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How 2.2-5 Low-PIM Connectors Can Be Used in Wireless Networks to Alleviate Passive Intermodulation

White Paper

The term “passive intermodulation” may sound harmless, but it spells trouble for users of wireless networks. Passive intermodulation, or PIM, creates unwanted interference and signal degradation, and can lead to reduced network coverage and increased costs.

However, over the past decade 2.2-5 low-PIM RF connectors have emerged as a popular solution to PIM distortion in some cases. With their small form factor, such connectors are particularly useful in tight spaces and where lightweight components are desirable.

In this paper we discuss the main causes and effects of PIM distortion as well as the qualities, benefits, and applications of 2.2-5 low-PIM RF connectors. We also cover a closely related topic − the surge protection needs of wireless networks, and we conclude with information about a PolyPhaser product that meets these needs: our quarter-wave stub SPD with 2.2-5 low-PIM RF connectors.

Causes of PIM

PIM distortion is caused by the nonlinear behavior of materials and components within an RF system. When two or more signals of different frequencies and amplitudes meet within a component or material that exhibits nonlinear behavior, they can mix together and generate additional signals at frequencies that are not present in the original signals. These additional signals can fall within the frequency range of the desired signal or nearby bands, leading to unwanted interference and degradation of signal quality.

The sources of nonlinear behavior in RF systems can include the following:

- **Metal-to-metal contact**, including any junction or contact between different metals in a connector or other passive component
- **Surface contamination** from dirt, oil, or other contaminants on a connector or other passive component
- **Magnetic materials** such as ferrites or magnetic metals
- **Mechanical stress** on connectors or other passive components
- **Environmental factors** such as temperature and humidity.

Negative Effects of PIM

Following are some of the harmful effects of PIM distortion:

- **Reduced signal quality:** PIM can cause a reduction in signal quality, resulting in poor voice and data transmission. This can lead to dropped calls, slow data transfer rates, and poor network performance.
- **Increased interference:** PIM can create unwanted signals at frequencies that are close to the desired signal, causing interference and reducing the overall signal-to-noise ratio. This can lead to increased noise and reduced network capacity.
- **Reduced coverage:** PIM can cause a reduction in the effective coverage area of a wireless network. This can lead to dead spots and reduced network capacity.
- **Increased cost:** PIM can cause increased maintenance and operational costs, as additional equipment and personnel might be required to locate and resolve PIM-related issues.

PIM can significantly disrupt wireless networks, leading to reduced network capacity, increased interference, and less coverage. To prevent PIM, it is important to use high-quality components, avoid metal-to-metal contact, keep connectors clean and dry, minimize mechanical stress on components, and

regularly test and measure PIM levels on an RF system. Another way to prevent PIM distortion is to consider your connector options.

2.2-5 Low-PIM Connectors

In the early 2010s, 2.2-5 low-PIM connectors were first developed as a smaller and more lightweight alternative to traditional RF connectors such as N and 7/16 connectors. This development was and continues to be driven by the growing demand for high-quality, reliable signal transmission in wireless communication systems, particularly in applications where space and weight are critical.

The 2.2-5 connector is designed to minimize PIM distortion, which can degrade signal quality and cause interference with other signals. It is smaller and lighter than traditional connectors like N and 7/16 connectors, making it more suitable for installations in smaller spaces and where weight reduction is desired.

The “2.2-5” designation refers to the connector’s size. The 2.2 is the diameter of the outer conductor in millimeters. The 5 refers to the length of the male pin (or the depth of the female connector) in millimeters.

Since their development, 2.2-5 low-PIM connectors have been widely adopted in the telecommunications industry, particularly in the rollout of 4G and 5G networks. They have also been used in a variety of other applications, including in military and aerospace systems, medical devices, and industrial automation.

Today, 2.2-5 low-PIM connectors are well-established in the market. They have become a popular choice for designers and engineers working on wireless communication systems, and are expected to continue to grow in popularity as the demand for high-speed and high-quality wireless connectivity increases.

Benefits of 2.2-5 Low-PIM RF Connectors

There are several benefits of using 2.2-5 low-PIM RF connectors in wireless communication systems:

- **Reduced PIM distortion:** The design of 2.2-5 low-PIM connectors minimizes PIM distortion, ensuring high-quality, reliable signal transmission.
- **Smaller and lighter:** Compared to other RF connectors such as N, 7/16, and 4.3-10, 2.2-5 low-PIM connectors are smaller and lighter, making them more suitable for space-constrained and weight-sensitive applications.
- **Higher frequency range:** 2.2-5 low-PIM connectors are designed to handle a frequency range of up to 2.2 GHz, making them suitable for high-frequency wireless communication.
- **Lower insertion loss:** 2.2-5 low-PIM connectors typically have lower insertion loss than traditional connectors, which means they can transmit signals with less attenuation.
- **Higher power handling capacity:** 2.2-5 low-PIM connectors are capable of handling higher power levels than traditional connectors.
- **Easy to install:** 2.2-5 low-PIM connectors typically have a snap-on design that allows for quick and easy installation without the need for special tools or soldering.

Best Applications for 2.2-5 Low-PIM RF Connectors

Low-PIM 2.2-5 RF connectors are ideal for a variety of applications that require high-quality, reliable signal transmission, particularly in space-constrained and weight-sensitive environments. These applications include:

- **Wireless communication systems:** 2.2-5 low-PIM connectors are widely used in wireless communication systems, particularly in 4G and 5G networks, where they help to ensure high-quality, reliable signal transmission. One example is connectors used to link base station antennas to radio equipment.
- **Distributed antenna systems (DAS):** DAS, where multiple antennas provide wireless coverage in large buildings and other areas, are utilized to enhance wireless coverage and capacity indoors and outdoors. Low-PIM 2.2-5 connectors are often employed in DAS installations to help minimize signal loss and ensure optimal performance.
- **Small cell systems:** Small cell systems are used to provide localized coverage in areas where traditional cell towers are impractical or insufficient. Low-PIM 2.2-5 connectors are well-suited for small cell systems because of their small size and weight.
- **Military and aerospace applications:** Low-PIM 2.2-5 connectors are employed in military and aerospace applications where reliability and durability are critical, and where space is limited and lighter weight is desirable. This includes: communications such as radar systems, satellite communications and military radios; avionics such as navigation systems, flight control systems and cockpit displays; and electronic warfare such as radar jammers.
- **Medical devices:** 2.2-5 low-PIM connectors are used in medical devices such as MRI machines and other imaging equipment, where signal quality and reliability are essential.
- **Industrial automation:** 2.2-5 low-PIM connectors are utilized in industrial automation systems such as robotics, where small size and weight are important for space-constrained environments.
- **Test and measurement:** 2.2-5 low-PIM connectors are used in test and measurement applications, such as network analyzers and spectrum analyzers. These connectors provide high accuracy and low PIM, which is essential for precise measurements in wireless communication systems.

Power Surge Disruptions

Like all systems of electronic connectivity, wireless networks are susceptible to damage from power surges caused by lightning strikes and other sources of power transients. The disruption, which can be extremely costly, can come in three forms:

- **Physical damage:** Lightning can directly strike an antenna, generating high-voltage surges on the power and data lines and damaging or even destroying the network's electronic equipment.
- **Induced voltage:** Lightning-induced voltage surges can enter a wireless network through the antenna or data cables, leading to damage to the radio equipment. These voltage surges can generate a significant amount of heat, leading to a short-circuit in the network equipment.
- **EMI/RFI Interference:** Lightning strikes can generate electromagnetic interference (EMI) and radio frequency interference (RFI), causing communication problems. The interference can lead to poor signal quality and reduced transmission range and can also cause errors in data transmission.

SPDs to the Rescue

To prevent lightning strikes and power surges from damaging wireless networks, it is important to install surge protection devices (SPDs) such as lightning arrestors and surge protectors at the antenna and

power/data connection points. SPDs typically work by providing a low-impedance path to ground for the surge current, effectively shunting the excess energy away from the equipment.

PolyPhaser's 2.2-5 Low-PIM SPD

PolyPhaser's wide selection of RF surge protectors includes an SPD with 2.2-5 low-PIM RF connectors that can be used in the applications listed above. Our Model QWP-22M22F-ER is an extended-range RF protector that will protect your equipment from electromagnetic pulse (EMP) or power surges that are commonly caused by lightning or other strong electrical changes.

Features:

- Extended range broadband performance from 555 MHz to 4.5 GHz
- Protection up to a Max. power of 300 watts
- Quarter-wave stub technology (see below)
- DC block topology
- Repetitive-strike protection
- System-level low PIM rating of 160 dBc
- Male input, female output

Applications Include:

- CBRS networks
- Cellular networks
- Distributed antenna systems (DAS)
- Emergency response systems
- Public safety systems

Quarter-Wave Stubs Are Fast and Tough

PolyPhaser's Model QWP-22M22F-ER incorporates quarter-wave stub technology, which stops surges faster than other types of surge protectors, requires no maintenance and can withstand repeated surges without being damaged.

A quarter-wave stub SPD is a type of coaxial cable that is cut to a specific length, typically one-quarter of the wavelength of the frequency being used. The quarter-wave stub works by reflecting any surge voltage that is present back towards the source, preventing it from reaching the equipment. When the surge voltage reaches the quarter-wave stub, it encounters an impedance mismatch that causes the voltage to reflect back down the cable towards the source.

Summary

PIM, or passive intermodulation, creates unwanted interference and signal degradation in wireless networks. It can lead to lower signal quality, more interference, less network coverage, and higher costs. Low-PIM 2.2-5 RF connectors can help solve this problem. They cover the high-frequency spectrum of wireless networks and their small form factor suits them for installations in tight spaces and where lightweight components are preferred.

Power surges are as much of a threat to wireless networks with 2.2-5 low-PIM connectors as to other types of networks. Fortunately, PolyPhaser offers a coaxial RF surge protector with 2.2-5 low-PIM connectors, a wide frequency range and a quarter-wave stub design that is robust enough to withstand multiple surge events.

PolyPhaser's extended-range surge protectors, and most of our entire line of RF surge protectors, are in-stock and available for same-day shipping. For more information, contact us at +1 208 635 6400.