White Paper

Powering Fiber in the Local Loop: FTTC and FITL Power Architectures

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Abstract

Just as loop access architectures are varied, powering topologies supporting these architectures can deviate remarkably from traditional means and methods. This paper maps several alternative powering strategies with two leading classes of emerging access technology, xDSL and FTTC, for the purpose o providing a starting point for planning successful and cost effective power solutions. Current powering techniques for ongoing DSL upgrades and FTTC network architectures are presented. The concept of a “power infrastructure” is introduced as a platform strategy for going forward. Specific application alternatives involving power solutions for legacy DLC upgrades and DSLAM/DLC deployments are presented. For new FTTC networks various methods and means of implementing –130V powering will be reviewed. Among the criteria considered in these powering assessments are scalability, reliability, longevity and cost. With the information provided in this paper a more informed inquiry into the specific technical and strategic requirements associated with powering a particular class of fiber based loop access technology is possible.

1. Introduction

Loop Access Technologies and Power

For our purposes here it will be useful to create an architectural demarcation between the use of existing plant for enhanced services, Figure 1, and the installation of newer architectures that extend fiber to the curb (FTTC). In each case a number of basic network powering options are available based upon the specific needs of the upgrade under consideration. Later each of these options will be reviewed both strategically and technically.

The common thread that runs through all of the deployment options is that the base power per living unit passed is increasing. Further, this increase does not always follow conventional POTS planning methodologies that are wrapped around standard network traffic modules. Power demands imposed by digital subscriber line technologies fluctuate only slightly as customer traffic changes. The increase in base power per living unit is thus driving up the base load demand from power plants which in turn increases heat dissipation demands associated with the hosting outdoor enclosures or other facilities. Both of these problems, power and heat transfer, must be effectively dealt with together to achieve reliable results.

Access Technology Evolution and Power Infrastructure

The simple fact that access equipment developers have made available such a host of alternatives belies the likelihood of technology obsolescence every 2 to 4 years. This rapid evolution calls for an infrastructure strategy that has some hope of remaining stable for a more conventional planning period of 15 to 20 years. Certainly all efforts will be made to ensure that what is buried below or suspended above the ground will stay put and be useful for this period or longer. With some foresight, network power and possibly remote terminal enclosures can also be planned such that they too will remain adaptable and technologically stable as access technologies and those companies providing the evolve.

The Effect of Broadband Services on Power Requirements

As previously mentioned, the single most important facet of powering DSL is that the load per line served does not fluctuate greatly over time. In other words, irrespective of whether the DSL modem is communicating or sitting idle, the power required is nearly constant. This can represent from 2 to 6 watts per line depending on the specific type of DSL technology being deployed. Along with this realization comes another side effect: the simple fact that unlike a traditional POTS current loop where significant power is lost to the copper plant a DSL line does not require a signaling current loop and thus line card dissipates nearly 100 percent of its power demand. This means whatever facility is housing this DSL line card it must be capable of dissipating the resultant heat without inducing elevated temperatures in the equipment.

As an example lets look at a 192-line SLIC terminal site that will be upgraded with a 96-line ADSL DSLAM node. A contemporary SLIC driving a 6 – 8 kilo-feet loop will draw slightly less than one watt while o -hook. Most of this loss is associated with the voltage drop across the tip and ring, power dissipated in the twisted pair and phone. Thus, if all 192 lines are simultaneously off-hook the circuits will draw up to 192 W from its power source to drive the network. Clearly it is very unlikely that every line will be o -hook at once and there is also the power demand associated with other items such as ringing. Commonly, network power engineers plan their SLIC power plant capacities based upon a 6 or 9 CCS traffic load. This approach assumes that each of the 96 lines will be active 600 to 900 seconds per hour or 17 to 25 percent of the time. Thus the power plant is sized for a 48W SLIC load plus some additional overhead power, 50 – 75 W, for ringing, pair gain equipment, housekeeping electronics and battery recharge capacity. Thus a 150 W power plant and a terminal enclosure that can safely dissipate 100 W was suitable.

Depending upon the product used an ADSL modem will require 5 - 7 watts per line continuously. Assuming the one half of the POTS lines will be coupled to ADSL modems the SLIC/DSLAM site will require an additional power plant capacity of 96 x 6 W = 576 W. This base load will be present inside the DSLAM cabinet 24 hours per day. This cabinet will have to house the power plant and worse yet it will have to dissipate 576 watts or 1728 BTU. More often than not it is the heat dissipated by DSL technology that creates a challenge in an upgrade such as this.

2. DSL Upgrades to the Existing Network

Existing DLC Hub Upgrades

As illustrated in Figure 1 DSL can be implemented in an existing telephony plant using a number o architectures. The most straightforward and presently the most common approach is to place the DSL equipment in an existing CO or CEV, identified as Upgrade A in Figure 1. Powering this configuration is typically straightforward, the CO's DSL modems are powered from the resident –48V plant. Modems at the customer premises are powered by the terminal equipment power system. Power at the CO is made very reliable through large battery plants and generator systems. Thus, as long as the ac power system feeding the customer equipment is functioning the network operates normally.

If the customer's DSL network connection must survive the loss of terminal equipment ac power, the DSL modems can optionally be powered from the CO via one or more powering loops that originate fro the CO. In some cases the DSL signal is superimposed on the powering loop. The loop power voltage is –138 V and is produced by a –48 V bu -fed DC-DC converter driving the loop via a 100 W power limiter. This selection of loop powering voltage and power limit meets various requirements and specifications imposed by the NESC and suggested by Bellcore for this class of communications powering.

Upgrade approach "B" and "D" of Figure 1 illustrates the collocation of a remote DSLAM with an existing copper or fiber fed DLC remote terminal or cross-connect hub. The DSL equipment can derive its power from one or more sources. The simplest approach is to tap into the RT's –48VDC power plant via an automatic disconnect if rectifier capacity is available. In the event of utility failure the automatic disconnect will drop the DSL load after a predetermined time period, commonly 15 to 30 minutes. Alternatively, if dc capacity is not available ac capacity may be available from the RT ac load center thus saving costs associated with an additional service drop and service entrance equipment. In the event the RT cannot provide power to the DSLAM cabinet or the cabinet is located remotely, as illustrated in approach "D", a number of other options are possible:

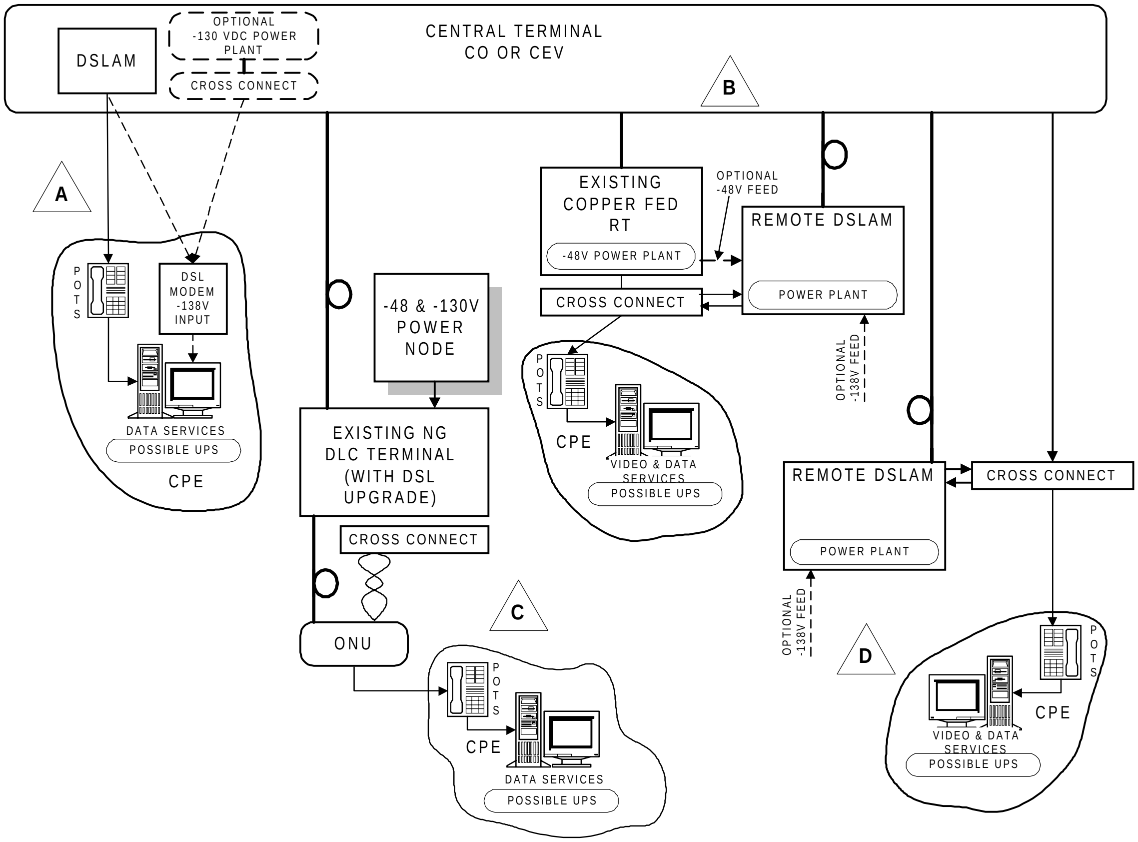

Figure 1. Powering DSL Upgrade Architectures.

1. Direct ac feed from the ac utility without ac backup.
2. Equip the cabinet with its own ac or dc UPS and suitable standby reserves.
3. Power the cabinet remotely with a –138V source located in a nearby CEV or remote power node.

Option 1 is the least expensive to implement if the digital services being offered are not required to be available during a utility outage and the DSLAM equipment can operate directly from ac utility voltages. The ramifications of a non-standby approach such as this will be covered in some detail later. It will be shown that there is a clear strategic advantage in planning ahead for battery and power equipment space in the event that it becomes necessary to prevent disruptions in services with each power glitch, sag or short term outage.

Standby or UPS operation during an ac outage can be implemented using a conventional rectifier/battery plant. The plant can be implemented following standards routinely established for remote terminals. I the DSLAM's services are not considered critical (life-line), a creative lo cost alternative to providing short term backup is the incorporation or collocate a small ac UPS. A UPS product similar to that commonly used to power cable TV systems will deliver 90VAC at 1000 W for up to 2 hours. Several cable TV power supply manufacturers offer products that can be inexpensively purchased without the UPS function and later, as need arises, the power supply can be upgraded to a UPS with a plug-in module and batteries. A cable TV UPS operates o -line with its loads operating from the utility via a transient isolation transformer, upon loss of the utility an inverter operating from batteries is started to pick up the load via an auxiliary transformer winding. The transient isolation transformer ensures that the DSLAM equipment is co pletely protected from hostile utility voltage transients due to lightning strikes or other adverse utility events.

Depending upon DSLAM deployment method option #3 may or may not be practical. The approach calls for several DSLAM locations to be remotely powered from a common power node. It is not uncommon for a DSLAM to serve over 200 living units, thus in suburban applications the design area radius can easily exceed 6 Kilo-feet. In this case, finding a practical common location to power multiple DSLAM's is made more difficult by large powering voltage drops over the necessarily long loops. Only when the nodes are small or backup power is required for a fraction of the node's total load does this option become viable.

Co-located Existing or New Remote HDT's & Power Systems

As illustrated in approaches "C" and "A" of Figures 1 and 2 respectively existing or new remote DLC HDT's can be upgraded or installed to provide a number of broadband DSL services. The corresponding ONU's are equipped with ne or replacement DSL modem equipped line cards. These cards are simply installed as services are sold. The key side effects of this apparently simple deployment are the increased demand for power by both the HTD and ONU's along with the associated increase in heat dissipation. As the DSL service is deployed both of these factors have to be monitored to ensure that the entire network does not develop power related troubles.

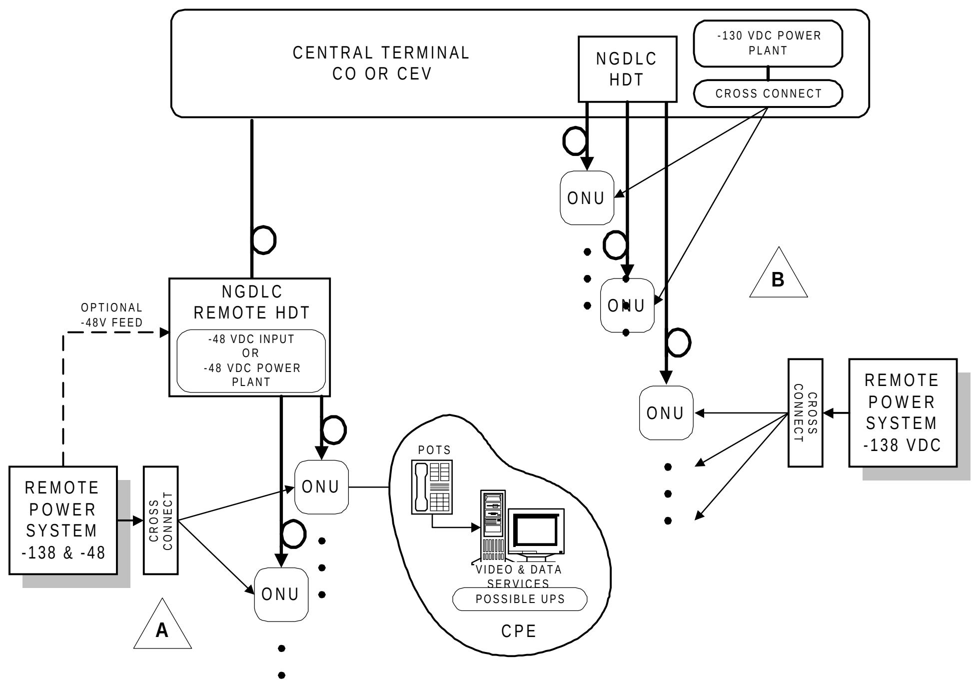

Figure 2. Powering New FTTC Architectures.

Commonly the ONU's are mechanically designed to handle a range of service upgrades. As ne services are added the additional thermal load at the HDT can be problematic [1]. The HDT typically has to supply the additional power demanded by both the ONU's and broadband optical cards. As a result an HDT's power, battery plant capacity, and heat dissipation demands can increase substantially. In many cases, this cannot be accommodated without replacement of the HDT or placement of additional HDT's, a very expensive service upgrade.

A much lower cost alternative to HDT replacement is a collocated power node directly adjacent to the HDT cabinet. The node would provide all of the –48VDC and –130VDC power demanded by the HDT and the ONU's by housing both the power supplies and batteries. This reduces the HDT thermal load from the rectifiers and converters as well as the physical rack space they occupy. Rack space and thermal capacity that can be used profitably for additional fiber banks and corresponding ONU placements. In this case costs avoided by not having to replace or add additional HDTs to the network pays for network power.

In the limit this strategy can be used to create a permanent power infrastructure for new FITL/FTTC plants that utilized remote HDT cabinets. The power node becomes as much of the plant infrastructure as the fiber, twisted pair and associated cross-connects. Selection of an access product for a specific deployment is made independently of these items, thus freeing the access provider to make access technology decisions independently.

CO Based HDT's and CO/CEV & Remote Power Systems

Access equipment deployed in high-density urban areas may not require the HDT to be located in a remote cabinet, but rather in the CO or and existing CEV, Figure #2 approach "B". This typically eliminates concerns about HDT real estate, power and heat dissipation demands. The only remaining issue is powering the associated ONU's. The simplest approach is to located a –130 VDC DC-DC converter power plant and cross-connect somewhere in the CO or nearby CEV. Typically the power plant operates from an existing –48VDC bus. Thus a powering network or infrastructure is created directly out of the CO in manner logistically similar to traditional POTS services.

As powering loop lengths exceed 6,000 feet from the CO or nearest available CEV, it may become necessary to deploy remote –130 VDC power systems (RPS). An RPS can be configured to support from 50 to 200 ONU's depending on ONU power demand and placement density. Each RPS is equipped with a –48 VDC power plant, batteries, DC-DC converters and their associated power limiters. The rectifier plant is sized to provide the base network load plus battery recharge capacity. Depending upon the nature of the access equipment being deployed the battery plant will be sized for either the entire base load over an 8 hour period or a reduced based load if the access equipment is capable of shedding broadband functions a short period after an ac power fail.

RPS's are available in a number of configurations to match available easement demands. Pole mounted units with output capacities for up to 50 ONU's are available for urban areas where pedestal space is not available. Pedestal mounted units can be considerably larger, powering up to 200 ONU's. Some products provide expansion options where up to one-half of the RPS capacity is initially installed, later as network power demands increase the second half can be installed without cabinet modifications or service interruptions.

3. Powering Fundamentals

Local Vs Network Powering

A very good introduction into the basic requirements and design objectives for powering fiber fed access systems is provide in Bellcore TA-1500. The following discussion will build upon core information of TA-1500 and offer some insight into workings of the associated equipment. The basic details of the alternative DSLAM powering approaches based upon local ac powering are also filled in.

Figure 3 illustrates a proposed family tree of access powering architectures. Starting from the top the ac utility represents any ac power network that is routinely made available to the powering equipment. The tree then branches to two principal powering paradigms, local powering or powering network. Routinely in the past, local powering was the paradigm of choice when it came to powering remote terminal or hub equipment. Across a serving district the number of hubs and subsequent power plants was manageable from a maintenance point of view. However as fiber is extended deeper into the network, the number o terminal locations or optical network units increases dramatically. Subsequently the number of power plants becomes unmanageable and the consolidation of power plant equipment becomes a mandate. Consolidation leads to the second paradigm where a centralized power plant drives a host of access devices via a copper based powering network.

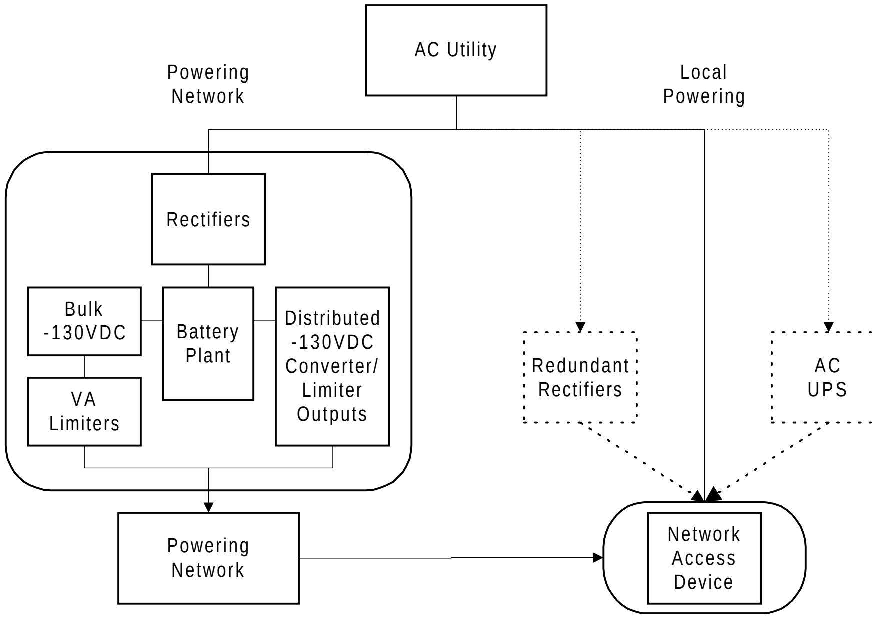

Figure 3. Family tree of powering architectures for FITL and FTTC.

The AC Utility

A common assumption regarding ac utility service is that of a typical 120/240V or 208/480V service routinely provided by electric utility companies, and indeed this is usually case. However, there are alternatives being aggressively investigated cooperatively by both communications companies and the ac utilities serving their networks [2].

The elements o a typical ac utility service entrance are illustrated in Figure 4. The actual service entrance apparatus used for the application will commonly be encumbered with a host of local code authority and utility requirements. It will be very important that the associated details are investigated fully and the appropriate equipment configuration selected. This problem can become so imposing that it may be more cost effective to purchase a preapproved integrated power pedestal from one of the many vendors that specialize in providing solutions to this problem.

A key reliability concern in outdoor applications is protection from ac line disturbances caused either by utility operations or lightening. These disturbances can be significantly more severe with outdoor

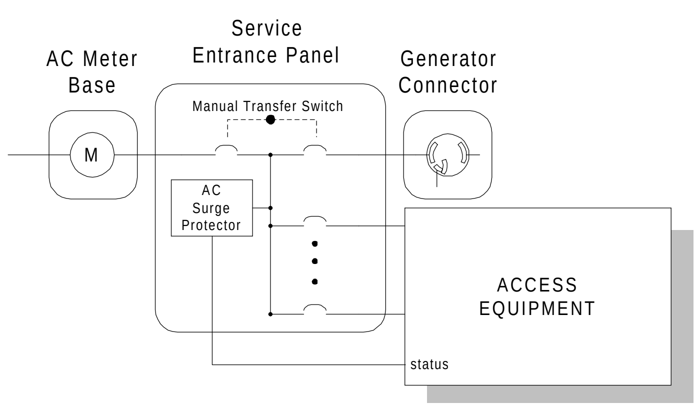

Figure 4. AC Service Entrance Elements

equipment due to the typically low transient impedance direct utility grid taps have compared with that o equipment within a building. A building's ac distribution system has a considerable dampening effect on this phenomenon. An excellent engineering reference detailing these conditions is provided in the IEEE document C62.41. The ac service and or the powered equipment must incorporate a method of transient suppression that can withstand the rigors of outdoor deployment. A host of products are available in the industry suitable for these applications. The chosen unit should be capable of repetitively withstanding a 200 KA surge while allowing a transient voltage let through less than that specified for the access equipment or power node electronics (typically between 330 V and 440 V). The product should also be able to communicate to the network that it has failed and in need of replacement. Once the unit fails, and they are likely to fail eventually, corrective maintenance action must be taken to ensure that network equipment does not then sustain damage.

Local Powering, Non-Standby

As illustrated in Figure 3 network planners have three primary alternatives to consider when powering access equipment directly from the ac utility. Clearly where ser ices are not related to POTS there is great temptation to follow the least expensive approach of directly powering the equipment from the ac line. For example, a 200 line DSL hub requiring 1,000 W of power can avoid up to $2,000 of power plant capital equipment cost and another $2,000 to $3000 in battery replacement cost over ten years. However, an overwhelming host of conditions can render direct non-standby powering as inexpensive only while the network is being built. Unfortunately history has shown repeatedly that a strong potential exists for a legacy of customer complaints and competitive attacks when power outages strangle network reliability. For example, it has been shown that "inexpensive" non-standby powering in cable TV networks are commonly the root cause of over 85 percent of customer perceived network failures

Non-standby powering is only viable when it is known that the customer will not perceive repetitive network outages as a distraction. Unfortunately a broad base of marketing statistics relating customer perceptions regarding digital service outages is not yet available. A classic assumption in this regard is; "If the service is down without power then the consumer will be down as well, thus there is no need for services nor will there be any perception that the network has failed." Related experience accumulated in the cable TV industry [3] suggests that the axiom is only likely to hold when these conditions prevail:

- The network is serviced by a reasonably reliable ac utility grid with a 99.99 percent yearly availability or more and is not prone to frequent glitches or sags.
- The customer's principal use of the service is passive, in that the customer is not purchasing custom third party services such as pay video or subscription information services from various news or entertainment companies. Experience has shown that interruption of such items quickly gains unwanted customer attention.
- Network equipment is designed such that brief interruptions in ac power, typically less than a tenth of a second, go unnoticed by the subscriber. This duration of ac outage is quite common and must not cause digital equipment to reboot or resynchronize, thus amplifying what otherwise would have gone unnoticed.
- The statistical exposure to a power outage is diminished when a customer's daily utilization o the service is known to be low, less than 1 hour per day. Unfortunately, commercial and home office equipment is routinely protected from utility outages and is being accessed continuously, thus exposing the customer to the network 8 to 12 hours per day. These profitable anchor accounts are very likely to become a routine source of trouble reports due to short-term power outages.
- The DSL hubs should be confined to small design areas serving less than 100 subscribers, this increases the likelihood that an outage will effect both the hub and its associated subscribers.
- Networks that offer video services may be classified by the local franchising authorities as critical to civil defense communications. This is a growing trend particularly in areas prone to natural disasters that have wide spread effects such as earthquakes and hurricanes. In these cases the franchise agreement can require that the network provide up to 8 hours of operation in the event of a wide spread power outage.

When these assumptions fail and customer confidence steadily erodes:

- Service brand names become tarnished.
- Customer service centers must be expanded to handle surging volumes of trouble reports.
- Other competitive service providers gain a marketing edge and erode market share, particularly when a competitor's network is perceived by the customer as more robust.
- The service can draw the unwanted attention of local municipal authorities acting on behalf o the community.

Finally, from another perspective, great care and expense is poured into qualifying and deploying advanced access equipment that by itself is expected to provide thousands of hours of trouble fee service. For a modest percentage of the overall deploy ent cost, typically less than 2 percent, a solid powering infrastructure can reduce power related customer trouble reports by as much as 400 percent over non-standby direct ac powering approach.

In the event that DSL access equipment is deployed without standby capability, accommodations for powering alternatives should be incorporated. This can be done inexpensively when these measures are taken early in the planning stages:

1. Specify that the access equipment's internal power supply accepts an alternative backup supply voltage input. One or more of the following alternatives are commonly supported -24 VDC, -48 VDC, -138VDC, 60 VAC or 90 VAC. This input may be configured to remain passive as long as ac line voltage is present, only in the event that the ac line is lost will power be drawn from this input. If it is known that the access equipment's internal power supply is suitably immune to ac line transients this feature can be used to reduce standby equipment costs.
2. Leave some room in or adjacent to the equipment enclosure for a small battery plant. The plant space should be sized to accommodate the batteries necessary to provide at least one and preferably two hours of energy reserve. Make sure this space is well ventilated to the outdoors and is not subject in any way to the waste heat being dissipated by the DSL equipment. In the event that the battery plant is deployed these measures will help ensure maximum battery life.
3. Equipment rack space and a possibly a portion of the enclosure's thermal budget should be reserved for powering equipment. The enclosure's thermal budget will only be adversely impacted if the backup power supply continuously powers the access equipment.
4. Equip the enclosure's service entrance with a generator receptacle and manual transfer switch.

If one or more of these steps are taken before executing a direct ac power deployment the strategic implementation of corrective measures for outage recovery will be greatly facilitated.

Local Powering, Standby

The rectifier alternative for local powering, shown in Figure 3, can be based on the conventional performance and implementation requirements associated with traditional DLC remote terminal applications. Power supply redundancy may only be justified when telephony services are also being provided. Basing the rectifier plant size on the desired battery plant recovery time once the ac line has returned can save costs in applications where the access equipment derives only its backup power fro the DC bus. Otherwise the rectifier plant will have to be sized to cover both the average equipment and battery recovery power demands. In this case the rectifier will impose an additional 10 to 15 percent energy efficiency penalty on the system. This additional energy will be wasted as heat and if the rectifier is co-located within the access equipment enclosure it must be capable of accommodating this additional thermal load.

In those cases where the access equipment can accept a 60 or 90 VAC input for backup power the ac UPS option o Figure 3 is possible and potentially preferable. In this case the UPS must be capable o supporting the maximum or peak power demand. Unlike the rectifier approach where the battery plant covers the transient peak power demands the UPS must be sized to serve all possible load conditions. Again there will be an energy efficiency penalty associated with the UPS. This typically ranges between 10 to 18 percent depending upon the unit's design.

An ac UPS can provide two unique strategic benefits that result in both a system reliability enhancement and an opportunity for access equipment capital and maintenance cost reduction. The majority of ac UPS products designed for communications applications such as this are based upon a single line-frequency trans ormer concept that commonly offers an MTBF of over 300,000 hours without redundancy. The transformer, an extremely durable device, is designed with a considerable amount o series inductance and parallel capacitance between the ac line and load connections. The combination provides over 60dBV of line transient isolation from the load. For example, a metallic 10,000 Volt ac line transient will only produce a 10 V transient across the access equipment power supply's terminals. This greatly improves syste robustness against adverse line conditions and correspondingly reduces engineering performance requirements and subsequent failures of ac service surge protection units and access equipment power supplies. This power configuration should be given serious consideration for regions prone to frequent lightning strikes.

DSLAM's equipped with either the DC plant or ac UPS the battery plant should be sized to provide at least one hour of standby energy. If extended outage coverage is planned via placement o a portable generator at the site the battery plant should include an additional hour of energy reserve. Commonly this additional hour will provide maintenance crews the time needed to get the generator to the site. Narrow band applications providing POTS service will of course require at least 8 hours of standby energy. The rectifier or UPS must be specified with these battery maintenance features:

- Battery temperature compensation
- Battery high voltage shutdown alar
- Battery on discharge alar
- Battery lo alarm
- Battery disconnect alarm and low voltage disconnect.

Valve regulated gel or absorbed glass mat (AGM) batteries are best suited for outdoor applications. Physically, the battery plant can be optionally equipped with battery-heating pads in regions where winter temperatures routinely fall and stay below freezing for extended periods to ensure that the required battery capacity is available during these periods. Heating pads will be required where POTS services are involved. It is also advisable to leave at least one inch of space around each battery and ensure that during the warmer months good outside airflow is maintained around the batteries. Batteries may swell slightly over their lifetime and when tightly restrained case problems can result. These measures will ensure maximum battery life and reduced extended battery warrantee costs if warrantees are offered or required.

Network Powering, Twisted Pairs and Network Loads

As previously discussed this form of powering is accomplished over a network of twisted pair wires connected to a power supply with an output voltage which cannot exceed ±140 VDC during normal operation. Each conductor pair can supply up to 100 watts of power measured at the power system's terminals, DPM's, as illustrated sche atically in Figure 5. The size and number of powering pairs must be selected to insure that under peak load conditions the terminal voltage at the network load does not fall below 60 percent of the supply voltage and that the loop(s) wattage limit is not being exceeded. To meet these two conditions additional or larger pairs may be required for long loops and additional 100 watt outputs will commonly be required for larger loads. It is important to understand that the 100-watt limit includes the wattage lost in the resistance of the wire pair(s).

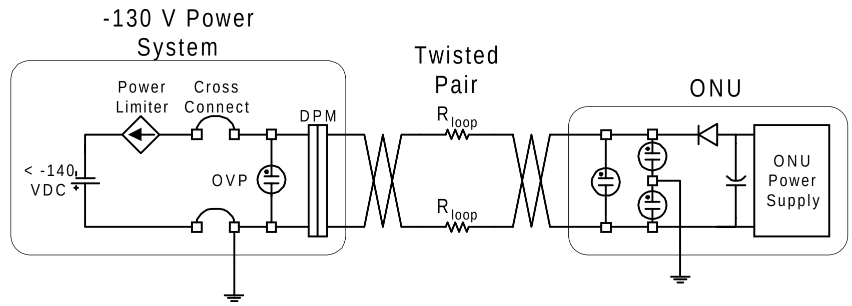

Figure 5. –130V Twisted Pair Powering Loop

In cases where the powering loops length exceed 12,000 feet it may be it may be necessary to use two outputs of opposite polarity with respect to ground, or 280 VDC between terminals as shown in Figure 6. The network load is then connected across the most positive and most negative wire pair of a two pair combination. This reduces the loop current and voltage drop by a factor of 2 and the loop power loss by a factor of 4.

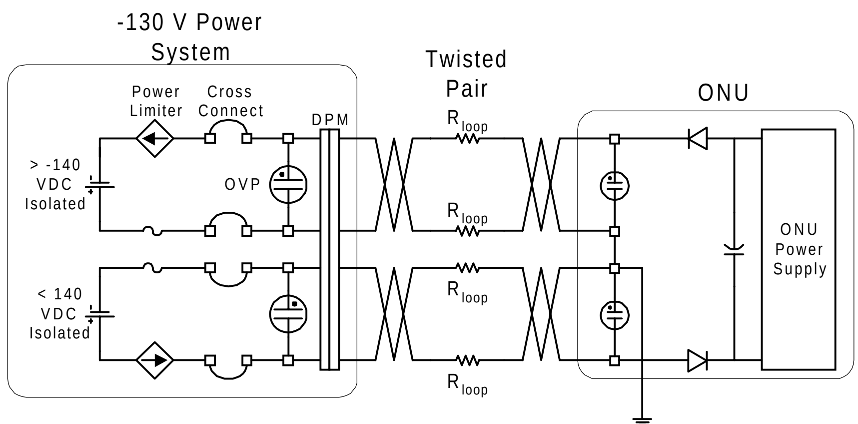

Figure 6. ±130V Twisted Pair Powering Loop

As is often the case in outside plant applications there are a host of more subtle complications that must be carefully considered when addressing this source, loop and load combination:

- The resistivity of copper has a positive temperature coefficient which must be incorporated in calculations when the powering pairs are routed above ground.
- The source and load must be compatible in all phases of operation; this is particularly the case during load startup and protective events such as that seen during an overvoltage protector (OVP) firing.
- The loops themselves may be flawed in that it may be burdened with improperly implemented splices or inadvertent bridges or taps. If this leads to multiple ground connections leakage currents can cause power limiter problems or fuse failures.
- Proper pair ground placement is critical:
  1. If the source is polarized to ground the power pair may not be regrounded at the load.
  2. If the source is not polarized it must have an isolated or floating output and the load must polarize the pair to its local ground.
  3. In the case of split powering leakage problems can be avoided if the sources are isolated and two wires (one positive and one negative) of the two twisted pairs are grounded at the load.

Network Powering, Distributed Vs Bulk DC-DC Conversion

As in Figure 3 network power systems typically are based on a rectifier/battery plant very similar to that found in many other telecom applications. The battery plant is usually designed for –48VDC operation.

This voltage is transformed or converted to something slightly less than –140VDC by a DC-DC converter. The converters accept the 42 to 60-V battery voltage and delivers an output that remains stable under all normal load conditions. This output stability is very important to the integrity of the powering network's performance, specifically with regard to the loop lengths and the corresponding minimum end of line voltage. Network planners will design powering loops based upon the staying above this voltage, if supply's voltage drops the ONU's become unstable.

There have been a number of attempts to utilize a –130 V battery system directly without conversion, clearly such an approach would avoid the cost of DC-DC converters all together. However, for a given ONU load the widely varying battery terminal voltage reduces the possible loop powering length by 40 percent as compared to a constant output voltage. Therefore this can only be considered when the avoid cost associated with 40 percent of the installed powering cable is less than the cost of DC-DC converters. Power limiters will still be required and must also be adapted to wide input voltage range. Typically a constant voltage is assumed and a limiter simply monitors the loop current. However when connected directly to a 130-V battery bus the input voltage will vary from 105 to 140 VDC. The limiter must then respond to a continuously changing current trip to maintained a 100 watt maximum. This will be critical when considering that the ONU power supply represents a constant power load.

In Figures 7 and 8 the DC-DC conversion functions can be provisioned with either a distributed set o small converters or by a collection of larger bussed converters with the twisted pairs being fed from the 130V bus by individual power limiters. Each arrangement achieves a common result and ultimately the final selection is made primarily on the cost when applied to a particular application. The key cost issue is stems from the simple fact that the distributed converter configuration integrates the converter and limiter functions together, thus saving the cost of a separate equipment shelf full of power limiters. However when many lightly loaded loops are required the network's low utilization of each converter is a severe penalty. It then becomes more cost effective to purchase fewer large converters and a separate set of power limiters. Thus the smaller loads of Figure 8 are more suited bulk converter configuration.

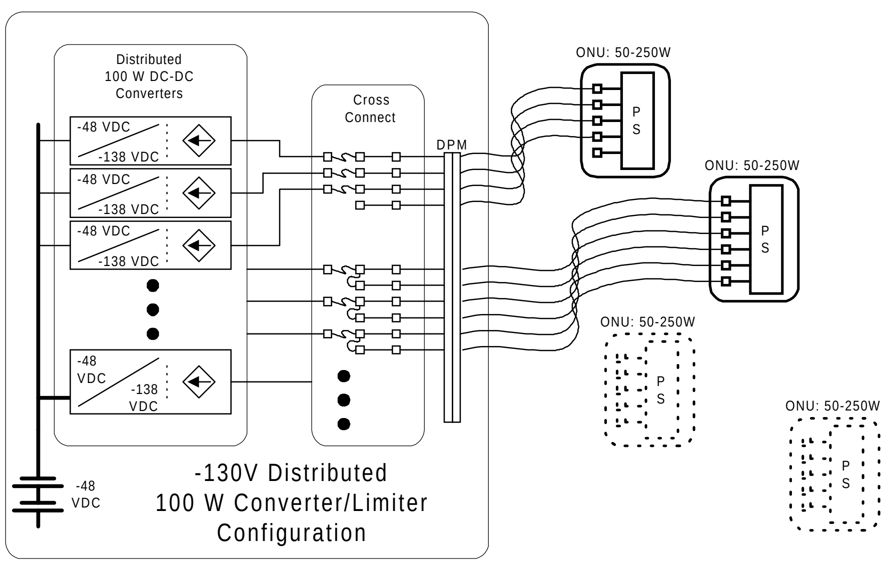

Figure 7. Distributed DC-DC Converter Configuration

Occasionally a distributed converter/limiter configuration can be difficult to match to a network's cabling plan. This occurs when the required powering pair count is not a multiple of the required number o converter/limiters. This would occur for example when a 125 Watt ONU required three powering pairs but only two converter/limiters. One pair must be wired to the first converter/limiter with the remaining 2 pairs connected to the second. The second converter will have the majority of the load due to the reduced loop resistance and my very well go into power limit causing the ONU to fail. Either another converter/limiter or powering pair must be added to the network for this ONU. Using bulk converter configuration in this example would simply required that another limiter be allocated to the ONU and the

DC-DC converter capacity is left unchanged. A loop power limiter can be purchased for approximately one-sixth the cost of a converter/limiter cost. Thus, when the power utilization of each converter/limiter is high and the required number of converter/limiters synchronizes with the network cabling plan the distributed –130V converter plant will be the best choice, otherwise a bulk converter plant will be advantaged.

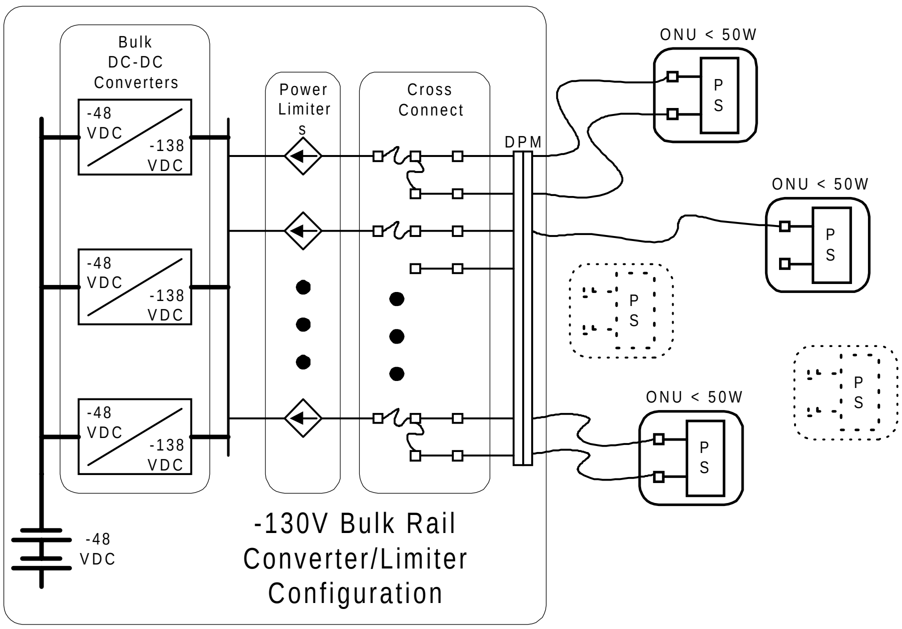

Figure 8. Bulk DC-DC Converter Configuration

4. Conclusions

A number of powering alternatives have been reviewed with respect to existing and new plant DSL and POTS deployments. These alternatives provide some planning insight and serve as a starting point for dialog with telecom powering specialists in the industry. The long-term benefit of segregating power physically from the access equipment and rolling it into a network's infrastructure was explored. Among choices reviewed here are local verses network powering, standby verses non-standby, -130 V and ±130 V powering loops and distributed verses bulk DC-DC converter combinations.

Commonly, network power is one of the last items to be considered while network business models are being assembled and one of the first items to get in the way when actual deployment begins. Experience has shown that this phenomena has at least some basis in the simple reality that business planners do not readily understand the technical and financial impacts involved with powering fiber based networks. Correspondingly, specifying engineers and construction managers do not fully appreciate their impact on an aggressive business plan when specifying equipment based upon outdated techniques or industry standards. It is hoped that this article has provided additional applications insight for everyone involved in the deployment and operations process.

References

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