Network Remote Power using Packet Energy Transfer

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I. Introduction

Network remote powering provides energy to telecom equipment over the existing conductors used to transport data; such as twisted pair or coaxial cable. A common implementation is the powering of Digital Subscriber Line Cabinets (DSLAM) over twisted pair from a telecom central office. More recently, a rapidly expanding Compact Base Transceiver Station (CBTS) market for 3G and 4G wireless networks is demanding innovative methods to minimize the capital and operational impacts of power conversion and energy storage components in small cabinets. Nearly a million CBTS installations are expected to be deployed over the next several years[i].

The amount of power transferred by remote network powering devices has traditionally been limited due to safety concerns for technicians or the public that may come in contact with the conductors. The concern is magnified by the general perception that data cables only carry low voltage signals; meaning that less care may be taken to avoid coming in contact with data cables versus cables that look like they are designed for high power.

Packet Energy Transfer (PET) is a new technology that separates electrical power into a series discrete time domains referred to as energy packets. Each packet has a time slot dedicated for energy transfer, and a second time slot dedicated for a digital and analog signature for verification. Using this new approach much higher levels of power can be transferred safely to downstream equipment. Moreover, the technique can distinguish between a person touching the power conductors and the regular current being drawn by the load equipment; something that has not been achievable using conventional methods.

II. Background

A. Remote Power Devices

There are a number of suppliers that are offering remote network powering equipment based on the IEC 60950-21 standard. Approved devices are limited to a maximum steady-state power of 100 Watts per conductor pair resulting in a maximum load current of 250mA[ii]. Multiple pairs can be combined to increase the power to the load device, provided that the pairs are individually monitored and protected according to the standard.

Figure 1: Microcell Cabinet in San Diego

Another more recent line powering technology is Power-over-Ethernet (PoE) that provides power over a CAT 5 ethernet cable. In its latest implementation, defined by IEEE 802.3AT, up to 25 Watts of power can be provided to a downstream device. Existing remote powering devices can serve a number of applications in the 25-100W power range. For example, inside picocell devices that support 3G,4G,Wi-Fi and WiMax offer PoE interfaces that operate in this power range and cover an office or small building. However, to support the rapid growth in the wireless and wire-line sectors, more power will be necessary.

Figure 1 shows an example microcell installation in San Diego that would serve one or two city blocks. The cabinet draws approximately 300 Watts.

B. Electrical Safety

The reaction of human muscle tissue to electrical current is dependent on the magnitude and duration of exposure. The magnitude of electric current through the body is determined by the contact voltage divided by the human body resistance, with the bulk of body resistance being dominated by skin resistance. For exposures of 10ms or more IEC 60947-1 provides a guide to the effect of various current-duration combinations on the human body with the worst case exposure resulting in ventricular fibrillation. For shorter exposure periods IEC 60947-2 is referenced. A number of electronic techniques are used by existing network powering equipment to limit human body current to safe levels when the fault is from a conductor to earth, the approaches are similar to those used in ground fault interrupter (GFI) devices found in homes. However, when the fault occurs from one conductor to the other conductor the exposure can quite easily fall into a dangerous category. At the 400Vdc maximum conductor to conductor voltage level allowed by IEC 60950-21 for voltage limited circuits, the human body resistance from hand to hand is approximately 2,000 Ohms. This results in a body current of 200mA. Since conventional network powering devices are unable to distinguish between say a person touching a damaged cable that has exposed conductors, and the normal load current, the exposure period will continue until the person manages to release contact. This is depicted by the vertical red line at 200mA in Figure 2.

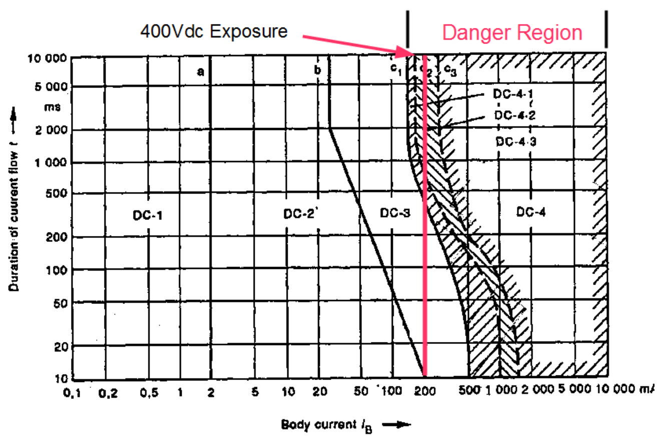

Figure 2: DC Current Effects (IEC-60947-1)

It is also important to note that injury may occur not only from ventricular fibrillation but from indirect injury if a shock is intensive enough to cause a technician to fall off a ladder for example.

III. Packet Energy Transfer (PET) Operation

PET Technology has the ability to distinguish the difference between an individual touching exposed conductors and the normal power draw of the load. PET separates electric power into a series of low energy packets of a duration of approximately 1.5ms. Each packet has a time slot dedicated to energy transfer, and a second time slot dedicated to a digital and analog signature for verification. If a person or other conducting object comes in contact with the conductors, the packet verification components are corrupted and the power is discontinued in under 3ms.

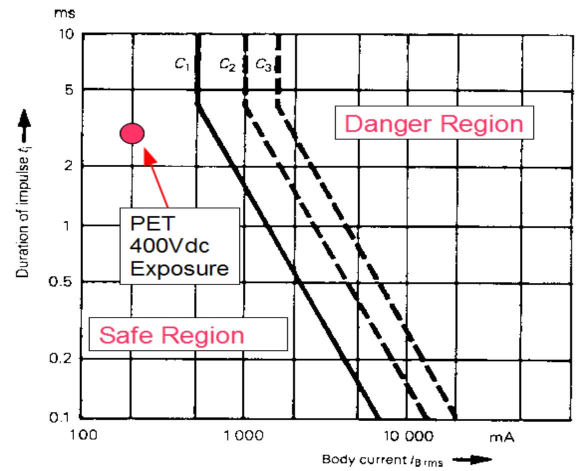

Figure 3: DC Current Effects (IEC-60947-2)

Figure 3 depicts how the body current at 400Vdc exposure falls well into the safe region and will also have much less probability of causing a technician to be jolted into falling off a ladder or otherwise being injured.

IV. Communications Infrastructure Benefits

A typical network power feeding application involves a central "hub" and a number of remote sites or cabinets. In the evolving CBTS market a common configuration involves a Base Station Controller (BSC) cabinet that often has CAT 5 or CAT 6 cable runs to a number of CBTS (Microcell) cabinets mounted on telephone poles, street lamp poles or buildings. When power for the CBTS cabinet is derived locally a number of provisions must be provided to safely provide AC service and often to allow the local utility to meter the services. Figure 4 depicts a typical installation with conduit run, disconnect, junction box and utility meter for a cabinet that has a power requirement of 300W.

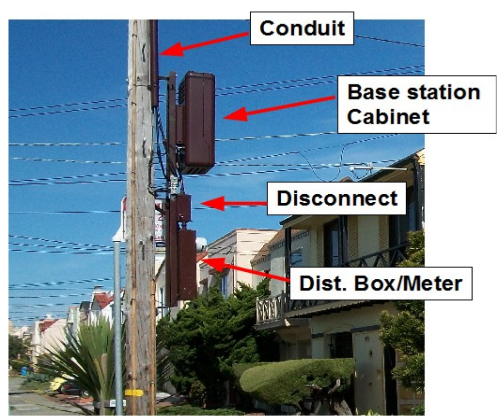

Figure 4: Microcell AC Service Components

Inside the Microcell cabinet the AC power is brought into an AC-DC power converter. In some regions an isolation transformer is required by local code to be placed in the cabinet. Depending on the carrier, a storage battery capable of providing from one to four hours of DC back-up is installed. The items are summarized in Table 1.

A PET system will require a receiver module in the Microcell cabinet and a transmitter module in the BSC cabinet. The receiver directly outputs 48Vdc or 24Vdc power to the cabinet. The transmitter module converts 24 or 48Vdc power from a central storage battery in the BCS to higher voltage and transmits it in PET format to the received unit.

Table 1: AC and DC Power Components (300W)

Item	*Est. Cost $*
Junction Box/Utility Meter	225
Disconnect	75
Conduit/Misc	100
Isolation Transformer	65
DC Power Converter Sys.	600
Battery (1 hour backup)	175
Installation	500
TOTAL	1740

Figure 5: PET Transmitter/Receiver shown with 100m of CAT-5 Cable

The AC service components, AC-DC conversion and storage battery will be relocated at the BCS, but the cost of larger batteries and conversion components can be 30-50% less in the larger format of the centralized BCS configuration. AC service, DC conversion and a battery are already needed by the BCS, meaning that the AC service costs are already incurred and the DC components must be made larger. Assuming five Microcell cabinets per BCS, it would be reasonable to expect a visit to each Microcell cabinet every 3 years for battery related maintenance using the conventional architecture. Site visits can cost from $500 to $1,000 in urban areas, particularly if the cabinet has limited accessibility. For a BCS with five Microcells attached, a potential annual maintenance savings of $800 to $1,600 could be achieved by centralizing the battery storage in the BCS.

A receiver/transmitter pair with 100m of CAT 5e cabling is depicted in Figure 5. Each unit is 2"x6.5"x9" and weighs approximately 4 pounds. In a Microcell cabinet this represents a 50-70% reduction in volume in the cabinet versus the convention DC conversion system and battery. Externally the AC disconnect, junction box, utility meter are eliminated reducing the cabinet footprint by 50% or more. The depicted system can support 10BASE-T and 100BASE-T communication and 340W of power transfer with a single Cat-5 Cable or 500W with a Cat-6 (23AWG) cable. Two cables are needed for 1000BASE-T, but up to 800W is possible in this configuration with a 3"x6.5"x12" receiver/transmitter unit.

V. Conclusion

The implementation of a remote power architecture can significantly reduce capital equipment and maintenance costs in networks that involve a "hub" that interfaces with a number of small installations, a prime example being Microcell cabinets that interface to a Base Station Controller (BSC) using CAT 5 or CAT 6 cables. Large savings can achieved from requiring only one AC power drop to the BSC and consolidating a number of smaller rectifiers and batteries into a larger BSC power system.

Using PET, a significantly safer network feeding device can be constructed under the IEC 62368-21 standard.

[i] In-Stat, "The Future of Infrastructure: Compact Base Stations", June 2010

[ii] IEC-60950-21, voltage limited equipment, section 6.2.1