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Data_Link 2000

APPLICATION NOTE AN006

Private Wires and Leased Lines

Summary

Although radio is the most appropriate telemetry communications medium for most applications, modems operating on private wires or leased lines sometimes offer a viable alternative. Private wires are cables owned by the user, whereas leased lines are rented from telecommunication network providers such as BT and Mercury.

This application note describes the technical requirements for successful operation of telemetry equipment on both types of line.

Organisations with equipment spread over large geographic areas sometimes have their own cables between sites. For example, water companies often lay multi-core cables alongside pipes. In some instances spare pairs within these cables are made available for telemetry use. Before using them, however, it is necessary for the system designer to understand the implications and limitations to ensure the network will function correctly.

In other cases there may be a need to rent lines from a network provider such as BT because a radio path is not practical. The user must ensure the equipment is installed in a way that complies with the relevant specifications, and that the correct type of line is provided. (BT's reference for lines typically used for telemetry is **Keyline 21A**)

In either case, it must be realised that long cables behave as transmission lines that exhibit losses, delays and distortion, and are susceptible to lightning surges. They are optimised for termination with a specified load (defined as the characteristic impedance), and may behave incorrectly if mismatched.

Leased lines may be multiplexed onto fibre-optic or microwave trunks. Telecommunication Network Providers therefore impose additional requirements to ensure compatibility with their equipment, and to ensure other users are not endangered and do not suffer interference.

Telemetry equipment operating on lease lines or private wires must be equipped with appropriate modems instead of radios. Modems can be supplied integrated with both ***Micro_Link*** and ***Nano_Link***.

Transmission Line Characteristics

Long cables exhibit imperfections due to inherent resistance, inductance and capacitance. These can cause the attenuation and transmission delay to vary with frequency, resulting in signal distortion. However, the distortion is minimised if both ends of the cable are terminated with a specified load, defined as the Characteristic Impedance. The universal Characteristic Impedance adopted for telephone-grade cables is about 600Ω. It is important that any modems connected to a leased line or private wire matches the characteristic impedance of the cable, and this is part of the approval requirement for leased line applications.

Telecommunication Network Providers reserve the right to process the signals sent down leased lines by amplifying them or converting them to formats suitable for transmission through digital exchanges or via fibre optics or microwave links. However, they will not distort the signal, provided it remains within defined limits of amplitude and frequency.

Signal amplitude is measured in decibels, and the maximum level allowed on a leased line is -13dBm. The allowable frequency range is typically 300Hz…3000Hz.

The above constraints are not always imposed on private wires, but it is good practice to keep within them.

Cable Loss

The signal source (transmitter) must have an output impedance of 600Ω, and the receiver an input impedance of 600Ω. The transmitter output signal therefore drops by 50% when the receiver is connected directly to it. The signal seen by the receiver will be further attenuated by the cable loss, which obviously increases with the cable length, and is typically 1dB/Km. (Note that losses in leased lines depend on the transmission media used by the Telecommunication Network Provider)

Multi-drop Applications

A typical telemetry system may have multiple outstations connected to a base-station. These could be 'daisy-chained' along a single cable or connected in a star network from the base-station. In either case the line becomes mismatched. Even ignoring the effect of the cable, the signal levels will drop due to additional loading. For example, two outstations will provide a combined load of 300Ω which will cause the transmitter output to drop to 33% of its open-circuit value instead of 50%. The mismatch loss can be quantified as follows:

No of Outstations	Mismatch loss
1	0dB
2	3.5dB
3	6dB
4	8dB
5	9.5dB
6	11dB

The mismatch loss must be added to the cable loss to derive the total signal loss between the telemetry base-station and any given outstation.

High Impedance Modems

In some cases the mismatch loss can be reduced by using high impedance modems at intermediate points along the line, whilst maintaining the 600Ω termination at each end. ***Nano_Link*** and ***Micro_Link*** can be supplied with high impedance modems. Note, however, that these cannot be used on leased lines.

Operational Limits

As defined above, the transmitter output power is limited to –13dBm. The receiver has a maximum sensitivity of –40dBm, so a telemetry system will function on networks with a maximum loss between any two points of 27dBm.

Lightning

Any long cable is susceptible to surges from nearby lightning strikes or electrical power faults. These surges have two components, common-mode (which appears simultaneously on both wires) and differential (which appears across the pair of wires).

All equipment connected to telephone lines includes some inherent surge protection. The signal is passed through a line transformer with typically 5000V isolation that gives some protection against common-mode surges. Voltage clamp devices are fitted across the pair to provide some protection against differential surges.

However, all protection is relative. A direct lightning strike on a cable will vaporise the wires, causing untold damage. Improved protection can be provided by adding surge arrestors external to the telemetry equipment.

Surge arrestors work by diverting the surge to ground, thus preventing it from reaching the protected equipment. The performance is therefore totally dependent on the effectiveness of the earth connection. Mains earth is not good enough. Ideally they require a substantial earth mat, but usually a good earth spike, buried at least 1m into the ground, is adequate.

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