Next-generation cluster connectors help operators take advantage of new antenna designs

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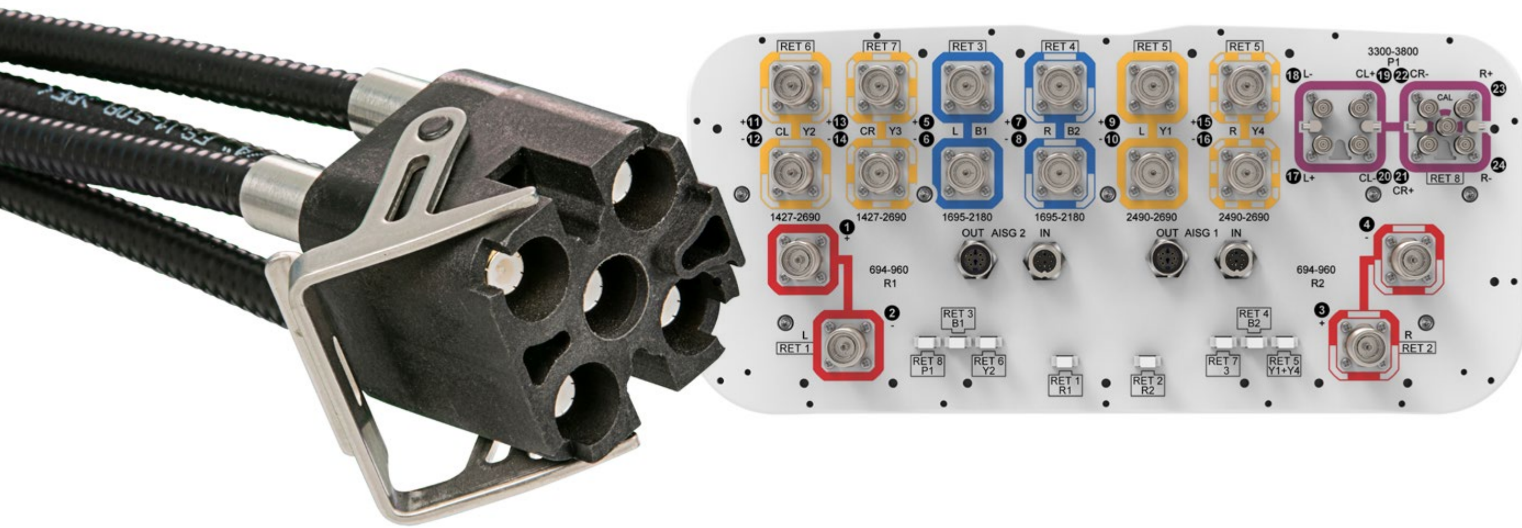
Executive summary

Driven by 5G adoption and an ever-increasing demand for capacity, the radios and antennas needed to support multiple frequency bands and higher-level MIMO are growing more complex. In under five years, port counts have increased from less than 10 per antenna to as many as 30. Mating each radio port to its associated antenna port—while suspended atop a tower—is becoming more costly and risky. Creating a secure, low-loss feed requires time and precision to prepare and torque each connection properly. Cluster connectors, which connect multiple ports at once, have addressed some of the issues. Now a new generation of tool-less cluster connectors, with TDD/FDD support and easier-to-handle cabling, offers more significant improvements. This article identifies some of the added capabilities of these new solutions and what to look for in selecting the right cluster connector.

In the search for capacity, every solution creates another challenge

Wireless operators are facing their most formidable challenge since the birth of the industry over 50 years ago. Even before the 5G buzz, capacity demand from a dizzying array of connected devices and applications threatened to push cell sites beyond their limits. Customer expectations for 5G only add to the pressure to increase bandwidth and speed. To address the problem, networks have begun adding more frequency bands and shifting to higher-level MIMO techniques to improve capacity efficiency.

While more frequency bands and more sophisticated signal-handling techniques significantly improve total available bandwidth at the cell, they create another serious problem. Cell towers are becoming increasingly over-crowded with antennas and related equipment. To alleviate tower loads and control tower-related expenses, mobile



operators are upgrading antennas to new models equipped with more arrays—often within the same-sized housing.

Each of these newer antennas typically supports two to eight radios. The result is an increasing number of RF ports that are packed within the same physical space as the older antennas. As antenna port counts increase, the time, complexity and physical risks of installing these new antennas creates a new—and perhaps more problematic—challenge for operators.

The costs and risks of installing antennas with higher port counts

RF path design requires each radio port to be mated to a specific port on an individual antenna. This involves a multi-step process. One end of the jumper cable is connected to the radio port and must be torqued to a specific setting. If the torque level is too high or too low, PIM levels increase—reducing overall data capacity.

After the port and cable end are mated properly, the installer then applies weatherproofing material to the connection to prevent water ingress. The installer then moves up the tower to connect, torque and weatherproof the other end of the jumper to the associated port on the correct antenna. The process is repeated until all individual connections—as many as 60 per antenna—have been properly completed. For a three-sector site, the process involves as many as 180 connections.

Operators routinely supply installers with detailed port diagrams to alleviate confusion and ensure proper connections. Nevertheless, the number of manual steps involved increases the risk of installer error as well as the danger to the installer.

Recently, the increasing deployment of radios using time-division duplexing (TDD) and frequency-division duplexing (FDD) beamforming schemes has introduced a new level of complexity. These techniques require the installers to connect the eight RF ports on the radio to their corresponding antenna ports in a specific arrangement.

Next-generation cluster connector technology

One way to simplify and speed installation is to group sets of transmission lines using cluster connectors. First introduced in 2016, cluster connectors integrate multiple RF ports into a single interface. Several connector manufacturers have proposed clustered designs for managing four, five or even nine transmission lines within a single connector. A well-designed cluster connector not only reduces the number of connections but can reduce the time needed for each connection. The overall installation time reduction can be significant. This saves the operator time and money while improving safety by reducing the time the installation crew must spend at the top of the tower.

Until recently, cluster connector development has focused almost exclusively on the connectors themselves—with the goal of reducing the connector footprint. The trend toward more complex radios, such as multiband FDD 4T4R and LTE TDD/5G NR 8T8R, has highlighted the need to expand the focus. This has given rise to second-generation cluster connector technology. In addition to reducing installation time and costs, these new cluster connectors address key challenges such as mating issues, PIM reduction, advanced radio support and cable manageability.

Mating accuracy

Radio complexity and increasing antenna port density intensify the challenge of orienting the connector, to ensure the correct ports are connected. This is especially important in TDD applications where the beamforming antennas contain nine RF connections—eight signal ports and a single calibration port. There is only one correct way to map the nine radio ports to the nine antenna ports.

Compounding the issue are the various connector types—some with four connectors, others with five. By attempting to mate four antenna ports using a five-connector jumper, the installer can easily damage the jumper or the antenna. Newer cluster connectors are designed to prevent such mistakes, as there is only one way for the connector to fit correctly.

Mating security

Cell towers are often subject to intense swaying due to windy conditions. Any antenna connection must, therefore, be highly robust to remain secure during severe climatic conditions. Existing RF connectors rely on coupling nuts torqued to a specific value using an expensive torque wrench. If the wrench is omitted or a cheaper, standard wrench is used, the result may be reduced RF performance. Some newer cluster connectors have eliminated the need for tools, adopting a latch and lock system to achieve a secure and watertight connection. An audible click lets the installer know the connectors are locked in place.

RF performance

As more passive and active components are added to the RF path, return loss, insertion loss and PIM pose a more significant threat to RF efficiency and performance. To ensure RF signal integrity, from the radio to the antenna, the performance of the cluster connector must be significantly better than the other, more complex components that make up the system. Advanced cluster conectors enable operators to improve the overall return loss performance. By adopting more robust design and testing approaches, connector OEMs can meet or exceed industry standards for return loss at all frequencies.

PIM vigilance and testing are also critical. For FDD applications, connectors should reliably meet PIM performance that is at least 10 dB better than the levels the antenna needs to perform properly. Operators can now choose from cluster connectors that are optimized for reliable and consistent PIM performance for a wide range of applications.

Similarly, connector OEMs are finding ways to better control insertion loss between the radio and antenna. Typically, insertion loss is dictated by the diameter of the jumper cable—the larger the cable diameter, the lower the insertion loss. By re-arranging the individual connectors, manufacturers can mate the cluster connector to larger diameter cables and reduce insertion loss.

Cable manageability

One of the biggest challenges posed by the new, more integrated antennas is the increased port density and its effect on installation density. As more ports are packed into the same physical space, maneuvering cables into position to connect them has become more difficult. As noted previously, cluster connector designs traditionally focused on the connectors themselves. While this provided improved multiport connections at the ends of the jumper, the cables themselves remained relatively stiff and hard to maneuver.

The development of second-generation cluster connectors has taken a more holistic approach, considering the entire assembly. This has yielded multi-connector cabling that is far more flexible and easier to install in tight spaces. It also allows the use of multiple cable diameters so smaller cables can be used where space and bend radius are critical. Larger diameter cables may be used to reduce insertion loss.

Big leaps, one small step at a time

Evolution in the wireless industry has always been marked by big leaps forward—the 2007 introduction of the iPhone, which sent data demand to unseen levels, or the much-anticipated jump to 5G. Ultimately, operators must be able to implement the big ideas in the most efficient manner possible if they are to succeed.

Over time, the operator's ability to focus on the myriad smaller details (such as how radios and antennas are connected) without losing sight of the bigger picture is the difference between profit and loss. While it's doubtful that developments like second-generation cluster connectors will make the headlines, it is hard to dismiss their potential impact.

A well-designed cluster connector will reduce installation time and errors—enabling operators to deploy the newest technologies faster and less expensively, despite the increasing complexity of today's multiband, multitechnology equipment. In the end, the incremental value provided by such advancements makes for a more efficient and profitable network and enables operators to continue making the big leaps forward.

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