ACOLAN® 2001 - *Copper*

Structure of copper cables

Possible screen

Outer jacket

Conductor assembly

General cable structure:

- Outer jacket: PVC or LSOH material.
- Screen (if provided): aluminium tape laid helically or longitudinally and/or tinned copper braiding.
- Conductor assembly: assembly of pair or quads. Possible individual screening.
- Insulation: PE.
- Conductor core: single red or multiple strand tinned or red copper.

Shielding: protection against interference

Two types of interference can be distinguished:
energy-based and non energy-based.

- **Energy-based interference:** this form of interference can cause physical damage to electrical systems (lightning, electrostatic discharge).
- **Non energy-based interference:** for a local computer network, these sources of interference can lead to: random malfunction at lower amplitudes and damage to communication boards at higher amplitudes (HF transients: switching to the mains electrical supply (30-300 MHz), commutator motors, fluorescent tubes, transformer stations, analogic telephone network, external sources: radar, radio transmitters, portable electronic equipment, HV supply lines).

The role of the screen is to form a barrier against magnetic fields occurring both inside and outside the cable.

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Shielding guarantees the longevity of the installations:

• An advantage in terms of investment:

Shielding multiplies the immunity of the cable by a factor of 100.

For a local network, a shielded cable protects against serious malfunction (e.g.: shutdown of computer systems) and thus against operating losses.

The use of shielded cables significantly reduces restrictions on the use of other electrical appliances or cables. Correctly installed, shielded data cable can thus be run next to power cables without the risk of deterioration in transmission performance.

• Developments in transmission:

The encoding of data for transmission over data cables makes use of carrier waves of ever-increasing frequency: previously it was 20 MHz, today it has risen to 100 to 200 MHz, and it is already possible to transmit at 300 or 600 MHz, or even 1.2 GHz.

At the same time the data encoding systems have also evolved and ATM transmission allows higher data transfer rates to be achieved.

The standard encoding process uses two voltages: e.g.: +5 V and -5 V. The most recent encoding systems use three levels: +5V, 0V and -5V. The increase in transfer rates is thus achieved by the introduction of an extra level of coding.

The immediate consequence of this is an increased sensitivity to interference which distort the signals. Shielded cables therefore allow an increase in frequencies and data transfer rates to be considered for a local network without calling the passive infrastructure of the system into question.

• Compliance with the Electromagnetic Compatibility (EMC) standards:

The use of shielded cables allows the requirements of European standards EN 55022 and EN 55024 to be met. These standards cover electromagnetic interference and the immunity of electrical systems against it.

The different types of shielding:

A conductor tube provides excellent protection against interference, but for obvious reasons of flexibility, this is not possible for data cables. It is thus necessary to form a screen using a strip of aluminium or braid, the best results (from the point of view of transfer impedance) being obtained when these two methods are combined.

A coding system allows the type of shielding of twisted pair or quad cables to be identified.

Designation	Meaning	General shielding	Individual shielding of pairs
UTP	Unshielded	None	-
FTP	Screen	Screen	-
STP	Braid	Braid	-
SFTP	Braid + Screen	Braid + Screen	-
SSTP	Braid + Screen per pair	Braid	Screen

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Transmission parameters

Primary parameters:

The parameters of a transmission circuit are those electrical values that fully define the properties of that circuit from the transmission point of view. The simplest parameters are the primary parameters, the values of which sult directly from the method of construction: the type of materials and the geometrical position of the wires.

They can be divided into two groups:

- longitudinal parameters: resistance and inductance,
- transverse parameters: capacitance and leakance.

These parameters are generally a function of the frequency and are defined in terms of unit length.

Resistance: the resistance depends on the frequency, on the diameter and type of conductor and on the temperature.
It increases at high frequencies according to the skin effect.

Capacitance: the capacitance depends on the distance between the conductors and on the type of insulation.

Inductance: inductor effect (skin effect, screen effect, proximity effect).

Leakance: defines insulation losses, dielectric losses and losses between conductors.
Leakance occurs in parallel with capacitance and is made up in the same way.

Secondary parameters:

The primary parameters can only be measured directly over very short distances. Furthermore, they only enter into transmission calculations in the form of fairly complex expressions. It is therefore preferable to replace them with other systems of parameters. Secondary parameters can be measured over long circuits and can be incorporated more simply into the calculations.

The secondary parameters most frequently used are the characteristic impedance and the propagation coefficient, the latter being directly related to the attenuation, per unit length.

Other parameters can also be considered, such as near end crosstalk, the signal to noise ratio and the transfer impedance.

1. Attenuation per unit length:

This represents the losses suffered by the electrical signal as it travels along the pair (depends on resistance and capacitance).

Traditionally, attenuation is measured by the so-called insertion method which defines an attenuation constant.

The signal is fed in at one end of the cable and the signal received at the other end is measured. The measured attenuation is obtained by the ratio of voltages. Its value is expressed in dB/km and is proportional to the length of the cable (and the square root of the frequency).

2. NEXT - Near end crosstalk attenuation:

This characterises a cable in its environment. In general, a pair is associated with other pairs in a same cable, leading to a phenomenon of inter-pair coupling.

Part of the signal transiting in the pair will thus radiate to the other pairs and pollute the signal they are carrying. This coupling phenomenon will depend on a combination of the twist length of the cable, the distance between pairs and the construction of the cable. This phenomenon is characterised by the value of the near end crosstalk between pairs. The voltage of the disturbed pair is measured at the end at which the signal is applied to the disturbing pair.

The difference between the original signal and the interference corresponds to the near end cross talk attenuation.

3. ACR - Signal to noise ratio:

An electrical signal travelling along one pair causes a voltage to occur on the other pairs of the same cable.

The signal will only be detected if it is significantly higher than the noise. The higher the signal to noise ratio, the higher the quality of transmission.

For a length of 100 metres and for each type of cable, a graph of the near end crosstalk and of the attenuation allows the Attenuation to Crosstalk Ratio to be visualised (difference between the two curves).

4. Characteristic impedance:

The characteristic impedance depends, at high frequencies, on the line capacitance and the inductance of the cable.

The characteristic impedance is defined by a method based on the measurement (using an impedometer) of the modulation and the phase of the cable input impedance in both open and short circuit conditions.

Line theory is then used to calculate the characteristic impedance and the propagation coefficient.
The characteristic impedance and the attenuation per unit length are intimately related through the capacitance: the lower the capacitance (the greater the distance between the two conductors), the lower the attenuation and the higher the impedance.

5. Transfer impedance:

The transfer impedance is a measure of the effectiveness of the protection provided by a screen against conducted or radiated electromagnetic interference.

The presence of an electromagnetic field causes a current to flow in the screening of a cable which could couple with the internal conductors and cause end noise voltage The transfer impedance Zt is constant at a given linear impedance, represented by the relationship between the voltage induced in the cable circuits and the disturbing current in the screen.
Its value varies according to frequency and is expressed in mΩ/m.

The resistance per unit length of the shielding and the depth of penetration (depending on the diffusion of the electric field within the thickness of the shielding, the skin thickness as a function of the frequency of the disturbing current, the conductivity, the relative magnetic permeability of the material) all play a fundamental role in transfer impedance.

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