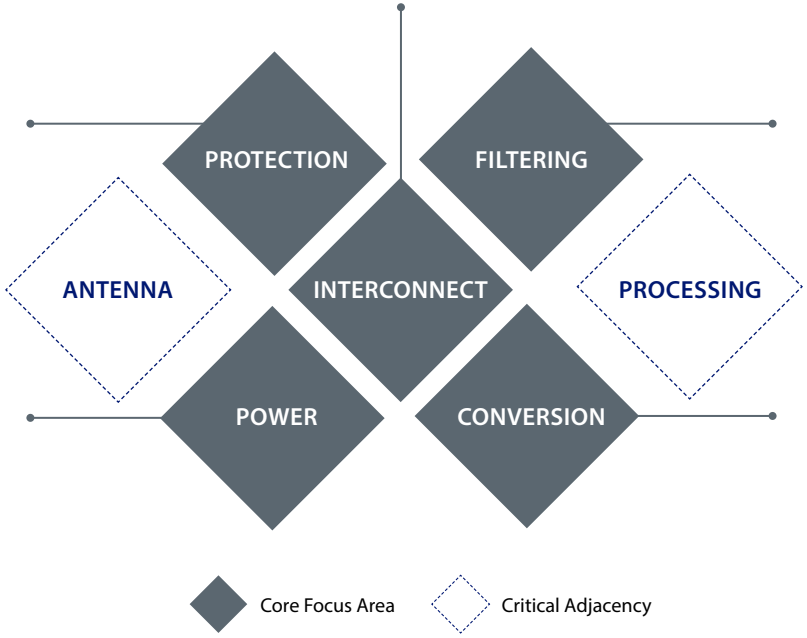
RF hardware and test systems are the keystone in bringing 5G to the masses and realizing new mobile wireless use cases. The competitive and fast pace landscape of mobile wireless is now expanding into new spectrum and technology developers are now facing previously unforeseen design, testing, and deployment challenges.

As shown in the block diagram below, APITech provides solutions in five core focus areas. From basic passive and active RF components, to integrated microwave and multifunction assemblies. APITech brings its unique legacy and multi-disciplinary expertise to modern wireless subsystems – allowing for support at every stage of product development and telecommunications deployment.

High-reliability interfaces and **INTERCONNECTS** for distributed RF systems

PROTECTION against increasingly congested electromagnetic spectrum for military and commercial systems

FILTERING to ensure the optimal mix of products are passed on to stages of an RF system to maximise mission success



DISTRIBUTED secondary power to connected rack mounted devices

Multi-disciplined integration enables complex **CONVERSION** of RF signals

Preparing for Tomorrow's World

A guide to developing innovative 5G and Wi-Fi 6E Radio Services is about solving the RF challenges for commercial wireless manufacturers and service providers that they are trying to solve, these include:

- **Successful conformance testing**
- **Ensuring network features perform as designed**
- **Optimizing MIMO and beamforming performance**
- **Integrating IoT as a standard network add-on**
- **Guarantee device feature compatibility**
- **Certify against standards (3GPP, Wi-Fi Alliance, etc.)**

We know the 5G and Wi-Fi 6E spectrum

This book talks about solving the RF challenges in component design and manufacture.

Watch a replay of our **"Meet the Author" Event!** Want to learn a little more about the book, and the authors who wrote it?

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Chapter 1
Building an RF Testbed for your Lab

Throughput Testing

Designed to perform simultaneous controlled conductive and over the air testing.

Certification Testing

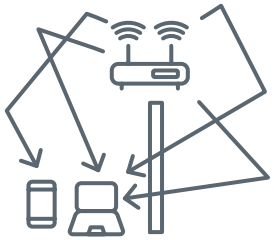
Designed for the certification of wireless radios in a controlled environment.

Hybrid Testing

Designed to allow for mobility testing for handover use-cases

Multipath Testing

Designed for testing of RF propagation in a virtual indoor or outdoor environment.



Handover Testing

Designed to allow for the testing of motion triggers roaming or cell handover and data rate adaptation.

Mesh Connectivity Testing

Designed to allow for the testing of an multi node mesh RF network conductively.

Features

Our RF testbeds provide a controlled and repeatable RF Test environment, that significantly reduces testing time. The APITech Digital Lab Assistant minimizes time-consuming setup and test execution. APITech RF Testbeds are ideal for device and network element certification, thereby confirming the highest achievable performance. APITech RF Testbeds supports the latest requirements in 5G/LTE and Wi-Fi technologies.

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Building an RF Testbed for your Lab

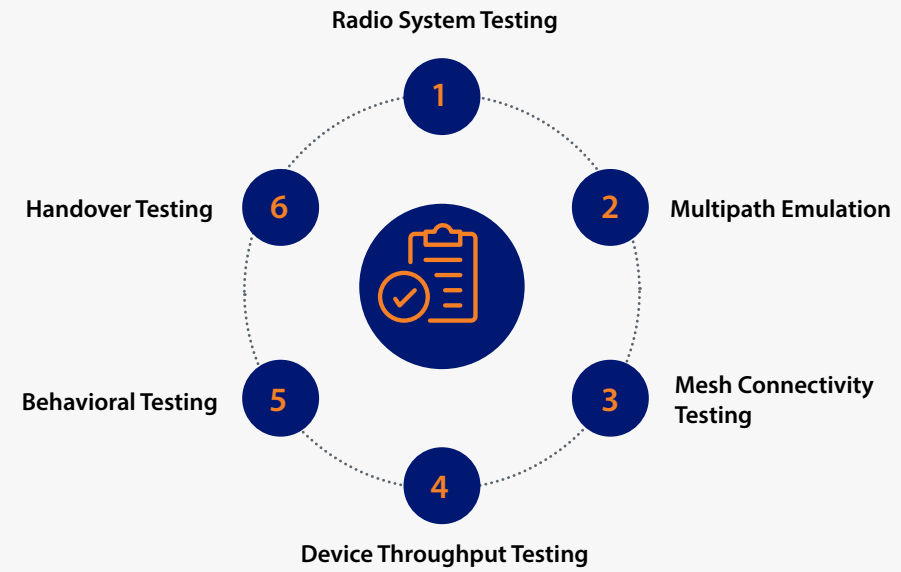
Know the early signals and what they mean now

Don't miss the Bus... Service providers and device makers can no longer make do with home-grown RF Testbed solutions.

Why operators and innovators need APITech RF Testbeds Lab to help with deploying next-gen wireless.

You could say there's an inverse correlation between how easy 4G, 5G & Wi-Fi has made broadband connectivity and how complicated network elements and device testing have become. Consider the plight of a Lab tasked with testing 4G, 5G, or Wi-Fi in recent years: constantly acquiring new components and figuring out their integration, and how to properly isolate components for repeatable testing. That was challenging enough when mobile or Wi-Fi was standalone technology, but with convergence on the horizon, "complicated" can no longer be tolerated when it comes to testing.

APITech RF Testbeds enable Test, QA, and engineers to predict the device and network performance when used in the real world. In this chapter we will introduce six RF Testbeds to accelerate your innovation. Our RF Testbeds enable performance behavioral and system tests.



> Our RF Testbed configurations deliver industry leading low insertion loss figures making it possible to efficiently test real implementations of ad-hoc and delay-tolerant routing protocols.

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RF Testbeds for labs delivering value to discover problems before launching new radio products and services

This is how to

Innovator's RF Testbed DNA serving present and future testing needs:

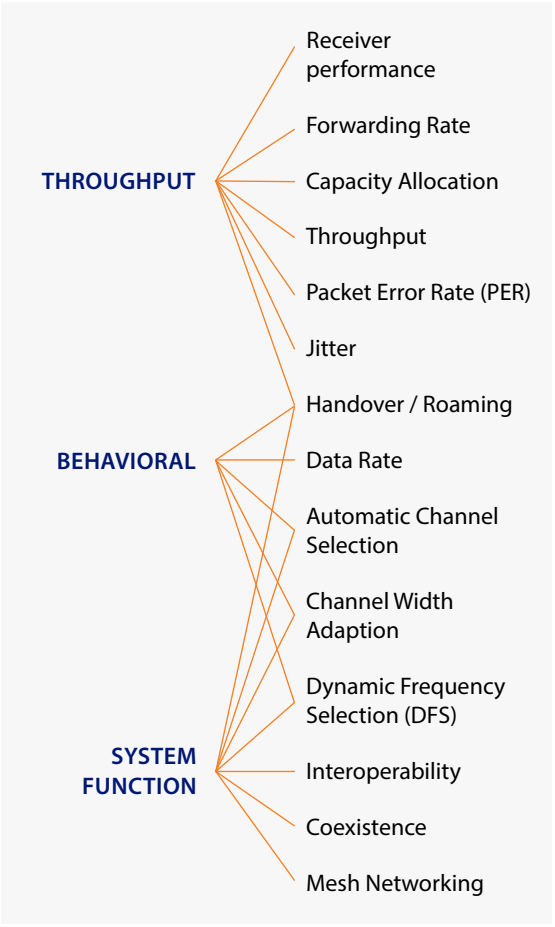
Throughput – tests the manner in which a physical system acts or functions under specified conditions is the most common performance test, but there are many other important tests for example voice and other real-time transmission such as video conferencing and gaming command stringent tests regarding packet error rate and jitter. Access point testing involves validating forwarding rate and capacity.

Behavioral – tests verify the implementation of mobility and adaptation functions to evaluate overall performance. Focus tests like data rate MCS adaption, channel:- selection, adaption and dynamic selection and roaming can help identify problems like poor throughput and packet error rate performance.

System Function – tests validate the behavioral, interoperability and coexistence protocols that must work properly to ensure reliable wireless service operation.

In response to this need APITech has designed a portfolio of six blueprint Testbeds for 5G and Wi-Fi 6 covering:

1. **Throughput Testing**
2. **5G Radio Certification Testing**
3. **Hybrid Conductive & Over-the-Air (OTA) Testing**
4. **Multipath Testing**
5. **Handover Testing**
6. **Mesh Connectivity Testing**



Do you know?

Being able to simulate, explore, and test with a low PIM RF Testbed Components has high appeal. Even seemingly small levels of intermodulation can have a significant effect on system throughput. By using Weinschel low PIM components, you can be sure that the test system accurately measures the performance of the device, and is not limited by residual PIM in the system.

APITech Weinschel offers low PIM, high power attenuators, with forward IM3 levels less than -150 dBc.

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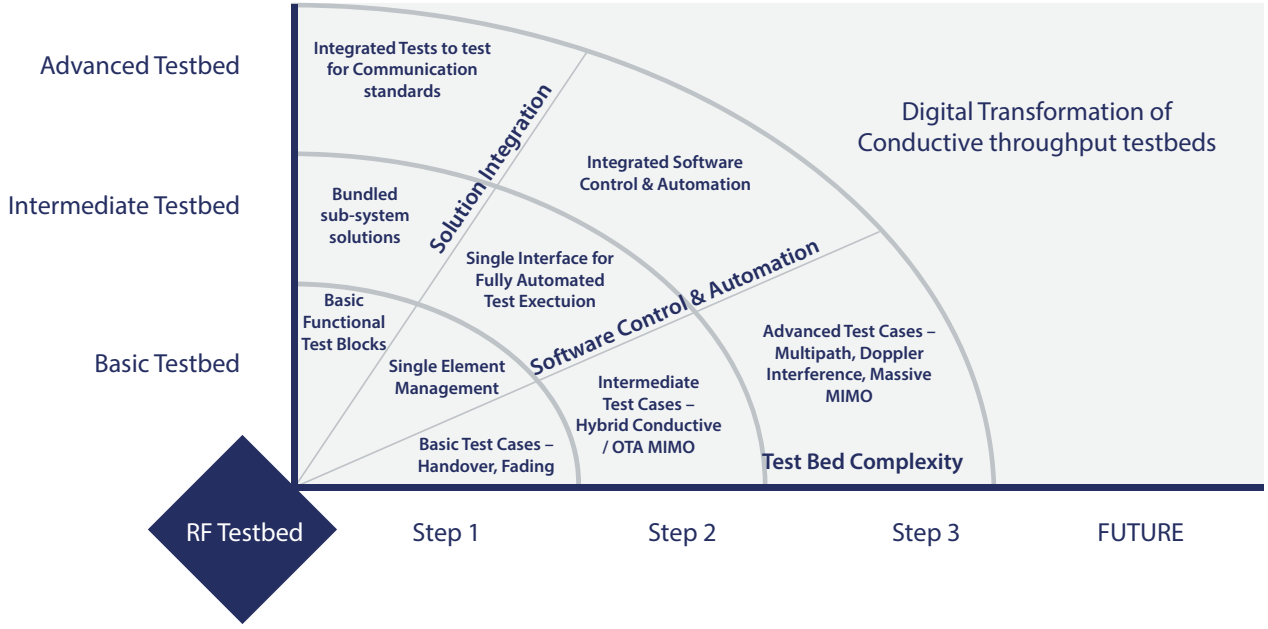
Building an RF Testbed Roadmap
This is how to

Ensuring wireless connectivity performance is fundamental for realizing the vision of 5G and Wi-Fi 6E technologies.

In APITech's experience, most RF Testbeds start with solving simple test-cases, such as throughput testing, handover, fading etc.

These conductive test cases are built using basic functional test blocks such as programmable attenuators, Butler Matrices, coaxial connectors and adapters. As test-cases evolve and become more complex and the number of test devices scale up, the complexity of the test-cases also become higher.

Today's RF Testbed's require smart bundling of sub-system testing functionality necessitating tighter integration between sub-systems . At this stage manual control of the individual test blocks is no longer feasible. The user requires a single interface to have the ability to control a variety of parameters across the different systems within the Testbed. Advanced software control and automation is desired. The ultimate goal of the RF Conductive Testbed is the full digital transformation, which includes integrated tests with integrated Software control and automation with the ability to simulate advanced test cases such as multipath, Doppler interference, Massive MIMO etc.



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RF Testbed Lab – Use case I: Throughput Testing

This is how to characterize performance of your devices

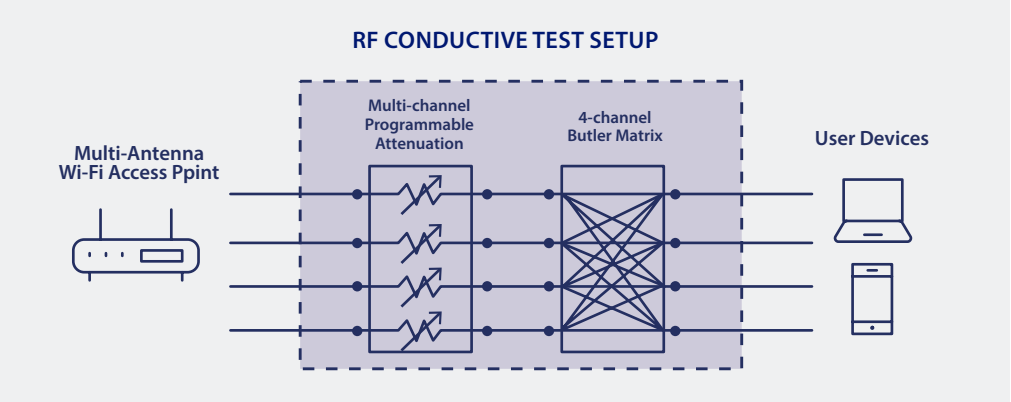
Use case I is a simple RF Testbed is designed to allow for the testing of the throughput of a number of wireless devices (5G and Wi-Fi) at various transmit and receive power levels. The RF conductive test setup shown here emulates an indoor Wi-Fi environment, with a Wi-Fi Access Point and multiple user devices. The RF Testbed can adapted for testing any other wireless technologies such as 5G, LTE, Bluetooth, Zigbee etc. as well.

This Testbed utilizes APITech's multi-channel programmable attenuators to simulate the fading loss between the access point and the user devices. Each attenuator can be programmed to continually step to different values in a sequence, or even step between random values, replicating signal loss in a wireless environment.

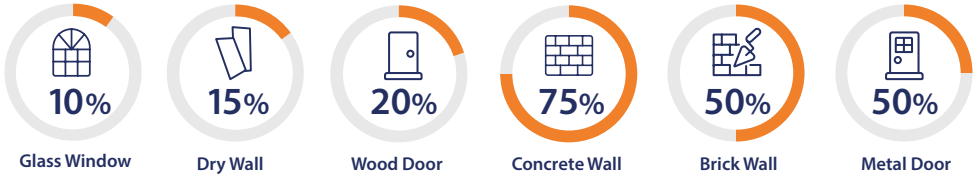
The APITech Butler Matrix enables the user to connect multiple access points to multiple user-devices and provide an optimal channel condition to the devices under test.

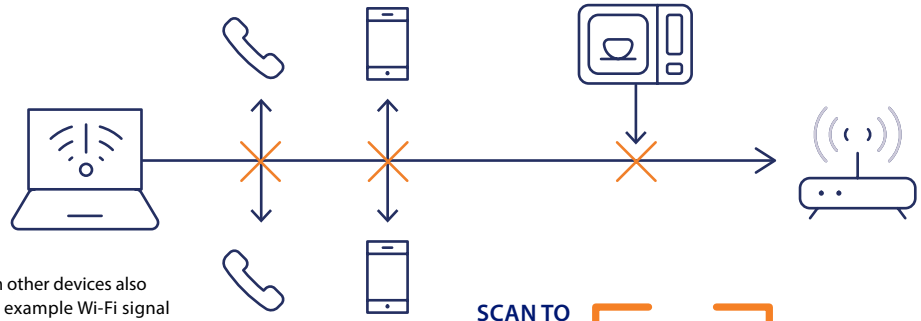
This RF Testbed comes with APITech's digital Lab assistant to help manage test automation for "out of the box" testing of device performance:

- Throughput
- Jitter
- Packet error rate vs range
- Device orientation
- Plus other aspects of device performance



Some of the other physical things that can affect your Wi-Fi signal





Interference from other devices also affects Wi-Fi. For example Wi-Fi signal in the living room could be affected whenever someone used the microwave in the kitchen.

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RF Testbed Lab – Use case II: 5G Radio Certification Testing

This is how to test and certify radios

Use case II is a RF Testbed for the certification of wireless radios. The RF conductive test setup shown here emulates an outdoor LTE/5G wireless environment, with a 5G/LTE Radio and user devices or a UE simulator. This RF Testbed can be adapted for testing any other wireless technologies such as Wi-Fi, Bluetooth, Zigbee etc. as well.

The radios under test are connected to High-Power attenuators, then into a programmable attenuator and multi-channel programmable switch. Finally the signal is routed to a commercial UE emulator. The High-Power attenuator allows the user to independently power down the power level of the High-power 5G/LTE Radios. APITech's multi-channel programmable attenuator simulates the fading loss between the radios and the user devices/UE simulator. Each programmable attenuator can be programmed continually to different values in a sequence, or even step between random values, replicating signal loss in a wireless environment. The APITech Multi-channel Programmable Switch will enable the user to connect multiple radios to multiple user-devices and control signal coordination to the devices under test.

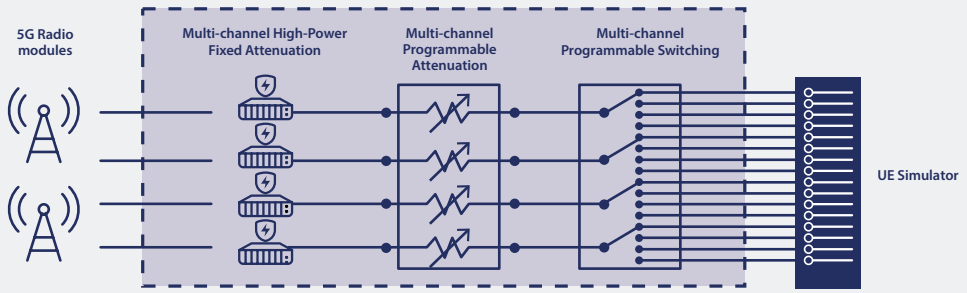
Radio Certification testing can be broken down into a number of sub tests as follows:

- **Throughput**
- **Forwarding rate**
- **Packet Error and Jitter Rate**
- **Data rate adaptation**
- **Associated capacity**
- **Receiver Performance**

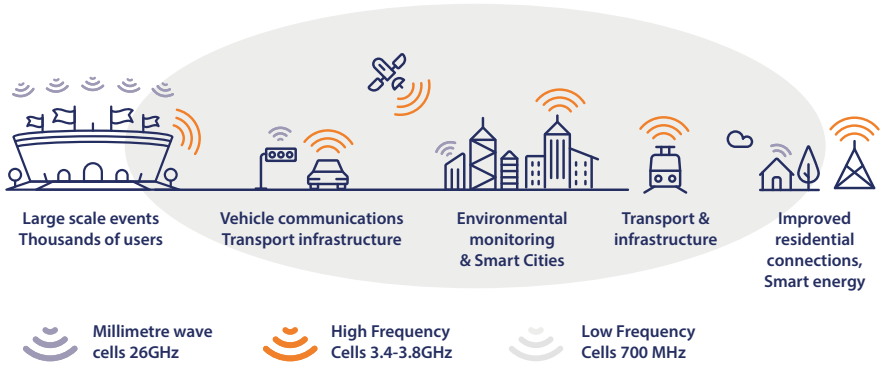
This RF Testbed comes with APITech's digital Lab assistant to help manage test automation for "out of the box" testing supporting secure remote operation and control through web, Telnet and TCP/IP interfaces.

With the addition of APITech Smart Power Distribution Subsystem, a full lights out lab that enables both RF testing and power control of the test platform and connected devices under test is created.

RF CONDUCTIVE TEST SETUP



EXPECTED 5G FREQUENCY BAND USAGE



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RF Testbed Lab – Use case III: Hybrid Conductive & Over-the-Air (OTA) Testing

This is how to enable hybrid testing

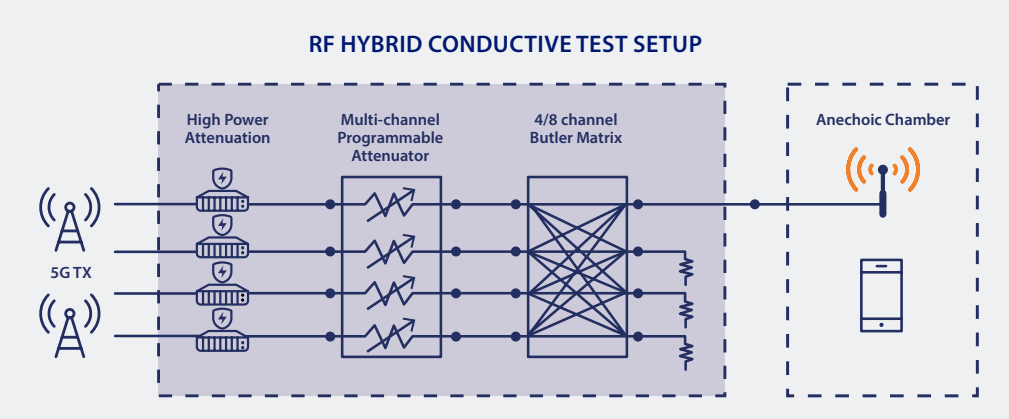
Use case III is a Testbed that allows the user to simultaneous conductive and hybrid over the air (OTA) testing. The key element of this Testbed is APITech Butler Matrix enabling the connection of multiple radios to a single antenna. A butler matrix ideally produces a channel condition number of 1, maximizing throughput. This enables the butler matrix to deliver a dissimilar number of channels and antennas to be connected.

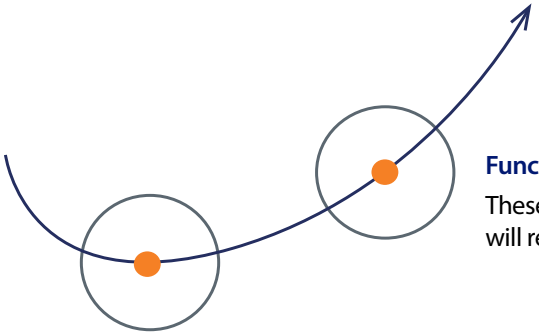
This testbed is also suitable when the DUT does not have an antenna port and controlled conductive testing cannot be performed.

This RF testbed can be upgraded by adding a Multipath emulator (10444-4) to reproduce multipath conditions in the Wi-Fi 6E frequency bands.

This RF Testbed comes with APITech's digital Lab assistant to help manage test automation for "out of the box" testing supporting secure remote operation and control through web, Telnet and TCP/IP interfaces.

A Smart Power Distribution Subsystem upgrade enables a full lights out lab enabling both RF testing and power control of the test platform and connected devices under test.





Functional Testing

These test determine how a device will react in a real environment.

Monitor information carried by the signal

This involves transmitting data from several directions over the air reducing the TX level until communications with the device is no longer possible.

> From a technical perspective, the RF architecture in 5G and Wi-Fi 6E devices and the higher frequencies being used will require hybrid Testbeds combining conductive & Over-the-Air testing as there won't be any physical connectors available in the devices. This test platform supports three OTA testing methodologies approved by 3GPP for conformance testing.

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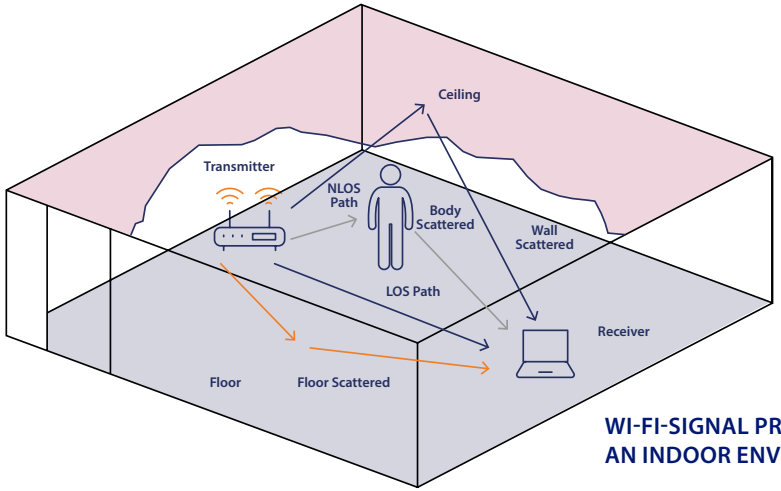
RF Testbed Lab – Use case IV: Multipath Testing
This is how to recreate real-world multipath effects

Use case IV is a Testbed that accurately models multipath in a Wi-Fi environment with a power delay path matching the IEEE TG-n channel model. It supports class B (indoor) NLOS and Expand Line of Sight (LOS) models, along with class D (outdoor) Expand Non-Line of Sight (NLoS) operation.

The broadband nature of the multipath emulator enables the tester to run multi-channel system tests and evaluate automated channel allocation models. This would be impossible using a traditional fader test systems, which only supports one channel at a time.

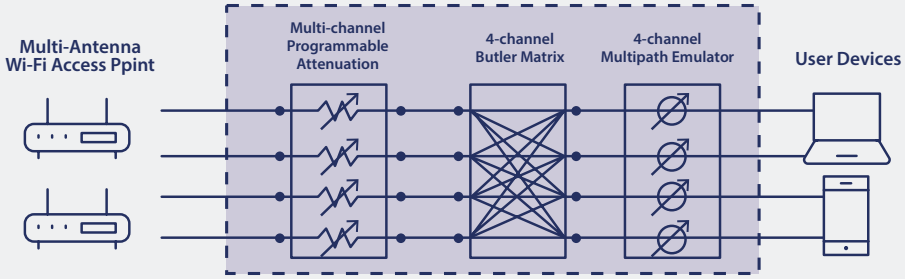
In class B mode, the Testbed produces two clusters, spaced 20 ns from one another, along with a continually decaying pulse train of taps, which are emitted by each cluster. The spacing of the taps is determined by the required system bandwidth, as specified in the TGac channel model. The system can switch between the following system bandwidth settings: <40 MHz, 40-80 Mhz, 80-160 Mhz, and 160 – 320 MHz. This corresponds to tap spacing of 10 ns, 5 ns, 2.5 ns and 1.25 ns respectively.

> Our RF Testbed configurations ensure you have the right knowledge to drive your business, essential in a world that never rests.



WI-FI-SIGNAL PROPAGATION IN AN INDOOR ENVIRONMENT

RF CONDUCTIVE TEST SETUP



An on-board phase shifter provides the ability to exercise the DUT under the full range of multipath conditions (both destructive and constructive interference).

This RF Testbed comes with APITech's digital Lab assistant to help manage test automation for "out of the box" testing of device performance:

- Throughput
- Jitter
- Packet error rate vs range
- Device orientation
- Plus other aspects of device performance

While the RF conductive test setup shown here emulates a Wi-Fi environment, with a wi-fi access points and user devices, this Multipath RF Testbed can adapted for testing any other wireless technologies such as 5G/LTE, Bluetooth, Zigbee etc. as well.

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RF Testbed Lab – Use case V: Handover Testing
This is how to test for mobility use-cases

Use case V is a RF Testbed that allows for the handover testing of wireless radios. Motion triggers roaming or cell handover and data rate adaptation and thus affects all performance and behavior matrixes of a device or system under test. The RF conductive test setup shown here emulates an outdoor LTE/5G wireless environment, with a 5G/LTE Radio and user devices. This RF Testbed can be adapted for testing any other wireless technologies such as Wi-Fi, Bluetooth, Zigbee etc. as well.

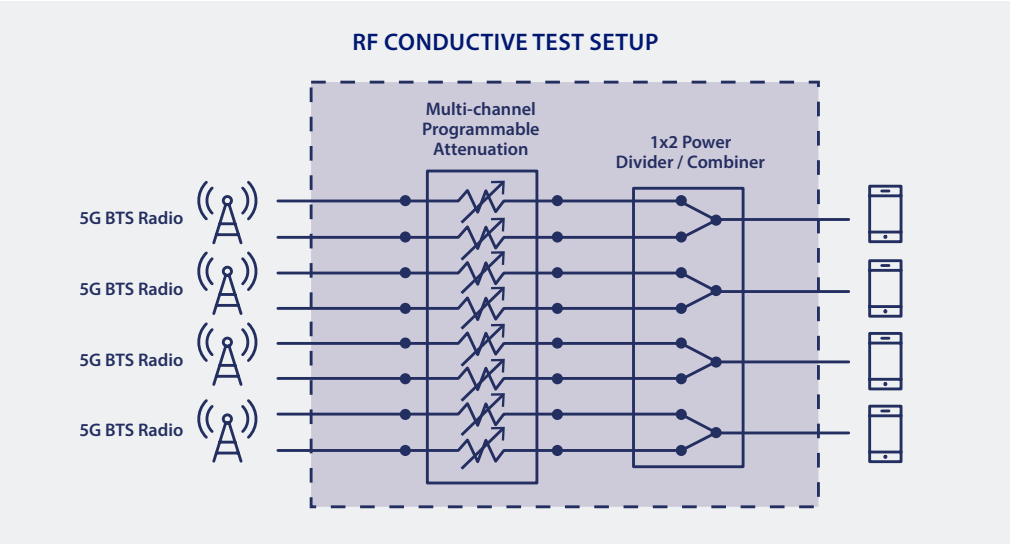
The radios under test are connected to power dividers/combiners, then into multi-channel programmable attenuators. Finally the signal is routed to a number of user-devices.

Motion can be emulated by ramping the attenuators to introduce signal fading loss versus time. The ramping rate can be accurately controlled to emulate velocity of mobile devices. APITech's multi-channel programmable attenuators help simulate the fading loss between the radios and the user devices in a dynamic wireless environment. Each programmable attenuator can be independently programmed to continually step to different values in a sequence, or even step between random values, replicating signal loss in a wireless environment.

Base stations or Access Points (Inter System Handover) between different user devices (Inter Technology Handover) and between different technologies (Wi-Fi 6E and 5G) (Inter Technology Handover).

This RF Testbed comes with APITech's digital Lab assistant to help manage test automation for "out of the box" testing of handover performance:

- Fading Simulation
- Received signal level and received signal quality
- Inter system handover
- Inter technology handover
- Inter technology hand off (Vertical handover)



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RF Testbed Lab – Use case VI: Mesh Connectivity Testing – This is how to emulate a multi node mesh RF network

Use case VI is a Testbed to emulate a multi node mesh RF network conductive Testbed dealing with complexities as the numbers of radios and number of peer-to-peer connections increase exponentially.

The APITech Mesh Network Testbed enables you to:

- **Test Mesh Node Placements** and the formation of dynamic routing connections for point-to-point or end-to-end environments ensuring that data and applications can be securely delivered and controlled across a wide range of environments.
- **Station Moving Patterns** moving between nodes sequentially, jumping out of sequence etc.
- **Load Patterns** – looking at fixed and mobile devices moving around in the business premieres handing over between nodes running data confirming data and applications can be securely delivered and controlled across the mesh network environments.

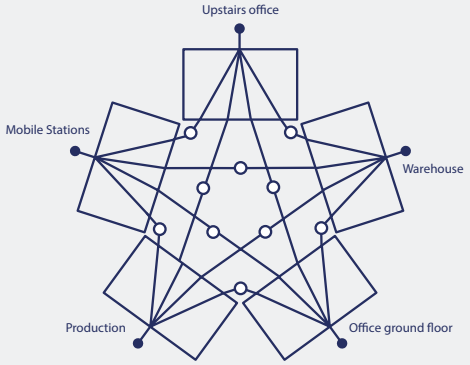
The Testbed shown in example schematic is a 5-port mesh network test system with a full fan-out architecture. Every user device is connected to every other user device, with an independently-controlled programmable attenuator in each path. In the case of a mesh network, each user device will need to connect to each other via a multiport power splitter/ combiner. Between each connection on each splitter, a programmable attenuator is being connected. Varying the signal levels in each programmable attenuator will recreate the real world fading and multipath scenarios that can occur in a mesh setting. The entire setup is bidirectional and hence each user device can be used to receive and transmit signals.

This RF Testbed comes with APITech's digital Lab assistant to help manage test automation for "out of the box" testing of mesh network performance:

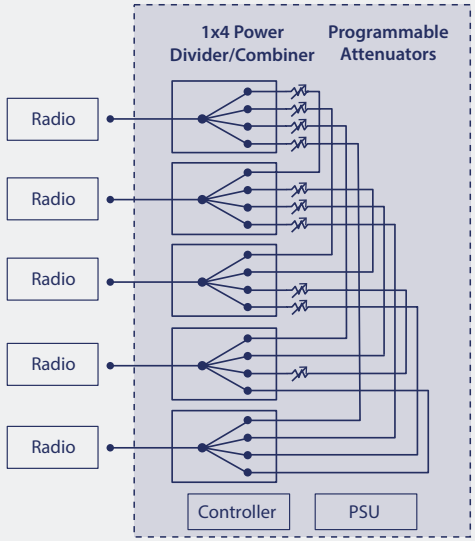
- Data Plane Performance per Hop
- Performance in Different Mesh Configurations
- Station Load Balancing
- Fast Roaming – 802.11k/v/r
- Auto Channel Selection
- Link Failover / Self-Healing
- Video Performance
- Mobile Client Performance / Handover Scenarios

RF CONDUCTIVE TEST SETUP

5X5 MESH NETWORK TEST FLOORPLAN – EXAMPLE SCHEMATIC



5X5 MESH TESTBED FUNCTIONAL SCHEMATIC



APITech 5x5 Mesh Network Test System

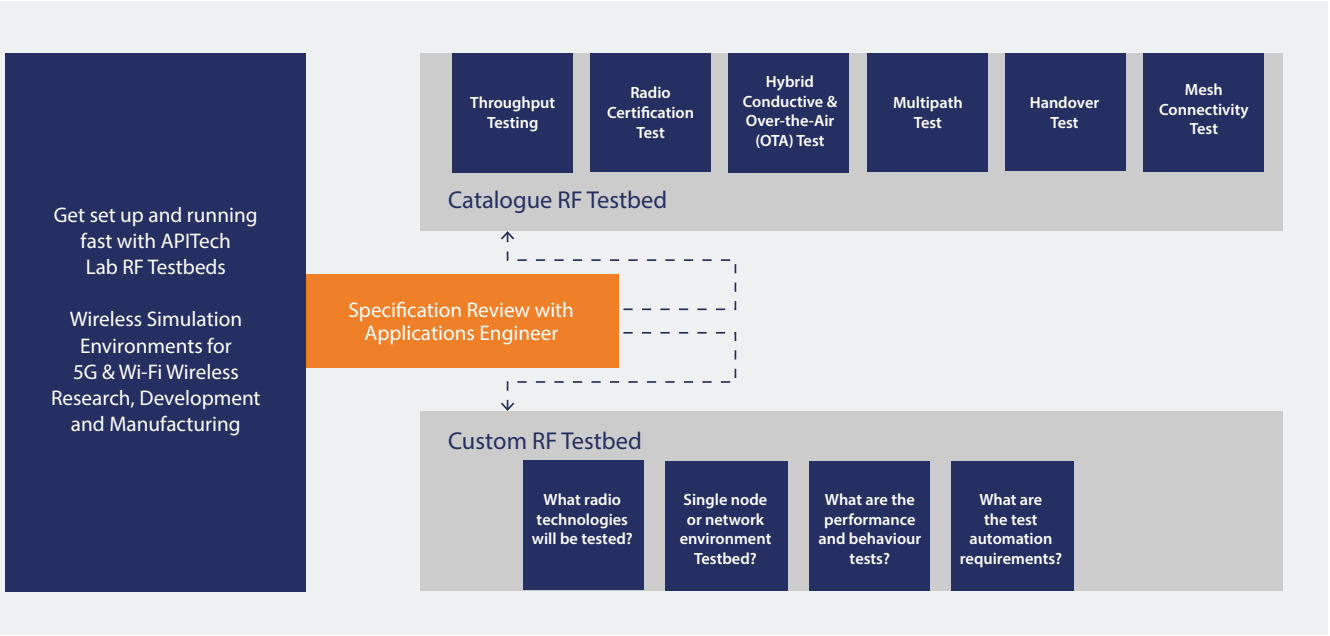
SCAN TO FIND OUT MORE

RF Testbed Design Support

Our RF Testbed configurations deliver industry tools to ensure reliable connectivity.

Yes a new technology might sound great in theory, but unless it can cope with the real world it is unlikely to be adopted by a target market. This is where APITech's six RF Testbeds step in. It is now easier than ever for tech entrepreneurs to test their new innovations – identify and solve potential issues and debug in the early stages before presenting to their customers.

Custom RF Testbed's can be designed and built to your specification. Contact us with your specialized needs.



Chapter 2
Programmable Products

Attenuators

Well-suited for transmission loss simulation, signal fading and handovers.

Switches

For routing RF signals between various inputs and outputs, enabling multiple tests without changing the setup.

Phase Shifters

For changing the transmission phase angle of an input signal by adding propagation delay.

High-Power Attenuators

Enables high power (up to 400W) radio testing & profile simulation.

Butler Matrices

For multichannel MIMO testing in a controlled conductive environment.

Digital Lab Assistant

For setup, control and automation of test measurements using APITech programmable products.

Features

APITech RF programmable products form the basic building blocks for RF testbeds. They are extensively used in labs and production test environments to perform RF conductive testing for a variety of use-cases and applications. They are available in a variety of performance levels, configurations and bandwidths and each product comes as "plug-and-play" supported by our Digital Lab Assistant and easy-to-use control scripts.

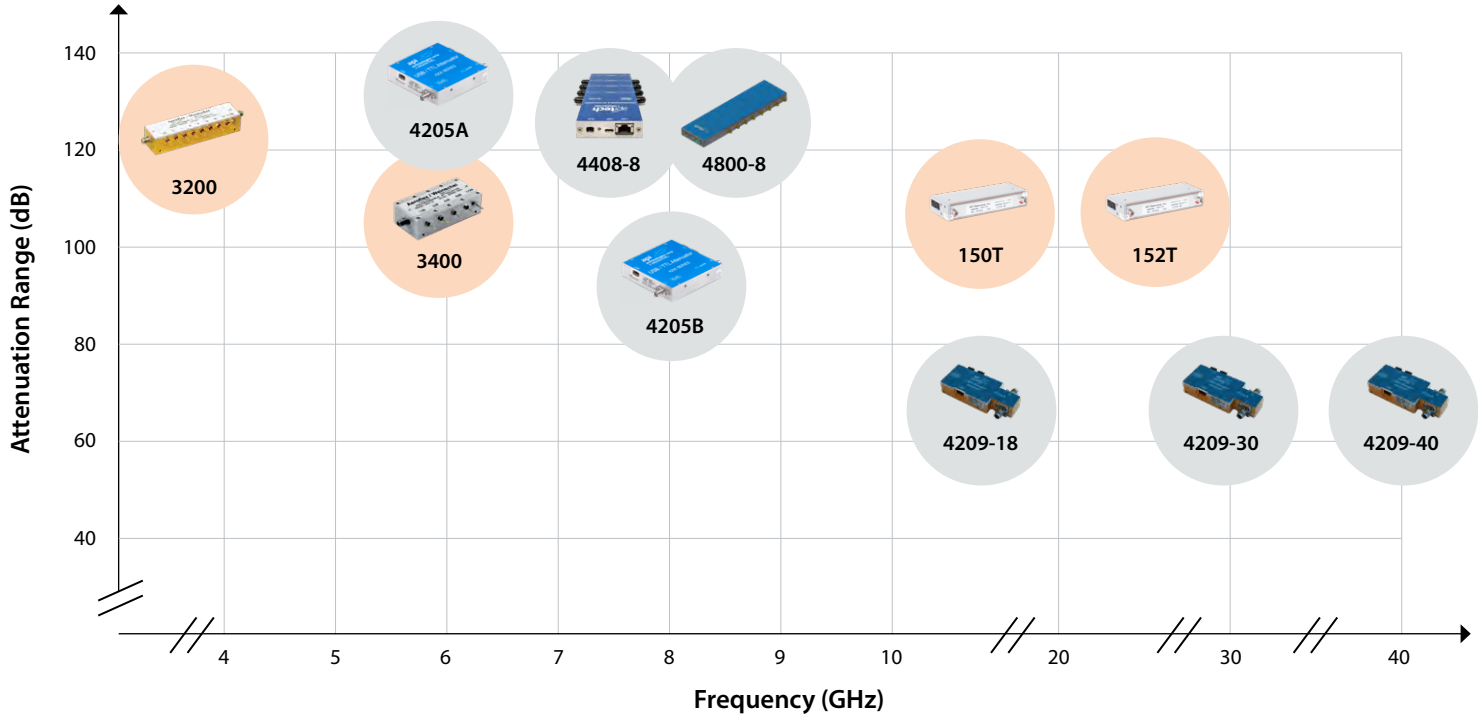
SCAN TO FIND OUT MORE

RF Testbed Lab Programmable Attenuators – It's what we do

APITech programmable attenuators are available in either solid-state or electro-mechanical configurations, providing precise level control with accurate, repeatable performance for a wide range of test applications from 'true' DC to 43 GHz.

Wide attenuation ranges are available up to 127 dB, with 0.1dB step fine tuning that maintains high linearity over the entire range of attenuation.

APITech programmable attenuators have a very low form factor and perfect for use in the lab or as part of a network deployment or portable test setup. All models are compatible with APITech Digital Lab Assistant facilitating test automation.



Solid-State

Electro-Mechanical

NOTES:

1. Attenuation range indicates the maximum attenuation range for each particular model series.
2. Lower attenuation ranges are available for all series.
3. Custom variants are available upon request.

SCAN TO FIND OUT MORE

RF Testbed Lab Programmable Attenuators – It's what we do

The key specifications

Series	Type	Channel(s)	Frequency Range (GHz)	Max Attn. (dB)	Step Size (up to)	Max RF Input Power	RF Connectors	Applications
320x	Electro-mechanical	1	DC to 3	127	0.1	+30	SMA	Antenna interface units, RF distribution & conditioning units, and patch panels.
340x	Electro-mechanical	1	DC to 6	103	1	+30	SMA	3G/4G/5G, Wi-Fi, V2X RF distribution & conditioning units.
3456	Electro-mechanical	1	DC to 3	63	1	+30	F-type	Cable modem DOCSIS 3.X & 4, Cable TV and Instruments.
15x	Electro-mechanical	1	DC to 4, 18, 26.5	110	1	+30	3.5mm	Radar, SATCOM, and Bluetooth (Low insertion loss).
4205A/B	Solid-state	1	0.003 to 6, 8	127	0.25	+28	SMA	Wi-Fi 6E, Wireless Access Points- Firmware testing and hardware development, wireless handsets at chip and retail product levels.
4209	Solid-state	1	0.1 to 18, 30, 40	63	0.5	+28	SMA, 2.92mm, 2.4mm	5G and Bluetooth wireless link simulation and testing, wireless fitness wearables, Mil/Defense EW, radar and communications bands (18 GHz), Point-to-Point radio.
4204	Solid-state	1	0.03 to 3	95	0.5	+28	F-type	Cable Modem DOCSIS 3.X & 4 - at chip and retail product levels, Cable TV; Instruments.
440x	Solid-state	4	0.003 to 8	127	0.25	+28	SMA	WiFi 6E, Wireless Access Points-Firmware testing and Hardware development; Wireless Handsets – Chip Level and Retail product.
480x	Solid-state	8	0.003 to 8	127	0.25	+28	SMA	WiFi 6E, Wireless Access Points-Firmware testing and Hardware development; Wireless Handsets – Chip Level and Retail product.

SCAN TO FIND OUT MORE

RF Testbed Lab Programmable Attenuators – It's what we do

Selecting an Electro-mechanical vs Solid-state programmable attenuator

Here are the key factors to consider when selecting a programmable attenuator are Insertion loss, linearity, and switching speed.

Electro-mechanical Programmable Attenuators – use a cascaded assembly of switched attenuator cells (typically 3 to 5). The attenuator elements located in the attenuator cell are created by APITEch's proprietary thin-film process which provides exceptional long-term stability and requires low power.

Our electro-mechanical attenuators use a reed switching structure that provides rapid switching together with low insertion loss. Step solenoids are used to switch each cell's internal thin-film resistor card (provides programmable step attenuators with a high degree of accuracy and the lowest possible VSWR uncertainty) into or out of the circuit.

Solid-state programmable attenuators – have no moving parts and are designed using semiconductor technology delivering faster switching times with an almost infinite lifetime. APITech's solid-state programmable attenuators come in a smaller light weight form factor. Solid-state programmable attenuators require less power, compared to their electro-mechanical counterparts. In addition, solid-state programmable attenuators are excellent for applications where repeatability and isolation are important.

The key differences

Attribute	Electro-mechanical	Solid State
Signal Type	Can operate at frequencies down to true DC	RF only
Insertion Loss	Lower	Higher
Life	Rated switch life of 5 million operations per cell	High MTBF
Switching Capabilities	Switching time for each cell is rated at 20 millisecond maximum (including the contact settling time)	Settles in nanoseconds
Linearity	High IP3, solid mechanical contact	Moderate IP3
DC Power required	High	Low

Model 150 Relay Switched Programmable Attenuator 50 ohm Bidirectional Unit operating DC to 18 GHz frequency range.

Model 4205B Programmable Attenuator. 50 ohm Bidirectional units operating over the 0.3 to 8000 MHz frequency range.

SCAN TO FIND OUT MORE

RF Testbed Lab Multi Channel Programmable Attenuators – It's what we do

APITech multi-channel programmable attenuators provide RF signal level control from DC to 43 GHz across multiple independently controllable channels. Each channel control provides up to 127 dB attenuation in 0.1 dB steps with more than 100 dB isolation between channels. APITech's design maintains linear attenuation change per dB, even at the highest attenuation settings.

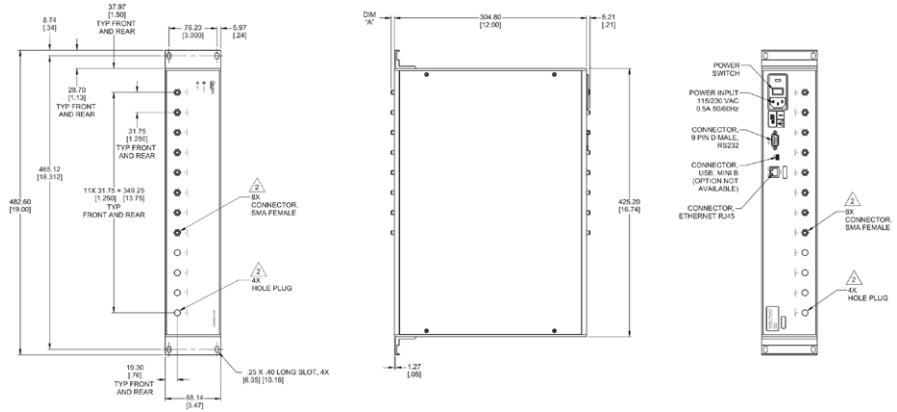
All models are compatible with APITech's digital Lab assistant programmable control software facilitating test automation controlled via USB, Ethernet, Serial and GPIB.

Multi-channel Programmable Attenuator with front-panel control (8321 Series)

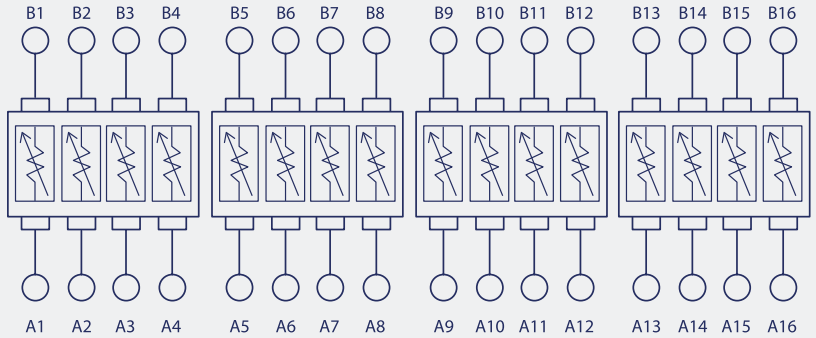
Multi-channel Programmable Attenuator without front-panel control (8331 Series)

Multi-channel Attenuator Profile System (8334 Series)

Front and Rear view with through connectors



Functional schematic of a 16-channel Attenuator system



SCAN TO FIND OUT MORE

RF Testbed Lab Multi Channel Programmable Attenuators – It's what we do

The 8320 Multi-channel Programmable Attenuator product is housed in half rack enclosure that can be configured up to 4 channels.

APITech 8320, 8321 and 8331 Multi-channel Programmable Attenuator products offer a high-degree of customization to the user in terms of:

- **Attenuator model (performance – frequency range , attenuation range and step size).**
- **Connector options (N, SMA, 2.92mm and F).**
- **Connector locations (front, rear, or front to rear connections).**
- **# of independently controlled channels (up to 16 for standard configurations).**

In addition, APITech also provides custom subsystems where a variety of test configurations can be incorporated within a single unit. Contact us with your specialized needs.

The key specifications

Series	Description	Frequency Range	Max. # of Channels	Rack-mountable	RF Connec-tors	Applications
8320	Half-rack bench-top enclosures that can be configured up to 4 independently controlled attenuator channels with front-panel local control.	DC to 40 GHz	4	No	N, SMA, 2.92, F-type	For bench test and ATE applications.
8321	Full 19" standard enclosures that can be configured up to 16 independently controlled attenuator channels, with front-panel local control.	DC to 40 GHz	16	Yes	N, SMA, 2.92, F-type	For bench test and ATE applications.
8331	Full 19" standard enclosures that can be configured up to 16 independently controlled attenuator channels.	DC to 40 GHz	16	Yes	N, SMA, 2.92, F-type	For ATE and systems applications.
8334	Multi-channel, high-speed, attenuation control , that can be synchronized with one another, supporting the programming of up to 131,072 attenuation sequence points per attenuator, that can sweep through them at user defined intervals.	DC to 18 GHz	8	Yes	SMA, N-type	Simulate channel path loss on each channel for mobility scenarios. Creates arbitrary, synchronous attenuation profiles to replicate fading and handover scenarios.

SCAN TO FIND OUT MORE

RF Testbed Lab Multi Channel Programmable Attenuators – It's what we do

Product Configuration Selector

Series	Attenuator Model	Frequency Range	Max Attn. (dB)	Min. Step Size (dB)*	Connector Options				Maximum Number of Attenuators / Channels per unit			
					N	S (SMA)	K	F	8320 T (front to rear)	8320 F(ront) or R(ear)	8321/8331 T (front to rear)	8321/8331 F(ront) or R(ear)
A	320x	DC-3.0 GHz	127	0.1	X	X	X		4	2	12	8
B	340x	DC-6.0 GHz	127	0.25	X	X	X		4	2	12	8
C	150T	DC-18.0 GHz	110	1	X	X	X		2	1	10	8
D	152T	DC-26.5 GHz	105	1		X	X		2	2	10	8
F	3456	DC-3.0 GHz (75Ω)	63	1				X	4	2	12	8
J	4226	0.8-3.0 GHz	103	0.25	X	X	X		4	2	12	8
K	4238	0.01-2.5 GHz	103	0.25	X	X	X		4	2	12	8
L	4246	0.01-2.5 GHz	103	0.25	X	X	X		4	2	12	8
M	4205A/B	300 KHz-6.0 / 8.0 GHz	127	0.25	X	X	X		4	2	16	8
N	4204	0.035-3.0 GHz (75Ω)	95.5	0.5				X	4	2	12	8
P	4209	100 MHz-18 /30/40 GHz	63	0.5	X	X	X		4	2	16	8

SCAN TO FIND OUT MORE

RF Testbed Lab Programmable Switches – It's what we do

APITech's RF programmable switches are designed for delivering best-in-class insertion loss, isolation and linearity and are used in a wide range of Wi-Fi and LTE/5G applications. They are ideal for RF testbeds simulating wireless fading and handover use-cases.

4284A Single Pole Four Throw (SP4T) digital switch operates over the 10 MHz to 8000 MHz frequency range. All unselected ports are internally terminated to a 50 ohm load. This product can be controlled using parallel (TTL compatible), I2C, SPI, UART, or USB interfaces.

8512 programmable is a multi-channel programmable switch and is available in electro-mechanical or solid-state switch options operating from DC to 8/18/26.5/40 GHz frequency range.

4284A Single Pole Four Throw (SP4T)

8512 Multi-channel Programmable Switch

The key specifications

Series	Frequency Range	Switch Type	# of Switch Positions per channel	RF Connectors
A	DC to 18 GHz	Failsafe to open; Make Before Break	SP3T to SP6T	SMA Female
B	DC to 18 GHz	Latching; Make Before Break	SP3T to SP6T	SMA Female
C	DC to 26.5 GHz	Failsafe to open; Break Before Make	SP3T to SP6T	SMA Female
D	DC to 40 GHz	Failsafe to open; Break Before Make	SP3T to SP6T	2.92 mm Female
M	0.01 to 8 GHz	Terminated	SP4T only (terminated)	SMA Female

SCAN TO FIND OUT MORE

RF Testbed Lab Programmable Phase-shifters – It's what we do

APITech programmable phase shifter products are used to change the transmission phase angle of an input signal, offering a phase accuracy down to 2° phase resolution.

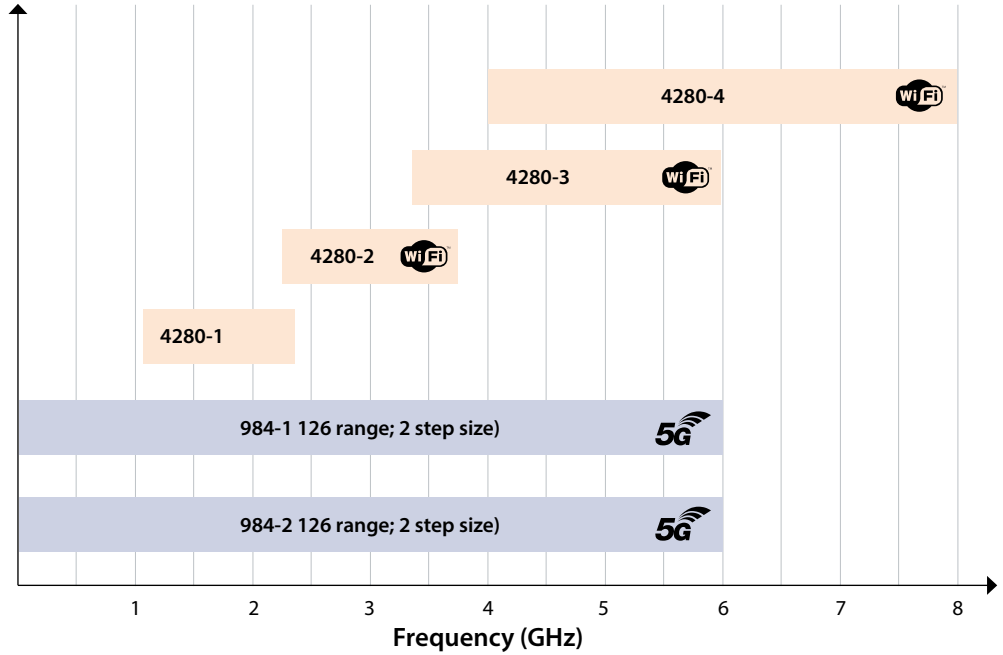
984 series programmable phase shifters are electro-mechanical relay based, operating from DC to 6 GHz frequency range. Electro-mechanical relays engage certain delay lines to achieve the required phase shift. This series is available with a phase shift range from 0° to 630° in 10° steps & 0° to 126° in 2° steps @ 6 GHz.

4280 series uses solid-state technology and combines a programmable phase shifter and programmable attenuator operating over several frequency ranges. They are available in an attenuation range of 0 to 63.75 dB in 0.25 dB steps and phase range of 360^0 in 5.625^0 steps.

Phase resolution can be set from the digital Lab assistant or configured from an uploaded phase profile or programmed using the APITech provided DLLs.

4280 Series Solid-State

984 Series Electro-Mechanical



The key specifications

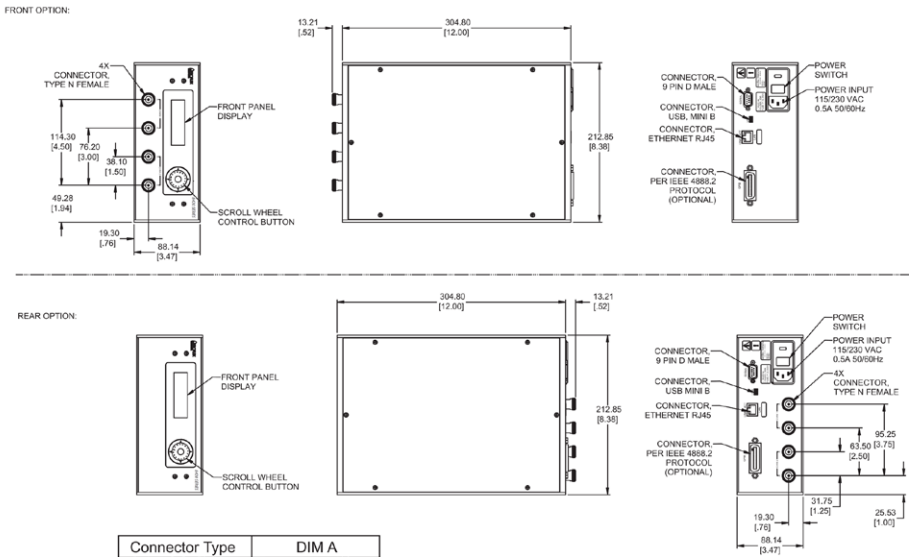
Series	Type	Frequency Range (GHz)	Max Attn. (dB)	Step Size (up to)	Max RF Input Power	RF Connectors	Control	Applications
984	Electro-mechanical	DC to 6GHz	360	2 deg	+30	SMA	+12V / TTL	Antenna interface units, RF Distribution & Conditioning units.
4280	Solid-state	Various bands between 1 GHz to 8 GHz	360	5.625 deg	+23	SMA	I	Ideal for Automated Test Equipment (ATE), 2G/3G/4G LTE/5G fading simulators, MIMO, WiMAX, WiFi, engineering /production test lab environments.

SCAN TO FIND OUT MORE

RF Testbed Lab Multi Channel Programmable Phase-shifters – It's what we do

8420 and 8421 multi channel programmable phase shifter products represent a new streamlined approach to independently control phase shift over multiple channels for bench test and subsystem applications. This series is designed to house and control multiple programmable phase shifters via front panel controls, Ethernet, USB, Serial and GPIB communications interfaces.

Benchtop Unit (8420 Series)



19" Rack with Front-panel control (8421 Series)

The key specifications

Series	Description	Frequency Range	Max. # of Channels	Rack-mountable	RF Connectors	Applications
8420	Half-rack bench-top enclosures that can be configured up to 4 independently controlled attenuator channels.	DC to 40 GHz	4	No	N, SMA	For bench test and ATE applications.
8421	Full 19" standard enclosures that can be configured up to 16 independently controlled attenuator channels, with front-panel local control.	DC to 40 GHz	16	Yes	N, SMA	For bench test and ATE applications.

SCAN TO FIND OUT MORE

RF Testbed Lab Multi Channel Programmable Phase-shifters – It's what we do

The 8420 series is a bench-top unit, housed in a half-rack enclosure and can be configured up to 4 interdependently controlled channels. The 8421 series is housed in full rack 19 inch enclosure and can be configured for up to 16 channels. Connector locations for 8420 and 8421 can be located on front, rear or front to rear RF connections. APITech also provides custom configurations where a variety of test configurations can be incorporated within a single unit. Contact us with your specialized needs.

APITech 8420 and 8421 series Multi-channel Programmable Phase-shifter systems offer a high-degree of customization to the user in terms of:

- Phase shifter model (performance – phase range , step size, etc.).
- Connector options (N and SMA).
- Connector locations (front, rear, or or front to rear RF connections).
- # of independently controlled channels (up to 16 for standard configurations).

In addition, APITech also provides custom RF subsystems where a variety of test configurations can be incorporated within a single unit. Contact us with your specialized needs.

Product Configuration Selector

Frequency Range (GHz)	Phase Shifter Designation	Phase Shifter Model	Range @ 6 GHz (˚)	Step Size (˚)	Connector Options		Maximum Number of Phase Shifter/ Channels per unit			
					S (SMA)	N	8420 (front to rear)	8420 (front or rear)	8421 (front to rear)	8421 (front or rear)
DC - 6 GHz	A	984-1	630	10	X	X	4	2	16	12
DC - 6 GHz	A	984-2	126	2	X	X	4	2	16	12
1.2 - 2.4 GHz	B	4280-1	360	5.625	X	X	4	2	16	12
2.3 - 3.8 GHz	B	4280-1	360	5.625	X	X	4	2	16	12
3.5 - 6.0 GHz	B	4280-3	360	5.625	X	X	4	2	16	12

SCAN TO FIND OUT MORE

RF Testbed Lab High-Power Programmable Attenuators – It's what we do

High-power programmables delivering low cost, easy to program flexible solution for your high power test application needs. Perfectly suited for: 4G LTE/ 5G Base Station Testing, Automated Test Equipment (ATE) and Engineering / Production Test Lab environments.

The 8351 series high-power programmable attenuator supports up to 6 channels at 400 watts C.W. The 8351 features conduction-cooled attenuators, mounted on an internal heat sink cooled with 2 automatic, variable speed fans. Each channel is monitored with temperature status reported through USB 2.0 and serial communication interfaces.

The 8343 series high-power programmable attenuator includes hot switching, broadband programmable attenuator, with power handling up to 100 watts on average. Available in 0-15 dB or 0-31 dB attenuation range configurations, delivering low Insertion loss, high accuracy and repeatability.

Custom configurations where multiple dB values and high power requirements can be configured. Contact us with your specialized needs.

High-Power Multi-channel Attenuator System (8351 Series)

High-Power 100W Programmable Attenuator System (8343 Series)

The key specifications

Series	Description	Power Handling per channel	Frequency Range	Max. # of Channels	Rack-mountable	RF Connectors	Applications
8351	High-power multichannel fixed attenuator product used to monitor up to 6 channels, with power handling of up to 400 watts C.W.	400W	DC to 6 GHz	6	Yes	N-type	FR1 band - BTS (Base Transceiver Station), Distributed Antenna Systems (DAS)Radio, and High Power RF Amplifier Testing.
8343	High-power hot-switching broadband programmable attenuator.	100W	DC to 12 GHz	2	Yes	N-type	For FR1 high power signal removal from the main signal path.

SCAN TO FIND OUT MORE

RF Testbed Lab Butler Matrices – It's what we do

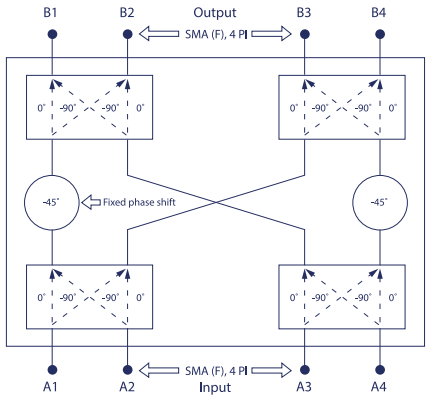
A Butler matrix allows the user to control the direction of the antenna beam, or beams. A Butler matrix consists of an n X n matrix, with n input and output ports and consists of hybrid couplers and fixed-value phase shifters.

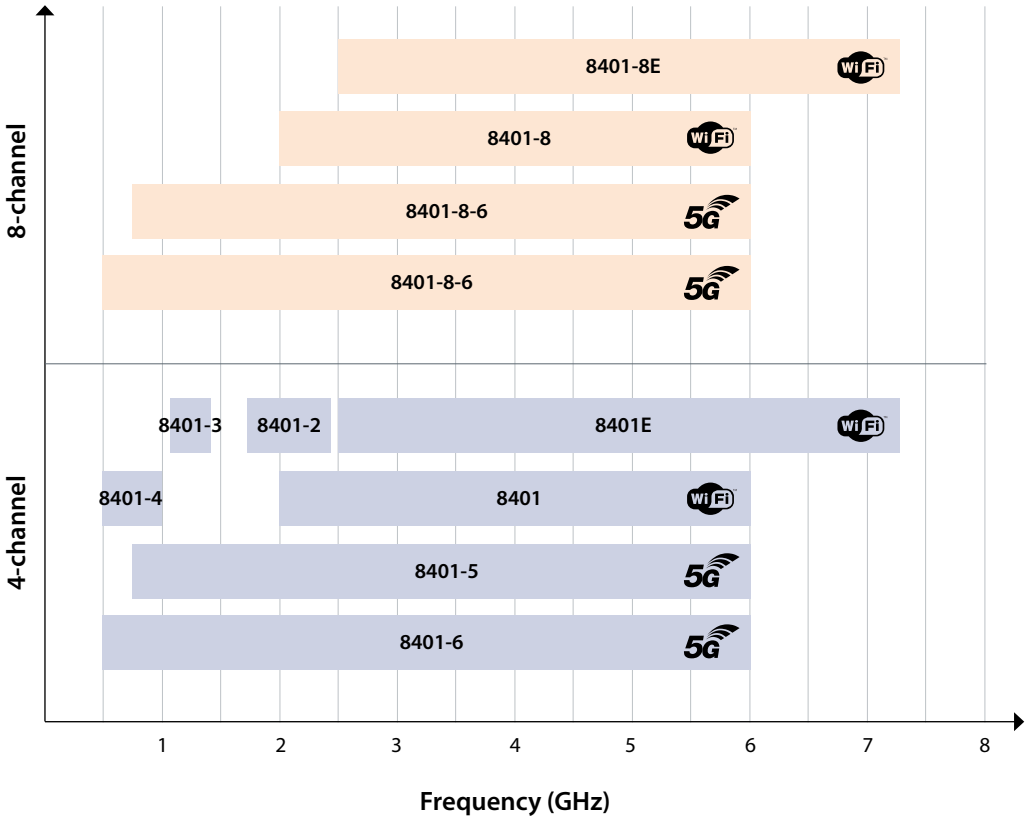
When connected to the phased-array antennas elements, a Butler matrix provides a progressive phase difference between elements, thereby steering the antenna beam in the desired direction. The additional advantage of Butler matrices is that they are passive devices and reciprocal networks, and can be used for transmission and receive networks simultaneously with the same performance.

Butler matrices are used in Multichannel Multiple Input/Multiple Output (MIMO) testing to simulate real-world, over-the-air conditions in a controlled conductive test setup. This enables 'true' testing of your wireless devices, whether its smartphones, sensors, routers and wireless access points.

The primary characteristics of the APITech Butler matrices are:

- n inputs and n outputs, with n usually 4 or 8.
- High degree of isolation between the input ports.
- Phases of n outputs are linear with respect to position.
- The phase increment between the outputs depends on which input(s) you use.





SCAN TO FIND OUT MORE

RF Testbed Lab Butler Matrices – It's what we do

The key specifications

	Butler Matrix 4x4	Butler Matrix 8x8
Frequency Range	Covers 5G FR1 and Wi-Fi 6E Bands up to 8 GHz	Covers 5G FR1 and Wi-Fi 6E Bands up to 8 GHz
Insertion loss	8 dB (Typical)	16 dB (Typical)
Amplitude Balance	±4 dB max	±4 dB max
Output Phase Accuracy	±10° typical	±20° typical
RF Input Power	37 dBm	37 dBm
Isolation	18 dB (Typical)	16 dB (Typical)
VSWR	1.5:1 (Typical)	1.8:1 (Typical)

8401 Series 4x4 Butler Matrix

8401-8 8x8 Butler Matrix

SCAN TO FIND OUT MORE

RF Testbed Lab Digital Lab Assistant – It's what we do

APITech programmable Digital Lab Assistant software facilitates test automation allowing the user to:

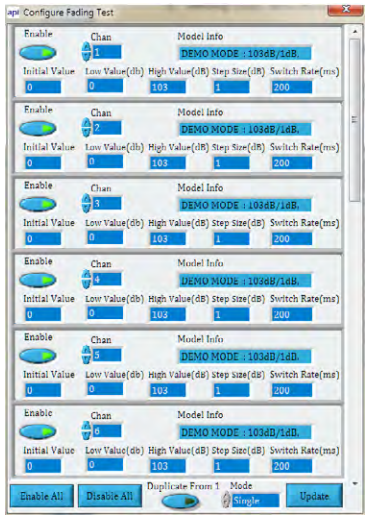
- Perform sweep or hop of attenuation and/or phase levels.
- Save and recall test profiles with specific attenuation patterns for R&D and production test.
- Track and control several connected programmable devices, simplifying multiple device test setups.
- Test macros enabling step through sequence of commands sequences for complex test schemes.
- Status and activity tracking allowing RF testbed to power up in a specific state. Additionally each programmable can store an internal alias string, allowing the user to correlate a digital listing with a physical application or location.

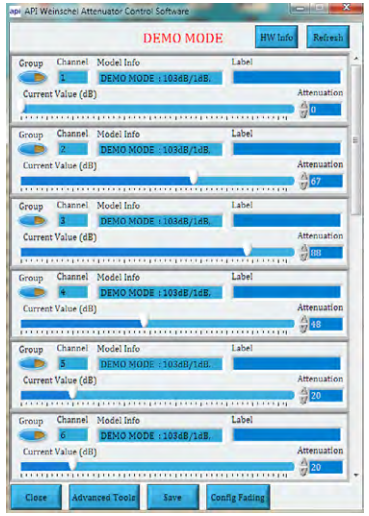
APITech Digital Lab Assistant's programmable control software is compatible with current versions of MacOS and Microsoft Windows 32-bit and 64-bit and low cost embedded computers like the Raspberry Pi.

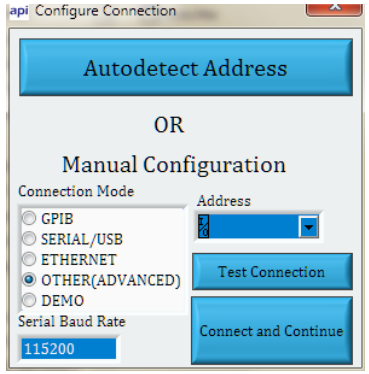
DLLs provide an easy-to-use but comprehensive Application Programming Interface (API) for controlling the programmable devices. The DLLs are designed so that their API functions can be called from traditional Windows applications, from .net applications, and from a variety of popular programming environments including C#, C++, Visual Basic, Python, TcL, LabVIEW, and MATLAB.

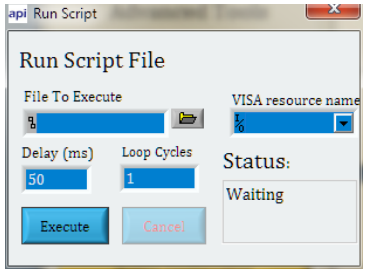
For Linux users, our Python and LabVIEW APIs are fully compatible with most popular distributions.

APITech provides example scripts and comprehensive post-sales support to ensure programmable products are setup correctly with full automation to ensure speedy testing of your devices in your lab environment.









SCAN TO FIND OUT MORE

Chapter 3
Connectors and Adapters

Attenuators

Low PIM up to 50 GHz to reduce signal amplitude without degrading its integrity.

DC Blocks

Preventing the flow of DC signals, while allowing the higher frequency signals to pass through.

Planar Blind-Mate®

Connectors for concurrent interconnection with virtually no interference.

Terminations

Used to absorb energy and prevent RF signals from reflecting back from open-ended or unused ports.

Bias Tees

Designed to inject DC current into an RF circuit without affecting the RF signal.

Connectors

FR1 attenuation up to 6GHz from entering interconnections.

EMI low insertion loss construction options- mixed pin loading, and selectively loaded lines.

Adapters

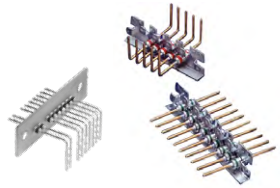
Passive components used to transfer signals from one connector interface to another.

EMI Filters

Filters focus on miniaturization and achieving high packing density in circuit design.

EMI Filter Plates

Provide EMI filtered signal line between electronic system modules at a reduced cost.



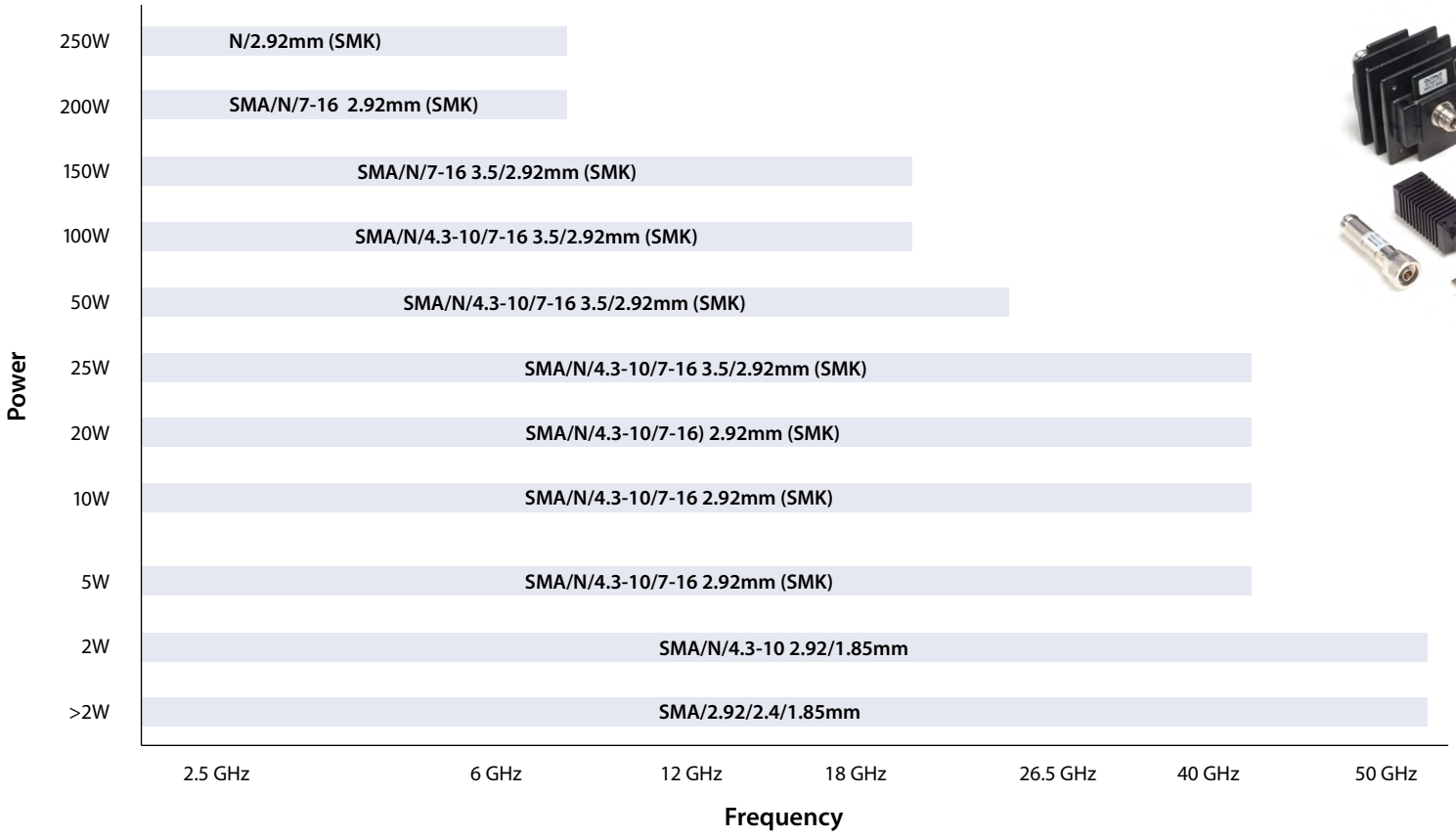
SCAN TO FIND OUT MORE

Features

At first thought, cables, connectors and adapters for FR1 set ups may seem like they are trivial aspect that can be mixed and matched as needed. In practice, connectors will influence test results in various and sometimes unpredictable ways. Test equipment can compensate for some of these influences but often with detrimental effects. The best setup would have the lowest attenuation to ensure high accuracy results.

RF Testbed Lab Fixed – Coaxial Attenuators – It's what we do

APITech's coaxial attenuators are specifically designed for frequency ranges from DC to 50 GHz with power handling to 1,000 W. Designed to reduce the signal power without affecting or reducing the waveform of the signal significantly.



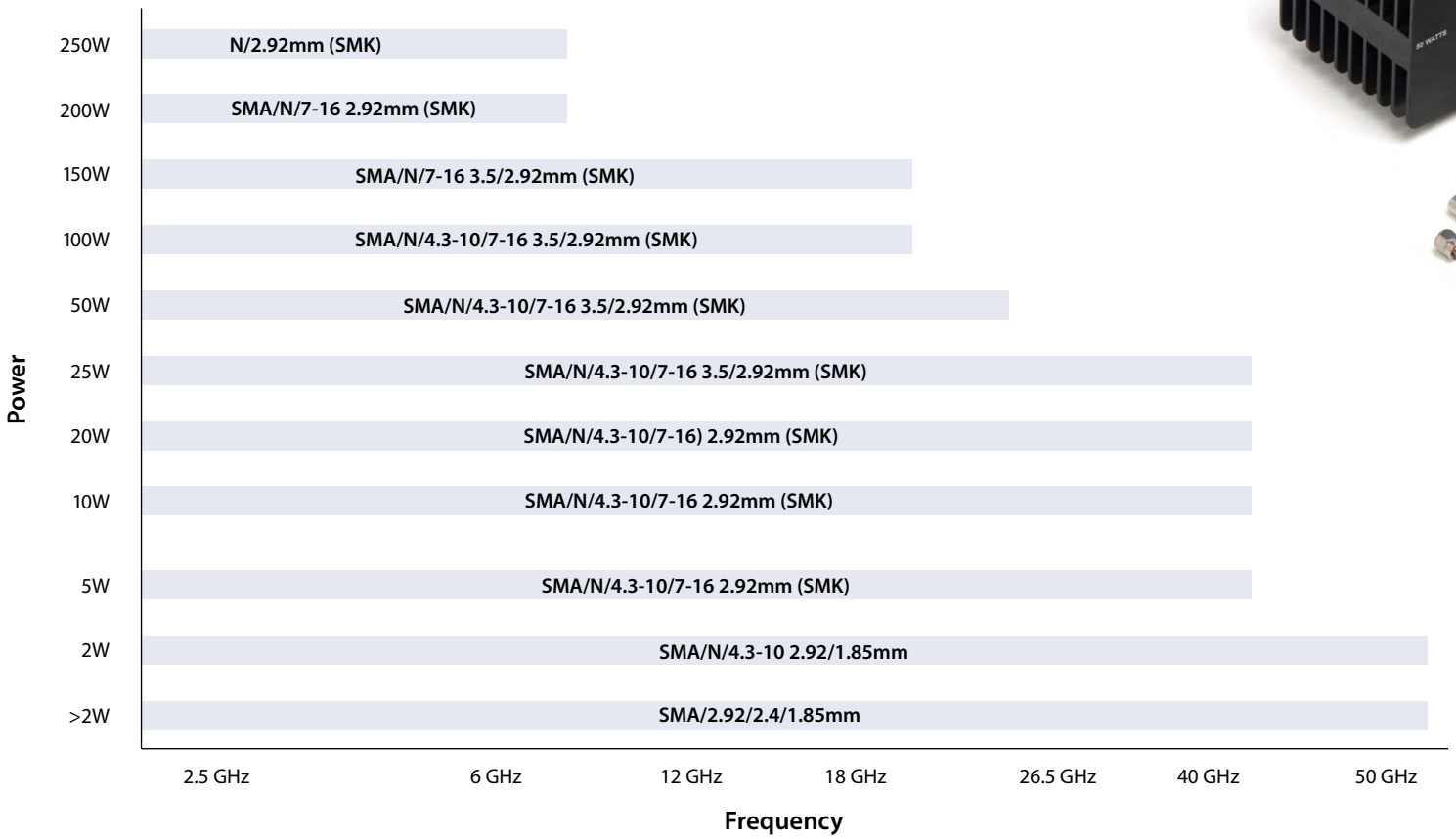
SCAN TO FIND OUT MORE

RF Testbed Lab Coaxial Terminations – It's what we do

Coaxial terminations are used to prevent an RF signal from being reflected back from the end, causing interference.

These coaxial terminations are designed for 2G, 3G, 4G LTE, 5G, Wi-Fi technology.

The chart below shows available coaxial terminations. Custom designs available, contact us with your specialized needs.



SCAN TO FIND OUT MORE

RF Testbed Lab Coaxial Adapters – It's what we do

APITech's coaxial adapters are offered as precision in-series operatiing at DC-65 GHZ, and between series up to 26.5 GHz.

The chart below shows available adapters. Customer designs available, contact us with your specialized needs.

Highlighted orange squares denote available connector configurations.

1 Adapter 75 Ω both sides.

2 Impedance Matching Pad where F connector only 75 Ω.

3 Also available with Quick Connect Option.

Adapter Reference Guide

Connector	F	7/16	BNC	N	TNC	7mm	SMA	3.5mm	2.9mm	GPO™/ SMP	2.4mm	1.85mm
F	1		1 2	1 2	2		2					
7/16												
BNC	1 2											
N	1 2	3					3					
TNC	2											
7mm												
SMA	2			3			3					
3.5mm												
2.9mm												
GPO™/SMP												
2.4mm												
1.85mm												

It is important to consider electrical properties of Interconnect products. Signal loss, or attenuation, is a significant consideration in the design of an Interconnect product. The loss occurs in three ways:

1. **Conductor loss is a direct function of the conductive properties of any connector.**
2. **RF leakage is a measure of the effectiveness of a connectors shielding.**
3. **Insulation loss is a fixed degree of attenuation inherent in the material of the connector's dielectric layer.**

SCAN TO FIND OUT MORE

RF Testbed Lab DC Blocks – It's what we do

DC Blocks available in Inner Only, Outer Only and Inner/Outer designs with various frequency ranges and voltage ratings.

Filtering on the partition inputs ensure a clean signal. To protect test equipment from unwanted EMI/RFI noise to ensure the equipment functions correctly.

Applications

- Ground loop elimination
- Signal source modulation leakage suppression
- System signal-to-noise ratio improvement
- Test setup isolation
- Other situations where undesired DC or audio current flows in the system

APITech Inmet inner DC blocks have a capacitor in-series with the center conductor which prevents the flow of audio and direct current (DC) frequencies while offering minimum interference to RF signals up to 50GHz. Similarly outer DC blocks have a capacitor in-series with the outer conductor and the inner/outer types have capacitors in-series with both inner and outer conductors.

The insulation material on the outer shell of our DC Blocks is a non-conductive PEEK (polyetheretherketone) polymer coating.

DC Block applications include ground loop elimination, signal source modulation leakage suppression, system signal-to-noise ratio improvement, test setup isolation and other situations where undesired DC or audio current flows in the system.

SCAN TO FIND OUT MORE

RF Testbed Lab Bias Tees – It's what we do

APITech Bias Tee's are a three-port network used for setting the DC bias point without disturbing other components. The bias tee is a diplexer. The low-frequency port is used to set the bias; the high-frequency port passes the radio-frequency signals but blocks the biasing levels; the combined port connects to the device, which sees both the bias and RF for frequencies up to 50GHz.

Bias Tee Reference Guide

MODEL NO.	FREQ. (GHz)	CONN.	CURRENT (Max.)	VOLTAGE (Max.)
General Purpose and High Power Bias Tees				
8800SMF1-02	.01-2.5	SMA-M/F	2.5A	100V
8800SMF1-04	.01-4 S	MA-M/F	2.5A	100V
8800SMF1-06	.01-6	SMA-M/F	2.5A	100V
8800SMF1-09	.01-9	SMA-M/F	2.5A	100V
8800SMF1-12	.01-12.4	SMA-M/F	2.5A	100V
8800NMF1-02	.01-2.5	N-M/F	2.5A	100V
8800NMF1-04	.01-4	N-M/F	2.5A	100V
8800NMF1-06	.01-6	N-M/F	2.5A	100V
8800NMF1-09	.01-9	N-MF	2.5A	100V
8800NMF1-12	.01-12.4	N-M/F	2.5A	100V
8800DMF1-02	.01-2.5	7/16-M/F	2.5A	100V
8800DMF1-04	.01-4	7/16 DIN-M/F	2.5A	100V
8800DMF1-06	.01-6	7/16-M/F	2.5A	100V
8800DMF1-07	.01-7.5	7/16-M/F	2.5A	100V
High Current Bias Tees				
8820SMF1-02	.5-2.5	SMA-M/F	7.0A	100V
8820SMF1-06	1.0-6.0	SMA-M/F	7.0A	100V
8820NMF1-02	.5-2.5	N-M/F	7.0A	100V
8820DMF1-02	.5-2.5	7/16-DIN-M/F	7.0A	100V
8821DMF1-02*	.5-2.5	7/16-DIN-M/F	7.0A	100V

MODEL NO.	FREQ. (GHz)	CONN.	CURRENT (Max.)	VOLTAGE (Max.)
Pulsed Bias Tees				
8860SMF2-02	.03-2.5	SMA-M/F	3.0A	100V
8860SMF2-06	.03-6	SMA-M/F	3.0A	100V
8860SMF2-09	.03-9	SMA-M/F	3.0A	100V
8860SMF2-12	.03-12	SMA-M/F	3.0A	100V
75 Ohm Bias Tees				
8875NMF1-03	.01-3	N-M/F	2.5A	100V
8875FMF1-03	.01-3	F-M/F	2.5A	100V
Broadband Bias Tees				
8810SMF2-12	50 kHz-12.4	SMA-M/F	750mA	25V
8810SMF2-18	50 kHz-18	SMA-M/F	750mA	25V
8810SMF2-26	50 kHz-26.5	SMA-M/F	750mA	25V
8810KMF2-26	50 kHz-26.5	2.9mm-M/F	750mA	25V
8810KMF2-40	50 kHz-40	2.9mm-M/F	150mA	25V
8812KMF2-26	12 kHz-26.5	2.9mm-M/F	150mA	16V
8812KMF2-40	12 kHz-40	2.9mm-M/F	150mA	16V
8810EMF2-50	50 kHz-50	2.4mm-M/F	150mA	25V

* Environmentally Sealed

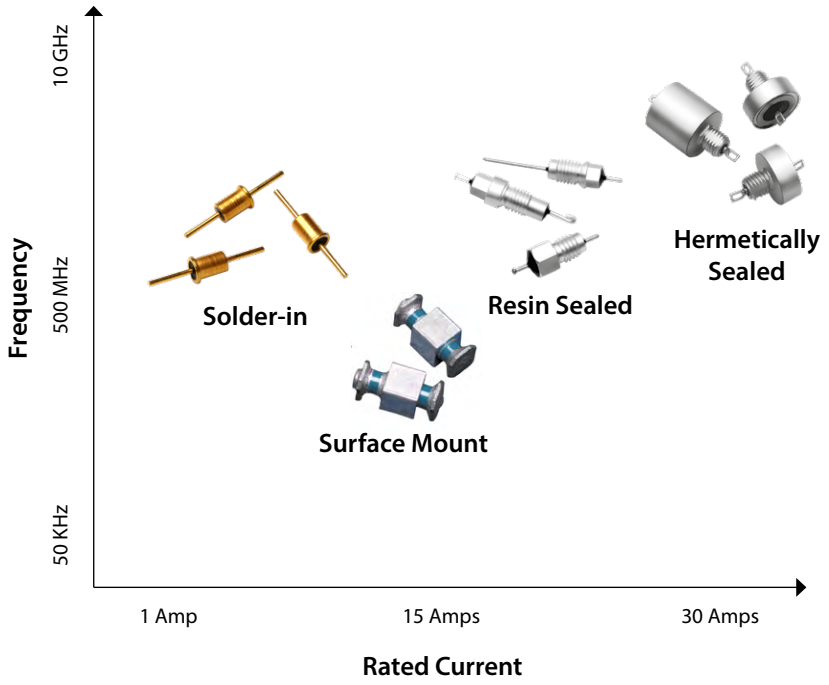
SCAN TO FIND OUT MORE

RF Testbed Lab EMI Filters – It's what we do

APITech solder-in filters are ideal for use in critical areas where space does not allow the use of mounting tools or hardware. The solder-in feature also allows installation in unison with other board-mounted components. Primarily used in filtering signal/data lines and DC power lines.

The key specifications

Insertion Loss Range	Effective filtering from 10 KHz to 18 KHz with proper installation
Capacitance	Up to 5.2 µF
Temperature Characteristics	NPO, X7R, Y5V, Z5U
Temperature Range	Up to 2500 VDC, 240 VAC @ 400 Hz
Voltage Rating (max)	Up to 100 Amp
Current Rating (max)	5 Amp



User case – Filtering for RF Test Equipment

To protect test equipment from unwanted EMI/RFI noise to ensure the equipment functions correctly.

Cost Effective Solutions – low cost filters provide protection in hostile environments.

Design Flexibility – wide range of bushing sizes, lead configuration options and circuit types including C, L. Pi, transient suppression Pi, T and TT.

Reliability – processes and facility certified to AS9100.

Safety – select filters UL 1459 recognized and CSAC22.2 certified.

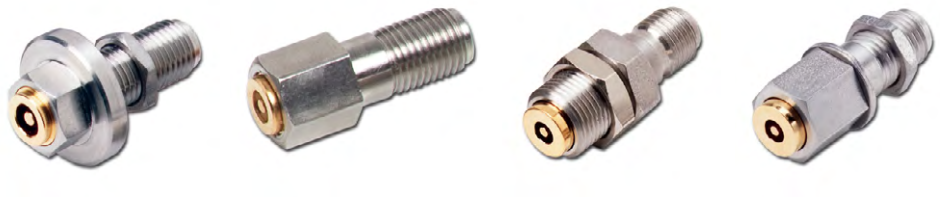
SCAN TO FIND OUT MORE

RF Testbed Lab Planar Blind-Mate® Connectors – It's what we do

Planar Blind-mate connectors offer a broad frequency range from DC to 40 GHZ, which includes most wireless bands.

The Planar Blind-mate series provides thread-less connector mating which is useful when mating an array of connectors on one RF module to another array within seconds. Each connector pair will tolerate typically 0.02 inches per pair radial and axial offset misalignment and still meet all of its electrical specifications.

Planar Blind-mates connectors are typically used as a pair or set which is comprised of two connector sub-assemblies that have a common mating interface.



The key specifications

Model Number	Connector Type	Frequency Range (GHz)	SWR (Maximum)	Loss (Maximum dB)
7008	Pressurized SMA Female	dc - 40.0	1.30 - 165*	0.3 - 1.5*
7034	2.92mm Female, Rear Lock, Floating	dc - 40.0	1.35 - 155*	0.50
7034-1	2.92mm Female, Rear Lock, Fixed	dc - 40.0	1.35 - 155*	0.85
7035	2.92mm Female, Front Locking, Hex Nut, Floating	dc - 40.0	1.35 - 155*	0.50
7035-1	2.92mm Female, Front Locking, Hex Nut, Fixed	dc - 40.0	1.35 - 155*	0.85
7035R	2.92mm Female, Front Locking, Floating, Round Nut	dc - 40.0	1.35 - 155*	0.85
7035R-1	2.92mm Female, Front Locking, Round Nut	dc - 40.0	1.35 - 155*	0.85
7041	2.92mm Female, Rear Locking, Fixed, Round Nut, Lower Cost	dc - 18.0	1.20 - 140*	0.60

* Varies with frequency.

SCAN TO FIND OUT MORE

RF Testbed Lab 5G D-Sub Connectors – It's what we do

APITech's 5G D-Sub filtered connectors are capable of 70 dB from 1 GHz to 6 GHz in a D-sub connector adapter form-factor. These connectors are ideal for test enclosures for high-frequency testing including 5G cellular hardware. The coaxial filter design includes all soldered electrical connections, resulting in low ESR/ESL at frequencies up to 6 GHz and beyond. These connectors have threaded inserts for easy installation and are RoHS compliant.

The key specifications

Dielectric Withstanding Voltage	150V
Working Voltage	50V
Temperature Range	-55°C to 125°C
Capacitance	1000 pF & 4000 pF available

User case – High frequency filtering for RF Test

Higher frequencies require higher performing filters. API Techs 5G D-Sub connectors filter up to 10 GHz.

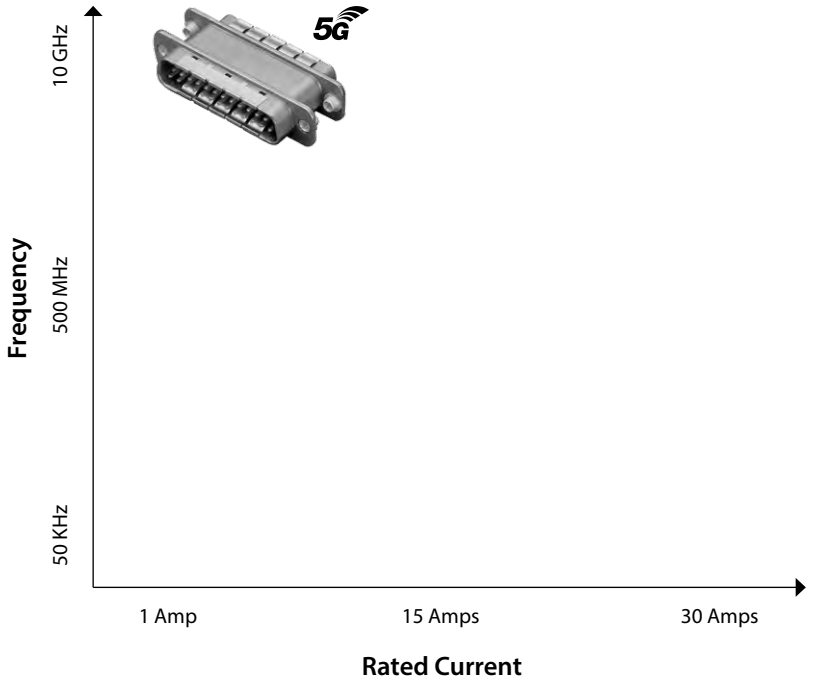
Performance – Coaxial filter design with all electrical connections soldered resulting in low ESR/ESL at frequencies up to 6 GHz and beyond.

Construction – multi-pole circuit utilizing materials specifically designed for 5G cellular bands.

25-pin adapter geometry – perfect for test enclosures applications that require fast and easy 'plug and play' on both sides. Other configurations (i.e., 9-pin, 15-pin) available upon request.

One-piece die-cast – housing and integrated ground clips for more effective high-frequency shielding and shell to shell continuity.

Connection – threaded inserts for easy installation.



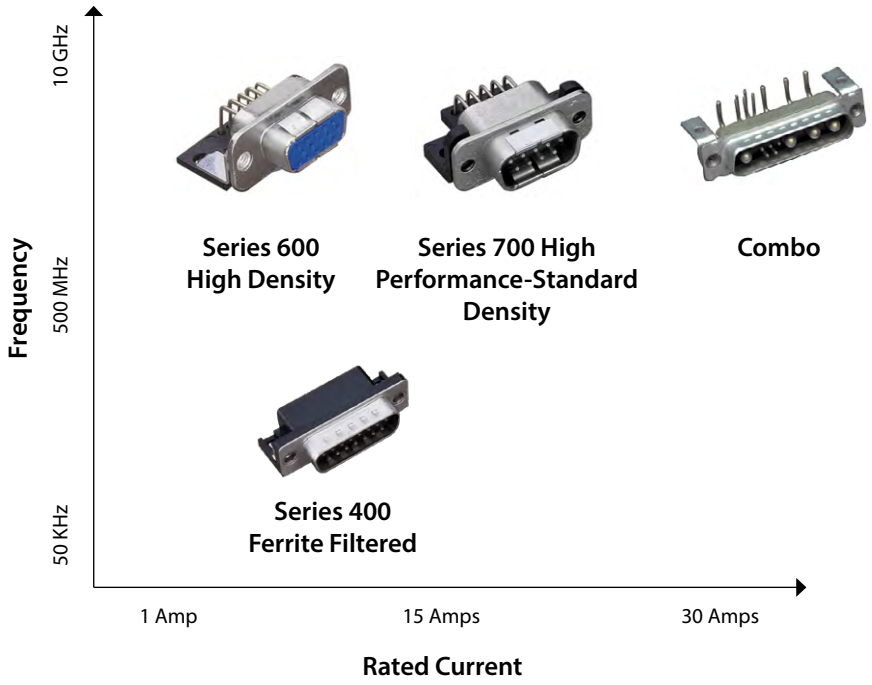
SCAN TO FIND OUT MORE

RF Testbed Lab EMI Filtered Connectors – It's what we do

APITech offers a wide range of d-sub connector options that will help improve performance, save board space, and reduce costs by managing EMI at the signal and power I/O. Our full ground plate and metallic shells maintain minimal impedance with superior performance. Filters located in the connectors provide additional space on the PCB board. These connectors offer capacitance values from 85 pF to 4,000 pF, with an insertion loss range of 1 MHz to 18 GHz and beyond.

The key specifications

Insertion Loss Range	1 MHz to 1 GHz and beyond
Capacitance	Up to 5600 pF
Temperature Characteristics	NPO, X7R, Y5V, Z5U
Temperature Range	-55°C to 125°C
Voltage Rating (max)	Up to 200 VDC
Current Rating (max)	5 Amp



User case – Filtering for RF Test

Filtering for partition inputs to provide clean signal.

Excellent Filtering – filter types include Pi or feed through capacitors; signal, power contacts; ground plane design provides superior EMI shielding.

Design Flexibility – 9 through 50 line construction, standard, high density, mixed pin loading & selectively loaded lines.

Reliability – Each connector position is tested 100% for critical electrical parameters to ensure consistent performance.

Numerous Options – Hardware, mounting, waved metal gaskets, hooded strain reliefs, combined filter types and plating.

Agency Approvals – UL 94V-0, UL/CSA recognized.

SCAN TO FIND OUT MORE

RF Testbed Lab EMI Filter Plates – It's what we do

APITech's focus on miniaturization and achieving high packing density in circuit design has allowed us to meet the needs of our customers where component size is a premium and the highest level of integration is desired.

The key specifications

Insertion Loss Range	Effective filtering from 1 MHz to 1 GHz with proper installation
Capacitance	Pi: 68 pF to 5000 pF, Feedthrough: 10 pF to 4000 pF
Temperature Characteristics	NPO, X7R, Y5V, Z5U
Temperature Range	-55°C to 125°C
Voltage Rating (max)	Up to 250 VDC
Current Rating (max)	Up to 5 Amp standard

User case – Filtering for RF Test

Filtering for partition inputs to provide clean signal. To protect test equipment from unwanted EMI/RFI noise to ensure the equipment functions correctly.

Total Reduce Costs – economical method of meeting EMC requirements.

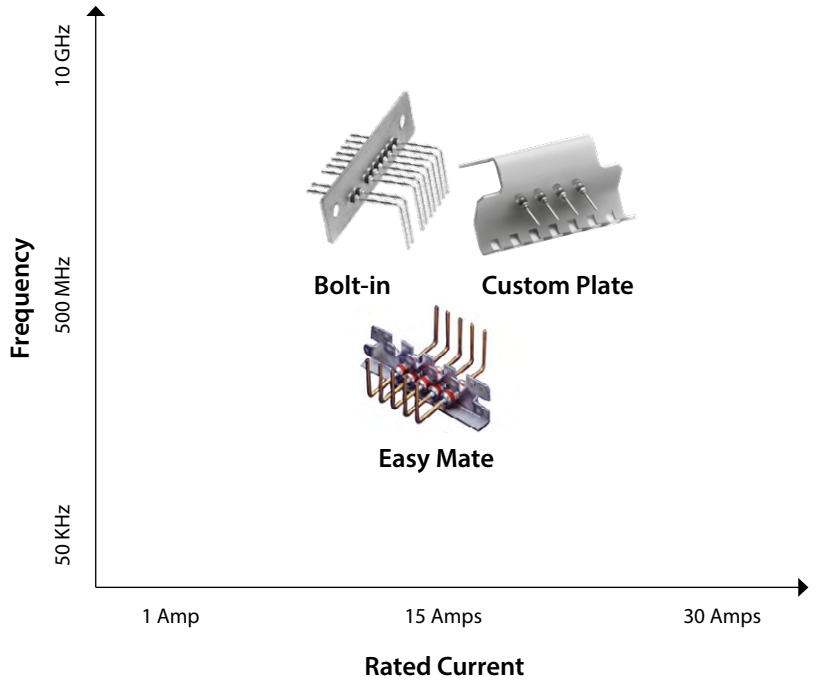
Excellent Filtering – outperform surface mount filters at frequencies above 30 MHz; provide and EMI filtered signal line between electronic system modules.

Reliability – every filter plate is tested 100% for key parameters.

Standard Centers – 0.100" and 2 mm centers allow for easy termination.

Easy Mate Filter Plate – design provides for quick installation into predefined cutout.

Microcircuit Packages – custom designs available with a variety of materials, filtering, and connectors.



SCAN TO FIND OUT MORE

Chapter 4
Optional Upgrades

RF Isolation Chambers

RF quiet zone for designing, integrating or testing the next generation wireless systems, ensuring tests are reliable and repeatable.

Multipath Emulator

Simulates 'true' multipath effects in an RF conductive environment.

Mesh Network Emulator

Allows simultaneous interconnection of up to n devices in mesh connectivity environment.

Power Distribution

Smart power distribution for both AC and DC with remote control and power monitoring.

Power Filters

Filtering AC or DC power entering an test platform preventing radiated or conducted EMI.

Cable Management

Manage, organize and protect your RF cabling in a complex lab test environment. Ideal for coax, fiber, copper wiring, patch cords, and other various needs.

Features

APITech has built its reputation on delivering robust and rugged solutions for Aerospace applications. We have applied that same expertise to the commercial sector by designing and building a range of optional testbed upgrades for your Lab RF environment, to handle specific use-cases or better lab device management.

SCAN TO FIND OUT MORE

RF Testbed Lab Isolation Chambers – It's what we do

APITech has built its reputation on delivering robust and rugged RF isolation chambers for the Aerospace applications. We apply that same expertise to the commercial sector by designing chambers for isolating unwanted wireless frequencies in an Interference-free testing environment for:

- Cellular – PCS, GSM, 3G, 4G, 5G, LTE
- WiFi 802.11 – all series
- WiMax, Bluetooth, RFID, IoT
- EMI, RFI test, Part 15

Questions frequently asked

What is RF Shielding?

Isolating unwanted wireless frequency.

What is an RF Shield Chamber?

Box or enclosure to provide isolation from outside unwanted wireless frequencies and provide a known controlled environment for various wireless technology testing.

What is the use of Shield Chamber?

Shield chambers are used for performance / reliability characterization of Wireless / Cellular / IoT Devices. In order to test these devices for precise test output with repeatability one has to carry out testing in an isolated environment. Shielded test enclosures provide a convenient and economical way to do this. Conventionally, this was done in an anechoic chamber which is a considerably large room and is comparatively very expensive. Shield chambers come in different sizes/shapes and mount options i.e. rack mount shield chambers for vertical test setups, bench-top shield chambers, stand-alone portable shield chambers on wheels.

How do I compare Shield Chambers from the Datasheet?

Shield chambers are an important integral part of an RF test setup it is critical to ensure the performance and quality of the shield box for your test requirements. The following should be considered:

1. Desired external and Internal dimensions based on the space available in the lab area.
2. Shielding effectiveness at different frequencies.
3. Set of inputs/outputs required.
4. Whether the shield chamber is ready for future technologies / test requirements.

SCAN TO FIND OUT MORE

RF Testbed Lab Isolation Chambers – It's what we do (continued)

The key specifications

Cabinet Mechanicals

- 4U 7U, 16U, 24U, 37U, 42U full height spacing.
- 25.6" wide - adjustable for up to 19" rack system. 39.4" deep, 31.49" option available.
- Welded, high strength frame/chassis 12U and over.
- Standard locking front door handle.
- Beryllium copper finger gasket.
- Shielding credentials - High level of RFI attenuation
- Minimizing emanations in a "quiet" environment. The ability to prevent RF fields from entering or escaping beyond the walled boundaries of the enclosure.
- Quiet zone RF isolation 60db, working frequency range 100khz - 1Ghz.
- Quiet Zone RF isolation 100db workingfrequency range 10Mhz - 18Ghz.
- Absorption >20 dB from 1.3 to 40 GHz; >15 dB down to 600 MHz.

Environmental

- Operating temperature 0 to 40 degrees C.
- Operating humidity 5% to 95% non-condensing @ 40 degrees C.
- Cooling fan inlet and outlet for isolation constant run, high-flow rear exhaust fans (optional thermostat controlled monitoring - Security, Temperature, Humidity).

Power

- Filtered power distribution module in frame - 100 to 240VAC filtered 10, 15, 20A breaker input and output options, QPS electrical certification.

SCAN TO FIND OUT MORE

RF Testbed Lab Multipath Emulator – It's what we do

The APITech multipath emulator is designed to create the conditions described by the TGn-B channel model, as detailed in IEEE 802.11-03/940r1. Two clusters are produced, spaced from one another by 20 ns of delay, each cluster produces a series of taps, which decay exponentially. The emulator includes 4 individual channels with a bypass switch in each one, allowing the user to bypass the multipath simulator, creating the conditions described in the TGn-A channel model.

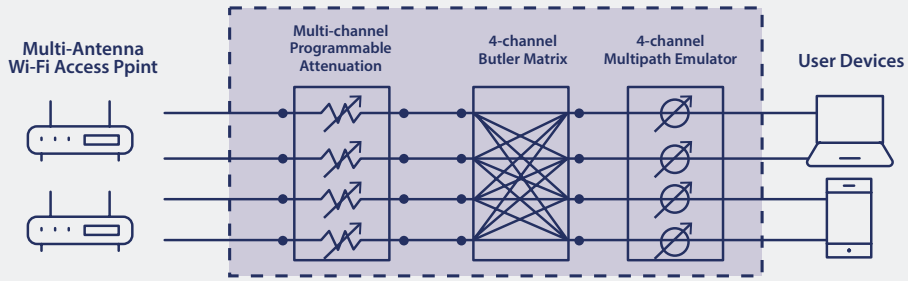
Additionally, the emulator includes a programmable phase shifter, allowing the user to precisely tune the frequency response.

Wi-Fi 6E Multipath Emulator
Model 10444-4

The key specifications

Insertion loss	4 dB (Typical)
Phase Shift	45 dB (Typical)
Switching Speed	100 nsec (10% RF to 90% RF)
Config RMS Time delay	15 nsec (nominal)
Command Processing Time	3-5 msec (typical)
Control	Ethernet (10/100), RS-232, USB 2.0 Supports Weinschel's LabVIEW Control Centre Software
Number of Clusters	2
Time Delay Detween Clusters	20ns +/- 1ns
VSWR	2:1 (Typical)
Size	19" 9W) x 3.3=5" (H) x 12"(D)
RF Connections	SMA Female input/output

RF CONDUCTIVE TEST SETUP



SCAN TO FIND OUT MORE

RF Testbed Lab Mesh Network Emulator – It's what we do

APITech's mesh network emulator is a multi-port network offering feature depth, integration and scalability needed to create accurate, controllable and repeatable test networks for organizations of all sizes. Our mesh network emulator simplifies the creation of real world test network scenarios from simple point-to-point to complex fully meshed with fast setup that is easily deployed, controlled and managed.

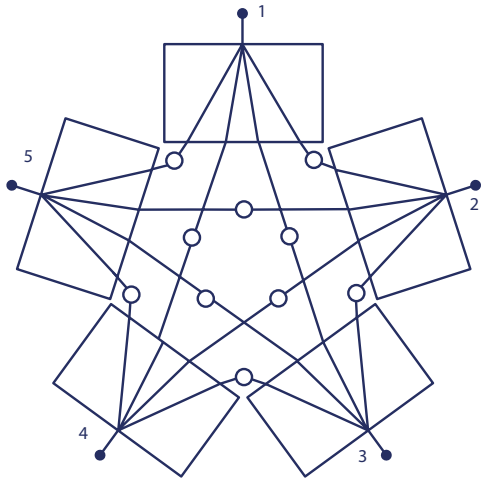
APITech has developed a range of mesh networks with independently variable attenuation on every path. This allows for RF signal interference injection to mimic real-world scenarios. Signal path loss can be varied independently between any pair of inputs, simulating the effects of distance and interference, without interfering with the other signal paths. Number of paths, operating frequency and path attenuation range (up to 127 dB) can be customized to your specific test equipment.

Common applications include testing of 5G, Wi-Fi, Bluetooth and Zigbee devices, wireless handsets and Wi-Fi systems. Different applications can be readily addressed by changing power dividers and attenuator frequency ranges.

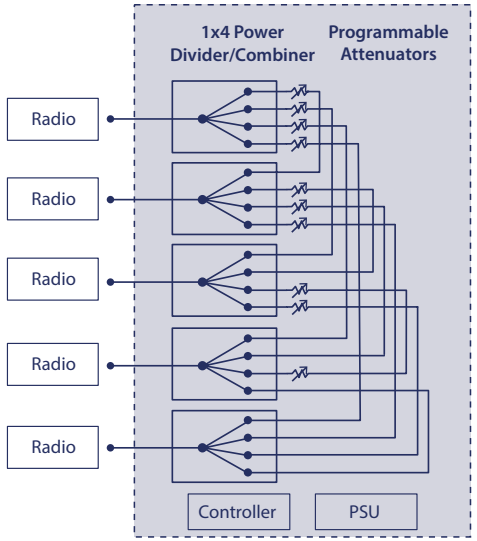
The key specifications

# of Ports	Freq. Range (GHz)	Attenuation Range	Connector
4	0.3 to 8	127	SMA
5	0.3 to 8	127	SMA
6	0.3 to 8	127	SMA
9	0.3 to 8	127	SMA

EXAMPLE 5-PORT MESH SCHEMATIC



VISUAL NETWORK SIMULATOR



5-User Mesh Network Test Unit

SCAN TO FIND OUT MORE

RF Testbed Lab DC Power Distribution – It's what we do

APITech has built its reputation on delivering robust and rugged solutions for the military. We apply that same expertise for the commercial sector by designing and building solutions for DC power distribution and power sequencing within test labs. Our DC lab power systems use electronic switchable solid state breakers enabling remote power cycling. It is ideal for lights-out Lab applications.

DC Power Distribution Subsystems are designed for RF labs that need different load types and flexible overload configurations. Our 2nd generation high-density model packs 10kW capacity in a 1U footprint. It provides secure, remote, and rapid reset of locked or overloaded equipment as well as on-the-fly configuration of overload short-circuit protection. The power distribution subsystem supports high-availability applications with dual-source inputs to drive redundant power supplies in critical loads.

Key specifications

- -48 VCC or +28 VDC input power. Dual feed inputs with associated output banks, consisting of six channels each.
- User configurable power up sequence and delay. User definable output channel banks. Network capacity and connectivity sequencing and cascade in a defined order and solid state (SS) power circuit breakers.
- Solid state circuit breakers with configurable nuisance trip auto reset. User configurable overload trip points per output channel.
- Monitors line voltage, input current, output channel currents, and internal temperature. Configurable alarm levels.
- Network Interface supports SSH, and HTTPS (with SSL/TLS VI.3) secure protocols, SNMPv3 (optional); includes web server for monitoring and configuration.
- Front panel push buttons for local output control. Output status is displayed through individual tri-colored LEDs for each output.
- Reverse polarity protection and transient voltage surge protection.
- Independent programmable power on and off sequencing delays to manage and reduce inrush current transients.

HV 380V DC Power Strips provides the best balance of economics and safety for modern labs. The use of 380VDC in the lab reduces the number of power conversion devices thus reducing cooling costs, extending the life of critical infrastructure, and lowering overall cost of ownership. By having a DC Lab, the operator can simplify the integration of on-site energy generation and storage from alternative energy sources such as wind and solar.

Secure remote operation and control thru web interface.

Key specifications

- The use of 380VDC in a test lab reduces the number of power conversion devices, the need for cooling them and extending the life of critical infrastructure.
- Lowers overall lower total cost of ownership.
- The DC approach to test labs power architecture, employs significantly fewer components than the current AC approach. Fewer components take less time to install and service and reduces heat lowering OPEX costs.

SCAN TO FIND OUT MORE

RF Testbed Lab AC Power Distribution – It's what we do

APITech has built its reputation on delivering robust and rugged solutions for the military. We apply that same expertise to the commercial sector by designing and building solutions for AC power distribution and power sequencing within test labs. Our AC solutions are designed to meet and exceed performance demands for commercial technologies.

AC Power Distribution Subsystems providing remote operation and control capabilities via Telnet or a web interface. Users can log into the PDU via an IP address to see the status of supply voltage, total current draw, outlet status indicators, and more. It's built to withstand extreme temperatures, mechanical shock and vibration. The device has a user capability to tailor the sequence and time delay, monitor input line voltage, total load current, line frequency, and remote external temperature.

Key specifications

- AC Power, Single Ø:100-127, 200-240, Max Input.
- Current Rating: 20A or 30A.
- User defined sequence and time delay and remote power control to a single or group of outlets.
- Remotely monitors input line voltage, total load current, line frequency, and remote external temperature (optional) via Telnet or Web interface.
- Monitors line voltage, input current, output channel currents, and internal temperature. Configurable alarm levels.
- Network Interface supports SSH, and HTTPS (with SSL/TLS VI.3) secure protocols, SNMPv3 (optional); includes web server for monitoring and configuration.
- Optional Emergency Power Off (EPO) configuration available.
- Independent programmable power on and off sequencing delays to manage and reduce inrush current transients.

The **AC Power Master Subsystem** offers sequencing, overload and circuit protection, and remote power monitoring. This high-powered device has a wide variety of configurations, multiple outlets that can support different power outputs, and many different communication protocols for monitoring, sequencing, and fault management. The system features remote on/off sequence, for each outlet in each of the three branches of the PDU.

Secure remote operation and control with APITech web based Digital Lab Assistant.

Key specifications

- Remote monitoring for autonomous equipment on land and sea.
- Optional EPO button adds safety to training simulations.
- Multiple types of AC outputs support a wide range of connected equipment.
- Remote power sequencing and outlet sequencing. Designed for MIL-STD 810 standards.

SCAN TO FIND OUT MORE

RF Testbed Lab Power Filters – It's what we do

APITech recognizes today's RF Testbed designs need to ensure they incorporate methods to prevent unwanted interference from entering the system, as well as eliminate emissions that can contaminate your test platform AC & DC power. APITech's Lab power filters will filter and condition the power to your equipment under test.

The key specifications

Current Rating (max)	Up to 500 Amp
Voltage rating (max)	Up to 400VDC and 240 VAC standard custom versions available on request
Insertion loss	Effective filtering from 100 KHz to 30 MHz
Temperature range	-25°C to +85°C
Leakage current	0.35 mA to 0.50 mA max for general purpose filters

Features

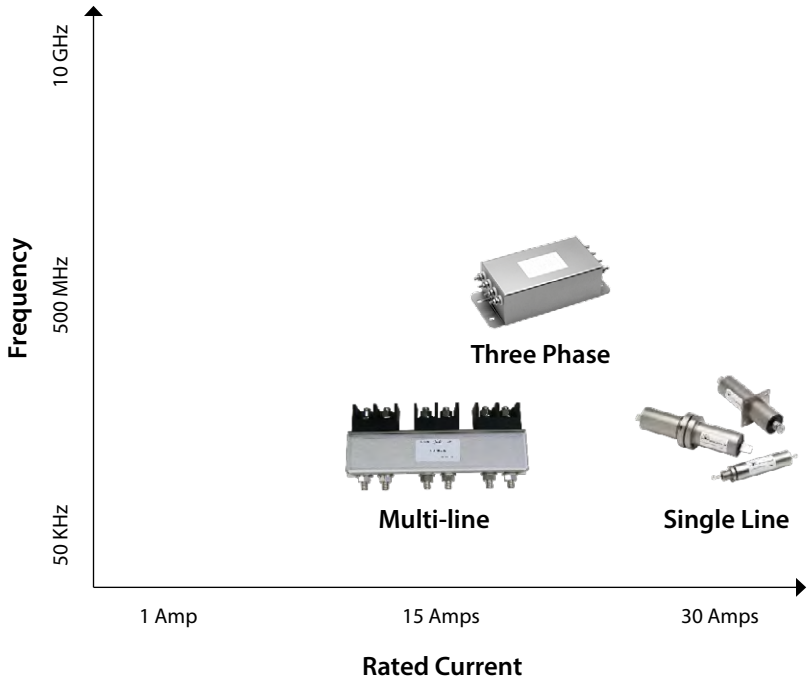
Rugged Construction – metal enclosures built to withstand harsh environmental conditions.

Design Flexibility – filters can be designed to meet customer's requirements. Transient protection, circuit breakers, voltage cut-off, and other options available.

Performance – provides quick and economical solutions to meet specific requirements. Increased speed-to-market, decreased development time. Designs optimized through EMC verification.

Agency Approvals – design for CISPR22/24 and EN55022/24 regulations.

EMI Design Verification – equipment verification can be accomplished through APITech's in-house EMI test lab.



SCAN TO FIND OUT MORE

RF Testbed Lab Cable Management – It's what we do

APITech's panel-mounted structures provide clean, organized management of cable runs and connections in complex, lab test environments using a standard 19" rack-mountable panel. Multiple connector adapters, power splitters, directional couplers and other essential RF components and test accessories can be integrated efficiently within the test system. Custom configurations are available upon request.

Features:

- Standard 19" rack-mounted panels.
- Mounting trays available with all configurations.
- Custom configurations available.

The key specifications

Description	Freq. Range (GHz)	Height
12 x N-F to SMA-F Adapter Panel	DC to 18	1U
12 x SMA-F to SMA-F Adapter Panel	DC to 18	1U
12 x N-F to SMA-F Adapter Panel	DC to 18	1U
12x 2.92-F to 2.92-F Adapter Panel	DC to 40	1U
12 x N-F to N-F Adapter Panel, with Mounting Plate	DC to 18	1U
24x N-F to N-F Adapter Panel	DC to 18	2U
24 x SMA-F to SMA-F Adapter Panel	DC to 18	2U
24 x N-F to SMA-F Adapter Panel	DC to 18	2U
24x N-F to N-F Adapter Panel, with Mounting Tray	DC to 18	2U
48x N-F to N-F Adapter Panel	DC to 18	4U
48 x SMA-F to SMA-F Adapter Panel	DC to 18	4U
48x N-F to SMA-F Adapter Panel	DC to 18	4U
48x N-F to N-F Adapter Panel, with Mounting Tray	DC to 18	4U

SCAN TO FIND OUT MORE

How Can We Help You Conquer Commercial Wireless Strategy?

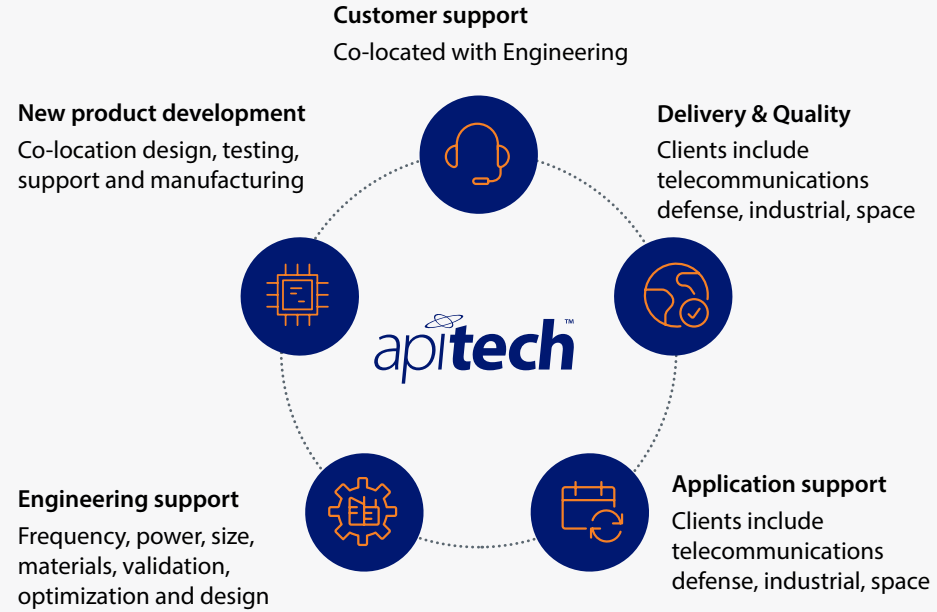
APITech can help 5G and Wi-Fi device manufacturers and telecommunications operators overcome these challenges and unleash a new paradigm of connectivity with a unique three stage approach:

- **Design Thinking Workshop**
- **Hackathon Prototype Strategy**
- **Product Fabrication Services For Full Commercial Rollout**

This approach leverages APITech's proprietary design thinking frameworks to discover insights and implications of a client's challenges. This strategy also benefits from APITech's design scenario driven style that takes into account the changing dynamics across industries and delivers new opportunities for key industries. APITech facilitates this process by engaging in dialogue and generating strategic options to bring 5G and Wi-Fi solutions to life.

APITech is here for you at every stage of product development and telecommunications deployment.

Contact APITech to learn more about our offerings for 5G and Wi-Fi technology. From passive components to EMI filtering and RF conductive test solutions, we cover the increasing RF power, frequency, and bandwidth constraints in next generation wireless protocols.



Contact us

Please get in touch if you would like to talk to us about anything related to 5G & Wi-Fi spectrum innovation.

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