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SOURCE[1]: TNO

TITLE: G.fast: Parametric cable models for specifying reference loops

ABSTRACT

This contribution proposes parametric models for wideband modeling of cables, and proposes to include these models in G.fast for specifying reference models for segments of loops. It also proposes specific sets of parameter values to define reference models for four different cable types. The theory and validity of these parametric models has been described in great detail in a separate contribution and that contribution has shown that they are applicable to frequency domain studies up to hundreds of MHz as well as to time domain studies.

1. Introduction:

Recently, the new project G.fast has been initiated within ITU-T SG15. In order for this project to become a success, it is of importance to realistically characterize and model the channels between the last distribution point and the end-user premises equipment. Several previous contributions [1,4,5,6,7] are demonstrating the need or asking for reference models to enable realistic performance studies to G.fast. Those models are needed to define the cable segments within a reference topology or within a set of test loops.
The present contribution proposes parametric cable models for inclusion in G.fast, and proposes specific sets of parameter values to define the first reference models for use within G.fast studies.

2. Proposed parametric models

We proposes the following two parametric models for inclusion in G.fast to describe all kinds of cable sections within reference topologies and test loops that are currently under development. Details about theory and validation of these models can be found in contribution [3], based on the measurements contributed in [2]. These models do not only facilitate a good match in the frequency domain over a wide frequency interval, but also facilitate the prediction of realistic impulse responses.
The first parametric model is a relatively simple model offering a good compromise between simplicity and match with measurements, and the second parametric model is more advanced (with two extra parameters) to improve the match with measurements. These two parametric models are defined as follows:

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Simple model, with square root function, 6+1 parameters:

$[Z_s, Y_p]$ = Model_01 ($Z_{0\mu}$, η_{VF}, R_{s0}, q_L, q_H, f, f_d)

$$Z_s(jw) = jw \cdot L_{s\infty} + R_{s0} \times \left(1 - q_s + sqrt\left(q_s^2 + 2 \cdot \frac{jw}{w_s}\right)\right)$$

$$Y_p(jw) = jw \cdot C_{p0} \times \left(1 + \frac{jw}{w_d}\right)^{-2 \cdot f/p}$$

More advanced model, with square root of rational function, 8+1 parameters:

$[Z_s, Y_p]$ = Model_02 ($Z_{0\mu}$, η_{VF}, R_{s0}, q_L, q_H, q_x, q_y, f, f_d)

$$Z_s(jw) = jw \cdot L_{s\infty} + R_{s0} \times \left(1 - q_s \cdot q_x + sqrt\left(q_s^2 \cdot q_x^2 + 2 \cdot \frac{jw}{w_s} \cdot \left(\frac{q_s^2 + jw/w_s \cdot q_y}{q_s^2/q_x + jw/w_s \cdot q_y}\right)\right)\right)$$

$$Y_p(jw) = jw \cdot C_{p0} \times \left(1 + \frac{jw}{w_d}\right)^{-2 \cdot f/p}$$

Where:

$$L_{s\infty} = \frac{1}{h_{VF} \cdot c_0} \times Z_{0\infty}$$

$$C_{p0} = \frac{1}{h_{VF} \cdot c_0} \times \frac{1}{Z_{0\infty}}$$

$$q_s = \frac{1}{q_H^2 \cdot q_L}$$

$$w_s = q_H^2 \cdot w_{s0} = q_H^2 \cdot \left(\frac{4p \cdot R_{s0}}{m_0}\right)$$

$$w_d = 2p \cdot f_d$$

$c_0 = 3 \cdot 10^8$ [m/s]

$m_0 = 4\pi \cdot 10^{-7}$ [H/m].

We do not exclude the addition of other parametric models in future, but if such models are being proposed then the should at least have the following properties.

- They should never predict non-real impulse responses (which is a fundamental short coming of the current reference models TP100 and TP150 being described for test loops for VDSL2).
- The validation of additional models should be demonstrated via a good match between wideband cable measurements and what the model predicts.

3. Proposed parameter values for reference models

We proposes to include the following sets of parameter values in G.fast in order to define different two-port reference models representing various cable types in combination with the above mentioned parametric cable models.

	Cable type	Parametric model	Parameters of reference model
1	CAT5 cable for Ethernet networks	Model_02	`Z0_inf=98.000000; VF=0.690464; Rs0=165.900000e-3; qL=2.150000; qH=0.859450; qX=0.500000; qY=0.722636; Phi=0.973846e-3; Fd=1.000000;`
2	30-quad telephony cable of medium quality	Model_02	`Z0_inf=132.348256; VF=0.675449; Rs0=170.500000e-3; qL=1.789725; qH=0.725776; qX=0.799306; qY=1.030832; Phi=0.005222e-3; Fd=1.000000`
3	Low quality cable, typically used for in-house telephony wiring	Model_02	`Z0_inf=98.369783; VF=0.681182; Rs0=170.800000e-3; qL=1.700000; qH=0.650000; qX=0.777307; qY=1.500000; Phi=3.023930e-3; Fd=1.000000`
4	Access cable from KPN, used in the Netherlands in the last copper drop (underground as well as in buildings)	Model_02	`Z0_inf=125.636455; VF=0.729623; Rs0=180.000000e-3; qL=1.666050; qH=0.740000; qX=0.848761; qY=1.207166; Phi=1.762056e-3; Fd=1.000000`

We do not exclude the addition of more parameter sets in future to define other cable types as well.

4. Summary

This paper should be presented under the G.fast agenda item, and addresses issue 5.1 and is related to issues 4.7.2.1.x.

The paper proposes parametric models for defining reference models of cable types, as well as parameter values for reference models, all for inclusion into G.fast

It is proposed to add the following new issues to the G.fast issues list and agree to them.

5.1.a	open	Should the parametric models proposed in section 2 of 11GS3-029 be included in G.fast for defining two-port reference models of loop sections for (a) performance studies for G.fast and (b) future testloop specifications for G.fast.	11GS3-029 (11GS3-028)
5.1.b	open	Should the parameter values proposed in section 3 of 11GS3-029 be included in G.fast to define two-port reference models of loop sections for (a) performance studies for G.fast and (b) future testloop specifications for G.fast.	11GS3-029 (11GS3-028)
5.1.c	open	Should additional parametric two-port models of cables sections for inclusion in G.fast be required to predict real impulse responses.	11GS3-029 (11GS3-028)
5.1.d	open	Should the validation of additional sets of parametric values for two-port models of cables sections for inclusion in G.fast be required to be demonstrated via measurements.	11GS3-029 (11GS3-028)

5. References

[1] TNO (Rob van den Brink, Bas van den Heuvel), *"G.fast: The need for wideband reference models of loop segments within twisted pair cable topologies"*, ITU contribution 11BM-020, April 18, 2011.

[2] TNO (Rob van den Brink, Bas van den Heuvel), *"G.fast: Wideband transfer and crosstalk measurements on twisted pair cables"*, ITU contribution 11BM-021, April 18, 2011.

[3] TNO (Rob van den Brink, Bas van den Heuvel), "*G.fast: Wideband modeling of twisted pair cables as two-ports*" , ITU contribution 11GS3-028, Geneva Sept 2011.

[4] Assia (Ken Kerpez), "*G.fast: Fast Maximum Number of Bits/Hz*", ITU contribution 11BM-028, Bedford, June 2011.

[5] Alcatel-Lucent (Danny Van Bruyssel), "*G.fast: Observations On Channel Characteristics Measurements*", ITU contribution 11BM-048, Bedford, June 2011.

[6] CopperGate (Erez Ben-Tovim), "*G.fast: G.hn performance preliminary predictions*", ITU contribution 11BM-071, Bedford, June 2011.

[7] Ikanos (Massimo Sorbara), "*G.fast: Proposal to define reference loop topologies for G.fas*t" , ITU contribution 11BM-077, Bedford, June 2011.