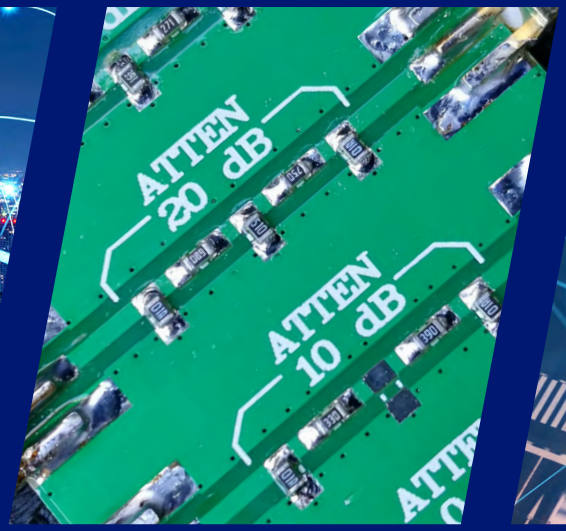
apitech™

A Guide to Developing Innovative 5G and Wi-Fi 6E Radio Services

Steaming Ahead to Bring 5G and Wi-Fi 6E Deployments to Life

3 The Role of Surface Mount Resistives



Introduction

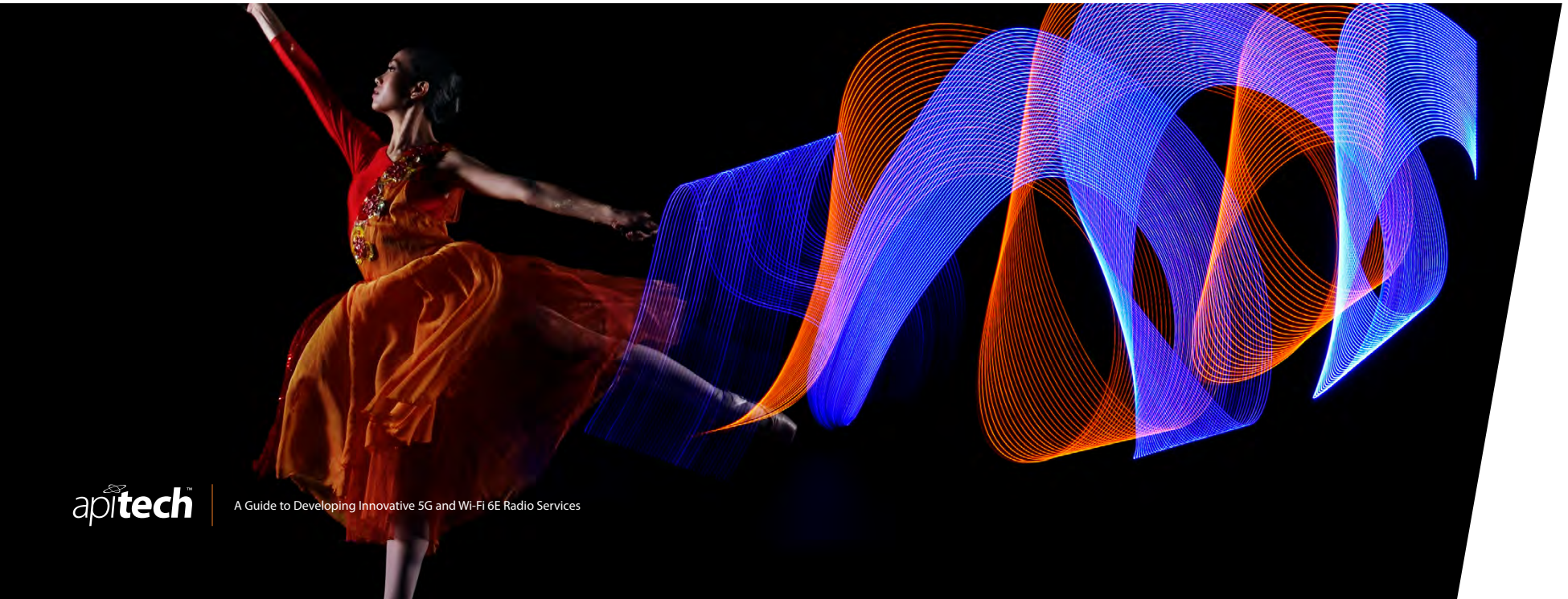
Dear Reader,

Surface mount (SMT) resistives such as chip resistors and chip attenuators provide the very basic functionality of dissipating unwanted RF energy. While the simplicity of this function can cause this technology to often be overlooked, it is cornerstone nearly every wireless system in order to mitigate the negative effects of standing waves, provide a basic level of impedance matching, control the signal level entering sensitive component, and to correct for inconsistent path loss over various transmission paths for antenna arrays and MIMO systems. From a production quality and cost perspective, these components can utilize either a thin-film or thick-film fabrication process on a variety of ceramic substrates. A number of resistor and termination wrap styles can also be leveraged in order to strike a balance between RF performance, price, ease of installation, and power handling. These components have become increasingly critical as cutting edge wireless networks such as 5G and new Wi-Fi standards call for tight tolerances on radiated power, allowing for the fundamental ability to custom tailor the signal levels at the input and output of discrete RF devices and systems.

This ebook is the third chapter to the "Guide to Developing Innovative 5G and Wi-Fi 6 Radio Services" series and covers the basics of SMT resistives including their construction, basic functional uses in microwave circuits, as well as the equipment and applications they are found in.

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



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

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

APITech has expertise in developing essential wireless communications components, accessories, assemblies/modules, and even entire systems. With the expanding use of wireless communications technology in various applications, 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.

Learn more about the evolving landscape of wireless communications in this book, and how APITech can augment your business with design services, wireless hardware, and innovative wireless network testing technology.

1. **The global perspective on 5G and Wi-Fi 6E as well as the need for conformance testing.**
2. **A spectrum innovator's view on how filter technology is critical in mitigating interference for a world with an increasing device density.**
3. **Mastering the implementation of surface mount resistives in cutting edge wireless networks.**
4. **Insights on advancements in 5G and Wi-Fi call for cutting-edge test systems and how APITech uniquely serves this niche with conductive testing solutions.**
5. **Learning how RF network simulators are fundamental to reliably prototyping and validating the varying wireless propagation environments found globally.**

The APITech team

APITech Insights – Commercial Wireless

We know the 5G and Wi-Fi 6E spectrum. By leveraging the power of our expertise in component design and manufacture, we can help you prepare for tomorrow's world.

David Swift

A hands-on wireless technology specialist who believes in innovative and disruptive technologies which challenge the status quo, and make a real difference. With over 24 years' experience involved working closely with customers and partners to successfully realise their visions.

John Yania

John has over three decades of experience in filter design for the harsh space environment. Co-founder and VP of FSY Microwave. Educated MSEE, Johns Hopkins University. Product Line Manager expert, responsible for design of Filter Products, RF/Microwave & Microelectronics technologies.

Norm Hansen

Norm is currently the Product Line Director for Passive Coaxial Products with over 30 years of experience in the RF/Microwave Industry including executive leadership roles in business development, sales, and marketing. He supports the wireless connectivity and optical markets.

Egor Alekseev

Egor Alekseev manages Powerfilm products for APITech Inmet, and holds PhD EE from UofM.

Aaron Singer

With over 15 years of experience with a Tier I automotive supplier, Aaron has experience with all levels of product development from concept and design to validation and production.

Nicholas Garneski

Nicholas specialisation is RF/Microwave design, computational electromagnetics modelling, test software and hardware development.

Prakash Hari

Prakash has been awarded 2 technology patents in telecommunications, with over 14 years expertise in the development of RF products, test platforms and managed services for commercial wireless, satellite and defence markets.

Jennifer Harkless

Jennifer is the Product Line Manager for Electro-Magnetic Devices at APITech, Electromagnetic Integrated Solutions Business Unit. She attended the University of Pittsburgh for Engineering and has been a Lean Six Sigma Black Belt for 18 years.

Donald Dilworth

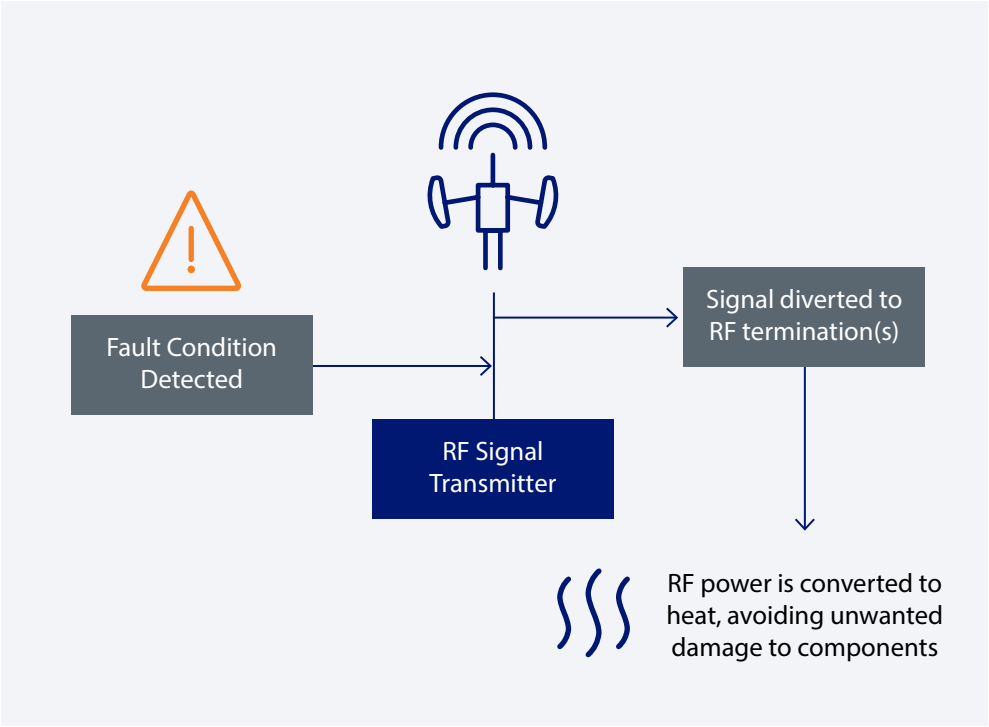
Don is a Product Line Manager with over 37 years of experience helping the top players in wireless telecom industry solve EMI and RFI problems to improve information transfer over their network interconnects for commercial RF systems. He has an engineering degree from Ryerson University in Toronto.

The Role of Surface Mount Resistives in 5G & Wi-Fi 6

Surface mount technology (SMT) resistives play a key role in a wide range of telecommunication circuits and are especially critical to 5G and Wi-Fi 6/6E applications.

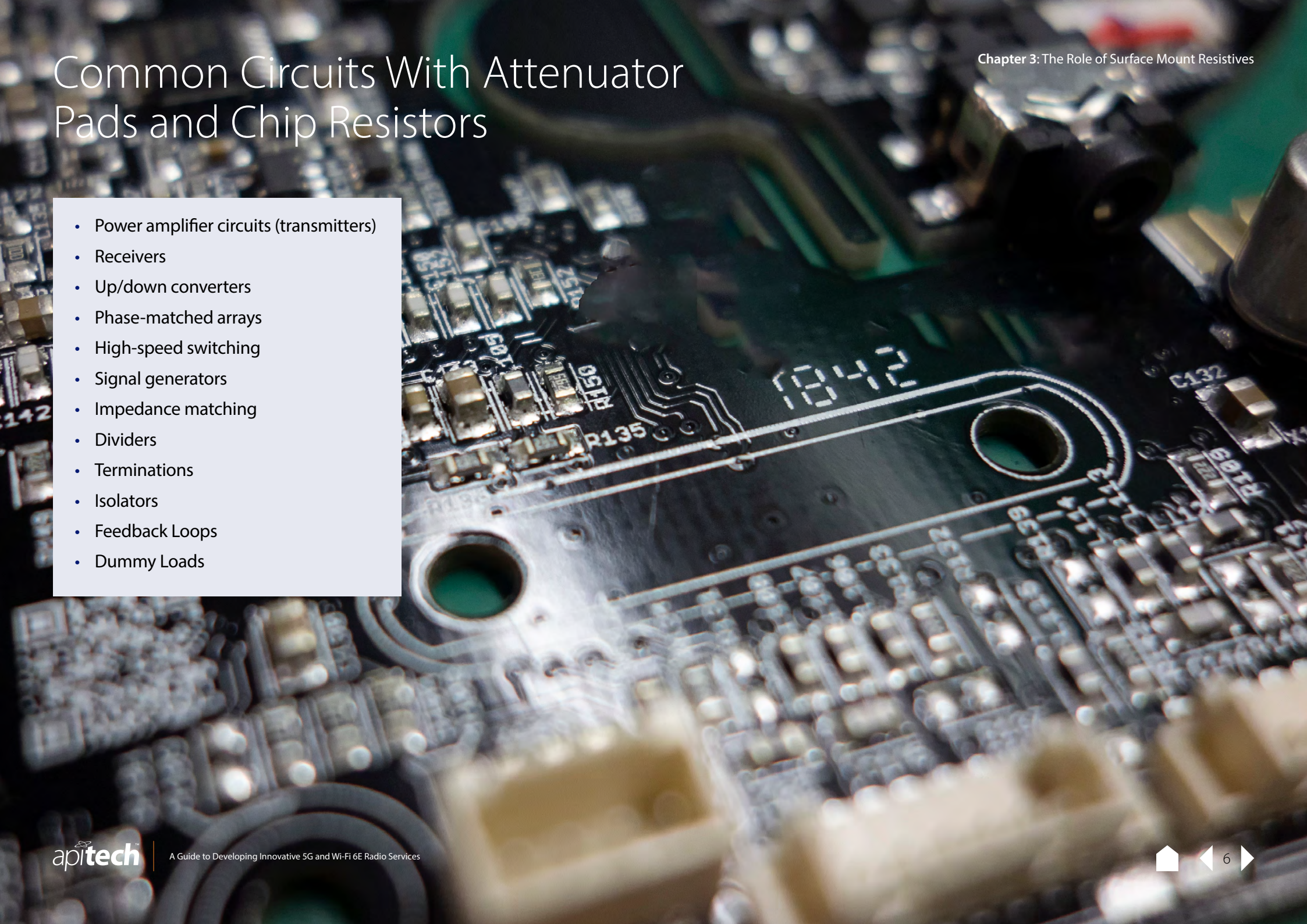
Mainly chip attenuators and chip resistors are used to control the signal level at the output or input of another signal chain element and for impedance matching between components. Though these use cases may sound simple, they are essential for ensuring high quality signal transmission through a wireless telecommunications circuit while using minimal circuit board real estate and headroom.

The basic function of chip attenuators and resistors is to absorb some of the RF signal energy that passes through them and to dissipate that energy as heat. It is crucial that these surface mount resistors only absorb a precise amount of signal energy over the desired frequency range, or the signal chain may experience too much loss. These components are found in circuits from precision test equipment, low cost Internet-of-Things (IoT) modules, or even high power transmitter circuits. As compliance requirements for the latest cellular and Wi-Fi standards are becoming more stringent, ensuring precise signal levels at the output of transmitters is especially critical.



Common Circuits With Attenuator Pads and Chip Resistors

- Power amplifier circuits (transmitters)
- Receivers
- Up/down converters
- Phase-matched arrays
- High-speed switching
- Signal generators
- Impedance matching
- Dividers
- Terminations
- Isolators
- Feedback Loops
- Dummy Loads

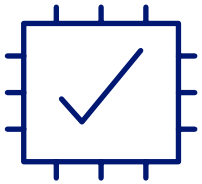


Types of Chip Resistors and Chip Attenuators

Chip resistors and attenuator pads (chip attenuators) are often fabricated on ceramic substrates with other thin-film or thick-film resistors. Common ceramics used for this purpose are beryllium oxide (BeO), aluminum nitride (AlN), or common alumina, though other material options are possible.

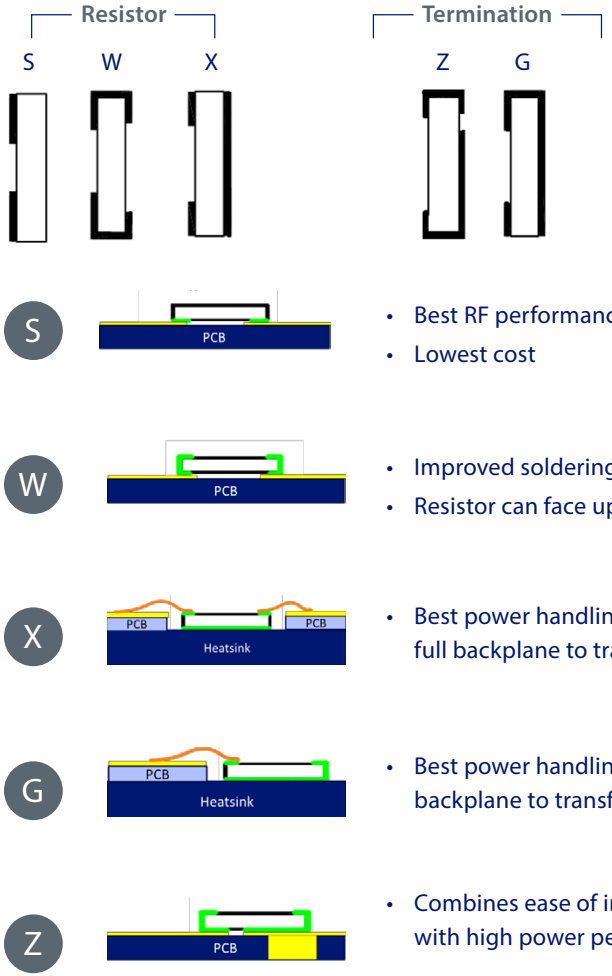
Chip resistors are often used to design custom T-, or Pi-type attenuators, hybrid attenuators and Wilkinson power dividers. Chip resistors are often available in a wide range of resistive values and precision levels. Additionally, chip resistors and attenuator pads are often used in telecommunications, where distortions from passive intermodulation (PIM) are a concern to network reliability, causing these resistives to be fabricated in a fashion that minimizes PIM response.

Chip attenuators can be made to either be temperature stable or temperature variable, depending on the application requirements. Temperature stable attenuators will maintain a precise attenuation level over a wide temperature range. Temperature variable attenuators, on the other hand, reduce their attenuation as a function of rising temperature; this helps to provide an optimal response for signal-leveling applications.



A variety of resistor and termination wrap styles can be employed in order to strike a balance between RF performance, upfront cost, ease of installation, and power handling.

Resistor and Termination Wrap Styles



S
- Best RF performance
- Lowest cost

W
- Improved soldering
- Resistor can face up or down

X
- Best power handling, with full backplane to transfer heat

G
- Best power handling, with full backplane to transfer heat

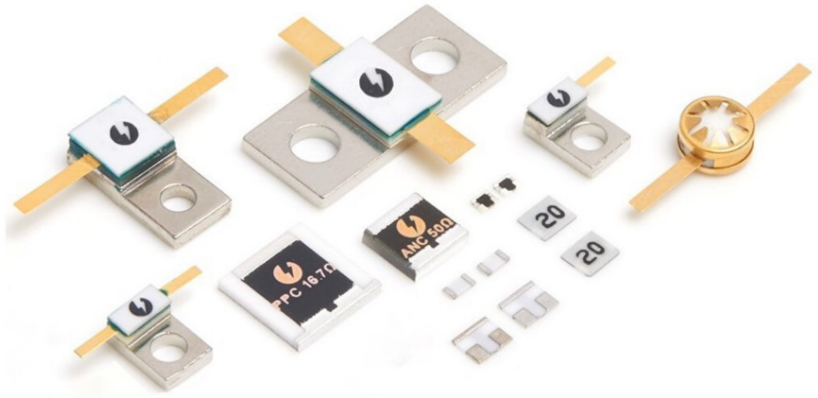
Z
- Combines ease of installation with high power performance

Common Use Case for SMT Resistives

Other uses for surface mount resistors is to reduce the reflected signal level between components in order to prevent the development of high voltage standing waves.

For instance, it is now commonplace to employ reflective filters to filter analog-to-digital (ADC) and digital-to-analog (DAC) circuits in RF telecommunication systems, mixers, and transmitters. These filters essentially reflect the signal energy outside of the passband. In other words, if the signal energy is trapped between two reflective components or between two components with excessive mismatch (e.g., non-linear components, mixers, amplifiers, etc), then the signal energy may develop a substantial standing wave. Thus providing enough voltage or signal energy for a non-linear component to generate unintended signals. Aside from adding noise and possibly interference in the passband, standing waves developed by reflected signals between components could also change the bias of active components and even damage more sensitive components. Inserting a small attenuator pad and reflective filters between the active components is a way of retarding the development of such standing waves and eliminating this concern.

Powerfilm surface mount resistors come in a variety of different terminal configurations and finishes, including coming installed on a flange for convenient attachment to a heat sink for high-power applications.



Common Use Cases for Attenuator Pads

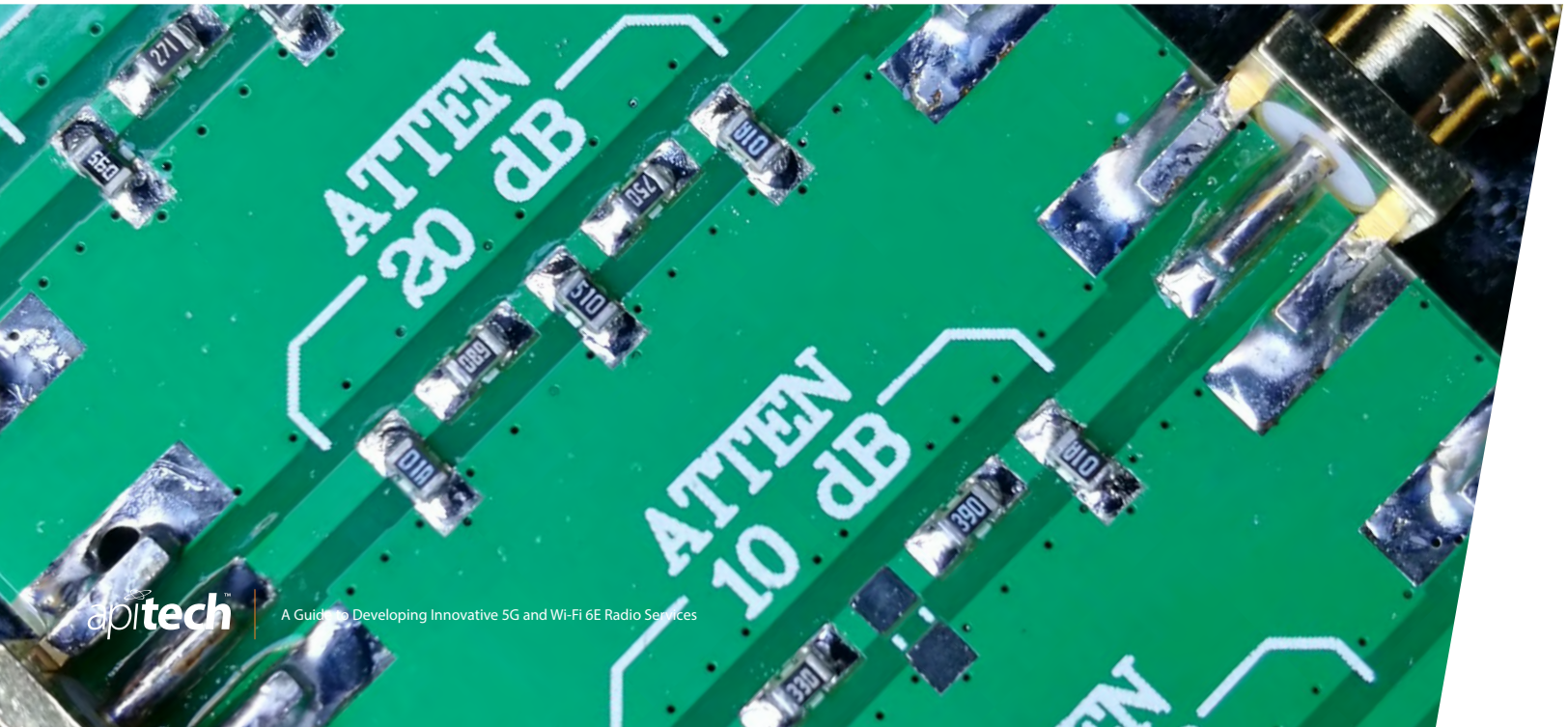
If two components in a signal chain are not well matched – that is if the two components' impedances are not equivalent – the mismatch results in reflections and a reduced signal transfer efficiency.

A method of handling this is to use an impedance matching chip attenuator that will diminish some of the perceived impedance mismatch at the nodes of the other components without the need to add a complete impedance matching network.

Attenuator pads can also be part of a switched attenuation network that is used for variable level control, such as from the output of a signal generator or transmitter. Switched attenuators may also be used at the input of a receiver to ensure that the signal level at the receiver input doesn't result in putting the LNA or receiver input into saturation.

In the case of advanced antenna systems for cellular and IoT applications, attenuator pads can also be used to correct for inconsistent path loss for antenna arrays and multi-input multi-output (MIMO) systems. For instance, the complex interconnect routing needed for high antenna element count antenna arrays may lead to some antenna paths requiring additional attenuation to present equal signal strengths at each element. Hence, antenna elements with paths that are shorter than other paths may benefit from attenuator pads to adjust the signal loss to match longer antenna element signal paths with greater RF losses.

As the RF path losses for electromagnetic signals traveling through a transmission loss increase as a function of frequency, this may be especially needed for millimeter-wave 5G and Wi-Fi systems.



How Can We Help You Conquer Your Commercial Wireless Strategy?

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

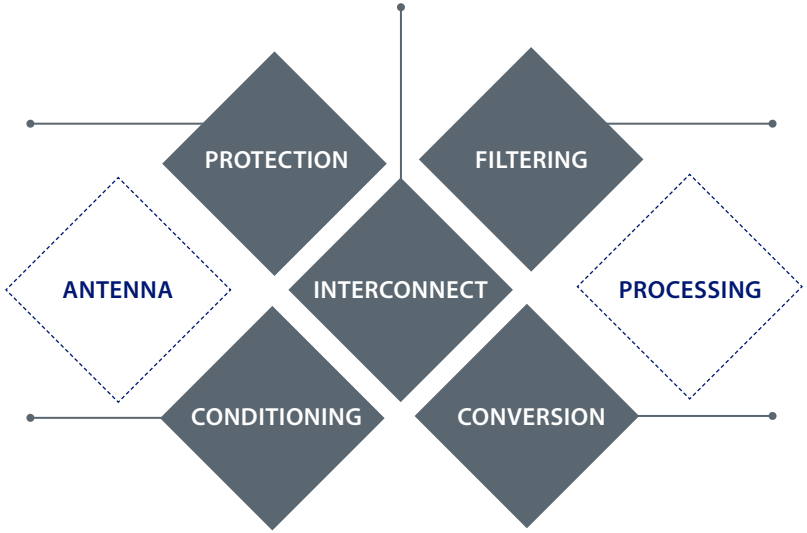
RF hardware and test systems are the keystone in bringing 5G to the masses and realizing new mobile wireless use cases. The competitive and fast pace landscape of mobile wireless is now expanding into new spectrum and technology developers are now facing previously unforeseen design, testing, and deployment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

As shown in the defense 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 systems – 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



Size, weight and **CONDITIONING** optimized for distributed processing of RF signals

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

How Can We Help You Conquer Your Commercial Wireless Strategy?

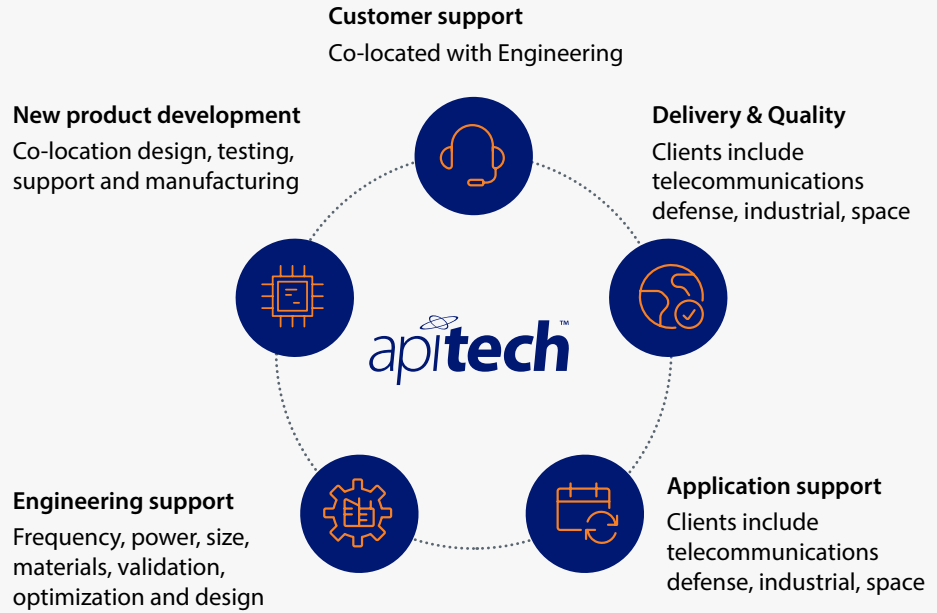
APITech can help 5G and Wi-Fi device manufactures and telecommunications operators overcome these challenges and unleash a new paradigm of connectivity with a unique three stage approach:

- **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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