INTRODUCTION

Powering IDAS Networks

An Alpha Technologies White Paper

by Kevin Borders
Director of Product Marketing

June 2014

Your Power Solutions Partner

The advent of Indoor Distributed Antenna System (IDAS) networks has greatly increased the capacity and reach of wireless service in public venues such as sports stadiums, convention centers and hotels. IDAS remote nodes, placed throughout the venue, enhance the user experience by enabling them to upload photos and videos, download site information or sports scores, send and receive texts and, on occasion, even make a voice call. Yet for all the benefits of the IDAS configuration, the service provider faces many deployment challenges, not the least of which is the ability to power each of these remote nodes.

Because DAS and other small cell networks are distributed and in greater quantity than macro cells, service providers have struggled with a variety of power issues. How much, if any, battery backup is needed? Should the RF network be designed to match the availability of AC or should the service provider pay electricians to install new AC access points? Should the power enclosure house the power conversion equipment, the batteries, or both? Where should the power enclosures be located?

Alpha Technologies pioneered a new power architecture for IDAS networks, one which does not require batteries or power conversion at the remote node. Instead, the new solution uses copper cable to deliver low voltage over the line from a centralized power system typically located at the host DAS node. To introduce this low voltage line power concept, Alpha Technologies has released a new white paper series called, “Line Powering IDAS Networks.” The white paper series consists of five chapters that divide the topic into easy-to-digest modules. The five papers include:

Line powered IDAS networks have become the standard for many service providers. Our goal is to introduce you to a new tool in the network design toolkit. At the conclusion of this series, you should have a basic understanding of how and when to use line powering for your IDAS networks.

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POWERING IDAS NETWORKS

Chapter 1
IDAS Network Overview

An Alpha Technologies White Paper

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June 2014

Your Power Solutions Partner

In this first installment of Alpha Technologies' white paper series, "Powering IDAS Networks," we provide an overview of DAS and the network topologies used in Indoor DAS and Outdoor DAS networks.

DISTRIBUTED ANTENNA SYSTEMS (DAS) OVERVIEW

The primary means of providing cellular service is through large cell towers, called macro cells. Though macro cells seem to be everywhere, dotting the landscape in both urban and rural settings, they are unable to provide 100% of the coverage needed for the ever-growing demand for wireless service. To augment the macro cell coverage, a new technology called Distributed Antenna Systems (DAS) was envisioned in the late 20th Century. A DAS network distributes radio energy over fiber or coax cable to antennas strategically placed inside buildings or in hard-to-reach outdoor areas. Capable of delivering voice and/or data, DAS networks can be configured to support multiple wireless service providers deploying a variety of frequency bands and technologies in a small form factor.

Though installations were sporadic for several years, DAS has recently become a mainstream deployment tool. Service providers have begun deploying DAS networks in both indoor and outdoor environments to ensure adequate service coverage. Third party companies, call neutral host providers, have created a new business model wherein they build DAS networks and lease access to the wireless service providers. Both approaches help solve the coverage problem.

Improved coverage is not the only driver for DAS deployments. Today, DAS networks are being deployed to increase network capacity or bandwidth, providing much-needed relief in an era where wireless data and video are pushing the capacity of the macro cell network to its limits.

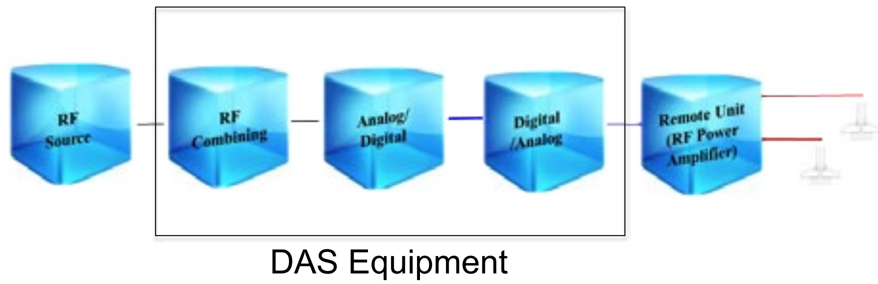
DAS networks offer potential relief for a variety of applications, including:

- Densely populated urban areas
- Tunnels
- Colleges and universities
- Hotels, resorts, and convention centers
- Stadiums and theme parks
- Hospitals and medical centers

HOW IT WORKS

A DAS network consists of a number of lower power antennas placed close to the users, and connected by high capacity media such as coax or fiber optic cable to a central communications hub site. Radio Frequency (RF) sources such those generated by conventional Base Station Terminations (BST), are combined into a common signal which is routed to the DAS Host Unit. The DAS equipment digitizes the designated RF bands and digitally transports them over single mode fiber to the Remote Units. The remote receives the digitized spectrum from the Host Unit and converts the spectrum back into RF to be distributed via an externally mounted antenna system. For communication from the remotes to the host, the process is reversed. *Figure 1 shows a block diagram of the various stages.*

Figure 1 DAS Block Diagram



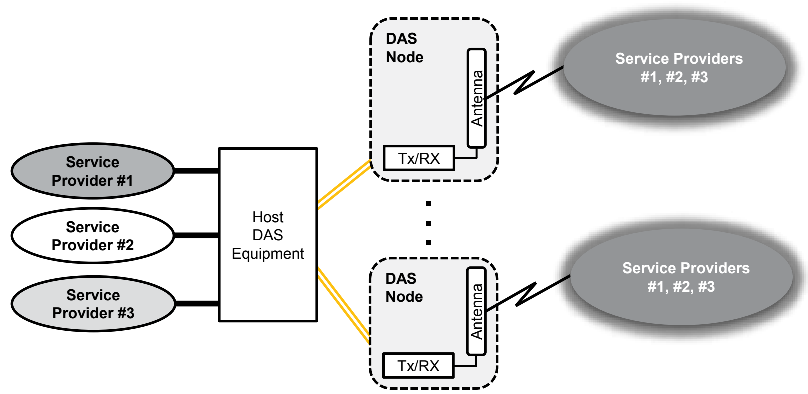
In essence, the DAS network can be thought of as extending the signal of the macro cell network. The close proximity of the antennas to the users improves coverage. And since each remote site has the same band of wireless spectrum (i.e. a band of frequencies used for wireless communications), the spectrum can be used again and again, increasing the overall capacity of the network.

The typical DAS network consists of three main parts:

1. **Host Site,** the central communications hub site that contains the transceivers that transmit and receive the RF signals that are delivered to/from the DAS Nodes
2. **DAS Nodes,** the remote antenna sites that are capable of transmitting and receiving the wireless service providers' signals
3. **Transport Medium,** the high capacity wired connection (typically coax or fiber optic cable) between the Host Site and the DAS Nodes

Multiple wireless carriers can connect to a DAS network. *A basic DAS Network diagram is shown in Figure 2.*

Figure 2 Basic DAS Network



PASSIVE AND ACTIVE DAS NETWORKS

DAS networks can be either passive or active. In a **passive DAS network**, high power amplifiers distribute RF signals over thick coaxial cable (0.5 to 1 inch in diameter) from the Headend to the antennas. Couplers are used to divert a fraction of the RF energy to each floor of a building. There are no electronic components required to setup a passive DAS network.

The passive networks are simple to deploy and have a low equipment cost, but the signal loss in the cable limits their effectiveness. Attenuation of the radio energy limits the distance to shorter cable runs. In essence, passive DAS networks are limited to smaller venues. *For the rest of this paper, we will focus on active DAS networks*.

In **Active DAS networks**, the radio signal is actively managed from the Headend, where the RF source is located, all the way to the antennas. At the headend, the RF is converted to fiber and transported through fiber optic cables to remote access units. At the remote node, the signal is converted from the fiber to RF and connected to low power amplifiers located at the antenna end points. With strong and consistent signals at every antenna, network planning is simplified. The active technique is used for all outdoor and most large indoor DAS networks.

Outdoor DAS (oDAS) networks are usually deployed in urban areas where large buildings interfere with service from a macro cell. The antenna heights of DAS nodes are much lower than macro cells, permitting placement on utility poles and street lights. This enables RF design engineers to pinpoint coverage throughout a community, which may result in deployment of a large number of oDAS nodes to provide coverage to a widespread geographic area. While primarily used to fill coverage gaps, oDAS networks are increasingly being used to provide capacity relief for bandwidth strained macro cells. *A typical oDAS node is shown in Figure 3.*

Figure 3

Indoor DAS (IDAS) networks are structured similarly to oDAS networks, but typically with even lower power antennas. Rather than mounting antennas on light poles, however, they are strategically placed throughout a building and located in ceiling tiles, HVAC vents, and telco closets. For both oDAS and IDAS networks, aesthetics is an important factor in deployment. In fact, aesthetics may be so important as to affect the topology and even the product selection.

IDAS ATTRIBUTES

There are five distinct attributes to an IDAS network. First, there may be one or more host nodes, each providing access to multiple wireless service providers. Each host node must be powered. Second, the IDAS remotes may be co-located transceivers and antennas, or may be transceivers that connect over passive coax cable to multiple antennas located remotely from the transceiver. Third, the cable that spans the host and remotes is often accessible by the public, so additional precautions are necessary. Fourth, the nodes require electricity in order to operate, so a source of power is needed for each remote node. And fifth, the distance between the hosts and remotes can vary from a few hundred feet to a few thousand feet.

SUMMARY

Both oDAS and IDAS networks are emerging tools for expanding capacity and coverage of wireless networks. Multiple wireless service providers can use the same infrastructure, minimizing cost and zoning hurdles. DAS networks employ a basic topology, with the host communications hub providing connections to multiple remotes to deliver RF signals for one or more wireless provider. Though similar in architecture, oDAS and IDAS networks differ by the amount of power delivered by the antenna, the requirements for aesthetics at the site, and the distance served. Both serve important roles in the expansion of wireless coverage.

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POWERING IDAS NETWORKS

Chapter 2
Local Power Solutions

An Alpha Technologies White Paper

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LOCAL POWER SOLUTIONS

The two main components of an Indoor DAS network – the Head End and the Remote Nodes – both require electricity to operate. In this second installment of Alpha Technologies' white paper series, "Powering IDAS Networks," we describe conventional methods of powering IDAS networks using local power supplies for each remote IDAS node. The paper starts by briefly summarizing the power required at the host site, and then shifts its focus to power at the remote node. Both AC and DC power solutions for remote nodes are covered.

POWERING THE DAS HOST

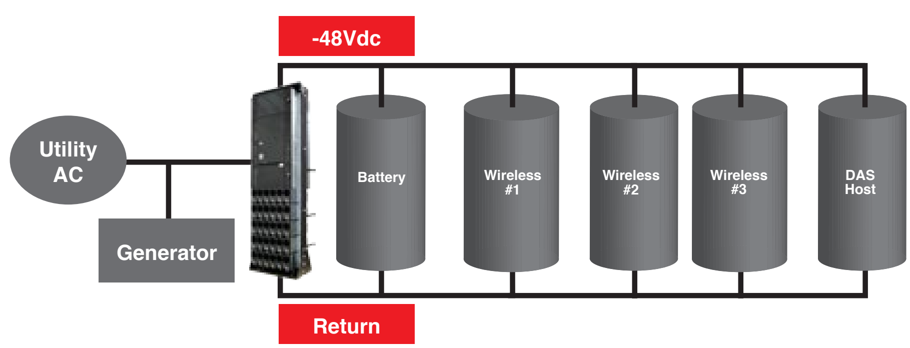
DAS networks must provide the same level of service as the wireless networks in order to assure the same quality of service for the wireless customers. Consequently, most DAS host equipment is powered by direct current (DC) converted from commercial, or utility, AC. The power conversion equipment not only powers the DAS equipment, but also charges a bank of batteries that provide service in the event of an AC outage.

Wireless service providers often elect to power their own equipment. But in some cases, the DAS network provider may offer a service whereby it powers the wireless base stations in addition to the DAS host equipment. Since most base stations are now powered by -48Vdc, it follows that most DAS equipment is -48Vdc as well. When the voltages used to power the equipment are the same, including the base station equipment, it becomes a straightforward engineering exercise of power system capacity.

For DAS host sites that provide power to both the DAS equipment and legacy +24Vdc base station equipment, DC-DC converters could be installed on the 48Vdc power plant to energize the +24V base station equipment. Otherwise, separate -48V and +24V power systems are required along with separate strings of batteries. The description below focuses on the -48V version of the DAS host, and assumes both the DAS host equipment and base station(s) are powered by the same plant.

At the IDAS host site, commercial AC connects to rectifiers, which convert the AC current into DC to run the host equipment. In the event of an AC outage, one or more strings of batteries provide backup power. In addition to the batteries, there is often a standby AC generator, or at least access to a portable generator, to protect against an extended AC outage. In Figure 1 below, a -48Vdc rectifier bay and batteries power the wireless base stations as well as the DAS host equipment.

Figure 1 Host Site Power Block Diagram



DAS REMOTE NODE POWER

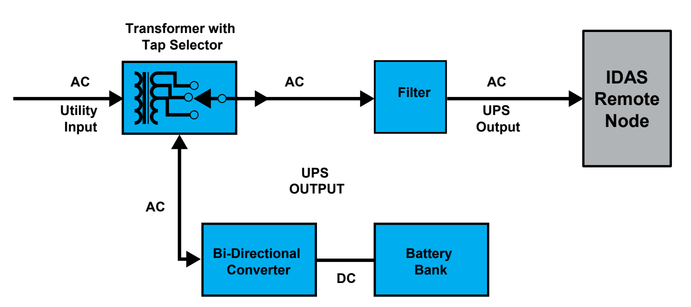
Powering the DAS remote nodes is not as straightforward as powering the host equipment. Depending on the product and the vendor, the DAS remote nodes may be either AC or DC powered, and they may or may not have battery backup. These options complicate the decision on how to power the unit. The provider can operate an AC-powered remote directly from an AC outlet (without battery backup) or by using Uninterrupted Power Supplies (UPS) to charge batteries that are used to back up the site. A DC-powered remote requires a rectifier to convert the utility AC power to DC for operating the remote and for charging the batteries.

For more on the subject of battery backup, see the inset. For the remainder of this paper, however, we will disregard unprotected local AC power as a viable solution. Regardless of the input power, most DAS providers elect to provide battery backup for each node. This requires a power conversion device to charge the battery and/or power the electronics. Both the AC and DC solutions are explored below.

AC POWERED DAS REMOTES

For AC powered DAS remotes, an Uninterruptible Power Supply (UPS) is used to charge the battery. Most sites use a line interactive style of UPS, i.e., one in which the incoming AC utility power is conditioned, or interacted with, by the UPS. The result is a sine wave output. The UPS can sense when utility AC is outside of the acceptable input range, either too high (surges or spikes) or too low (outage). At that point, the UPS derives an AC output by converting the DC power from the battery. The entire process is extremely quick and efficient. A line interactive UPS is relatively inexpensive and can be designed to operate over a wide temperature range, which is sometimes needed when “indoor” DAS equipment is placed in outdoor settings such as sports stadiums. A block diagram of a line interactive UPS is shown below in *Figure 2.*

Figure 2 Line Interactive UPS



BATTERY BACKUP – IS IT WORTH THE COST?

While battery backup is effective in improving network reliability, it does increase the installed first cost of the site and requires ongoing maintenance of the batteries. To eliminate these costs and maintenance issues, some service providers have elected to forego battery backup, preferring instead to simply power the devices with local AC power. While less expensive, the lack of battery backup leaves the network vulnerable to utility AC outages.

The providers that avoid the battery backup investment argue that the macro cell could handle the traffic in an emergency such as the loss of utility AC power. Yet, deployment of an IDAS network is specifically intended to augment coverage and capacity, overcoming a limitation in the macro cell. Moreover, a failure to deliver service at these venues can result in more publicity than a provider desires. Imagine the outcry at the 2013 Super Bowl had the wireless users not been able to talk, text and upload photos of the power outage.

Battery backup can be thought of as an investment that ensures higher levels of customer satisfaction. Even a few minutes of battery backup will protect the service provider from the vast majority of AC power interruptions. In the end, the DAS providers have to determine if avoiding some first cost expense is worth the risk of alienating a group of target customers.

DC POWERED DAS REMOTES

DC powered DAS remotes require rectifiers to convert the utility AC into DC for operating the DAS equipment and for trickle charging a string of batteries. Rectifier plants may be either integrated (like most UPS's) or modular. The modular approach enables the operator to offer N+1 redundancy on the power conversion equipment, improving reliability. The modularity and redundancy features do require more space, so some operators prefer the integrated approach. Battery backup varies from a few minutes to several hours.

LOCAL POWER: PROS AND CONS

Both UPS- and rectifier-based solutions are familiar, readily available options for service providers. There are multiple vendors so pricing is reasonable for this approach. Technicians understand the technology, which reduces the learning curve when it comes to deployment and maintenance. In all, both approaches are suitable solutions for improving network reliability.

Yet both local power solutions have several drawbacks. First, the locally powered solution must be located near an AC outlet. Since the power solution needs to be near the DAS remote, the operator must decide if it wants to design its RF network around the location of existing AC outlets, or if it wants to invest in electricians to install new AC outlets and wiring.

Second, deployment of batteries in many locations throughout the venue increases upfront equipment cost as well as the ongoing cost for management and upkeep. The batteries require occasional maintenance and/or replacement, requiring technician site visits, or truck rolls, which can be costly. Third, a power conversion solution and batteries are required at each DAS node. This requires the power equipment to be either mounted in a discrete area or housed in a secure enclosure that is visible to the customer base. The proliferation of mounting enclosures does not always meet the venue owner's requirements for aesthetics, which can make local power solutions problematic.

SUMMARY

When used with batteries, both AC and DC solutions can increase the reliability of an IDAS installation. The technology is well understood, but the cost of powering the multitude of nodes can add up. And the recurring cost of maintaining batteries at the edge of the network can have a big effect on operating budgets. With venue operators demanding installations that visually complement the surroundings, these power and batter boxes can present a major obstacle to network deployment.

POWERING IDAS NETWORKS

Chapter 3
Line Powering IDAS Remotes

An Alpha Technologies White Paper

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June 2014

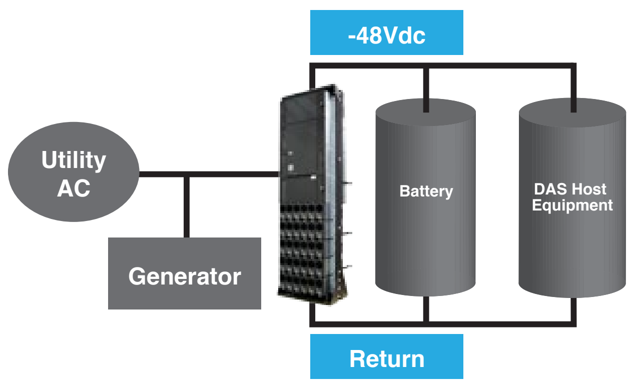
Your Power Solutions Partner

In the previous installment of Alpha Technologies' 5-part white paper series, "Powering IDAS Networks," we explored the pros and cons of powering DAS remote nodes using local power methods. The shortcomings of local power led Alpha to pioneer the development of a new IDAS power architecture that uses power at the DAS host to supply current over copper cables to energize the remote nodes. An overview of this technique, called Line Power, is presented in this third installment of the white paper series.

CENTRALIZED HOST: THE IDEAL POWER SOURCE

The drawbacks with local power solutions have led some service providers to consider using the highly reliable host power system to power the remotes. The host equipment is typically powered much like a carrier's base station. Utility AC is converted to -48Vdc by rectifiers, which in turn power the DAS Host equipment. There is much emphasis on reliability – the rectifiers are typically configured using N+1 redundancy; the battery reserve time is often 4 to 8 hours; and there is usually a permanent standby generator or at least access to a portable generator. This configuration meets the requirements for a carrier grade power plant, making it an ideal source of power for the remote nodes. *A typical power arrangement at the host site is shown in Figure 1 below*.

Figure 1 Host Site Power Block Diagram



CONNECTING THE DAS REMOTES

The two key aspects of line powered IDAS are (1) taking the bulk -48Vdc output of the power plant and distributing it to multiple nodes; and (2) delivering the power in a manner that is safe for both technicians and the public. Let's address distributing the power first.

The host power is distributed to the remotes over copper cables. The size, or gauge, of the cable is dependent on the amount of power required by the remote nodes and by the distance between the host and remote. To maximize reach, heavier gauge copper cables such as 12AWG or 14AWG are used. The lower resistance of these bigger cables reduces the amount of power lost during transmission over the copper cables, which translates to a larger serving radius for the host plant.

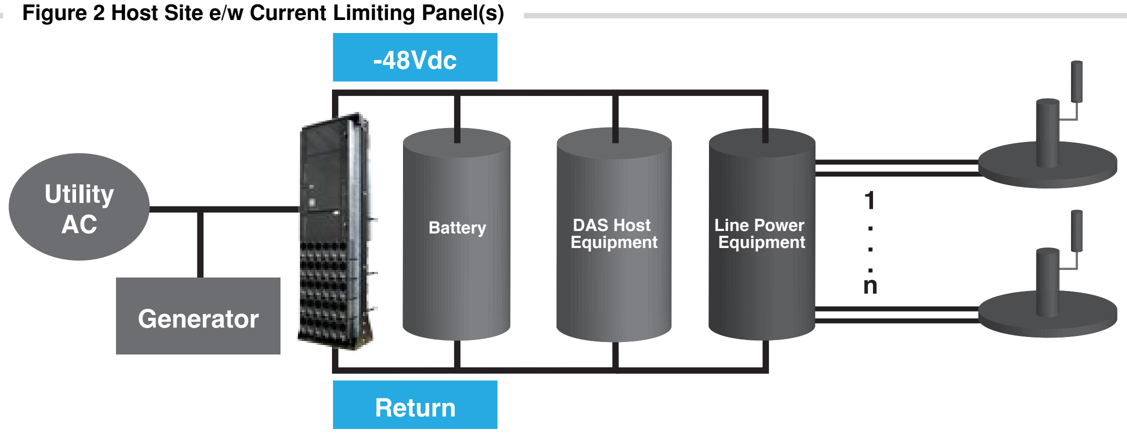
At the host site, a device is required to take the bulk output of the host power plant and distribute it evenly to multiple cables. There are two ways to accomplish this – through a conventional fuse panel or through a special panel that limits current.

Some providers have deployed fuse panels to distribute the power, using the rationale that a low current fuse would limit the overall power delivered on the circuit. But fuse panels do not meet the requirements of the National Electrical Code (NEC) which requires the circuit to be less than 100 Watts even when the primary protection device (i.e. fuse) has failed. So when fuse panels are used to distribute the current, the operator must deploy armored cables or encase the cables in conduit. In addition, a licensed electrician is required to install the cable. The introduction of conduit and electricians make it difficult to prove the business case for IDAS remotes powered by fuse panels.

A new device, called a current limiting panel, provides active electronic circuitry to limit the power to 100 Watts. The NEC defines a Class 2 circuit as one with a voltage <60Vdc and power <100 Watts. Class 2 circuits can be deployed using surface-mounted communications cable (no conduit) and do not require licensed electricians to install. For more information on NEC Class 2 circuits, please refer to Alpha Technologies' White Paper, "Powering Indoor DAS Networks: NEC Class 2 and Safety Considerations".

Avoiding the cost of the electrician and the conduit significantly reduces the total cost of ownership of an IDAS network powered with current limiting panels. At the host site, the current limiting panels are installed between the bulk output of the 48V plant and the cables, *as shown in Figure 2 below*:

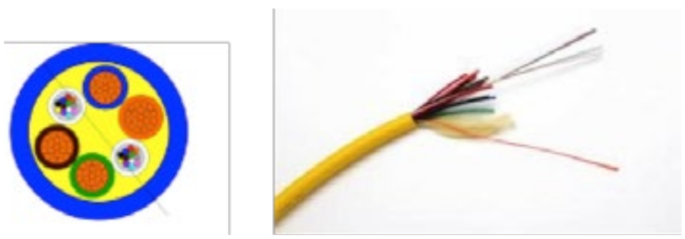
Figure 2 Host Site e/w Current Limiting Panel(s)



MANAGING INSTALLATION COSTS

As we just covered, the first step in managing cost is to use the NEC Class 2 circuits. The next step is to determine the right type of cable to use. Two types of cables are required between the host and the remotes: the fiber carries the traffic and the copper supplies the current. Most providers and integrators have found that pulling two separate cables is too costly because they incur twice the installation labor cost. The more common approach is to use composite fiber/copper cable, i.e. cable that includes both fiber and copper in the same sheath. *A typical composite cable and cross-section diagram are shown in Figure 3 below.*

Figure 3 Composite Fiber/Copper Cable



LINE POWER – HOW IT WORKS

The current limiting panel couples the -48Vdc bulk output of the host site power plant to the cables that connect to the remote nodes. Each current limited circuit supplies the same voltage as the bulk power plant to the cable. But, because of the current limiting circuitry, the maximum power delivered to each cable is 100 Watts.

For Line Power to work, the remote node equipment must accept a DC input. Due to voltage losses in the cabling, a wide range input is preferred. Some remote devices operate from -36 to -60Vdc, others operate all the way down to -20Vdc. Of course, the remote device needs to consume less than 100 Watts. Depending on the load, distance and gauge of the cable, a single Class 2 circuit can power the remote. If multiple cable pairs are required the remote must provide multiple, isolated inputs in order to comply with CSA/UL. The standards forbid the coupling of power between cable pairs because it defeats the purpose of the 100 Watt safety limitation.

SIZING THE PLANT

Capacity varies among current limiting panels, but most fall somewhere between 24 and 36 circuits per panel. Let's look at an example using 24 circuits in the panel. The maximum output of the panel is 2400 Watts (24 circuits x 100 W/circuit). Assuming a high efficiency of 90%, the input power required at the panel is 2667 Watts (2400W ÷ 90%). For 48 Volts, this load translates to 56 Amps of input power; in other words, the current limiting panel requires a rectifier plant with a minimum output of 56 Amps.

HOW FAR CAN IT REACH?

To minimize losses in the cable, most IDAS providers are using heavier gauge cable to connect the remotes to the headend. The larger diameter enables much greater distances than the skinnier Cat 5 or Cat 6 cable. The most common cable sizes are 12-16 AWG. (The NEC prohibits the use of cables larger than 12 AWG for indoor communications circuits). As a rule of thumb, a low power IDAS remote can be powered up to 750 feet from the current limiting panel, depending of course on actual power consumption and the gauge of the cable.

SUMMARY

Centralized power offers high reliability and low life cycle cost through the elimination of batteries at the IDAS remote nodes. To avoid the cost of conduit and the need to use licensed electricians, the distribution equipment must contain active current limiting circuitry that limits the voltage to less than 60Vdc and the power to less than 100W per cable pair. These current limiting panels can reach low powered IDAS remote nodes up to 750 feet away when powered over 12 AWG copper cables. To further simplify installations, many service providers and integrators use composite fiber/copper cable between the host and remote nodes.

POWERING INDOOR DISTRIBUTED ANTENNA SYSTEM (IDAS) NETWORKS:

Chapter 4
Extending the Reach

An Alpha Technologies White Paper

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June 2014

Your Power Solutions Partner

In the previous installment of Alpha Technologies' white paper series, "Powering IDAS Networks," we learned about powering Remote DAS Nodes using centralized power from the Head End power system. This technique, called Line Power, eliminates the need for batteries at the remote nodes, making it a preferred design method for many service providers and integrators. In Chapter 3, we also noted that 750 feet (230 meters) is the general rule of thumb for maximum distance served using a Line Power solution. While 750 feet is adequate for many sites, how do you address remote nodes that happen to lie greater than 750 feet from the host site? In this installment, we discuss different techniques for extending the reach in larger venues.

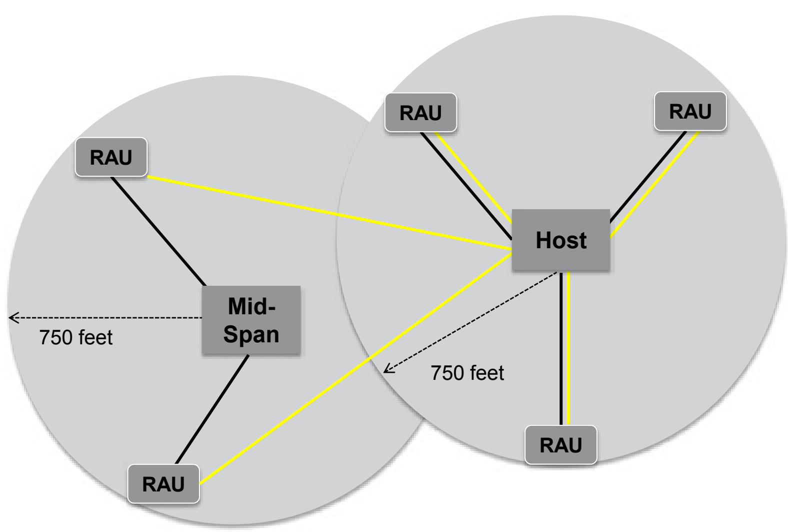
OVERVIEW

There are two ways to line power remotes located greater than 750 feet from the host: (1) add a supplemental power system located mid-span between the host and remote; or (2) increase the voltage level at the host. Each method is discussed below.

SUPPLEMENTAL POWER SYSTEMS

A supplemental power system is an entirely new and separate power plant installed at a location somewhere between the Head End and the furthest DAS Remote. This mid-span IDAS Power System (IPS) includes its own AC connection, rectifiers, batteries, distribution and one or more line power systems. The copper cable originates from the mid-span site, but the fiber comes from the DAS Host Site. The Head End power system will likely have more capacity than the mid-span system; otherwise, the structure and content of Head End and mid-span power systems are similar.
A diagram of a mid-span power application is provided in Figure 1:

Figure 1 Mid-Span Power Network Architecture



Deploying a supplemental power system is a straightforward concept as its structure follows the pattern of the host power system. However, there are some drawbacks, as noted below:

1. Incremental capital is required to reproduce the rectifier system and batteries as well as the line power equipment.
2. Additional space is required in the facility, perhaps in a telco closet or other designated area, to house the supplemental power system. This may involve cost for construction as well as recurring operating expenses for renting the space.
3. An additional AC connection is required and another set of batteries must be maintained. Both run counter to the primary reason for using Line Power in the first place.
4. Since the power is originating from a different location than the IDAS Head End fiber, additional labor is required to install dedicated copper cable.
5. The overall network design can become more complicated due to two different power locations, but one DAS Head End site.

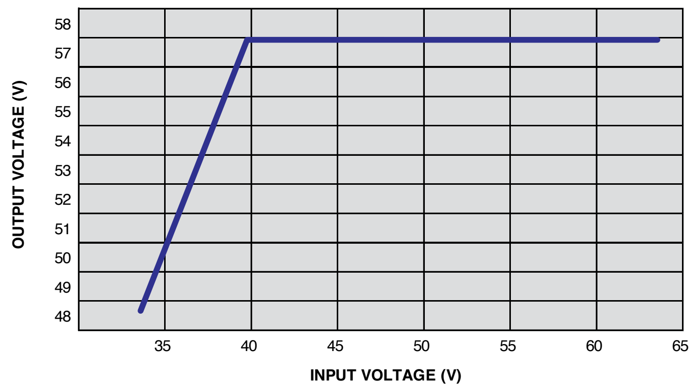
Despite these concerns, the incremental capital and maintenance expenses may still be less than populating the venue with local power solutions, making the mid-span IPS approach a viable alternative for certain extended reach applications.

BOOSTING THE VOLTAGE AT THE HOST

At the host site, the nominal output of the power system is 48Vdc. This source voltage is then distributed via the Line Power system to the remotes. But during a power outage, the rectifiers are off line and the batteries take over delivery of the power. As the batteries discharge, their voltage begins to gradually drop until it reaches a level known as the battery cut-off voltage, or the point at which the batteries will go off line in order to avoid damaging the batteries. For most DAS applications, the battery cut-off voltage is 42Vdc. The network planner has to use that 42Vdc value in designing the network in order to ensure network operation while the batteries are in service. The 750 foot distance limitation was determined using a 42V source.

There is a way to boost the voltage at the Head End and take the battery cut-off level out of the equation. A device called a DC-DC converter can be inserted between the 48V power plant and the line power equipment. This DC-DC converter is designed to produce a constant 57Vdc output across a wide input voltage range, typically -40 to -60Vdc as shown in Figure 2. The output of the system will be 57Vdc, regardless if the rectifiers or the batteries are supplying the voltage. In other words, even at the battery cut-off level of 42Vdc, the output voltage of the system and in turn the line power equipment will be 57Vdc.

Figure 2 DC-DC Converter Voltage Graph



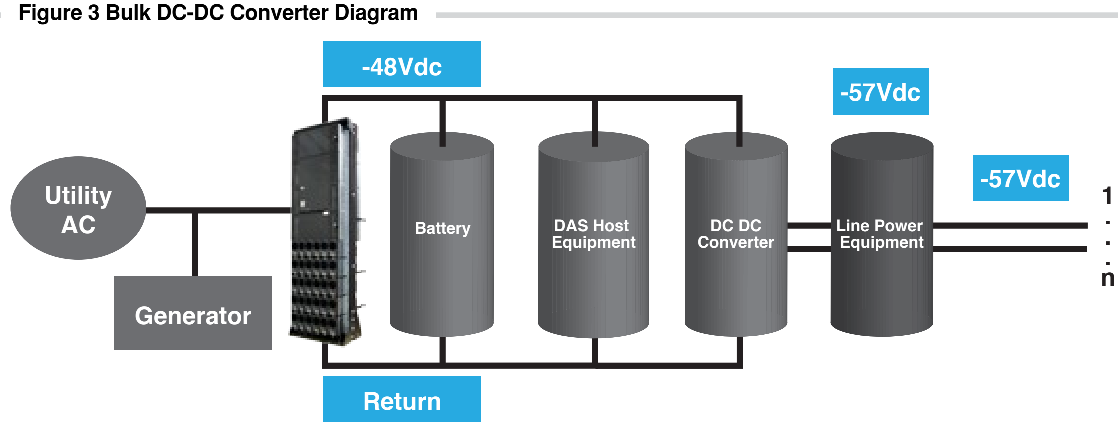
Though the increase in voltage is only 35% (57 ÷ 42), the distance nearly doubles to a reach of 1500 feet. This phenomenon is attributable to how power is lost in the cable (known as I2R loss). Because of Ohm's Law (V=IR), a lower current results from a higher voltage. But the lower current not only results in less loss in the cable, but also does so at an exponential rate; hence, the extraordinary increase in distance for a much smaller increase in voltage.

The output of the DC-DC converter is limited to 57Vdc, rather than the 60Vdc permitted by the NEC, to allow for tolerance and provide for safety margin. There are two methods of achieving the 57Vdc output. The first method inserts a bulk DC-DC converter shelf between the 48V power plant and the line power equipment. The second approach integrates the DC-DC converter into the Line Power equipment.

BULK DC-DC CONVERTER METHOD

A 48:57V DC-DC converter shelf can be installed in either a miscellaneous equipment rack or along with the power plant and Line Power equipment. A standard converter plant, typically occupying only 2RU of rack space, is simple to implement. The 48Vdc power plant distributes power to the DC-DC converter through a protection device (fuse or circuit breaker). The output of the converter connects to the input of the Line Power equipment. This arrangement equips the host for a 57Vdc output, enabling it to reach the far end remotes. A block diagram of this configuration is provided below:

Figure 3 Bulk DC-DC Converter Diagram



Though easy to comprehend, there are nevertheless some drawbacks to using the bulk DC-DC converter arrangement. First, it increases the amount of rack space required as well as adds another connection point. Second, it also reduces the system efficiency to the 85-86% range. This loss of efficiency means that more 48V power (i.e., rectifiers and batteries) is required at the input of the converter to ensure enough power at the Line Power equipment. Third, investment in the DC-DC converter shelf is required up front, though the deployment may take place over a longer period of time. This can result in underutilized assets, at least until the circuits are required in the venue.

Fourth, cabling can be an issue. By inserting the DC-DC converter shelf into the design, an extra connection is needed between it and the current limiting panel. Depending on the capacity and configuration of the DC-DC converter equipment, the connection from the 48V plant can require very large cables, up to 350MCM. While manageable on initial installation, adding a DC-DC converter shelf to an existing installation at a later date can create a cabling nightmare.

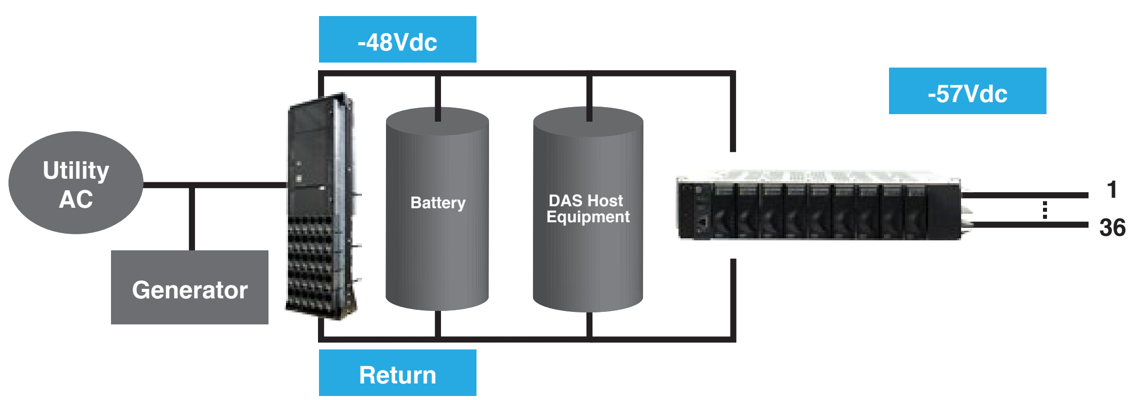
INTEGRATED DC-DC CONVERTER METHOD

An alternative to the bulk method is to build the DC-DC converter functionality into the Line Power equipment. In this architecture, each circuit includes both the converter circuitry and the active current limiting circuitry. This technique produces a 57Vdc Class 2 circuit for every output, without the need for additional planning.

Adding modularity to the Line Power design enables the DAS provider to equip the system for the right number of circuits to serve the current application. When new remotes are added, new modules can be deployed. The modular approach ensures the capital matches the need, minimizing the amount of investment in unused capacity deployed up front.

As both the DC-DC converter and current limiting functions are designed into one system, a single system controller can be deployed to access, monitor and control the device. Alarm reporting and remote control can be provided at the system level all the way down to the individual circuit. The single controller approach also simplifies the network design and planning. A block diagram of the integrated method is provided in Figure 4.

Figure 4 Integrated DC-DC Converter and Current Limiting Panel



The integrated technique has several advantages. First, combining the functions into a single system minimizes the amount of rack space required at the DAS host site. Second, the modularity enables the provider to more closely time the capital investment to the network deployment. Third, the single controller provides circuit level monitoring, alarming and control with only a single IP connection back to the network. Fourth, system efficiency exceeds 93%, a marked improvement over the 85-86% efficiency of a bulk DC-DC converter arrangement.

Fifth, the design and installation is significantly easier and simpler. With the DC-DC conversion circuitry built into the Line Power system electronics, there is only a single power connection required from the 48V system to the Line Power shelf. Adding shelves as the installation grows is as simple as installing the new shelf and connecting it to the 48V system. Since there is no intermediate DC-DC converter shelf, the cabling is straightforward and easy to manage.

SUMMARY

For larger venues, there are techniques for extending the distance between the host and remote nodes. A supplemental power plant, called a mid-span IDAS Power System, can be placed between the host site and the furthest remote nodes. Though there is incremental cost and complexity to this approach, it is effective in backing up the IDAS circuits and avoids the proliferation of batteries at the remotes.

However, the preferred solution is to add DC-DC conversion at the host site to boost the output to 57Vdc. This approach leverages the 48V power system and batteries, while nearly doubling the reach. Only one AC connection is required, and battery support and maintenance is focused at a single location, the host site. The integrated approach also enables the use of composite fiber/copper cabling throughout the venue, minimizing the installation cost for cabling.

As a general rule, venues with a maximum distance between host and remotes of less than 1500 feet should take advantage of the benefits of the integrated method. But for larger venues, adding a mid-span IDAS Power System can meet the distance requirements while adding only one more AC connection and battery maintenance site. Both approaches are simpler and less expensive than local power alternatives.

POWERING INDOOR DISTRIBUTED ANTENNA SYSTEM (IDAS) NETWORKS:

Chapter 5
Powering Large Loads

An Alpha Technologies White Paper

by Kevin Borders
Director of Product Marketing

July 2014

Your Power Solutions Partner

POWERING INDOOR DISTRIBUTED ANTENNA SYSTEM (IDAS) NETWORKS: CHAPTER 5 POWERING LARGE LOADS

In the previous installment of Alpha Technologies' white paper series, "Powering iDAS Networks," we learned about how to extend the reach of an iDAS network to eliminate batteries in even the largest of venues. To date, our focus has been on iDAS remotes that consume less than 100VA of power, i.e. those that can be served by a single NEC Class 2 circuit. However, the trend is toward iDAS remote nodes that consume more than 100VA of power, perhaps as much as 400 to 600VA. Because of the cost benefits of using Class 2 circuits, the ideal scenario is to use multiple circuits to power these devices as well. The purpose of this chapter is to explain how to power these larger loads while still complying with the requirements of the NEC for Class 2 circuits.

OVERVIEW

The National Electrical Code (NEC) states that Class 2 circuits may not exceed 60Vdc of voltage or 100VA of power. It also says that circuits may not be paralleled. In other words, the cables cannot be bonded (i.e. directly connected together) at the remote node to increase the amount of output power available for the node. For example, the leads of three Class 2 circuits cannot be simply twisted together to supply 300VA of power. This violates the NEC, as the circuits can no longer be "considered safe from a fire initiation standpoint and provide acceptable protection from electrical shock." The good news is that multiple Class 2 circuits can be used to power a large load, provided the device and circuit meet special requirements to ensure compliance with the NEC.

CURRENT LIMITING REQUIRED ON "HOT" AND "RETURN" LEGS OF THE CIRCUIT

For NEC Class 2 compliance, current limiting is required on both the "hot" leg and the "return" leg of the circuit. This concept can best be explained with network diagrams. In Figures 1 and 2 below, we show an example of four Class 2 circuits powering a remote node. In both cases, active current limiting is only provided in the "hot" leg of the circuit. In normal conditions, 400VA (or 400W since the voltage is DC) is sent to the remote and returned to the current limiting device. However, when a fault occurs in the Return leg, like the Return to Ground fault shown in Figure 2, the downstream power delivered to the remote is still the sum of the four circuits, or 400W. That same 400W is returned to the current limiting device. But since there are now only three available return legs, the 400W divides among the three returns resulting in a total power of 133W per leg. This is clearly a violation of the NEC's 100W limitation for Class 2 circuits.

Figure 1 CL only in Hot Leg: Normal

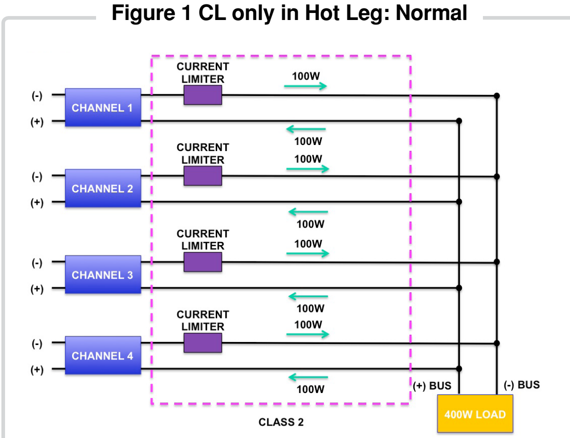


Figure 2 CL only in Hot Leg: Fault

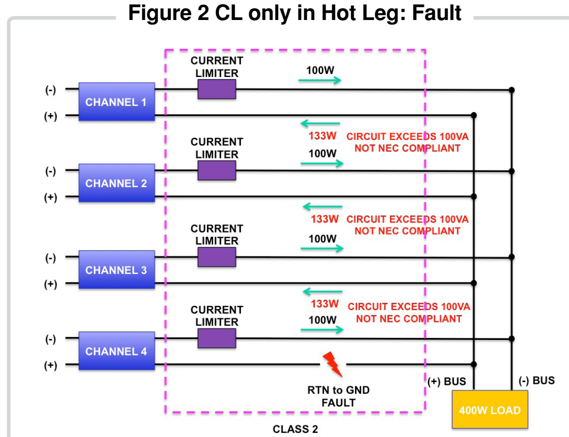


Figure 3 depicts circuits that have current limiting circuitry in both the active and return legs. Again, it shows a fault in the return leg of Channel 4, with 133W of power being delivered over the remaining three return legs. The current limiting circuitry in the return legs of the other channels detects the excess current/power condition. Once the Class 2 violation is identified, the current limiter opens and drops the load, triggering an alarm condition as shown in Figure 4. If a single channel is affected, the device issues a Minor alarm. If more than one channel is affected, the device issues a Major alarm. The alarms are reported as LED indicators (turning from Green to Red) and Form C contact connections. Therefore, as illustrated by these examples, to ensure compliance with NEC Class 2, current limiting is required in both the active and return legs of the circuits.

Figure 3 CL in Both Legs: Fault

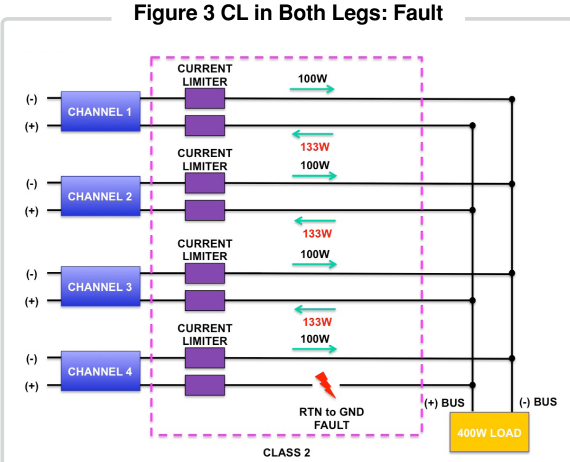
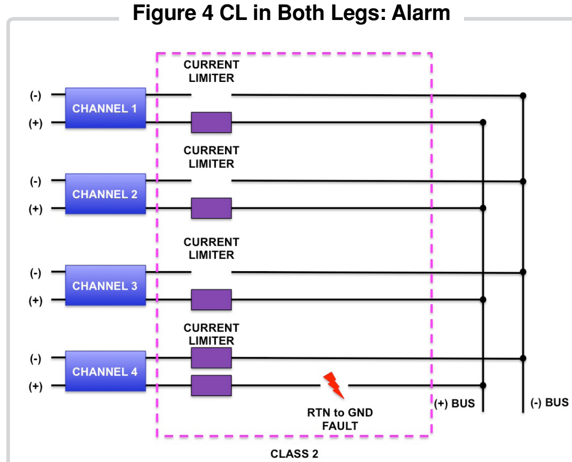


Figure 4 CL in Both Legs: Alarm



REQUIREMENT FOR ISOLATION AT THE REMOTE UNIT

An additional requirement for powering large loads is to ensure the currents in the multiple circuits are isolated. This means that there can be no condition or situation wherein current from one circuit could leak into another circuit causing an increase in power greater than 100W. Let's consider an example where there is a fault between the active and return legs of one of the channels, as depicted in Figure 5. To make our calculations simple in this example, we assume the fault is approximately 300W as shown in Figure 6. When the load drops, the cumulative power routes through the fault rather than the load. In this example, this means there is 300W of power in the faulted circuit, a clear violation of NEC Class 2 requirements.

Figure 5 Line-to-Return Fault Condition

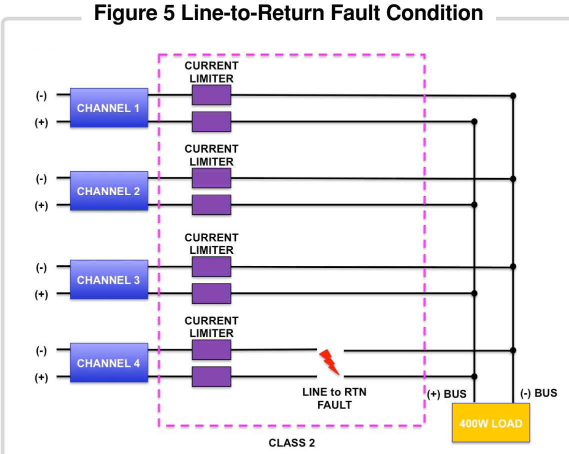
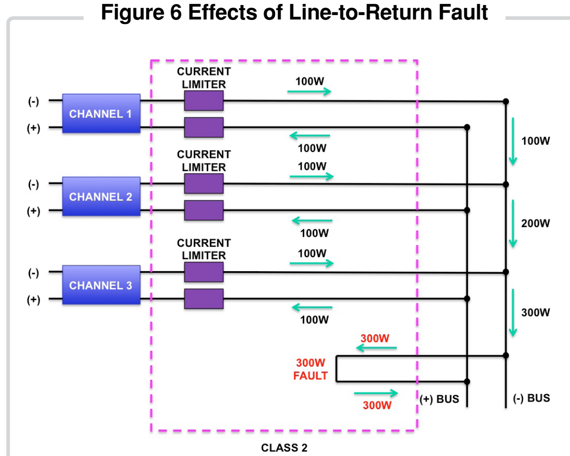


Figure 6 Effects of Line-to-Return Fault



In order to comply with the NEC Class 2 requirements, current isolation must be provided at the load side. This situation is shown in Figure 7. The current sensing functionality employed on each leg at the remote prevents the increase in total power on any of the other leads. As shown in Figure 8, an overcurrent condition will cause the current sensing device to open the circuit, ensuring that the current does not “leak” into the other Class 2 circuits and cause a violation of the NEC requirements.

Figure 7 Load Isolation

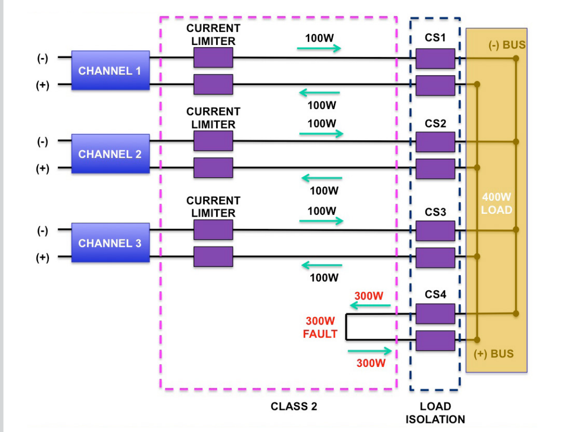
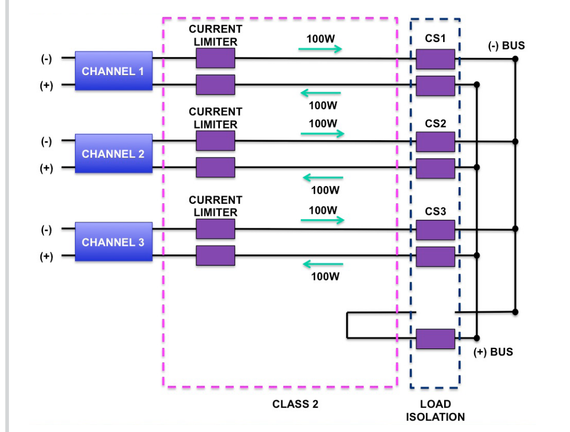


Figure 8 Fault Response



Isolation can be provided by the load with integrated isolation circuitry; however, there are only a couple of manufacturers of iDAS equipment that provide isolation in their large remote nodes. The solution that is gaining traction with the iDAS industry is to provide the isolation in a separate device.

ALPHA TECHNOLOGIES’ SOLUTION

Alpha developed a device that can terminate up to eight (8) Class 2 circuits when used in conjunction with an Alpha eLimiter™ current limiting source. The device provides a bulk 48V output at a nominal 800 Watts. The Alpha solution, called the IDAS Aggregator™, is shown in Figure 9. The compact unit is 1RU high, and has reversible mounting ears that enable it to be mounted in a rack or flush onto a wall.

Figure 9 Alpha Technologies’ IDAS Aggregator

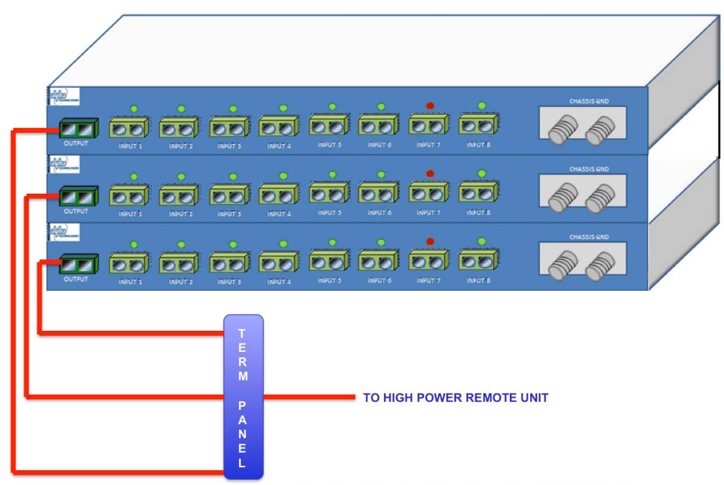
While the Aggregator provides circuit isolation at the remote end, it does not by itself provide NEC Class 2 compliance. In order to satisfy the NEC requirement that forbids the paralleling of Class 2 circuits, the remote device must be certified as part of a system along with the unit at the host. The Alpha Technologies' unit that distributes the Class 2 circuits, called the eLimiter+™ (pronounced elimiter plus), is shown in Figure 10.

Figure 10 Alpha Technologies' eLimiter+

The eLimiter+ is a modular device that incorporates both current limiting and 48:57 DC-DC conversion circuits on each module. The 57Vdc provides extended reach while maintaining compliance with the NEC's 60Vdc limit. The shelf is equipped with nine (9) modules, each supplying four (4) Class 2 circuits. A digital controller is also included in the shelf to provide remote access, monitoring and control of the unit and/or individual circuits.

While the combination of the eLimiter+ and iDAS Aggregator meet NEC requirements for circuits consuming up to 800 Watts, what happens if an iDAS device is deployed that consumes more than the capacity of the Aggregator? In that case, the outputs of two or more Aggregators could be connected to a termination panel to deliver the combined outputs. This paralleling function is NEC-compliant because it takes place on the drop side of the Class 2 circuits. Figure 11 shows an example of combining the outputs of three Aggregators.

Figure 11 Very Large Load Application



SUMMARY

Using Class 2 circuits to power remote iDAS nodes has become very common due to lower capital and operating costs. Extended reach devices can now supply power to remote nodes at some of the largest venues. But total elimination of remote batteries has been constrained because the 100VA limit of Class 2 circuits prohibited their use in powering large loads. With the advent of a device that provides isolation between the incoming Class 2 circuits, and produces a bulk 48V output, the ability now exists to eliminate batteries in all remote iDAS applications. When used together, the combination of Alpha Technologies' eLimiter products and iDAS Aggregator provide a system that cost effectively meets the NEC's requirements for powering large remotes with Class 2 circuits.

About the Author

Kevin Borders is the Director of Product Marketing at Alpha Technologies. He has over 30 years of experience in the Telecommunications and Power sectors, having worked extensively in Marketing, Sales and Product Management roles at PECO II and Marconi Communications, Inc. Kevin holds a Bachelor of Science in Electrical Engineering from the University of Missouri and an MBA in Corporate Finance from the University of Dallas.

About Alpha Technologies

Alpha Technologies Ltd. (a member of The Alpha Group of companies) develops power conversion, protection and standby products for Telecommunications and Broadband cable industries, including custom and application-specific powering. By developing an intimate understanding of specific powering needs combined with over 30 years of powering innovation and expertise, Alpha's distinctive excellence is the ability to quickly develop solutions tailored to solve our customers' unique powering challenges.

As a member of The Alpha Group, ATL is part of a global alliance of companies that share a common philosophy – to create world class powering solutions for communication, commercial, industrial and renewable energy markets.

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