ISSN 2310-6697

otoiser—open transactions on independent scientific-engineering research

FUNKTECHNIKPLUS # JOURNAL

Théorie—Expérimentation—Métrologie—Logiciel—Applications

ISSUE 10 - TUESDAY 31 MAY 2016 - YEAR 3
REPRINT

N.I. Yannopoulou, P.E. Zimourtopoulos



About

This small European Journal is In the Defense of Honesty in Science and Ethics in Engineering

Publisher — otoiser—open transactions on independent scientific engineering research, www.otoiser.org — info@otoiser.org : Hauptstraße 52, 2831 Scheiblingkirchen, Austria

Language — We emphasize the origins of the Journal by using English, German and French, as well as, a Hellenic vignette in the cover page. However, since we recognize the dominance of US English in the technical literature, we adopted it as the Journal's language, although it is not our native language.

Focus — We consider Radio—FUNK, which still creates a vivid impression of the untouchable, and its Technology—TECHNIK, from an Advanced—PLUS point of view, Plus—PLUS Telecommunications Engineering, Electrical Engineering and Computer Science, that is, we dynamically focus at any related scientific-engineering research regarding Théorie, Expérimentation, Métrologie, Logiciel, ou Applications.

Scope — We emphasize this scope broadness by extending the title of the Journal with a Doppelkreuz-Zeichen # which we use as a placeholder for substitution of our Editorial Team disciplines: # Telecommunications etc. as above, or # High Voltage, # Software Engineering, # Simulation etc. as below.

Frequency — We publish 3 issues per year: on 31st of January, on 31st of May, and on 30th of September, as well as, an extra issue every 3 papers and a volume every 2 years.

Editions — We increase the edition number of an issue only when is needed to reform one or more of its papers—thus to increase their version numbers—but we keep unchanged its 1st edition date shown on its front page and we number its pages sequentially from 1. We count the editions of *About* separately.

Format — We use a fixed-space font, hyphenation, justification, unfixed word spacing, and the uncommon for Journals **A5** (half A4) page size to achieve WYSIWYG printing and clear reading of 2 to 4 side-by-side pages on wide-screen displays.

Printing-on-Demand — We can email gratis PDF files at 300-4000 dpi in booklet page scaling of brochure and book type.

Copyright — We publish under a Creative Commons Attribution, CC-BY 3.0 Unported or CC-BY 4.0 International, License only.

Please download the latest *About* edition from http://about.ftpj.otoiser.org

Editorial Team

Electrical Engineering

Professor Michael Danikas, mdanikas@ee.duth.gr EECE, Democritus University of Thrace, Greece # High Voltage Engineering # Insulating Materials

Assistant Professor Athanasios Karlis, akarlis@ee.duth.gr EECE, Democritus University of Thrace, Greece

Electrical Machines # Renewable Energies # Electric Vehicles

Computer Science

Professor Vasilis Katos, vkatos@bournemouth.ac.uk
Head of Computer and Informatics Dept, Bournemouth Univ, UK
Computer Engineering # Software Engineering # Cyber Security
Lecturer Sotirios Kontogiannis, skontog@gmail.com
Business Administration Dept, TEI, Western Macedonia, Greece

Internet Engineering # Learning Management Systems
Dr. Apostolos Syropoulos, asyropoulos@yahoo.com
BSc-Physics, MSc-Computer Science, PhD-Computer Science
Independent Researcher, Xanthi, Greece

Hypercomputation # Fuzzy Computation # Digital Typography

Telecommunications Engineering

Dr. Nikolaos Berketis, nberketis@gmail.com BSc-Mathematics, MSc-Applied Maths, PhD-Applied Mathematics Independent Researcher, Athens, Greece

Applied EM Electromagnetics # Applied Mathematics
Dr. Nikolitsa Yannopoulou, yin@arg.op4.eu [*]

Diploma Eng-EE, MEng-Telecom-EECE, PhD-Eng-Antennas-EECE Independent Researcher, Scheiblingkirchen, Austria

Dr. Petros Zimourtopoulos, pez@arg.op4.eu [*] BSc-Physics, MSc-Radio-Electronics, PhD-Antennas-EE Independent Researcher, Scheiblingkirchen, Austria

Antennas # Metrology # EM Software # Simulation # Virtual Labs

Applied EM # Education # FLOSS # Amateur Radio # Electronics

* Copy and Layout Editing, Proof Reading, Issue and Website Management, Paper and About Reprints, Volumes and Web Pages

Technical Support

Konstantinos Kondylis, kkondylis@gmail.com Diploma Eng-EECE, MEng-Telecom-EECE, Doha, Qatar Christos Koutsos, ckoutsos@gmail.com Diploma Eng-EECE, MEng-Telecom-EECE,Bratislava,SK

Information for Authors

This is a small, but independent, low profile Journal, in which we are all—Authors, Reviewers, Readers, and Editors—free at last to be Peers in Knowledge, without suffering from Journal roles or positions, Professional—Amateur—Academic statuses, or established "impact factorizations", under the following guiding principles:

Authors — We know what Work means, we respect the Work of the Independent Researcher in Science and Engineering and we want to exhibit his Work. Thus, we decided to found this Free and Open Access Journal in which to publish this Work. Furthermore, as we care indeed for the Work of the technical author—especially a young or a beginner one—we strongly support the publication of his Work, as follows:

- 1 We do not demand from the author to transfer his own copyright to us. Instead, we only consider papers resulting from original research work only, and only if the author can assure us that he owns the copyright of his own paper as well as that he submits to the Journal either an original copy or a revised version of his own paper, for possible publication after review—or even for immediate republication, if this paper has already been published after review—but, in any case under a Creative Commons Attribution, CC-BY 3 Unported or CC-BY 4 International, License, only.
- 2 We encourage the author to submit his own paper written just in Basic English plus Technical Terminology.
- 3 We encourage the author even to select a pen name, which may drop it at any time to reveal his identity.
- 4 We encourage the author to submit an accepted for publication paper, which he was forced to decline that publication because it would be based on a review with unacceptable evaluation or derogatory comments.
- 5 We encourage the author to submit any paper that was rejected after a poor, impotent, inadequate, unreasonable, irresponsible, incompetent, or "just ticking" review.
- 6 We encourage the author to submit an unreviewed paper of his own that he uploaded on some Open Access repository.
- 7 We encourage the author to upload his published paper in our Journal to at least one Truly Free Open Repository, e.g. such as http://viXra.org and https://archive.org.

FUNKTECHNIKPLUS # JOURNAL

- 8 We provide the author with the ability to update, at any time, the reference links of his paper.
- 9 We provide the author with a decent, express, peer review process, of up to just 4 weeks, by at least 2, either anonymous or onymous, reviewers.
- 10 We provide the author with the option to choose from 2 review processes: the traditional, anonymous, close one, as well as, a contemporary, onymous, open review in our private mailing list for Peer Discussion.
- 11 Under the Clause 1: We immediately accept for publication a research paper directly resulting from a Project Report, or a Diploma-, Master-, or PhD-thesis, which already the author has successfully defended before a committee of experts, as long as he can mention 2 members of this committee who approved his Work.
- 12 Under the Clause 1 : We immediately accept for publication any paper which is not Openly Accessible on the Internet.
- 13 We immediately publish online a paper, as soon as it is accepted for publication in the Journal.
- 14 We quickly publish an extra issue—that is in excess of the 3 issues we publish a year—as soon as the review process of 3 papers is completed.

Reviewers — Every peer may voluntarily become a reviewer of the Journal in his skillfulness for as long as he wishes. In addition, each author of the Journal must review one paper in his expertness for each one of his published papers.

 ${\bf Readers}-{\bf Every}$ reader is a potential post-reviewer: we welcome comments and post-reviews in our private mailing list for Peer Discussion.

Editors — Every editor owns a PhD degree—to objectively prove that he really has the working experience of passing through the dominant publishing system. An editor pre-reviews a paper in order to check its compliance to our guiding principles and to select the appropriate reviewers of it. We can accept for consideration papers only in the expertise areas currently shown in the Editorial Team page, above. However, since we are very willing to amplify and extend the Scope of the Journal, we welcome the volunteer expert, in any related subject, who wants to join the Editorial Team as long as he unreservedly accepts our guiding principles.

Electronic Publishing

We regularly use the Free Libre Open Source Software Libre Office with the Free Liberation Mono font and the Freewares PDFCreator and PDF-Xchange Viewer. We also use, with some basic html code of ours: the Free Open Source Software Open Journal System OJS by the Public Knowledge Project PKP installed in our website, and the Free Open Digital Library of Internet Archive website, where we upload the FTP#J Collection of Issues, Paper reprints, About documents, and Volumes, in both portrait and landscape orientations, for download or very clear online reading with the Free Open Source BookReader.

<u>Submissions</u>

We can only consider papers written in the preferable and recommended odt format of LibreOffice, or even a paper in the MS Office with MathType doc format, if it would be proved that it is fully compatible with LibreOffice indeed.

Legal Notice — It is taken for granted that the submitter—correspondent author accepts, without any reservation, the totality of our publication conditions as they are analytically detailed here, in this About, as well as, that he also carries, in the case of a paper by multiple authors, the independent will of each one of his co-authors to unreservedly accept all the aforementioned conditions for their paper.

<u>Internet Addresses</u>

Submissions : sub@ftpj.otoiser.org
Send Updates : updates@ftpj.otoiser.org

Printing-on-Demand : pod@ftpj.otoiser.org

Technical Support TS: technical-support@ftpj.otoiser.org **Principal Contact**: principal-contact@ftpj.otoiser.org

Peer Discussion List : www.peers.ftpj.otoiser.org
Editorial Team & TS List : www.etts.ftpj.otoiser.org

The FTP#J Collection at Internet Archive Digital Library: https://archive.org/details/@funktechnikplusjournal

Sample Paper Templates : www.template.ftpj.otoiser.org
Reference Link Updates : www.updates.ftpj.otoiser.org

Internet Publishing : www.ftpj.otoiser.org

This document is licensed under a Creative Commons Attribution 4.0 International License — https://creativecommons.org/licenses/by/4.0

[tlnomiva]: Transmission Line Nominal Values without Tolerance - from Cable Specifications and Technical Data Sheets: FLOSS for MS Windows

N.I. Yannopoulou, P.E. Zimourtopoulos *

Antennas Research Group, Austria

Abstract

[[tlnomiva] is a visual software application developed by the authors for a transmission line characterization from the user's point of view. The numerical computations are based on the precise formulation within the distributed circuit coefficients model of a transmission line, which was theoretically developed by the authors and published in a previous paper. The use of [tlnomiva] is fully demonstrated by an example for the popular RG 214 coaxial cable. This application is Free Libre Open Source Software and provides an option for more detailed figures by calling the executable of the freely distributed source [wgnuplot].

Keywords

transmission line, nominal value, propagation characteristics, circuit coefficients, floss

Introduction

A lot has been published for transmission lines in general, as well as, specifically for their use at high frequencies. The software application [tlnomiva], that is under development and illustrated here, is an intermediate step in the authors' recent effort to clarify a number of obscure or confusing points on this subject. It is intended to reveal the limits in the coexistence of precise

formulas of transmission line theory with the available nominal values, usually without tolerance, which are given as cable specifications by established authorities or as data sheets from manufacturers.

The main formulas of [tl-nomiva] were presented in [1], while the basic theory is cited in [2], thus only a small part of them is repeated here and just for the sake of completeness. The

cut-off frequency has not been taken into account. The data for the presented examples are publicly available through internet.

[tlnomiva] is provided both as Free Libre Open Source Software and ready to install and use executable. It is developed in MS Visual Basic 6 in MS Windows XP 32 and in order to support a more sophisticated way of plotting data and functions it optionally uses the [wgnuplot] software, version 5.0 patchlevel 3 [3]. It is tested for compatibility with various MS Windows operating systems, up to W10-64.

To the best of the authors' knowledge, there is no available FLOSS for transmission lines, especially with a precise formulation one.

[tlnomiva]

Fig. 1 shows the main window of [tlnomiva] with the window of [About] open, while Fig. 2 contains all the menu items along with their submenu options numbered from 1 to 6. The application features can be divided according to their functionality in three groups:

(1) R, L, G, C intervals computation from the nominal values of: the attenuation factor α or accurately A in [dB/100m], the velocity fac-

tor vf and the characteristic impedance Z_0 and plotting with respect to frequency f [MHz], using working formulas from [1], [2],

- (2) a new estimation of A, vf and Z_{θ} using the numerical results from the previous window for the R, L, G, C, intervals either directly or reading them from a previously saved file and plotting them and
- (3) α , β , R_0 , X_0 computation as functions of frequency considering R, L, G, C constant in a range of frequency and plotting them.

In these three groups the plot of all the involved quantities with respect to frequency is possible. Except of R, L, G, C distributed circuit coefficients and α , β , R_{θ} , X_{Ω} propagation characteristics there are included: the A attenuation factor, the vf velocity factor, the E, and H terms, the $m\alpha\beta$ angles as the upper and lower limit of the \dot{Z}_{o} phase angle and finally the ωL , ωC and f/vf. The used units are remain to all forms the same: R $[m\Omega/m]$, L [nH/m], G $[\mu S/m]$, C [pF/m], f [MHz], α [Np/m], A [dB/100m], β [rad /m], R_{θ} , X_{θ} , Z_{θ} [Ω], $m\alpha\beta$ [deg], $\omega L [m\Omega/m], \omega C [\mu S/m], f/vf$ [MHz]. The [feet] option is disabled.

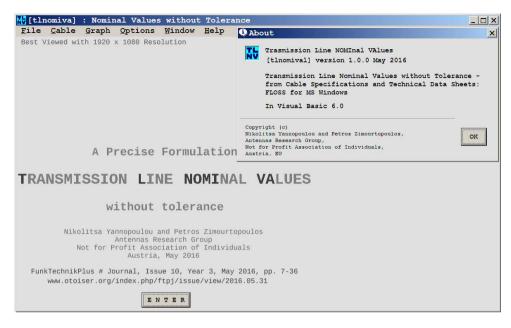


Fig. 1: [tlnomiva] : The main window

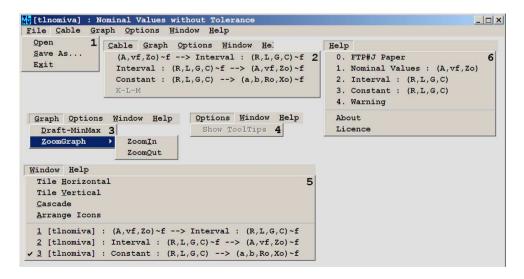


Fig. 2: Main window: The unfolded menu items

Working Formulas

The basic expressions between the nominal values of A, vf and Z_0 and the R, L, G, C distributed circuit coefficients of a line are given in [1] and repeated here as:

$$R = \alpha R_0 - \beta X_0 \tag{1}$$

$$L = (\alpha X_0 + \beta R_0)/\omega$$
 (2)

$$G = (\alpha R_{\theta} + \beta X_{\theta})/Z_{\theta}^{2}$$
 (3)

$$C = (-\alpha X_{\Theta} + \beta R_{\Theta})/(\omega Z_{\Theta}^{2})$$
 (4)

It is obvious that if the nominal value of Z_0 is substituted with R_0 , then X_0 will be zero and the above expressions will be actually independent of frequency, a case that will be examined last. Thus, we have to consider Z_0 , as it is usually given in data sheets of cables, as the amplitude of \dot{Z}_0 . Then by using the standard relation

$$Z_{\theta}^{2} = R_{\theta}^{2} + X_{\theta}^{2} \tag{5}$$

where

$$R_{\theta} = Z_{\theta} \cos(z_{\theta}) \tag{6}$$

$$X_{\theta} = \pm Z_{\theta} |\sin(z_{\theta})| \tag{7}$$

the above (1)-(4) become functions of the z_0 phase angle.

Since:

i. the interval of z_0 is the open interval $(\pi/4, \pi/4)$,

ii. the four quantities R, L, G, C do not have an extreme inside this interval. This results from the fact that the phase angle of \dot{Z}_0 , which is the angle (z-y)/2, and of $\dot{\gamma}$, which is the angle (z+y)/2 [1], can not be equal inside this interval but only for the case of y=0 which is impossible since $y\neq 0$ always,

we have to look for the two extreme values only at the ends of the open interval. Furthermore, since the four functions (1)-(4) are continuous with respect to z_0 in the above closed interval, the mentioned extremes will be the values of the continuous extension of these functions at the closed interval, at its ends. Three separated cases are distinguished:

$$\alpha < \beta : -\alpha/\beta < X_0/R_0 < \alpha/\beta \tag{8}$$

$$\beta < \alpha : -\beta/\alpha < X_{\theta}/R_{\theta} < \beta/\alpha$$
 (9)

$$\alpha = \beta : -1 < X_0/R_0 < 1$$
 (10)

Tab. 1 contains the two extreme values for the four coefficients and for the H term if we consider that

$$H = \omega L G - \omega C R . \qquad (11)$$

Tab. 1: RLGC and H Open Intervals

	α < β	α > β	α = β			
R	$(0, \frac{2\alpha\beta}{\gamma}Z_0)$	$\left(\frac{\alpha^2-\beta^2}{\gamma}Z_{\theta}, \gamma Z_{\theta}\right)$	(Θ, γZ _Θ)			
L	$(\frac{\beta^2 - \alpha^2}{\omega \gamma} Z_{\theta}, \frac{1}{\omega} \gamma Z_{\theta})$	$(0, \frac{2\alpha\beta}{\omega\gamma}Z_0)$	$(0, \frac{1}{\omega} \gamma Z_{\theta})$			
G	$(0, \frac{2\alpha\beta}{\gamma Z_0})$	$(\frac{\alpha^2-\beta^2}{\gamma Z_0}, \frac{\gamma}{Z_0})$	(0, Y /Z ₀)			
С	$(\frac{\beta^2 - \alpha^2}{\omega \gamma Z_{\theta}}, \frac{\gamma}{\omega Z_{\theta}})$	$(0, \frac{2\alpha\beta}{\omega\gamma Z_0})$	$(\Theta, \frac{Y}{\omega Z_{\Theta}})$			
Н	(-2αβ , +2αβ)	(-2αβ , +2αβ)	$(-\gamma^2, +\gamma^2)$			

The reverse relations of The reverse relations of α , β , R_0 and X_0 from the RL $Z_0 = \sqrt{\frac{Z}{Y}} = \sqrt{\frac{R^2 + X_L^2}{G^2 + X^2}}$ GC values are also presented in [1] and repeated here as

$$\alpha = \frac{\sqrt{ZY + RG - X_L X_C}}{\sqrt{2}}$$
 (12)

$$\beta = \frac{\sqrt{ZY - RG + X_L X_C}}{\sqrt{2}}$$
 (13)

$$R_{\theta} = \frac{\sqrt{ZY + RG + X_L X_C}}{\sqrt{2} Y}$$
 (14)

$$X_{\theta} = \operatorname{sgn}(LG - RC) \frac{\sqrt{ZY - RG - X_{L}X_{C}}}{\sqrt{2}Y} (15)$$

where $X_L = \omega L$ and $X_C = \omega C$, or directly for Z_0 from its definition as

$$Z_{\theta} = \sqrt{\frac{Z}{Y}} = \sqrt{\frac{R^2 + X_L^2}{G^2 + X_C^2}}$$
 (16)

RLGC Intervals from A, vf, Z_e Nominal Values

The most usual case of available cable data concerns the attenuation factor per some length of cable, i.e. 100 [m] or 1000 [ft], denoted here as A, the velocity factor vf as a number between 0 and 1, and the characteristic impedance \dot{Z}_{Θ} [Ω], or more accurately its amplitude Z_0 , of the cable. Fig. 3 shows the first window of [tlnomiva] where it is possible from these data to calculate an interval for R_0 , X_0 , and R,

L, G, C coefficients in a [Single] frequency. The user must first type the frequency in [MHz] and then the three data A, vf, Z_0 . The application will evaluate all the other quantities through (1)-(11), and display them at the corresponding text boxes using the indicated units. The letter m stands for the minimum and the letter M for maximum for all the quantities.

The $m\alpha\beta$ [°] is significant since it results the boundary angle inside which \dot{Z}_{a} will be. This angle is defined by both $-m\alpha\beta$ and $+m\alpha\beta$ and depends on the relation between α and β as it is described in (8)-(10) above. Fig. 4 shows the three cases with the grayed horizontal and vertical thick lines to represent the values range of R_0 , X_0 .

When the option [Multiple] is selected a grid opens where the values for each frequency will be written and two more buttons appear at the right part of the window: [Add Values to Grid] and [Estimation]. The user must give the first and last frequency. Then type each frequency at the text box above and the corresponding A, vf, Z_0 as in [Single] option. By pressing the [Add Values to Grid] button all the calculated values are transferred to a grid line, as it is shown in Fig. 5. In any time it is possible to select from the [File] menu the [Save As] item and save these data to a text file for later use.

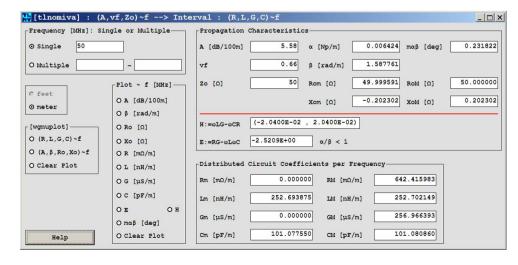


Fig. 3: $[(A, vf, Z_n) \sim f \longrightarrow Interval : (R, L, G, C)] \longrightarrow [Single]$

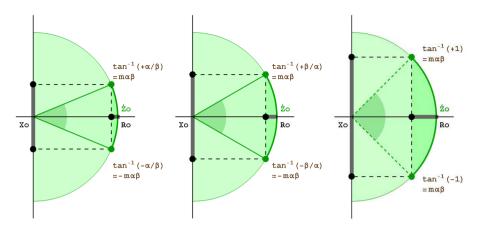


Fig. 4: $\pm m\alpha\beta$ angle: Intervals for $R_{_{\theta}}$, $X_{_{\theta}}$

The [Multiple] option enables simultaneously all the buttons in frames [Plot ~ f [Mhz]] and [wgnuplot], but if there is no data available a message will appear to the screen to guide the user. It is possible to enter as many frequency data as it is desired but not for frequencies below or above the first and last frequency respectively.

The user may either plot all the quantities versus f [MHz], directly in the application, as for example is illustrated in Fig. 6 where A [dB/100m] is selected or to use [wgnuplot] and take one of the two possible quadruples as shown in Figs. 7 and 8. Only the points are plotted in wonuplot application while inside [tlnomiva] it is possible to plot either points with lines, the default state, or only points

if the user uncheck the box [Show Lines] at the right of the picture. The lines used here between points are only straight segments of lines.

The chart inside nomival is movable with the left mouse button. Two verv useful features have been added under the [Graph] menu: [Draft-MinMax] and ΓZoom-Graph] with two items [Zoom In] and [ZoomOut] as it is shown in Fig. 2 (3). The first produces a plot exactly with min and max values for both vertical and horizontal axis, and with the second a much bigger chart appears for the plot, centered at the screen. The access to both features is also possible through their shortcut kevs Alt+G+D and Alt+G+ Z+T or Alt+G+Z+O and in addition through the (+) and (-) from the keyboard's numerical pad.

Fig. 9 shows an example for the L coefficient, where it is obvious that the points of different color and shape for its interval ends reveals the existing too small difference between them.

The user may not enter one by one the frequencies and the corresponding nominal values of A, vf and Z_0 but just to read them from an already existing text file using the [File][Open] menu item. An example of such a file is given in Fig. 10, where the first line is a text line. The second contains the number of frequencies (10 in this example) and the common characteristics of the cable

as 0.66 for vf, 50. for $Z_{\rm 0}$, separated by spaces. Then a list of f in MHz and A in dB/100m couples follows. The grid will be filled in automatically after reading the file. The width of the grid columns is adjustable to ensure the visibility of all the produced values.

Another way is to open an already existing file with previously saved data from this application, as in Fig. 11. Then, again the grid contains the read values while all the text boxes for all the quantities are remain blank except the vf, Z_0 , and the first and last frequency as it shown in Fig. 6.

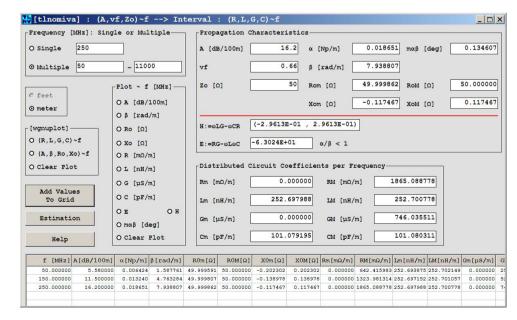


Fig. 5: $[(A, vf, Z_0) \sim f \longrightarrow Interval : (R, L, G, C) \sim f] \longrightarrow [Multiple]$

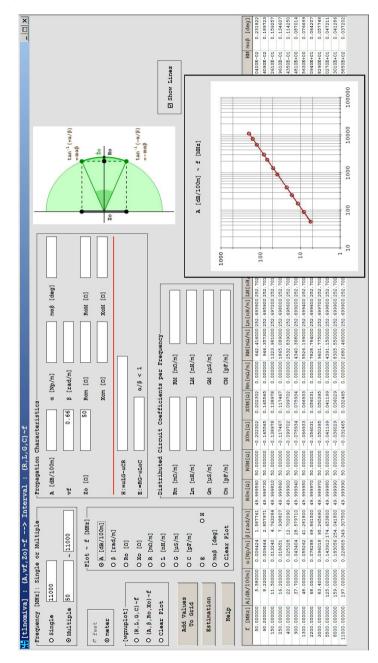


Fig. 6: $[(A, vf, Z_0) \sim f \longrightarrow Interval : (R, L, G, C) \sim f] \longrightarrow Plot$

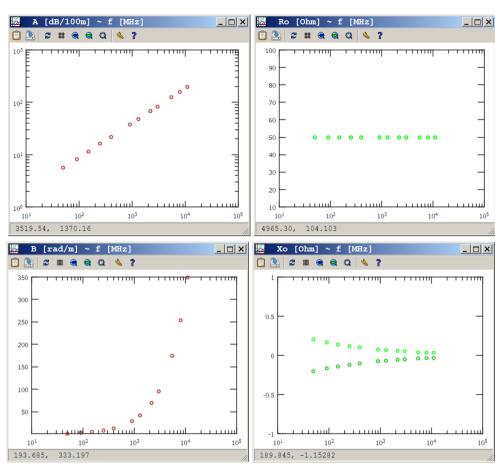


Fig. 7: A, β , R_{θ} , X_{θ} versus frequency from [wgnuplot]

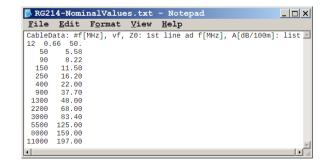


Fig. 10: Nominal data values in a text file

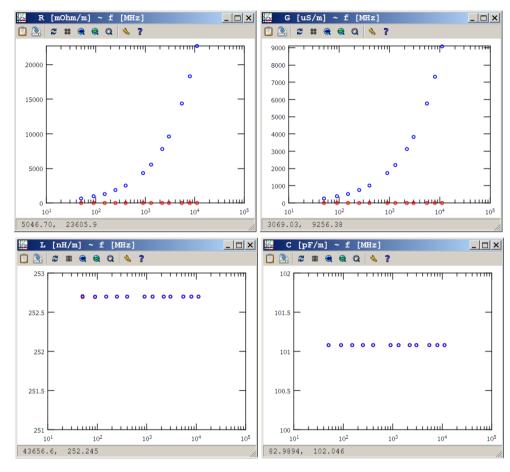


Fig. 8: R, L, G, C, coefficients versus frequency from [wgnuplot]

RG214-RLGC-Intervals.txt - Notepad														_ □ >			
<u>F</u> ile	Edit	Format	View He	lp													
12		20	0.66	50													-
50	5.58	0.006424	1.587761	49.99959	50	-0.202302	0.202302	0	642.416	252.6939	252.7021	θ	256.9664	101.0776	101.0809 -2.5209 -0.02046	0.02040	0.231822
90	8.22	0.009464	2.857971	49.99973	50	-0.165565	0.165565	0	946.357	252.6959	252.7015	θ	378.5429	101.0784	101.0806 -8.1679 -0.05409	0.05409	0.189723
150	11.50	0.013240	4.763284	49.99981	50	-0.138978	0.138978	0	1323.981	252.6972	252.7010	θ	529.5925	101.0789	101.0804 -22.689 -0.12616	0.12610	0.159257
250	16.20	0.018651	7.938807	49.99986	50	-0.117467	0.117467	0	1865.089	252.6980	252.7008	θ	746.0355	101.0792	101.0803 -63.024 -0.29616	0.29610	0.134607
400	22.00	0.025328	12.70209	49.99990	50	-0.099702	0.099702	0	2532.839	252.6986	252.7006	Θ	1013.135	101.0794	101.0802 -161.34 -0.64356	0.64350	0.114250
900	37.70	0.043404	28.57971	49.99994	50	-0.075934	0.075934	0	4340.368	252.6992	252.7004	θ	1736.147	101.0797	101.0801 -816.80 -2.48108	2.48100	0.087014
1300	48.00	0.055262	41.28180	49.99995	50	-0.066933	0.066933	0	5526.199	252.6994	252.7003	Θ	2210.480	101.0798	101.0801 -1704.2 -4.56306	4.56300	0.076699
2200	68.00	0.078288	69.86150	49.99997	50	-0.056031	0.056031	0	7828.784	252.6996	252.7002	θ	3131.514	101.0798	101.0801 -4880.6 -10.9406	10.9400	0.064207
3000	83.40	0.096018	95.26569	49.99997	50	-0.050395	0.050395	0	9601.775	252.6997	252.7002	Θ	3840.710	101.0799	101.0801 -9075.5 -18.2908	18.2980	0.057748
5500	125.00	0.143912	174.6538	49.99998	50	-0.041199	0.041199	0	14391.15	252.6998	252.7002	θ	5756.461	101.0799	101.0801 -30504 -50.2706	50.2700	0.047211
8000	159.00	0.183056	254.0418	49.99999	50	-0.036029	0.036029	0	18305.55	252.6999	252.7001	Θ	7322.219	101.0800	101.0801 -64537 -93.0106	93.0100	0.041286
11000	197.00	0.226805	349.3075	49.99999	50	-0.032465	0.032465	0	22680.46	252.6999	252.7001	θ	9072.184	101.0800	101.0801 -122020 -158.506	158.500	0.037202
																	- N

Fig. 11: Previously saved Data in a text file

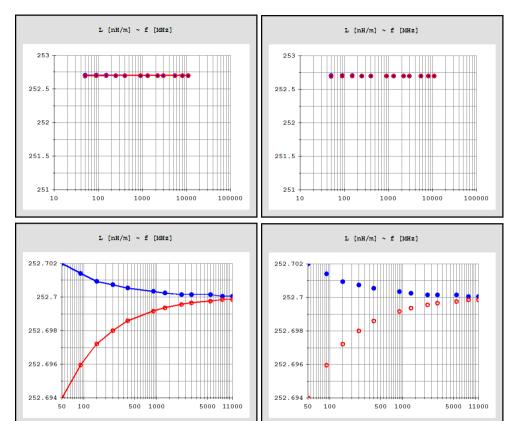


Fig. 9: L with-without lines and [Draft-MinMax]

The first line of this file contains four (4) numbers: two (2) integers, the number of lines and columns, and two (2) reals, vf and Z_{θ} . The following lines are exactly the same as the grid lines of the window.

Fig. 12 shows $R_{\rm 0}$, $X_{\rm 0}$, maß and H with the [Draft-MinMax] enabled. The difference of $R_{\rm 0}$ from 50 [Ω] is small enough and the values of maß permit

a small imaginary part X_0 , since they are less than a quarter of 1° in both sides of the horizontal line of real Z_0 . It is also evident that for lower frequencies the H intervals are, initially, closer to zero (0) which means closer to the Heaviside condition while more data are needed to characterize the line as capacitive or inductive.

This window generates eight (8) files in the directory of

[tlnomiva] which are used from
the [wgnuplot.exe], with specific filenames of obvious
meaning:

R-points L-points G-points C-points A-points B-points Ro-points Xo-points

Finally, the [Clear Plot] button in the [wgnuplot] frame just closes all occurrences

of the wgnuplot application [4] while the same button in the [Plot \sim f [MHz]] frame clears the displayed plot, leaving the chart empty. A short help is available by pressing the [Help] button. The [Estimation] button opens the next window of [tlnomiva] that uses the intervals of RL GC circuit coefficients for a new estimation of A, vf, Z_0 .

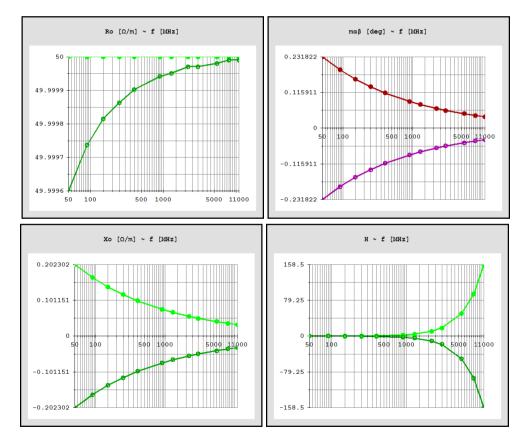


Fig. 12: R_0 , X_0 , $m\alpha\beta$ and H with [Draft-MinMax]

A, vf, Z_{θ} estimation from RLGC Intervals

Relations (12)-(16) are actually result directly from the definition of \dot{z}_{a} and \dot{y} . The problem is that R, L, G and C are not easily determined. They are closely related to the geometrical characteristics of the line and as distributed quantities not measured directly. Here, an attempt is presented to determine some values for A, vf, Z_{α} and thereafter for α , β , H, E, m $\alpha\beta$ using the RLGC intervals from the previous widow of [tlnomiva]. Additionally, the ωL , ωC and f/vfare also given.

In particular three values are evaluated: the one that corresponds to the lower end of the RLGC intervals, the mean value and the one from the upper end of the intervals. The nominal values are given, respectively, where they are available. The main purpose of this effort is to estimate A, vf, and Z_0 and to achieve a closer approach of RLGC by means of the known nominal values.

Fig 13 shows the second window of [tlnomiva], when it is opened from the [Cable] [Interval : $(R,L,G,C)\sim f-->(A,v,f,Z_0)\sim f$] menu. The table contains the values at the frequency selected from the drop down list box, 400 [MHz]

here. Initially, the table has no values and the message of Fig. 14 is at the top of the window. After pressing the [Load Data] the well known in windows users [Open] dialog box appears to select a file to read. The first line in Fig. 13 shows the path of this data file. If the window is accessed through the [Estimation] button of the previous window $[(A, vf, Z_0) \sim f --> Interval : (R,$ L,G,C)~f] then there is no message at the top and the table is filled automatically with the values corresponding to the first frequency.

The first four (4) lines of the table shows the values of RLGC as described above. The next eight (8) lines in the red frame contain the new estimated values. Their corresponding nominal values are shown at the right. To plot one of these quantities versus frequency, its option button under the label [Plot] must be selected. The colored little squares beside its data column (Red for minimum, Green for mean value, Blue for maximum) and the Black larger square above the nominal values correspond to the used color for the plot and they are buttons. Their default state is on. Pressing one of them or all, changes the state to off and the corresponding data are removed

from the plot for each line.

Fig. 15 shows the full window with the plot of A [db/100m] in the chart. The light blue open circles in the plot indicate the current frequency which is selected from the drop down list box,

1300 [MHz] in this example. Since all the colored buttons are on, all the values are plotted. The menu item [Draft -MinMaxl is active for a closer view of the plot as described in the previous section and it is selected here.

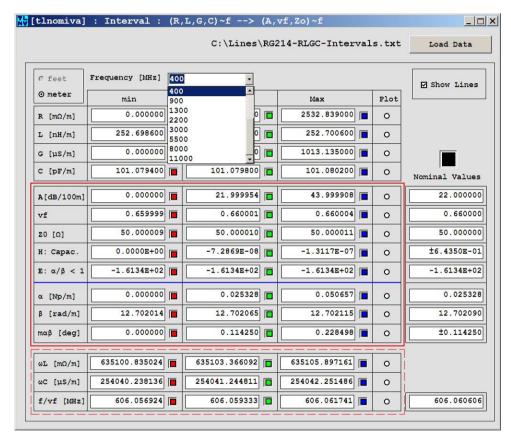


Fig. 13: [Interval : $(R,L,G,C,)\sim f \longrightarrow (A,vf,Z_0)\sim f$] - Table

Read File as saved from [Cable] $[(A, vf, Zo) \sim f \longrightarrow Interval : (R, L, G, C) \sim f] :$ Load Data

Fig. 14: Initial message: Load Data

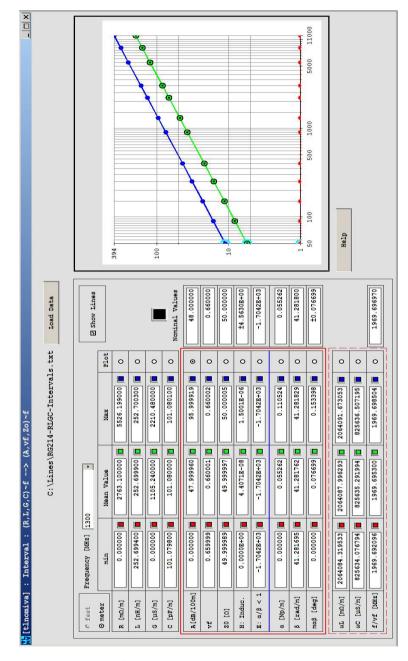


Fig. 15: [Interval : $(R,L,G,C,)\sim f \longrightarrow (A,vf,Z_0)\sim f$] - Plot

The minimum value results from (12) to be zero since the lower limits for R and G are equal to zero and the same is true for $m\alpha\beta$ and H. for this cable. It is obvious that the nominal value of A is achieved for the mean value as shown in Fig. 16 where the green and black colored points are plotted. The light blue point corresponds to the values shown above the chart. Velocity factor is illustrated in Fig. 17 and in Fig. 18 m $\alpha\beta$ is given. Both of them are shown with [Draft-MinMax] enabled. For $m\alpha\beta$ only the positive number is written at the table, while at the plot both

plus and minus $m\alpha\beta$ is shown. Fig. 19 contains Z_0 in both scales, where it is obvious that the difference from nominal value can not be denoted and Fig. 20 shows the H term, almost zero, similarly. If it is positive/ negative in both mean and maximum value then a Capacitive/Inductive label is added. For completeness Figs. 21-22 shows α and β respectivelv.

The [feet] option is again disabled, the [Show Lines] acts the same as in the previous window, while the [Zoom Graph] item with its sub-items is disabled in the current [tlnomiva] version.

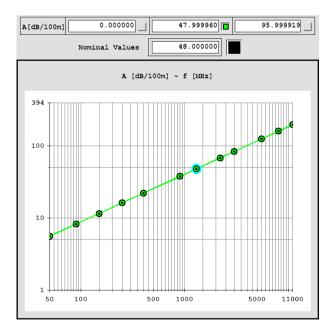


Fig. 16: Attenuation factor estimation and nominal value

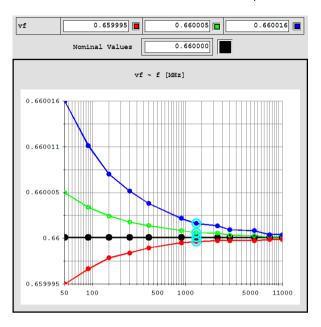


Fig. 17: Velocity factor estimation and nominal value

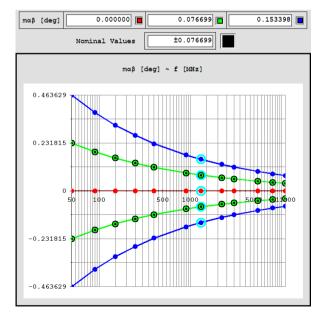
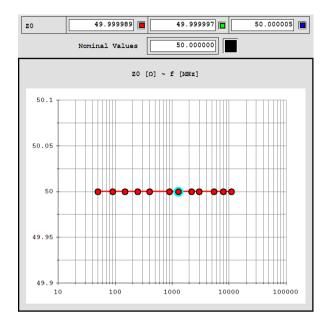


Fig. 18: $m\alpha\beta$ estimation and nominal values



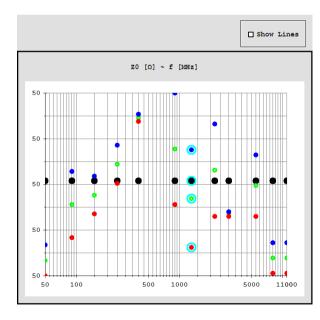
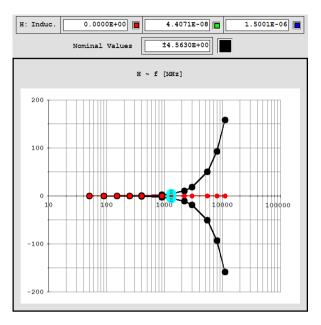


Fig. 19: Z_{0} estimation and nominal values



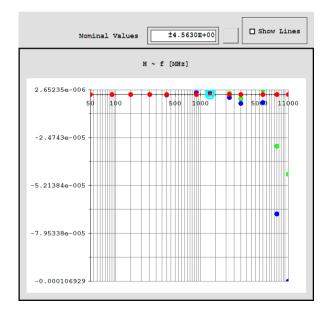


Fig. 20: H estimation and nominal values

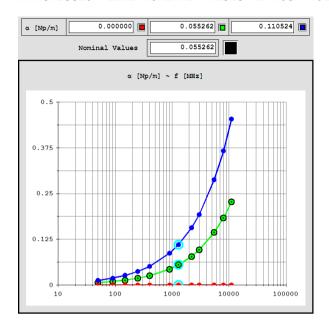


Fig. 21: α estimation and nominal values

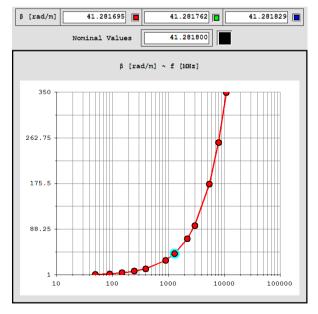


Fig. 22: B estimation and nominal values

α , β , R_{θ} , X_{θ} from Constant R, L, G, C

The next window of [tl-nomiva] concerns the investigation of the propagation characteristics behavior with frequency when the circuit coefficients remain constant. The question is, is there any possibility this case to be true in real transmission lines or it is simply a matter of theoretical research as a mathematical exercise?

Well, even if it is only an academic problem it has a considerable interest by itself. From the one hand, (1)-(4) show that if $X_0 = 0$ then R, L, G, C become frequency independent. But this means the Heaviside term is equal to zero. From the other hand, the C distributed circuit coefficient is almost constant over a wide frequency range and L has a small variation. Thus, R and G are the most variable coefficients, and G has in most cases rather small values compared with R [2]. In addition, as it is stated in [2], there is a range of low frequencies over which R, L, G, C can be considered effectively constants. Thus, it is worthwhile to examine the relation of all the four propagation characteristics with frequencv as the four circuit coefficients take specific values.

 $Ro,Xo)\sim f$] is shown in Fig. 23. It opens with the [Singlel frequency as the default state and with some predefined values. The user may type the RLGC coefficients and the desired frequency or frequency range. When [Range] is activated then the text boxes contain the values of all the quantities at the middle frequency and the buttons for plots are enabled. In this figure the predefined values for RLGC was used and the range [0.001, 1000] [MHz] was selected. A in [dB/100m] is depicted in the chart with the [Draft-Min Max] enabled and with [Show Lines] unchecked.

Fig. 24 shows A of the line used in previous sections, with RLGC almost equal to their mean value at the lower frequency, to the whole permitted range, from 1 Hz to 100 GHz. Evidently there is a limit to what can be drawn in this application. The [wgnuplot A, β, Ro, Xo, mαβ, vfl produces the two triples of Fig. 25, where at the right top side of the plots the RLGC values are written. The white area indicates the band of the line operating frequency. In wgnuplot application the developed script plots the (12)-(16) as functions of frequency, that is, curves are plotted and not evaluation in specific number of points.

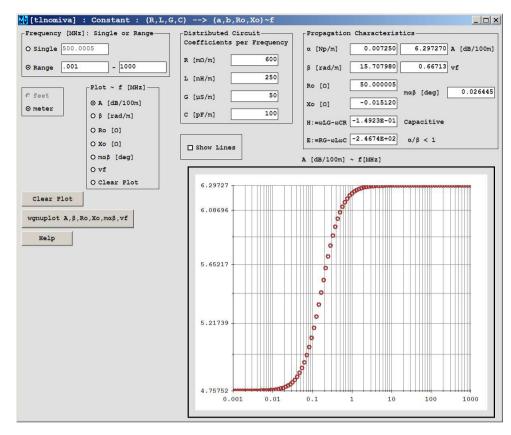


Fig. 23: [Constant: $(R,L,G,C) \longrightarrow (\alpha,\beta,Ro,Xo,) \sim f$] - [Range]

Thus, considering a much lower frequency range and a range for A between its minimum and maximum value, which substantially differ slightly, and plotting A function in wgnuplot, we get Fig. 26, where we distinguish the form of "S" we have seen before in Fig. 23 for the first line example.

Six text files are written in the directory of [tlno-miva], which are used from the

[wgnuplot.exe], with specific filenames of obvious meaning:

A-function B-function Ro-function Xo-fuction mab-function vf-function

In order to emulate the curve structure in the current version of [tlnomiva], the mentioned relations are evaluated in 100 points equally spaced in the logarithmic scale of frequency f in [MHz].

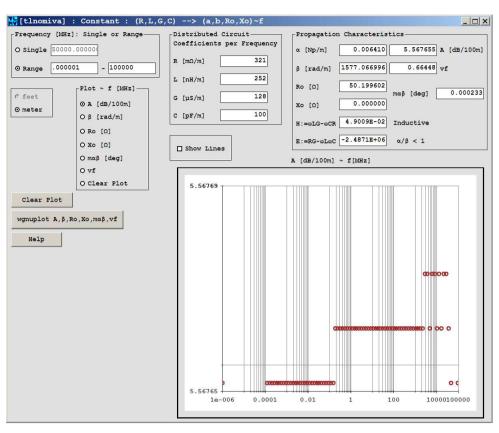


Fig. 24: A [dB/100m] versus f [MHz] with Draft-MinMax

A significant characteristic of this window is that when the [Range] is selected and one of the six quantities is plotted, then every change to the value of any of the four RLGC will immediately cause the change of the plot. All the other features are the same with the previous windows.

Using this feature of some kind of interaction and varying slightly by one (1) the

value of C and particularly by varying the value of L significantly, we get Fig. 27 for a transmission line with R, L, G, C equal to 321 $[m\Omega/m]$, 111 [nH/m], 128 $[\mu S/m]$ and 100 [pF/m], where the velocity factor seems to take values larger than its upper limit of unit (1) (red), from 2.6 [MHz] and above. A fact that needs further research, and restates the issue of line definition.

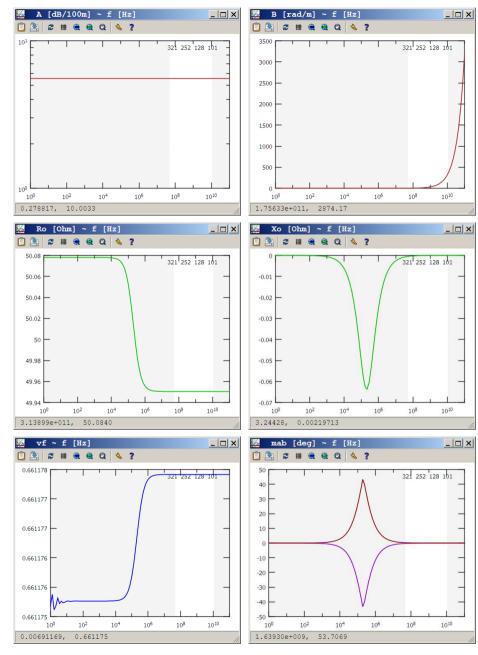


Fig. 25: A, β , R_{θ} , X_{θ} vf, $m\alpha\beta$ from [wgnuplot]

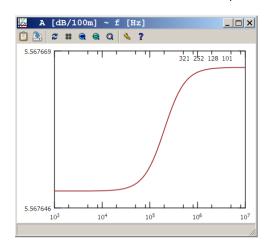


Fig. 26: A [dB/100m] versus f [MHz] from [wgnuplot]

Final Remarks

There are two important matters. The first concerns the application [tlnomiva] itself and the second the way that the available cable specifications can be exploited.

1. In order to avoid unpredicted errors in calculations, caused by the different notation of decimal symbol used in various local MS Windows versions, a decision has to be made. Thus, the dot "." was selected to be the decimal symbol, as well as, the comma "," as the digit grouping symbol - although the later is not used at all here. Notably, this choice is a mandatory requirement for [wgnuplot], which does not recognize comma as decimal symbol. Hence, the window of Fig. 28 appears on the screen just after opening the application when a non-dot definition exists in the Regional Settings of Control Panel.

2. The transmission line used to serve as an example of the features of the [tl-nomiva], is the RG 214 cable and its specifications which are given in [5]. Since, only four (4) values for the attenuation factor A in [dB/100ft] are explicitly reported there, we decided to use the accompanying chart, which covers the whole operating frequency range from 50 [MHz] to 11 [GHz].

Fig. 29 shows a straight line for A in the logarithmic chart. Such a line can be represented by:

$$y = k x^{\lambda}$$
 (17)

that is:

$$= a \log(x) + b \tag{18}$$

where $a=\lambda$ and b=log(k), and from (17) and (18) we take:

$$y = 10^b x^a$$
 (19)

Then, we graphically estimate the coordinates of the staring and ending points of the straight line in Fig. 29, as well as, we cross check the results by using the [Opti-Graph] application [6] as it is shown in Fig. 30. After that, we formulate and solve the following linear system:

$$log(1.7) = a log(50) + b log(60) = a log(11000) + b$$
 (20)

and by using the Aurora Scientific Calculator SC 500 Plus [7], the solution for a and b is given, with nine (9) decimal digits, as follows:

a = +0.660727178

b = -0.892106736

from which we finally have:

$$A_{[dB/100m]} = \frac{0.128201546}{0.3048} \; f_{[MHz]}^{0.660727178}$$

In this way, since A has now an analytical expression in terms of frequency, we can determine as many points as we like, that is, for example, those of three (3) significant figures we put in the grid of Fig. 6.

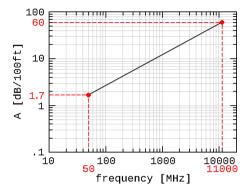


Fig. 29: Extracting analytical expression from a LogLog plot

Conclusion

The limits of what can be estimated or predicted using precise formulation from the nominal values without tolerance of A, vf, and Z_0 , which are usually given nowdays as cable specifications for transmission lines, without taken into account the cut-off frequency, was investigated in this paper.

It seems that the curves for all the involved quantities have more or less the same form, as it was expected and explained by their defining expressions, with a possible differentiation of course in their slope. These curves are strongly depended on how wide is the considered frequency window. Therefore, it is most important to pay special attention in the op-

erating frequency range in order to be sure that the model presented in this paper describes adequately the transmission line characteristics in accordance with its specifications.

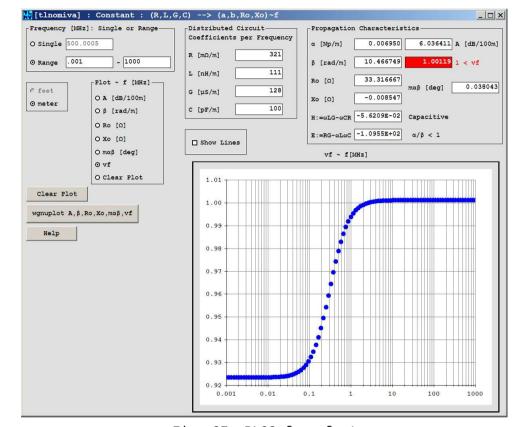


Fig. 27: RLGC for vf > 1

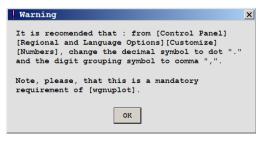


Fig. 28: Warning Message

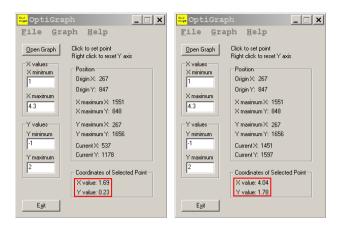


Fig. 30: [OptiGraph] : Starting and Ending points

The [tlnomiva] application is developed and presented as a research tool. The intention is to be used: (1) as a reference in the study of the already existing approximate techniques for finding the distributed circuit coefficients and the propagation characteristics, and 2) to be expandable in order to cover: (2a) not only the case of the RLCG theoretical calculation from the cable geometrical characteristics, but in addi-

tion (2b) the case of using the new approximation method for the determination of attenuation factor, which is under current development by the authors.

Finally, the whole of [tl-nomiva] software, that is the MIT licensed source code, the installation package, as well as, its future improvements, updates and upgrades, can be always downloaded from the author's website address [8].

References

- [1] Yannopoulou N., Zimourtopoulos P., "Transmission Lines Part 1: A Precise Formulation within the Distributed Circuit Model", FunkTechnikPlus # Journal, Issue 9, Year 3, 2016, pp. 369 389, under revision with expanded additions
 www.otoiser.org/index.php/ftpj/issue/view/2016.01.31
- [2] Chipman R.A., "Transmission Lines", McGraw-Hill, 1968, pp. 15, 17, 26, 31 32, 42, 44, 47, 58 60

- [3] gnuplot,
 "Version 5.0 patchlevel 3 last modified 2016-02-04":
 https://sourceforge.net/projects/gnuplot/files/gnuplot/
- [4] "How To Programmatically Close a Single Instance of a Windows-Based Program", https://support.microsoft.com/en-us/kb/176391
- [5] "Detail, Specification Sheet: Cable, Radio Frequency, Flexible, Coaxial, 50 Ohms, M17/75-RG 214 and M17/75-RG365, MIL-DTL-17/75F, w/Amendment 2", 23 February 2010, https://assist.dla.mil/online/start/
- [6] Yap Chun Wei, Optical Graph Recognition and Manipulation Util for Win32, OptiGraph, Version 1.0, 28 January 2000 First release, ftp://ftp.sk.debian.org/pub/pc/educult/
- [7] Aurora Scientific Calculator SC 500 Manual, www.arg.op4.eu/aurora/sc500p/
- [8] [tlnomiva],
 http://arg.op4.eu/software/tlnomiva/
 *Active Links: 19.05.2016 Inactive Links : FTP#J Link
 Updates: http://updates.ftpj.otoiser.org/

Previous Publication in FUNKTECHNIKPLUS # JOURNAL

"Transmission Lines – Part 1: A Precise Formulation within the Distributed Circuit Model", Issue 9, Year 3, pp. 369 – 390

* About The Authors

Nikolitsa Yannopoulou, Issue 9, Year 3, p. 390 yin@arg.op4.eu

Petros Zimourtopoulos, Issue 9, Year 3, p. 390 pez@arg.op4.eu

This paper is licensed under a Creative Commons Attribution 4.0 International License — https://creativecommons.org/licenses/by/4.0/

[This Page Intentionally Left Blank]

[This Page Intentionally Left Blank]

In case of any doubt, download the genuine papers from genuine.ftpj.otoiser.org

ARG NfP AoI

Antennas Research Group Not-for-Profit Association of Individuals [*] www.arg.op4.eu — arg@op4.eu

Hauptstraße 52, 2831 Scheiblingkirchen, Austria Telephone: 0 6646311483 — International: 0043 6646311483

- * The Constitution of Greece, Article 12(3) 2008:
- www.hellenicparliament.gr/en/Vouli-ton-Ellinon/To-Politevma
 * The Hellenic Supreme Court of Civil and Repal Law:
- * The Hellenic Supreme Court of Civil and Penal Law:
- www.areiospagos.gr/en Court Rulings:Civil|A1|511|2008

FRONT COVER VIGNETTE

A faded synthesis of an anthemion rooted in a meandros

The thirteen-leaf is a symbol for a life tree leaf.

"Herakles and Kerberos", ca. 530—500 BC,
by Paseas, the Kerberos Painter,
Museum of Fine Arts, Boston.

www.mfa.org/collections/object/plate-153852

The simple meandros is a symbol for eternal immortality.

"Warrior with a phiale", ca. 480—460 BC,

by Berliner Maler,

Museo Archeologico Regionale "Antonio Salinas" di Palermo.

commons.wikimedia.org/wiki/File:Warrior MAR Palermo NI2134.jpg