SmartClass ADSL/Copper Combo Kickstart Training

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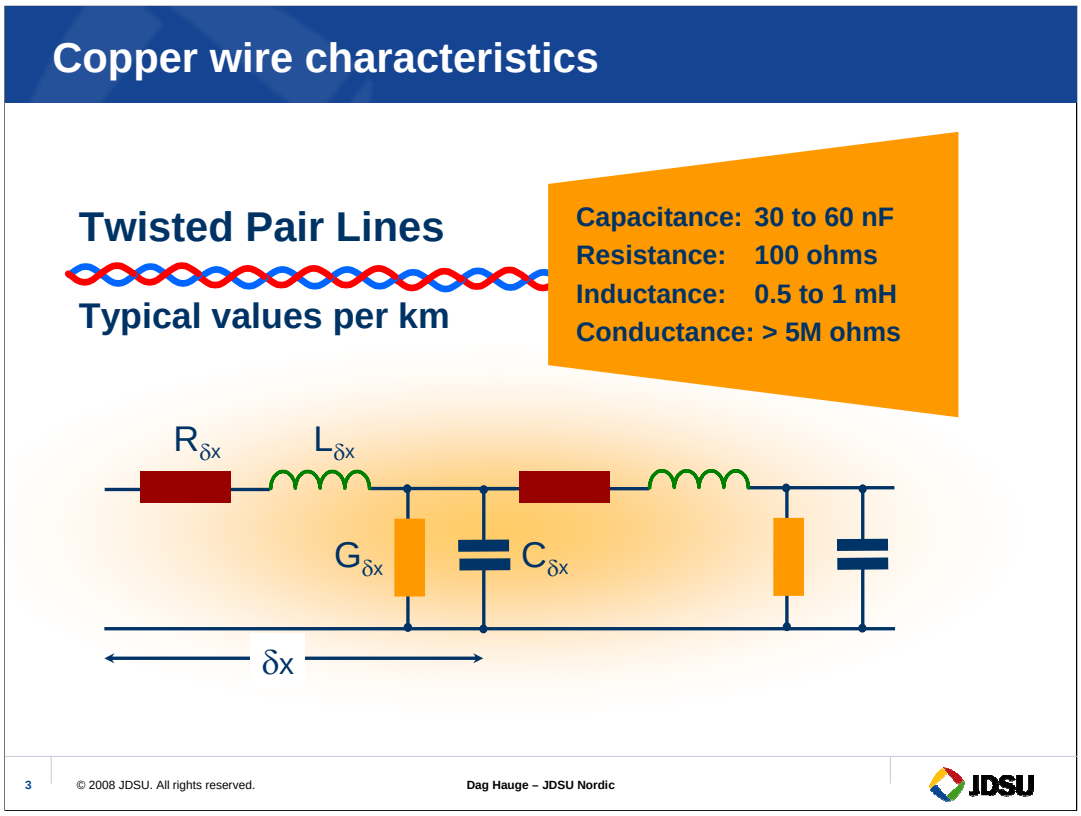
Version 3.0

Copper Testing

Copper Wire Characteristics

- Resistance
- Capacitance
- Inductance
- Bridged Taps
- Bonding and Grounding



Paired telephone cables, for example, are made up of a few to several thousand twisted pairs. However, the copper strands have a slight amount of resistance as well as a small amount of capacitance and inductance, which causes impedance when put together. In other words, it holds back the flow of the electrons and signal.

The twisting of the two strands of copper causes a constant impedance level. The further apart the cables are, the greater the impedance level. When there is a fluctuation in the constant impedance, a TDR will indicate a fault.

A Transmission Line usually comprises two metal conductors (eg: copper, aluminium, cadmium) that physically run parallel to each other between the near and far end of the connection.

The Line will introduce resistance into the circuit made with this being usually quoted as the Loop Resistance in Ohms/km. As the signal frequency is increased the Loop Resistance of the Line may increase due to Skin Effect.

The Line's conductors can be considered as being mutually coupled leading to the Line introducing inductance into the circuit, this is usually quoted as Loop Inductance in mH/km.

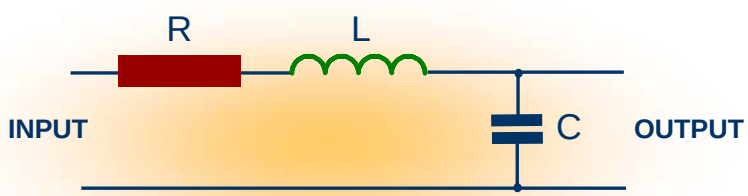
The Line's parallel conductors will exhibit capacitance between them with the Line Capacitance usually being quoted in nF/km.

The insulation between the conductors (usually air, plastic or paper) will introduce a very high resistance path between them. This allows the signal to be conveyed to be "leaked away" as the line is made longer and longer. It is common for the Line's Leakance (or Conductance) is measured in Siemens/km.

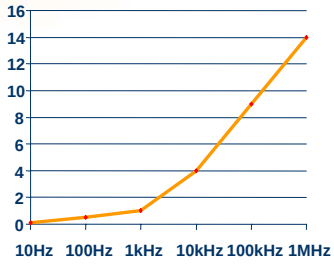
δx is the length of each segment and is made to tend towards zero in analysis.

Copper wire characteristics

The transmission line acts like a low-pass filter



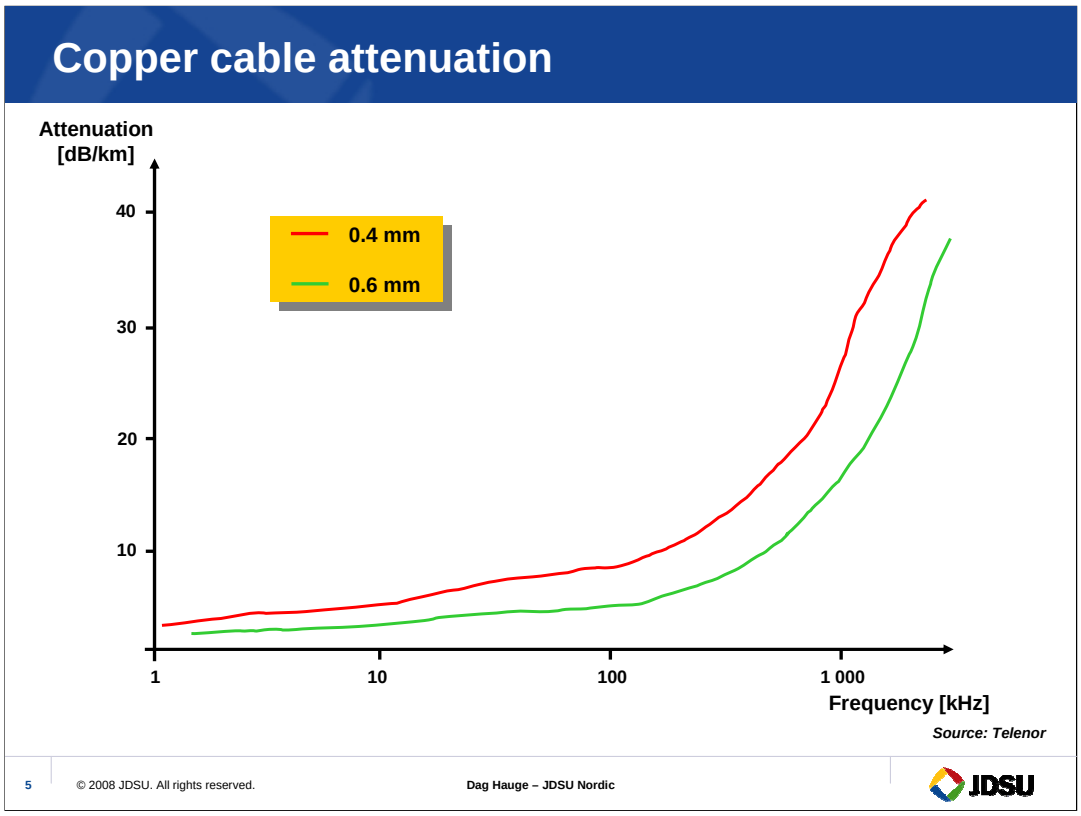
At higher frequencies the effects of "X_C" and "X_L" become more prevalent



The combination of the Lines "Primary" parameters of R, C, L and G tend to make a Transmission Line behave in a manner similar to a Low-Pass Filter.

As the conveyed Signal frequency is increased, so the Inductive Reactance increases and this tends to reduce the conveyed Signal's power as measured at the Far-End of the Line.

In addition, the Line's Capacitive Reactance reduces with frequency, so the conveyed Signal can be considered as being gradually shorted with Line length leading to a reduction in the power delivered at the Far-End.



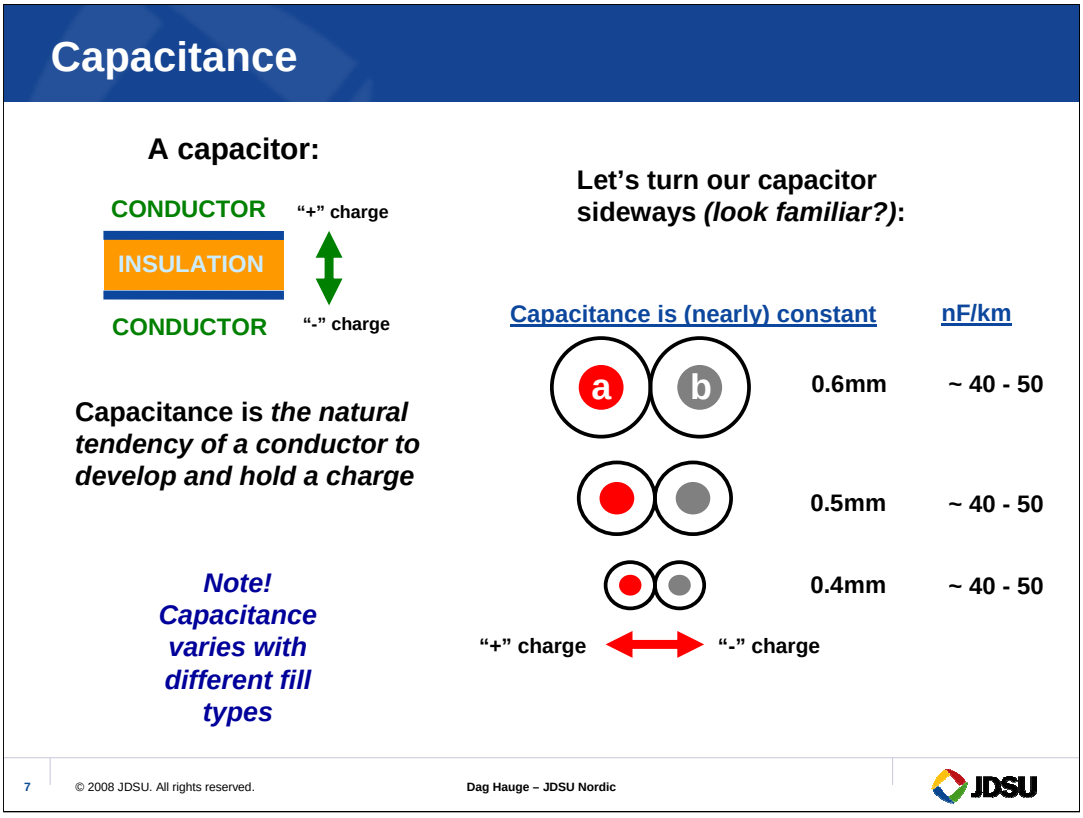
For example, 5 km of 0.5 mm copper has a loss of 55 dB at 300 kHz. This means that the signal power is reduced by a factor of 300 000. For comparison, the optical fibre attenuation at 1.55 μm is 0.2 dB/km and is independent of the signal frequency. A 55 dB attenuation corresponds to 275 km.

The problem could be reduced by increasing the transmission power:

- However, as we will see later, crosstalk effects will limit the maximum strength of the signal so that typically the received signal is very small.
- Note also that due to EMC legislation, it is a requirement that the network transmission system does not interfere with radio transmission, which also places a limit on the strength of signal being sent on the line.
- The modem must be able to cope both with the 0 dB attenuation on short lines as with the 55 dB on long lines, because it is not known in advance which line the modem will be installed on.

Resistance

- Causes attenuation of signals
- Signals must be amplified or repeated before they attenuate too much
- Dependent on cable dimension
- Changes with temperature
- Can be used to measure loop length (short required at far end)



The understand how an opens meter works and how it can tell you the length of the loop, we have to understand capacitors a little bit (you know, those things that "kick" start electric motors):

A capacitor is two conductors separated by insulation

You can make one at home if you roll up some tin foil (aluminum foil) between paper towels.

So what do you know that has two conductors separated by insulation?

TWO LONG SKINNY conductors separated by insulation?

(ask for a volunteer to answer)

RIGHT: THE LOCAL LOOP!

Kapsitanse:

Mål kapasitansen, og benytt denne som referanse for målinen. Ta 1m av kabelen og mål for å få en referanseverdi.

1 mile = 1.609344 km (0.083uF/mile tilsvarer 0.052uF/km)

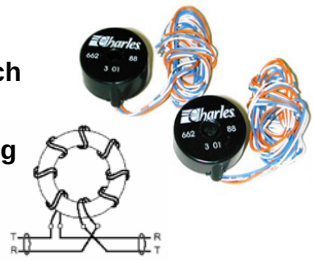
The local loop is a LONG, SKINNY CAPACITOR, and acts just like one:

It develops a natural charge (capacitance)

Inductance (Load coils) and Bridged taps

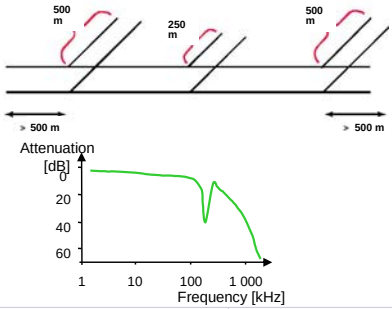
Inductance

- **Add inductance - counters effects of too much capacitance.**
- **Used to improve the quality of speech on long POTS lines.**
- **Not allowed on "special" pairs.**



Bridged taps

- **Length of dangling, unterminated cable on a communications line.**
- **Usually left over from an earlier POTS line.**
- **Causes mismatch and other undesired effects (reflections/echos) in transmission.**



Load coils

As the distance between the customer premises and the CO approaches approximately 18,000 feet, a natural capacitance begins to develop among the tip, ring, and ground conductors. This excess capacitance adversely affects alternating current (AC) signal quality by introducing loss to the higher frequencies of voice and modem transmissions.

As a result, voices sound deeper and modems connect at lower than expected transmission rates. The effect of this excess capacitance can be reduced by adding an equivalent amount of inductance to the loop. The primary function of load coils is to add this inductance, providing the loop with a flat loss characteristic over the entire voice spectrum. This load coil-increased performance is ideal for both analog voice and analog data services because they operate within the voice spectrum. However, for wideband digital services such as ISDN, DDS, and xDSL, load coils must be removed. The load coil operates as a low pass filter, thereby attenuating all frequencies (e.g., wideband digital services) above the voice band.

load coil

A device placed into a telephone circuit between the end office and the subscriber to step up the voltage and compensate for signal loss due to bridged taps. The load coil is an inductive device that acts as a high-frequency choke and must be removed if the line is converted to high-speed digital use. As digital service (digital loop carrier) is moved closer to the customer and the analog lines become shorter, load coils are no longer required.

A loading coil is an induction device placed on a local loop longer than 5 400m that carries analog signals. The device compensates for wire capacitance and boosts the frequencies carrying the voice information. Loading coils cause distortion at the higher frequencies used to carry digital information and so are not used on these local loops.

Bridged Taps

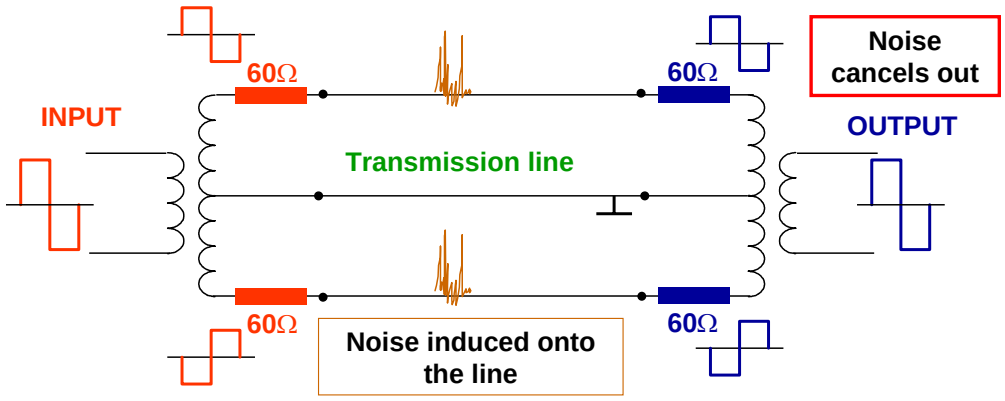
A bridged tap is an extraneous length of dangling, unterminated cable on a communications line, usually left over from an earlier POTS configuration, that can cause impedance mismatches and other undesired effects in transmissions.

Bridged taps are twisted pair junctions that tap off the main copper pair. When service from bridged lines is discontinued, the capacitance from these unterminated wires is still present on the circuit and can cause significant phase distortion. Bridged taps degrade digital circuit performance by causing extremely high signal loss and reflections at specific transmission frequencies. The frequencies affected depend on the length of the bridge tap and the distance from the transmitter. The frequencies affected also vary from bridge tap to bridge tap. All bridged taps not meeting technology-specific specifications must be removed from the cable pairs to guarantee error-free digital transmission.

Note that bridged taps do not affect span current or loop resistance measurements since these are DC measurements and bridged taps do not affect DC measurements.

In telephone communications, any cable pair spliced into the main pair. Many unused bridged taps remain from the early days when party lines were the norm and two or more taps were made on every line. The extra taps were later cut, taken off the termination block and buried into the wire maze, making them difficult to locate. Bridged taps cause undesirable reflection that can distort the high-frequency signals in modern transmission technologies.

Balanced line



xDSL Testing Principle