Achieving High Voltage Isolation when Provisioning an MPLS Network

Multiprotocol Label Switching (MPLS) is used in high performance business networks as the desired method for managing the exchange of data. An MPLS network is highly scalable and can be implemented by telecom providers to make the exchange of data communications easy and efficient. It enables them to build next-generation intelligent networks that deliver a wide variety of advanced and cost effective services over a single infrastructure.

Power utilities are migrating their networks to this protocol to improve capacity and speed in consideration of current and future technology needs and Smart Grid initiatives. Service providers use the speed and capacity made possible by MPLS to deploy more effective Virtual Private Networks (VPNs). This enables power utilities to integrate substations and other facilities into their corporate network.

The Issue: MPLS in a High Voltage Environment

Power substations present a unique challenge to the reliability of a functioning MPLS network. Ground fault events at substations will create network interruptions. Depending on the severity of the Ground Potential Rise (GPR) event, network elements such as communication cables, modems and routers will be damaged or destroyed due to high voltage emissions. This may cause service interruptions and injury to personnel working on the equipment.

The Solution: Isolate the Network from High Voltage Disturbances

Positron's Teleline and TeleLite isolation solutions offer the best in high voltage protection. For over 40 years, Positron has been providing high voltage isolation products to protect critical circuits in power substations, cellular sites, E-911 Public Safety communications centers and wind farms.

The basic objectives for protecting communication facilities entering a power substation are to ensure personnel safety, protect the telecommunications plant and terminal equipment and maintain reliability of service. Figure 1 below depicts a communication network without isolation protection. The potential difference between the ground planes connected via a conductor (e.g. a wireline telecom circuit) will produce a fault current. Figure 2 illustrates that breaking the metallic continuity with an isolation device will stop high voltage from flowing in the communications telephone cable between two ground planes of different potential (Substation Ground Potential and Remote Ground Potential). Therefore the same GPR will not cause any damage, since the two ground planes are completely isolated from each other.

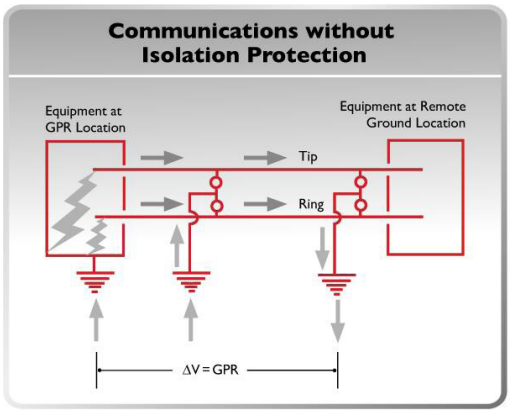


Figure 1

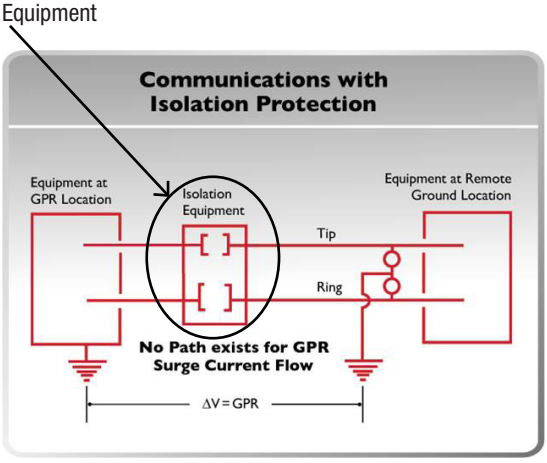
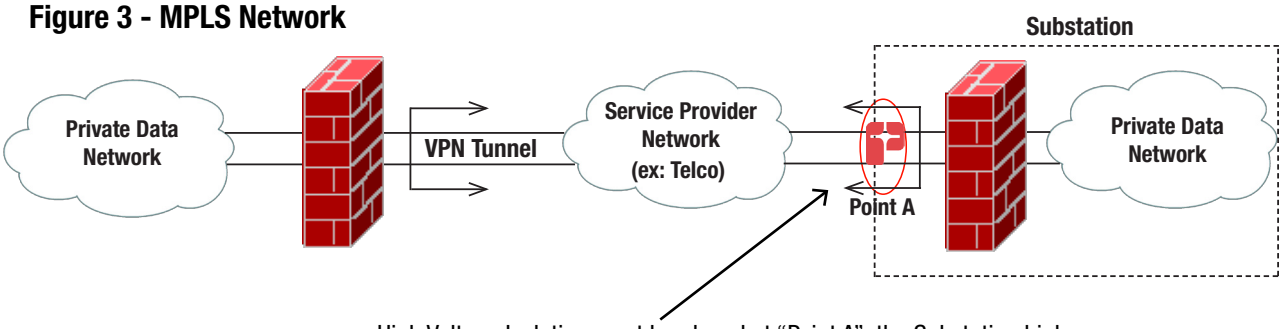


Figure 2

Provisioning an MPLS Network Connection

A VPN extends a company's Private Data Network beyond its traditional firewall, as seen in Figure 3. This permits private data to be transmitted over the Public Switched Telephone Network (PSTN) in "VPN Tunnels" carried over an MPLS data network.

Figure 3 - MPLS Network



An MPLS network can be delivered over a private or public data network or a combination of both using a number of different technologies, such as:

- **ADSL** High speed data superimposed over a POTS line
  - 1.2 Mb/s up to 24 Mb/s downstream
  - 0.5 Mb/s up to 1.3 Mb/s upstream
- **DS0** 56 Kb/s or 64 Kb/s corresponding to the capacity of one voice-frequency-equivalent channel
- **T1** DS1, which is made up of 24 DS0s
  - Frequency/data rate = 1.544 Mb/s
  - Comprised of 24 channels of 64 Kb/s (24 x 64 $\cong$ 1.544 Mb/s)

The End-User Perspective

From an end-user perspective, the objective is to procure telecom service that will ultimately deliver an MPLS connection end-to-end.

The Telecom Provider Perspective

From the telecom provider perspective, the challenge resides in provisionning the service delivery to carry the data and create the conditions to support the VPN connection. There are several considerations:

- Length of the loop
- Number of pairs available
- Proximity of the Central Office (CO)

The Telecom Network Perspective

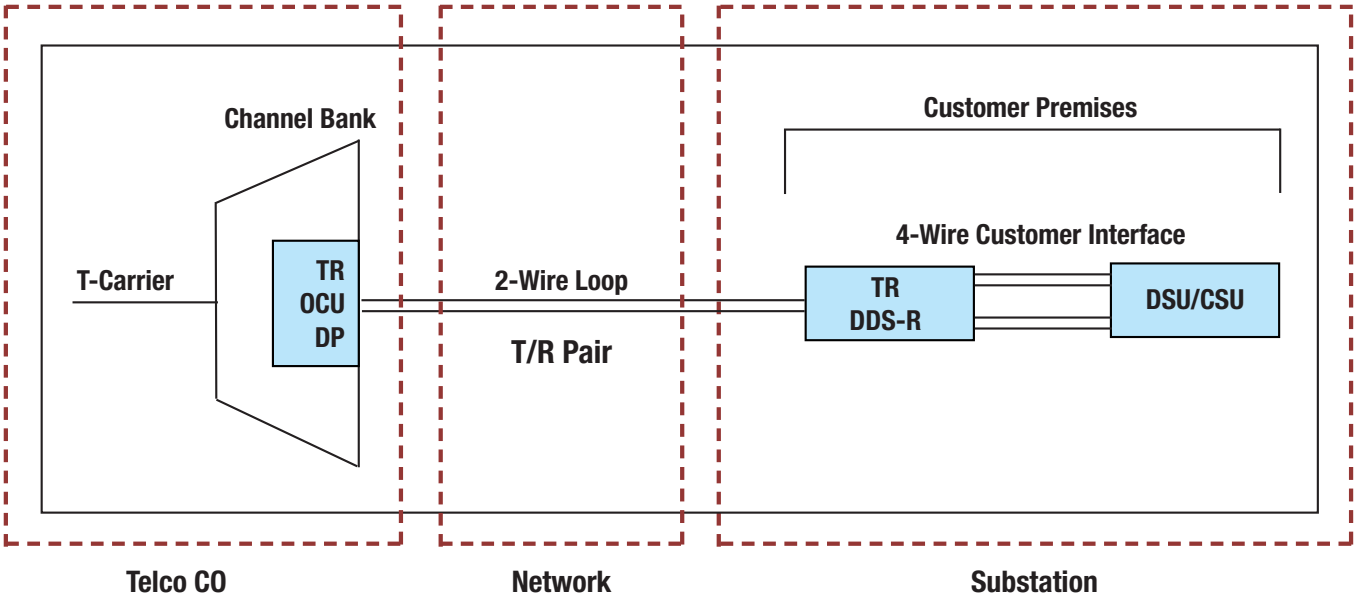
From the telecom network perspective, the distance between the service location and the CO is important and determines the service delivery method. The data stream can be provisioned (at point A as illustrated in Figure 3 on page 2) using the following:

- 2 pairs to transport a 4-wire 56 Kb/s or 64 Kb/s circuit that terminates into an Ethernet modem at the end-site
  - The CO must be very close for this to be practical (see Figure 4 on page 4)
- 2 pairs to transport T1 signaling that terminates into an Ethernet modem at the end-site
  - The loop length can be greatly extended using regenerators
- 2 pairs to transport HDSL, over which a T1 channel can be delivered (see Table 1 on page 5)
  - The maximum loop length is 3.65 Km (12,000 ft)
  - With regenerators, the maximum loop length is 18.25 Km (60,000 ft)
- 1 pair to transport HDSL2, over which a T1 channel can be delivered (see Table 1 on page 5)
  - The maximum loop length is 3.65 Km (12,000 ft)
- 2 pairs to transport HDSL4, over which a T1 channel can be delivered (see Table 1 on page 5)
  - The maximum loop length is 4.855 Km (16,000 ft)
  - With regenerators, the maximum loop length is 14 Km (46,000 ft)
- 1 pair using ADTRAN Total Reach® enabling the 4-wire DDS service to be transported over a single pair in the network, and then converted to 4-wire on the drop side of the ADTRAN equipment on the customer premises (see Figure 4 on page 4)
  - Loop length should not exceed 15 Km (50,000 ft)
  - Maximum cable lengths:
    - 15 Km (50,000 ft) of 22 gauge
    - 11 Km (36,000 ft) of 24 gauge
    - 8.3 Km (27,000 ft) of 26 gauge

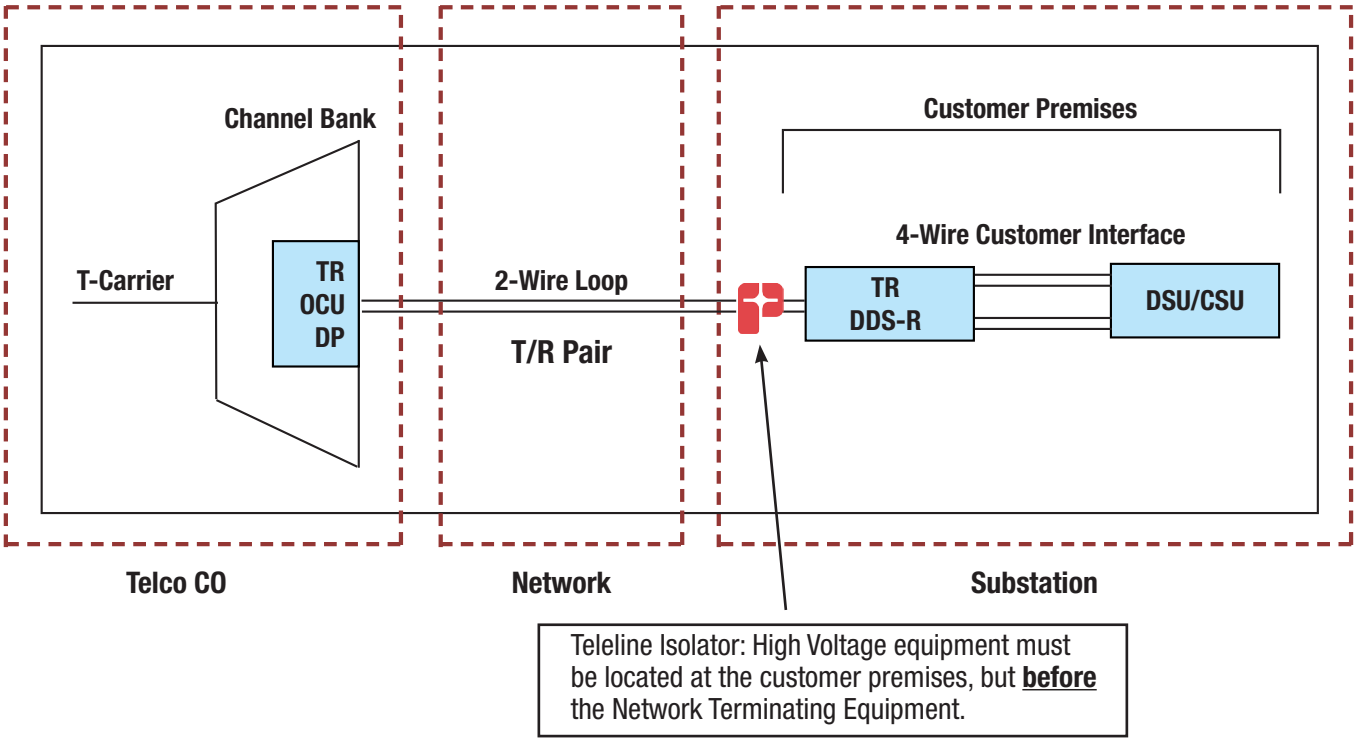
The High Voltage Isolation Perspective

The customer may order a 4-wire circuit for an MPLS connection. It is imperative to know how the local operating Telco will provision the circuit prior to choosing the appropriate protection solution. Given that the served sites are situated within high voltage areas, the network terminating equipment must be located on the protected side of the network. Therefore, the protection equipment must be selected to be suitable with the method of transport chosen by the Telco.

Figure 4 - ADTRAN Total Reach® DDS



Protecting an ADTRAN Total Reach® DDS



As illustrated in Figure 4, the protection equipment needs to be placed before the Network Terminating Equipment (NTE) at the substation location. Therefore, selecting the appropriate protection solution is contingent on knowing the method used by the local operating telephone company to deliver the service.

High Voltage Protection

IEEE 487 is the recommended practice for the protection of wireline facilities at electric supply locations. It states that High Voltage Protection (HVP) is required at sites with a peak GPR greater than 1,000 volts. It also states that for sites with a GPR of 1,000 volts peak or less, gas tubes or other shunting devices are suitable.

While this is true for most services, for digital services, a gas-tube operation will short out the power for the span and the digital signal. During this period, the network would be unavailable, which could have catastrophic consequences for an interconnected Smart Grid. After the gas-tube operation, there will be a period of latency (circuit down time) while the digital services reinitialize. Therefore, to achieve a robust protection scheme for digital services entering electrical supply locations, isolation techniques are superior to the use of shunting devices. Using an isolation device will enable the circuit to continue operating during a high voltage event.

Table 1 - Comparison of HDSL, HDSL2 and HDSL4 Technologies

Characteristics	HDSL	HDSL2	HDSL4
Standard	TR-28	T1.417	T1.417 Issue, 2
Number of Pairs	2 Pairs	1 Pair	2 Pairs
Line Rate	784 Kbps x 2 Pair	1.544 Mbps	784 Kbps x 2 Pair
Line Code	2B1Q	16-TCPAM	16-TCPAM
Transmit Power	+13.5 dBm	+16.8 dBm Downstream +16.5 dBm Upstream	+14.1 dBm
Spectrum Mask	Symmetric	Asymmetric	Asymmetric on 1st span Symmetric on 2nd/3rd span
Power Back-Off	None	Yes	Yes
Maximum Reach - without Repeaters - with Repeaters	 12 Kft 60 Kft with 4 repeaters	 12 Kft N/A	 16 Kft 46 Kft with 2 repeaters
Spectral Compatibility - without Repeaters - with Repeaters	 Yes No	 Yes No	 Yes Yes
Support Interoperability	No	Yes	Yes
Span Powering Voltage	Across Loop 1 and 2	Across Tip and Ring (Loop 1)	Across Loop 1 and 2

Table 2 - Choosing Circuit Protection Equipment when Provisioning an MPLS Network

Service Delivery Method	Standalone Configuration	Plug-In Isolator Card Configuration*
DS0 (56 Kb/s or 64Kb/s)	7501-53	7501-24
T1	751228R2 or 751228SP	751329R2 or 751329SP
ADSL	Not Available	751325
HDSL	751239R2 or 751239SP	751339R2 or 751339SP
HDSL2	751239R2	751340R2 or 751340SP
HDSL4	751239R2 or 751239SP	751339R2 or 751339SP
ADTRAN Total Reach®	751233/2A	751333A

*Note: The plug-in cards must be housed in the Teleline Isolator 3-card, 5-card or 8-card shelves

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