LAN Cables Characterization - Primary parameters RLCG

Introduction

Basic parameters Resistance R, Capacitance C, Inductance L and Conductance G are of prime interest when designing twisted pairs cable. They all depend on frequency, but actual standards only require values measured in certain given conditions.

The theory below has been taken out of a reference guide for transmissions in voice frequencies range.

1. Resistance R: measured in loop, Kelvin method and appropriate connecting frame to remove unwanted electromagnetic perturbations. R increase a lot with frequency because of the skin effect.

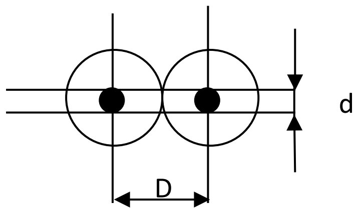
2. Mutual Capacitance C: highly depends on pair environment, but measured with high precision in AESA Wheatstone Bridge. C stays quite stable as frequency increases, because of great behaviour of new isolating compound PE low loss (tg delta<>0) and so on.

3. Inductance L or coefficient of self-induction. Not directly measured with AESA test systems. See below some theoretical considerations. Value decreasing with frequency in order to maintain flat impedance value.

4. Conductance G: very small value in [Siemens or Gigaohm]. Generally neglected or measured with special Insulation tester at 500V: min value > 5000 MOHm

L/R coefficient

Some customers of us asked for this coefficient to be available in regular low frequency reports. L depends highly on cable construction: quads or pairs, etc.. and only the cable designer is able to simulate the wanted inductance coefficient. Ignoring these geometrical parameters, we choose the method of calculating L knowing exactly the mutual capacitance.



d : diameter of the cores
D : distance between cores

Basic theory is giving us for a length unit l:

$$L = \frac{\mu_0}{\pi} \cdot \left(Ln \frac{D}{r} + \frac{1}{4} \right) \cdot l$$

and

$$C = \frac{\pi \cdot \varepsilon}{Ln \cdot b \cdot \frac{D}{r}}$$

Where:
ε is the average permittivity of the isolating compound.
(For example in the air: $\varepsilon = \varepsilon_o = 1/36\pi \times 10^{-9}$ F/m, knowing that in this case permeability $\mu_o = 4\pi\ 10^{-7}$ H/m)

k: relative permittivity of isolating compound $1 < k = \varepsilon/\varepsilon_0 < 5$ (typ 1.5 to 2.5)

b: geometrical coefficient depending on the cable construction:

- b = 0.94for pair design
- b = 0.64 for star quad desisgn
- b = 1.30 for random quad design
- b = ??? (number from cable design simulation)

Our RCKE Whetastone type accurate bridge allow us to calculate L, knowing C mutual:

from C we got

$$Ln\frac{D}{r} = \frac{k \cdot 10^{-6}}{36C} - \ln b$$

introduce in

$$L = 400 \cdot \left[\frac{k \cdot 10^{-6}}{36C} - \ln b + \frac{1}{4}\right][\mu H / Km]$$

This is of course not replacing a direct measurement on a dedicated LCR bridge like HP 4263B or reference Wayne Kerr manual bridge. Usually value of L should be smaller than 800 µH/Km.

Please note that this value L or L/R depends on length with a semi-quadratic law:

$$(Ls + \sqrt{Ls * Lr}) / (Lc + \sqrt{Lc * Lr})$$

Where Lc=cable length, Lr : reference length and Ls selected length (could be Ls=Lr)

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References

"*Transmission téléphonique, Théorie des lignes*" from Mr. R. Croze, L. Simon and J.-P. Caire, 4th Edition 1968

Fig 1 AESA Puma low frequency measuring system

