Protecting T1 Circuits Entering Power Substations and Cell Sites

Background

Circuit interruptions often occur as a result of power system electrical faults, lightning strikes on power lines or high metal structures. Electrical operations, cell site communications facilities and 911 call centers require extremely reliable circuits for emergency communications. T1 circuits have become a key element to these types of communications applications, ensuring reliable communications between energy control centers, substations and radio towers.

T1 technology provides data communications or rapid Internet access up to 1.544 Mb/s or can be used to provide 24 standard voice channels over a four-wire twisted pair connection. The primary innovation of the T1 was to provide a "digitized" voice communications channel opposed to several analog channels. Both the electric power industry (uses analog voice channels for data transfer i.e. modems) and telephone systems (use analog channels for trunk lines) use digital T1 systems.

More specifically, T1 high-speed digital networking technology has numerous applications, of which the most common are:

- T1 access using DSU/CSU: Integrated voice and internet access over a single T1 line
- T1 access through T1 Routers: Integrated voice and data over a single T1 line point-to-point with integrated DSU/CSU
- T1 frame relay technology: Entirely digital technology, which reduces the chance of error and offers excellent transmission rates
- T1 ISDN Primary Rate Interface (PRI) access: Well suited technology for connecting PBXs and ISPs to local telephone company exchanges
- Cell site data backhaul: Loop-bonded Ethernet over T1/E1 and Ethernet over SHDSL solutions, which is the key to providing high-capacity mobile base-station data backhaul services

With T1 becoming a key part in improved substation Energy Management Systems (EMS) functions, reliability of the service is crucial. However, many of the T1 circuits deployed today are located in areas that expose them to extraneous energy sources. These energy sources can cause equipment damage and downtime, and in a worst-case scenario, injury or even fatality to personnel working on the circuit wiring or equipment when the event occurs.

Challenge

- Provide safe reliable communications services for monitoring power system control, cellular phones, 911 call centers and many other applications
- Ensure reliable service and revenue streams
- Provide reliable communications to high voltage facilities
- Provide safe and reliable communications to any site where Ground Potential Rise (GPR) can be an issue
- Secure existing services while economically providing for future communication needs with minimal change to current methodologies or functions

GPR is defined in I.E.E.E. Standard 487 as "the product of a ground electrode impedance, referenced to remote earth, and the current that flows through that electrode impedance."

A GPR event can be caused by a power system fault or by a lightning strike. The energy from a lightning strike, while dissipating into the earth, causes a GPR just as if it were a power system fault. Therefore, any site containing a tower is subject to GPR energy.

Standard protection methods of shunting technology do not work on circuits that are subjected to GPR. This is because with a GPR potential the ground is the source of the energy, rather than a location designed to drain momentary bursts of energy. Standard drainage equipment would directly connect the electrical potential of the GPR onto the circuit. In effect, the energy would flow from the ground onto the circuit. This energy at the very least causes damage to equipment with the possibility of injury or fatality being the foremost issue of concern.

Solution

Protection on these circuits should have isolation equipment deployed rather than standard drainage protection equipment. The isolation process allows the electrical potential of the site to change as the GPR occurs from the event. At the same time, the rest of the circuits on the Central Office (CO) side of the isolation equipment remain at the stable CO potential. Therefore the differing potentials across the isolation equipment are not seen by the total circuit, thereby providing safe reliable communication.

With standard protection technologies incapable of protecting these sites, it is important to install affordable High Voltage Isolation equipment on the existing communication circuits while providing for future growth or changes.

The Teleline equipment is designed to provide isolation to wireline services at a site subject to GPR. The isolation methodology is in concert with I.E.E.E. Standard 487. The Teleline product line can provide economic isolation to a variety of circuit types by deploying differing circuit cards and mounting methods.

This deployment will provide a minimum of an I.E.E.E. Service Performance Objective (SPO) Class 'B' circuit. With additional equipment a Class 'A' SPO can be established on some circuit types. The following SPO Classifications are extracted from I.E.E.E. Standard 487:

A) Class 'A': Non-interruptible service performance
(should function before, during and after the power fault condition)

B) Class 'B': Self-restoring interruptible service performance
(should function before and after the power fault condition)

Circuit Description: T1 Circuit

This detailed application note applies to a standard T1 digital 1.544 Mb/s Pulse Code Modulated Circuit. A standard T1 requires regenerators every 6,000 feet of cable length (22 Ga) and usually requires a single gauge of wire for a cable pair from one end of the circuit to the other. The Network Interface Unit (NIU) will hand off the circuit to a Customer Premise Equipment (CPE) device. This may be a channel bank, a BTS unit or other equipment that will utilize the circuit. The span power is simplex in function and consists of 96 to 130 Vdc at 60 mA (nominal) current. This energy is used to power line regenerators or the NIU. Other installations may utilize a local power option for the NIU device.

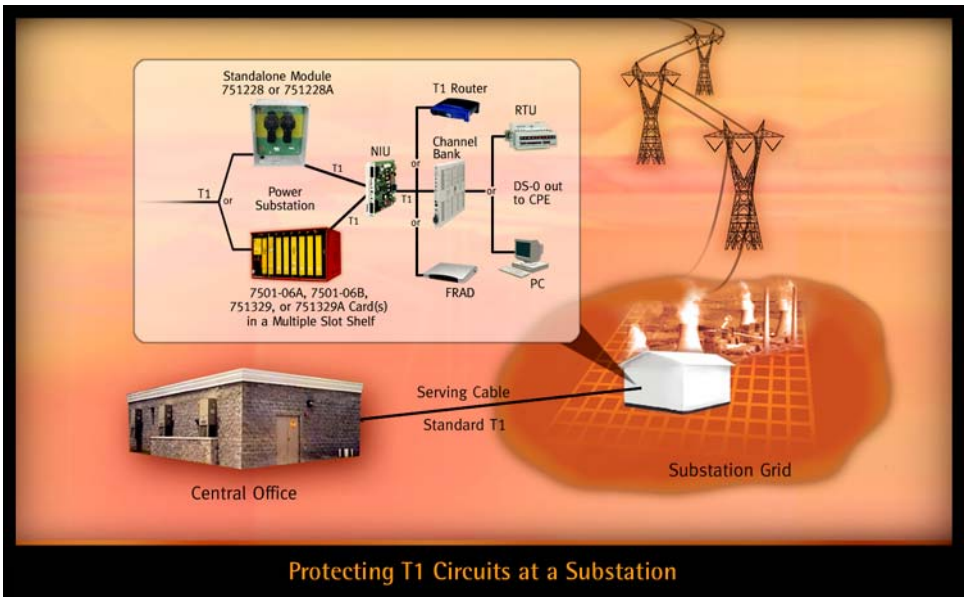
Positron manufactures standalone units and plug-in circuit cards that provide isolation protection for this circuit type. Because of the DC voltage on the cable pairs, a T1 circuit cannot be configured for the more critical Class 'A' functionality. The usual additional equipment required for a Class 'A' utilizes full period drainage on the circuit, which cannot be done with the required DC power on the circuit.

Teleline isolator equipment is the essential protection device required to support a Class 'B' circuit. Additional equipment may be required to adequately satisfy the Class 'B' functionality of the circuit.

Required Wireline Isolation Equipment

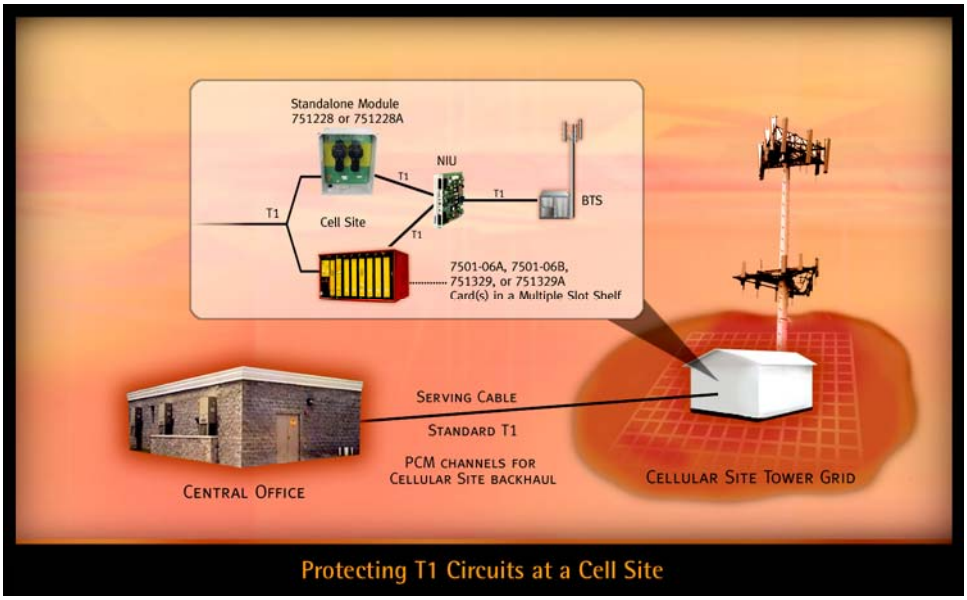
Teleline standalone units or plug-in circuit cards in multiple slot shelves can be used to isolate T1 circuits from GPR events. See Figure 1 (next page) for a graphical representation of the T1 circuit in use in a substation and Figure 2 (next page) for a cell site.

Figure 1



This Figure shows a standard T1 circuit from a Central Office to a substation connecting to end user equipment. This is configured as a Class 'B' circuit.

Figure 2



This Figure shows a standard T1 circuit from a Central Office to a cell site connecting to BTS equipment. This is configured as a Class 'B' circuit.

Supported T1 Configurations

Standalone Units

The Teleline cards for a standalone application are: 751228 or 751228A four-wire standalone unit.

Plug-in Circuit Cards

The Teleline plug-in cards for a multiple slot shelf application are: 751329, 751329A four-wire card, 7501-06A or 7501-06B two-wire card (two cards are required).

Multiple Slot Shelves

Two and four-wire circuit cards are supported by 751101, 751109, 751112 or 751127 model shelves. The early version 7501-08 shelf can only use the two-wire 7501-06A or the 7501-06B circuit cards. This shelf requires two circuit cards for a single four-wire T1 circuit.

Span Current and Circuit Signal Processing

751228, 751228A, 751329, 751329A cards

Span current is presented to the circuit card in a simplexed balanced nature on side one of the circuit. The voltage referenced Tip to Ground equals that of the voltage referenced Ring to Ground. At the same time the voltage referenced Tip to Ring is equal to zero.

The span current (CO side) is routed through the input transformer to the center tap of that transformer. It is then routed to the center tap side two of the transformer. At that point it is reinserted into the circuit on side two and returned to the CO completing the circuit. The circuit path for the second side uses the second cable pair for the shelf card slot.

The digital circuit is passed through the transformers to the station side of the card on to the station cable pairs. This portion of the circuit does not have span or sealing current therefore it is called a “Dry Span”. Due to the lack of span or sealing current on this portion of the circuit, it is necessary for the NIU to be locally powered and should be in close proximity to the Teleline shelf.

If the circuit length from the shelf stub cable to the NIU is very long and/or has several connections, problems may be encountered and may show up as circuit errors. This is usually caused by the excessive length of the circuit, the many connections and the oxidation at those connections. The recommended corrective action is to remove all connections from terminal blocks (punch or press type) and solder these connections. This problem is usually prevented by sealing current, which is not present on the station side.

7501-06A, 7501-06B cards

The T1 circuit requires two of these circuit cards (which are two-wire cards) to isolate and complete the four-wire circuit. One card is used for side one and the other card is used for side two. Circuit Signal processing is identical to four-wire T1 cards. These cards can be used in any Teleline shelf. For information about placement position in the shelf for Span Current processing, please consult the installation guide.

50/60 Hz Filtering

The various T1 carrier cards (751228 standalone four-wire, 751329 plug-in four-wire, 7501-06A(s) plug-in two wire) feature 50/60 Hz filters. In cases of line imbalance, common mode 60 Hz (or 50 Hz) can become metallic and disturb the isolation transformer. The filters will permit normal functionality with up to 30 V of 60 Hz induction.

The 751228A standalone four-wire, 751329A plug-in four-wire and 7501-06B plug-in two-wire units do not have 50/60 Hz filters installed. This presents a more cost efficient card for applications where 60/50 Hz induction is not considered to be a problem.

Benefits

- Less downtime (if any) in the circuits, thereby not affecting revenue. In addition, maintenance dollars are saved since less equipment is damaged by GPR events
- Communication circuits are built extremely reliable and affordable with additional growth potential built into the protection scheme. The circuits will work to a Class 'B' SPO. Some can be equipped to function to a Class 'A' SPO when the required additional equipment is installed at critical circuit points on the cable route
- Reduces the risk of personnel injury through exposure to GPR-caused potentials on communication circuits and equipment

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