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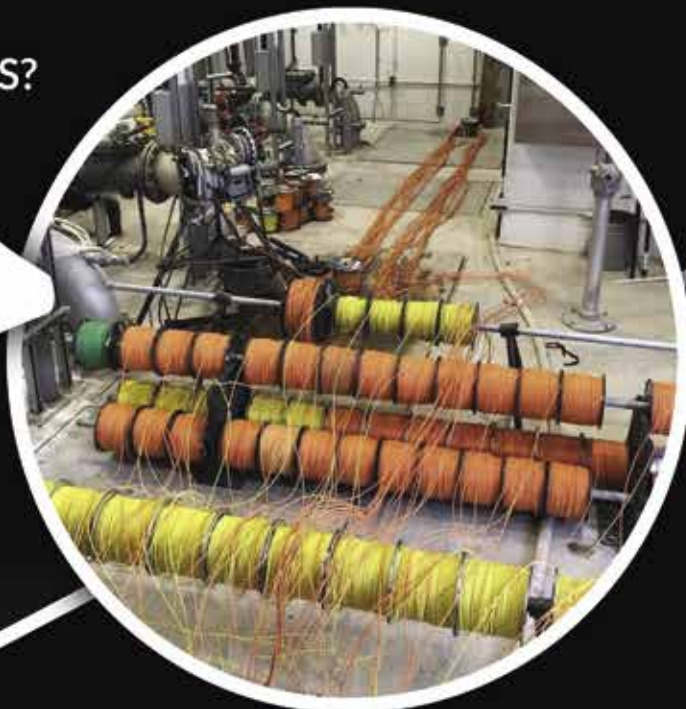
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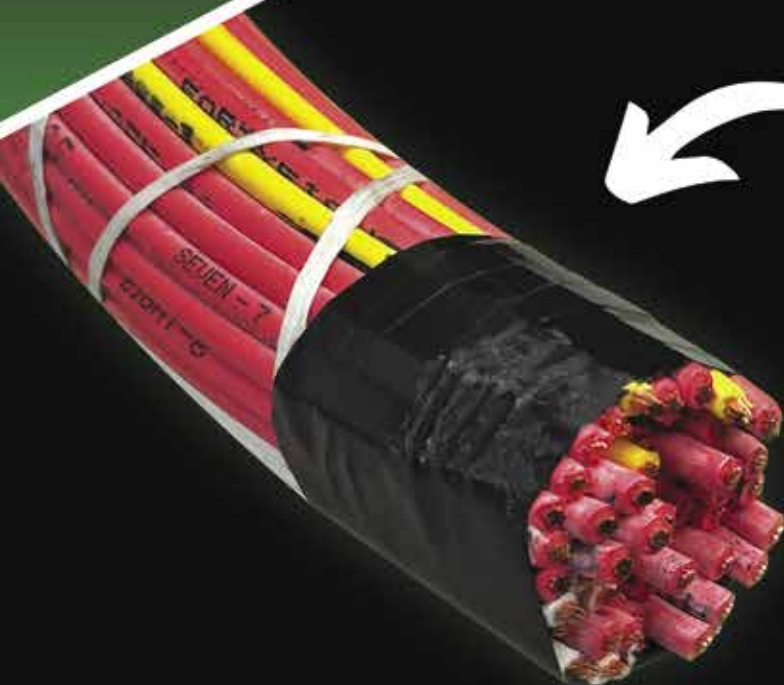
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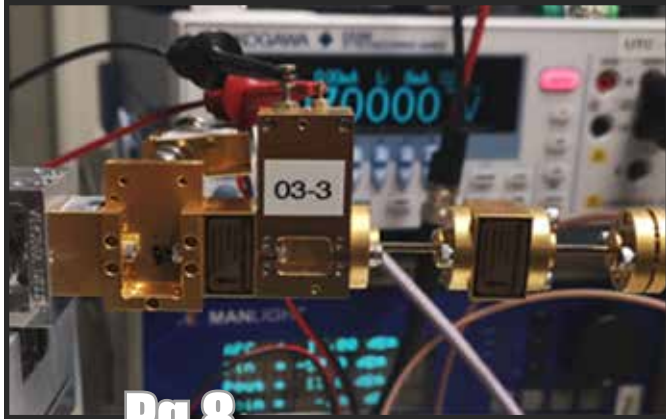


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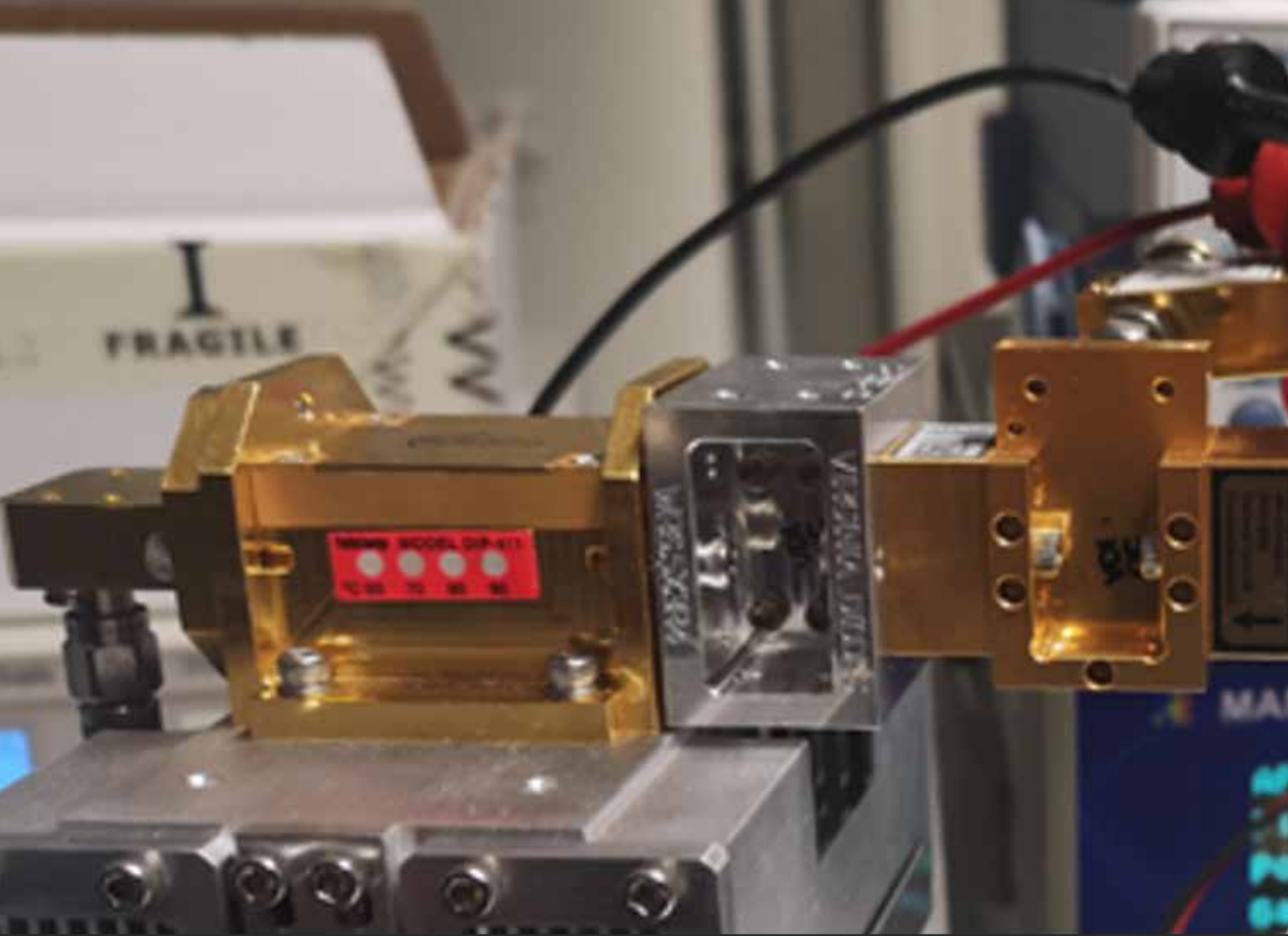
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Top Research Institutions Try to Unlock 6G

Academia is attempting to resolve the issues surrounding 6G, but a deficiency of mmWave-capable components could delay the next leap forward in wireless communications

While the rollout of 5G is still in its infancy, bleeding-edge research around the world is now heavily focused on solving a significant problem that is expected to arise within the next few years. Antenna-to-antenna links or the “backhaul of the network” are essentially limited to frequencies under 100 GHz. However, experts are predicting that by around 2025 these lower frequencies, under 80 GHz, will no longer be enough to support the evolution of 5G or 5G plus, especially within densely populated areas.

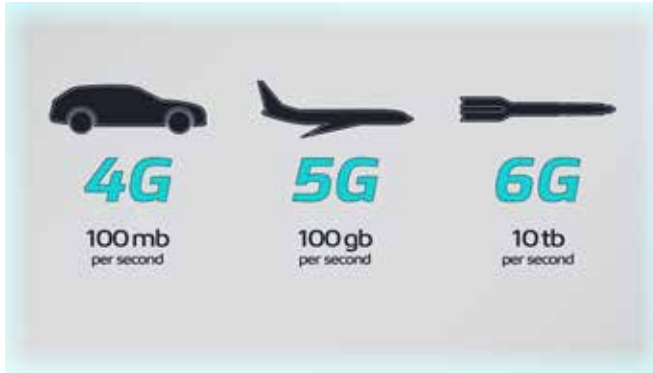
“For 5G networks, at some point, every user will expect to have at least 1 GB/s or higher,” says Dr. Guillaume Ducournau. “So, if you’re running 5G in a crowded place, like a commercial center or a big city, we have to be able to manage the huge data rates at the antenna collecting point.”



Dr. Ducournau is a professor at Université de Lille in France and a top academic researcher in THz communications. He has authored over 100 peer-reviewed papers published in international journals and developed several experimental setups dedicated to the characterization of THz devices for communications in the Lille THz communication cluster.

“Currently there is a dearth of components capable of operating in excess of 100 GHz and then even fewer when you push into the THz regime where 6G is expected to excel,” continues Dr. Ducournau. “So, unless the industry can come up with better components the problem is going to grow exponentially.”

6G is not yet a functioning technology but will deliver data rates that are 100 times faster than 5G and shift from primarily connecting people and things to connecting intelligence. Connected Robotic and Autonomous Systems (CRAS), Unmanned Aerial Vehicles (UAVs), artificial intelligence, and even remote robotic surgery. However, without resolving the issue of working at millimeter wave (mmWave) and THz frequencies, 6G could be greatly delayed.



"There is an urgent need right now to develop components, devices, testbeds, and concepts to operate at higher frequencies because, by 2030 or so, 6G will require these things," says Dr. Ducournau.

Pushing towards THz components

The issue with creating components at frequencies above 100 GHz comes down to physics. As you move up the electromagnetic (EM) spectrum the wavelengths get shorter. In fact, at a frequency of 300 GHz, the wavelength shrinks to just one millimeter. At these higher frequencies, the constituent parts are tiny and even small alignment errors can significantly degrade performance.

At such a small-scale, available power and device power handling become a big challenge. Therefore, components at these frequencies must operate with exceptionally low insertion loss and extremely high performance to allow engineers to develop effective signal chains.

In addition to sufficient device power handling, high isolation between active components becomes of critical importance to minimize signal degradation and potential device destruction from signal reflections between components.

For example, Faraday rotation isolators – more commonly referred to simply as isolators – are two-port components that allow EM signals to pass in one direction but absorb them in the opposite direction. Isolators are often used in communication systems because they do a good job of suppressing standing waves.

"Isolators have low insertion loss within the microwave bands, but at mm-wave frequencies, where we were working at, the loss becomes increasingly problematic," explains Dr. Ducournau.

A boost for mmWave components

"After doing significant research a few years ago, I discovered NASA had awarded a project to Micro Harmonics to develop mmWave isolators all the way to 300 GHz, and they showed very good performance," recalls Dr. Ducournau. "I immediately called them up."

Micro Harmonics Corporation (www.Micro-Harmonics.com) specializes in components for mmWave applications and successfully developed an advanced line of commercial off-the-shelf (COTS) circulators, isolators, and hybrid circulators, many of which can operate well into the THz regime.

Professor Ducournau selected an isolator that operates with WR-3.4 (220-325 GHz) and features a large usable bandwidth of dozens of GHz on either side of the center frequency.

"This allowed us to get the first-ever device characterization of a low noise amplifier operating at 300 GHz," states Dr. Ducournau.

His research team successfully characterized the noise floor (NF) along with the IP3 and IP5 of the

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amplifier, which are measurements of nonlinear frequency performance.

In addition to isolators, “there’s also a need for circulators at these very high frequencies,” explains Dr. Ducournau. “Circulators form part of the core system for communication applications but also for radar. Having these available could be a big boost for system implementation of early prototypes.”

For example, a new hybrid circulator recently developed operates in the 100+ GHz range which will be crucial to solving many of the 6G bottlenecks within the backhaul of the network.

The hybrid circulator has a much larger working bandwidth from 150 GHz to 190 GHz. The current state-of-the-art Y-junction circulator has a bandwidth of only a few GHz at these frequencies. The bandwidths required for 6G are not remotely possible using a Y-junction approach.

“Looking at the D-band development for backhauling, such devices would be very useful as duplex links targeted in such applications,” says Prof. Ducournau.

A small footprint

Simply attaining higher frequencies is not the only consideration when moving new research from the lab to commercial production. An overriding theme in commercialization is the drive to reduce the size, weight, power, and cost (SWaP-C) of components.

Minimizing the size and weight of mmWave components is especially important in today’s wireless applications. A standard traditional-style isolator in the WR10 band is about 3 inches long, with a

cylindrical section in the center that’s about 1.3 inches in diameter. While that may seem small, new designs are only 0.75 inches per side and 0.45 inches thick and are packaged in a designer-friendly rectangular cuboid.

These types of improvements in commercial components, along with leading researchers in the field, are pushing towards widespread commercial 6G technologies potentially by the end of this decade.

Unlocking new technologies

Of particular interest to Professor Ducournau is the development of remote, robotic surgery where a very low time-latency transmission system would be required. This is where the development of new components for systems with 6G speeds and high-reliability low latency communications are opening the door for the world’s best doctors to perform operations on people anywhere on the planet.

“If the energy consumption is low and the devices can be mass produced at low cost, the possibilities for new techniques for medical procedures would be endless.”

The technical challenges to implementing 6G systems are enormous. There is a good chance that the push to higher frequencies will halt near this point due to the practical limits of physics, health and safety.

“There is a strong argument to stay within the mmWave or lower THz frequencies because these wavelengths keep the radiated power densities within the bounds of what most people consider safe,” concludes Prof. Ducournau. •



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Achieving Power System Balance

A small utility in Tennessee installed a complete automated power factor balancing system without complex SCADA

For the power generation industry, maintaining power system balance as closely as possible to the ideal power factor (PF) of 1.000 using correction capacitors and other technology is critical. Power factor is a measure of how effectively electricity is used, with an equal 1.000 PF benefiting both the customer and utility, and a low or high PF indicating poor electrical power utilization. A low power factor can overload generation units making them work harder for the same amount of power. A high power factor can cause instability to equipment on the distribution network as the voltage rises beyond normal capabilities. In contrast, improving the PF can maximize current-carrying capacity, improve voltage to equipment, reduce power losses, and lower electric bills.

“The challenge for small municipal utilities and co-ops required to maintain proper power system balance is that they are more susceptible to large industrial loads and typically do not have complex SCADA systems to automate the process”, says Ryan McAuliffe, Sales Engineer, NovaTech Automation, a substation automation company that has served the power transmission and distribution market for over 30 years. In addition, smaller utilities may not have enough operators to manually monitor and effectively control the PF on a 24/7 basis.

Fortunately, cost-effective, self-contained, automation platforms can utilize programming logic schemes to maintain power system balance, minimizing the need for manual oversight and control.

“Today, automation platforms can maintain system balance with PF at virtually 1.000 with accuracy to 3 decimal places. The control system



calculates whether the power system is out of tolerance, and if so, initiates a correction using the capacitor banks to keep the power factor at 1.000,” says McAuliffe.

Automating System Balance

In a recent example, a small municipal power utility in Smithville, Tennessee required an automatic capacitor control logic scheme for their distribution network.

“The municipal utility has a small distribution network and is contracted [with a major Transmission Network Operator], under penalty of fine, to keep the PF of the power system as close to 1.000 as possible. However, the system includes a rather large industrial customer, so the utility needed a better way to manage their PF,” says McAuliffe.

The utility has two substations with interconnecting feeders through their distribution network with the feeder circuit breaker on either end acting as the open or closed point. The capacitors are positioned outside the substation fence at various locations on those interconnected feeders.

As a solution, the utility chose to implement a complete integrated power balancing system including capacitors, a capacitor bank controller, circuit breakers, and a controlling RTU.

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The system uses open-source web technologies and pre-configured template pages. This simplifies the building of interactive SCADA and local HMI screens to view data from connected IEDs and RTUs using standard web browsers. Engi-

neers can open multiple browsers to have graphical interfaces for the different substations and key remote monitoring features on different tabs, which eases network monitoring. Multiple users can be logged in simultaneously.

"With the substation automation platform, the utility did not need a dispatcher for PF balancing, only a supervisor to oversee the facility," says McAuliffe.

According to McAuliffe, the platform's System Balance scheme helps to ensure that each substation maintains a 1.000 power factor. The scheme will initialize values and then load all previous retentive values or default values if there are no retentive values. With the scheme, an overall leading power system state will turn off one or more capacitors, and an overall lagging power system state will turn on one or more capacitors, providing alerts and control.



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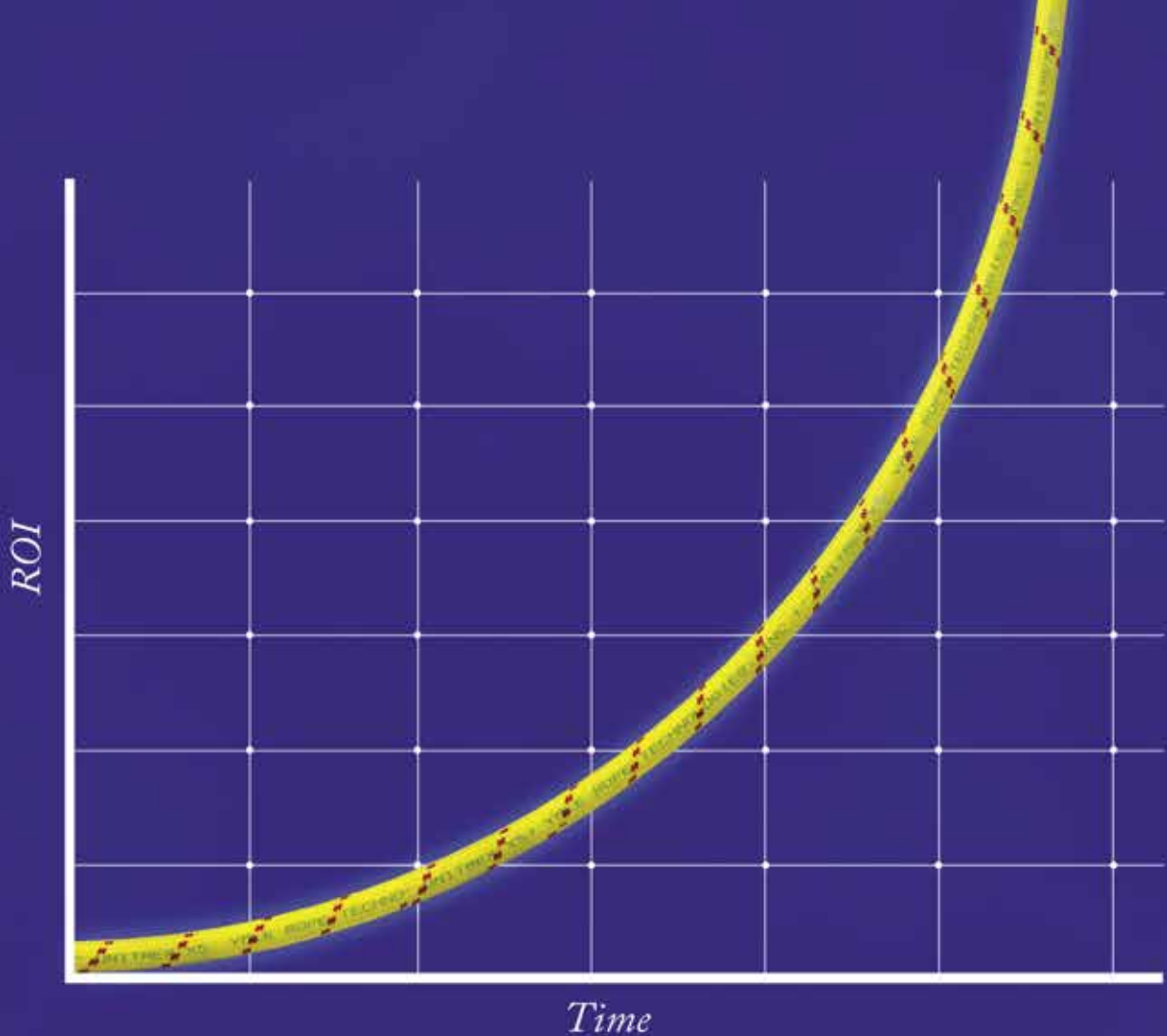
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To ensure that individual feeders are in balance and within tolerance, a second logic scheme has been proposed for Individual Feeder Balance that will run every five minutes after completion of the primary scheme. This is needed due to the configuration of the utility's distribution network assets. Although total substation power factor can be balanced, it is possible to have two feeders out of balance in the condition of one lagging and one leading. The second scheme looks at individual

feeder power factor tolerance and makes corrections as needed.

Together, the primary and secondary balancing schemes provide integrated Volt-VAR regulation and optimization. The schemes automatically switch capacitor banks in and out to maintain power factor very close to balance, summing PF on each feeder and comparing it with the metered value reported to the power provider. The

automation includes features to reduce wear and maintenance such as never switching the same capacitor bank twice in a row.

The system maintains the ability to manually control all capacitor banks and provides web-based HMI for monitoring and control of breakers and IEDs in substations.

"Automated power system balancing comes in handy for smaller utilities because they don't need to monitor as closely. With installation comes more automatic control that can be scaled up to the number of required substations," says McAuliffe.

Overall, the primary and secondary balancing schemes have been extremely beneficial for the small municipal utility in Tennessee. The schemes have reduced the labor required for the utility to look after the distribution grid, and it has maintained almost full power factor compliance with the Transmission Network Operator.

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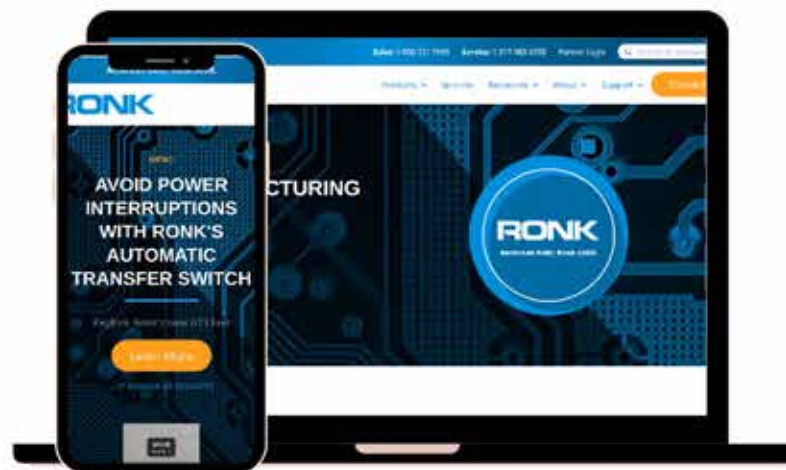
We want our customers to benefit from our deep understanding of the industry, our products, and our ideals. We strive to eliminate the risks of disruption, failures, and other challenges.

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Rock Electrical is a leading manufacturer of electrical equipment committed to building the highest quality products that are made in America and uphold true American values of quality, efficiency, safety, and freedom. Our proven products are easy to install, enhance power usage, and last for decades in America's toughest powering locations.