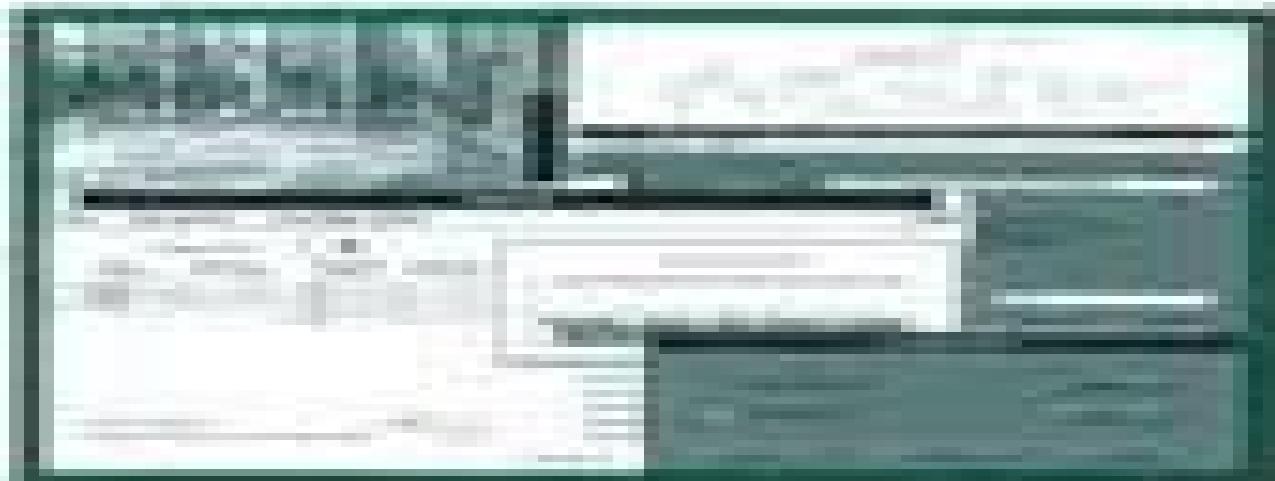


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# Multlin For Windows Circuitanalysis Models For Multiconductor Transmission Lines

**Thomas Stephan Blazeck**

## **Multlin For Windows Circuitanalysis Models For Multiconductor Transmission Lines:**

**Multlin for Windows** Antonije Djordjevic,Darko Cvetkovic,Tapan Sarkar,Goran Cujic,Miodrag B. Bazdar,1996-01

Serving as a complete replacement for its predecessor stand alone programs LINRES and MATPAR and as an extension of LINPAR for Windows this work is used to create models for quick accurate analysis of circuits containing multiconductor transmission lines    *Analysis of Multiconductor Transmission Lines* Clayton R. Paul,2007-10-26 The essential textbook for electrical engineering students and professionals now in a valuable new edition The increasing use of high speed digital technology requires that all electrical engineers have a working knowledge of transmission lines However because of the introduction of computer engineering courses into already crowded four year undergraduate programs the transmission line courses in many electrical engineering programs have been relegated to a senior technical elective if offered at all Now Analysis of Multiconductor Transmission Lines Second Edition has been significantly updated and reorganized to fill the need for a structured course on transmission lines in a senior undergraduate or graduate level electrical engineering program In this new edition each broad analysis topic e g per unit length parameters frequency domain analysis time domain analysis and incident field excitation now has a chapter concerning two conductor lines followed immediately by a chapter on MTLs for that topic This enables instructors to emphasize two conductor lines or MTLs or both In addition to the reorganization of the material this Second Edition now contains important advancements in analysis methods that have developed since the previous edition such as methods for achieving signal integrity SI in high speed digital interconnects the finite difference time domain FDTD solution methods and the time domain to frequency domain transformation TDFD method Furthermore the content of Chapters 8 and 9 on digital signal propagation and signal integrity application has been considerably expanded upon to reflect all of the vital information current and future designers of high speed digital systems need to know

*Multiconductor Transmission-Line Structures* J. A. Brand?o Faria,1993 The new and original material in this book will appeal to a diversified audience R D microwave scientists will appreciate the use of a perturbation approach to modal

analysis and generalized modal theory Owing to its rigorous treatment of both theoretical issues and practical applications it is sure to become an indispensable handbook for engineers concerned with the design and modelling of microwave circuits telecommunications systems or power systems    *Electromagnetic and Circuit Modelling of Multiconductor Transmission*

*Lines* Niels Faché,Frank Olyslager,Daniël de Zutter,1993 Multiconductor transmission lines form the basic building blocks of microwave and millimeter wave integrated circuits and are omnipresent in digital systems This book gives a detailed account of the way in which self consistent computer aided design circuit models for such coupled lines carrying either TEM or hybrid modes can be obtained from a full wave solution of Maxwell's equations Latest advances for lossy lines are covered The book also details the full wave integral equation solution for basic transmission structures on MMICs PCBs and multiwire and microwire boards with the method of moments For thin coupled microstrips and striplines the proposed space domain

solution offers an alternative to the classical spectral domain approach This book is the first to handle the full wave analysis of discrete wire structures and of lossy polygonal conductors The book is sure to appeal to a wide range of electrical and electronics engineers **Linpar for Windows** Antonije R. Djordjević, Miodrag B. Bazdar, Tapan K. Sarkar, Roger F.

Harrington, 1995-01-01 LINPAR lets you quickly analyze arbitrary planar transmission lines in multilayered dielectrics including microstrip lines coupled suspended lines coupled striplines and coplanar waveguides

**Analysis of Multiconductor Transmission Lines, 2nd Edition** Clayton Paul, 2007 The essential textbook for electrical engineering students and professionals now in a valuable new edition The increasing use of high speed digital technology requires that all electrical engineers have a working knowledge of transmission lines However because of the introduction of computer engineering courses into already crowded four year undergraduate programs the transmission line courses in many electrical engineering programs have been relegated to a senior technical elective if offered at all Now Analysis of Multiconductor Transmission Lines Second Edition has been significantly updated and reorganized to fill the need for a structured course on transmission lines in a senior undergraduate or graduate level electrical engineering program In this new edition each broad analysis topic e.g. per unit length parameters frequency domain analysis time domain analysis and incident field excitation now has a chapter concerning two conductor lines followed immediately by a chapter on MTLs for that topic This enables instructors to emphasize two conductor lines or MTLs or both In addition to the reorganization of the material this Second Edition now contains important advancements in analysis methods that have developed since the previous edition such as methods for achieving signal integrity SI in high speed digital interconnects the finite difference time domain FDTD solution methods and the time domain to frequency domain transformation TDFD method Furthermore the content of Chapters 8 and 9 on digital signal propagation and signal integrity application has been considerably expanded upon to reflect all of the vital information current and future designers of high speed digital systems need to know Complete with an accompanying FTP site appendices with descriptions of numerous FORTRAN computer codes that implement all the techniques in the text and a brief but thorough tutorial on the SPICE PSPICE circuit analysis program Analysis of Multiconductor Transmission Lines Second Edition is an indispensable textbook for students and a valuable resource for industry professionals

Field Analysis, Network Modeling and Circuit Applications of Inhomogenous Multi-conductor Transmission Lines Chih-ming Tsai, 1993

**Simplified Transmission Line Models for Use with Computer-Aided Circuit/System Analysis**

**Programs** Jerry I. Lubell, TRW SYSTEMS GROUP REDONDO BEACH CA., 1973 Two distinct but complimentary techniques for modeling multiconductor transmission lines for use with the SCEPTRE computer program are presented The transmission line models developed can be modified for compatibility with other circuit system transient analysis programs and are amenable to modification to include nuclear weapon effects The general modeling approach has been to develop computationally efficient and accurate terminal models which can be arbitrarily loaded at the source and load ends and

which can be used in conjunction with nonlinear electronic circuit models using either simplified or discrete modeling techniques The two modeling techniques developed are the state space method and the orthonormal function method For both cases all required parameters can be determined from terminal measurements The state space method is a new approach to modeling transmission lines using a lumped approximation For the multiconductor case the orthogonal characteristics of wave propagation are used to decouple the modes of propagation except at the source and load boundary conditions circuits The concept of the orthonormal function method is to derive a set of transfer functions in the Laplace domain relating forward and backward traveling waves on the line to voltages and currents at the source and load ends of the line approximate the transfer functions with Laguerre polynomials and representing the resulting rational polynomials in the time domain with state variable differential equations For the multiconductor case the orthogonal characteristics of wave propagation are used to separate the modes and the transfer functions for each mode are determined

### **Transmission**

**Lines and Lumped Circuits** Giovanni Miano, Antonio Maffucci, 2001-02-23 The theory of transmission lines is a classical topic of electrical engineering Recently this topic has received renewed attention and has been a focus of considerable research This is because the transmission line theory has found new and important applications in the area of high speed VLSI interconnects while it has retained its significance in the area of power transmission In many applications transmission lines are connected to nonlinear circuits For instance interconnects of high speed VLSI chips can be modelled as transmission lines loaded with nonlinear elements These nonlinearities may lead to many new effects such as instability chaos generation of higher order harmonics etc The mathematical models of transmission lines with nonlinear loads consist of the linear partial differential equations describing the current and voltage dynamics along the lines together with the nonlinear boundary conditions imposed by the nonlinear loads connected to the lines These nonlinear boundary conditions make the mathematical treatment very difficult For this reason the analysis of transmission lines with nonlinear loads has not been addressed adequately in the existing literature The unique and distinct feature of the proposed book is that it will present systematic comprehensive and in depth analysis of transmission lines with nonlinear loads A unified approach for the analysis of networks composed of distributed and lumped circuits A simple concise and completely general way to present the wave propagation on transmission lines including a thorough study of the line equations in characteristic form Frequency and time domain multiport representations of any linear transmission line A detailed analysis of the influence on the line characterization of the frequency and space dependence of the line parameters A rigorous study of the properties of the analytical and numerical solutions of the network equations The associated discrete circuits and the associated resistive circuits of transmission lines Periodic solutions bifurcations and chaos in transmission lines connected to nonlinear lumped circuits

### **Transient Analysis of Lossy Multiconductor Transmission Lines in Nonlinear Circuits** Thomas Stephan

Blazeck, 1989 Using the frequency dependent transmission line parameters two time domain models are developed for lossy

multiconductor transmissions lines It is shown that the endpoints of a lossy multiconductor line can be represented at each time step by discretized Thevenin or Norton equivalent circuits Because these models contain only lumped elements they can be easily implemented in a general circuit analysis program for simulating the transient responses of nonlinear circuits The analysis procedure developed makes exclusive use of infinite line impulse responses in the formulation of the time domain models Because infinite lines are matched there are no reflections in the impulse responses The result is that these impulse responses are relatively short A number of simulation examples are presented exercising the lossy multiconductor transmission line model in circuits that contain linear and nonlinear elements Of particular interest is the interconnection of high speed digital circuits by lossy multiconductor transmission lines containing discontinuities Results are shown for the most general case of lossy multiconductor transmission lines with discontinuities and nonlinear terminations in which the modal transformation matrices are necessarily frequency dependent In addition simulation results show good agreement with experimental results for both lossless and lossy multiconductor transmission lines

### **Radiating Nonuniform**

**Transmission-Line Systems and the Partial Element Equivalent Circuit Method** Prof. Dr. Juergen Nitsch,Dr. Frank Gronwald,Prof. Dr. Gunter Wollenberg,2009-10-29 High frequencies of densely packed modern electronic equipment turn even the smallest piece of wire into a transmission line with signal retardation dispersion attenuation and distortion In electromagnetic environments with high power microwave or ultra wideband sources transmission lines pick up noise currents generated by external electromagnetic fields These are superimposed on essential signals the lines acting not only as receiving antennas but radiating parts of the signal energy into the environment This book is outstanding in its originality While many textbooks rephrase that which has been written before this book features an accessible introduction to the fundamentals of electromagnetics an explanation of the newest developments in transmission line theory featuring the transmission line super theory developed by the authors a unique exposition of the increasingly popular PEEC partial element equivalent circuit method including recent research results Both the Transmission Line Theory and the PEEC method are well suited to combine linear structures with circuit networks For engineers researchers and graduate students this text broadens insight into the basics of electrical engineering It provides a deeper understanding of Maxwellian circuit like representations of multi conductor transmission lines justifies future research in this field

### **Circuit Simulation of**

**Incident Field Coupling to Multiconductor Transmission Lines** Guangxi Chen,2005 *Multiconductor Transmission Line Networks* Tibor Lapohos,1998 The analysis and validation of various Multiconductor Transmission Line MTL models are presented The studied discrete MTL models are based on the assumption that the electromagnetic fields in the vicinity of the MTLs are quasi Transverse Electromagnetic quasi TEM in nature Three different techniques namely leap frog and first and second order upwind schemes are used to discretize the models It is shown that unlike the leap frog scheme the relatively new upwind schemes produce good results for both initial and boundary value problems with insignificant numerical

dispersion if employed to simulate inhomogeneous MTLs In certain situations this remarkable behaviour of the upwind scheme makes them a better choice to model MTLs Regarding the well known leap frog discretized quasi TEM MTL equations the treatment of the forcing terms representing the external field coupling to MTLs is in the focal point of the analysis The known finite differencing technique of the forcing terms is analysed and modified so that the new scheme is more accurate at absolutely no extra computational cost The boundary conditions are formulated with the Modified Nodal Analysis MNA technique For the pure linear boundary conditions the MNA equations are discretized using backward Euler finite differencing in conjunction with a special trapezoidal rule employed for the source terms The non linear boundary conditions are solved using the Newton Raphson algorithm with a predictor corrector formula All these techniques are incorporated into a non linear circuit solver tool UWO MTLNet recognizing SPICE like statements with emphasis on MTL networks subjected to external electromagnetic disturbances This tool is used to simulate the problems subjected to experimental validation and as such to show that the incorporation of the surface waves into the field coupling models is crucial Ignoring the field distorting effect of the dielectric substrates of the printed circuit boards PCBs leads to erroneous results Another software tool UWO MSPICE is developed to create SPICE readable source codes of some of the SPICE implementable MTL models

Multiconductor Transmission Line Analysis Sidney Frankel,1977

*Time-domain*

*Macromodeling of High Speed Distributed Networks*2 Amir Beygi,2011 With the rapid growth in density operating speeds and complexity of modern very large scale integration VLSI circuits there is a growing demand on efficient and accurate modeling and simulation of high speed interconnects and packages in order to ensure the signal integrity reliability and performance of electronic systems Such models can be derived from the knowledge of the physical characteristics of the structure or based on the measured port to port response In the first part of this thesis a passive macromodeling technique based on Method of Characteristics referred as Passive Method of Characteristics or PMoC is described which is applicable for modeling of electrically long high speed interconnect networks This algorithm is based on extracting the propagation delay of the interconnect followed by a low order rational approximation to capture the attenuation effects The key advantage of the algorithm is that the curve fitting to realize the macromodel depends only on per unit length parameters and not on the length of the transmission line In this work the PMoC is developed to model multiconductor transmission lines Next an efficient approach for time domain sensitivity analysis of lossy high speed interconnects in the presence of nonlinear terminations is presented based on PMoC An important feature of the proposed method is that the sensitivities are obtained from the solution of the original network leading to significant computational advantages The sensitivity analysis is also used to optimize the physical parameters of the network to satisfy the required design constraints A time domain macromodel for lossy multiconductor transmission lines exposed to electromagnetic interference is also described in this thesis based on PMoC The algorithm provides an efficient mechanism to ensure the passivity of the

macromodel for different line lengths Numerical examples illustrate that when compared to other passive incident field coupling algorithms the proposed method is efficient in modeling electrically long interconnects since delay extraction without segmentation is used to capture the frequency response In addition this thesis discusses macromodeling techniques for complex packaging structures based on the frequency domain behavior of the system obtained from measurements or electromagnetic simulators Such techniques approximate the transfer function of the interconnect network as a rational function which can be embedded with modern circuit simulators with integrated circuit emphasis SPICE One of the most popular tools for rational approximations of measured or simulated data is based on vector fitting VF algorithms Nonetheless the vector fitting algorithms usually suffer convergence issues and lack of accuracy when dealing with noisy measured data As a part of this thesis a methodology is presented to improve the convergence and accuracy issues of vector fitting algorithm based on instrumental variable technique This methodology is based on obtaining the instruments in an iterative manner and do not increase the complexity of vector fitting to capture the frequency response and minimize the biasing

Applications of Multiconductor Transmission Line Theory to the Prediction of Cable Coupling. Volume 7. Digital Computer Programs for the Analysis of Multiconductor Transmission Lines ,1977 Four digital computer programs XTALK XTALK2 FLATPAK FLATPAK2 for determining the electromagnetic coupling within an  $n \geq 1$  conductor uniform transmission line are presented Sinusoidal steady state behavior of the line as well as the TEM or quasi TEM mode of propagation are assumed XTALK and XTALK2 consider lines consisting of  $n \geq 1$  wires cylindrical conductors and a reference conductor The surrounding medium is homogeneous and lossless XTALK assumes that all  $n \geq 1$  conductors are perfect conductors whereas XTALK2 considers the conductors to be lossy There are three choices for the reference conductor a wire a ground plane an overall cylindrical shield FLATPAK and FLATPAK2 consider  $n \geq 1$  wire ribbon flatpack cables in which all wires are identical and are coated with cylindrical dielectric insulations of identical thicknesses All wires lie in a horizontal plane and all adjacent wires are separated by identical distances FLATPAK considers the wires to be perfect conductors and FLATPAK2 considers the wires to be lossy The dielectric insulations are considered to be lossless General termination networks are provided for at the ends of the line and the programs compute the voltages with respect to the reference conductor at the terminals of these termination networks for sinusoidal steady state excitation of the line

**Symmetry Properties in Transmission Lines Loaded with Electrically Small Resonators** Jordi Naqui,2015-10-16 This book discusses the analysis circuit modeling and applications of transmission lines loaded with electrically small resonators mostly resonators inspired by metamaterials focusing on the study of the symmetry related electromagnetic properties of these loaded lines It shows that the stopband functionality resonance that these lines exhibit can be controlled by the relative orientation between the line and the resonator which determines their mutual coupling Such resonance controllability closely related to symmetry is essential for the design of several microwave components such as common mode suppressed differential lines novel

microwave sensors based on symmetry disruption and spectral signature radio frequency barcodes Other interesting aspects such as stopband bandwidth enhancement due to inter resonator coupling and related to complex modes and magnetoelectric coupling between the transmission lines and split ring resonators are also included in the book

**Electromagnetic Modeling of Multiconductor Transmission Lines** Pierre-Marie J. Piel,1999 *Matrix Parameters for Multiconductor Transmission Lines* A. R. Djordjević,1989 A menu driven program in executable form which evaluates quasi TEM matrices L C R and G of multiconductor transmission lines embedded in piecewise homogeneous dielectrics The program can analyze seven predefined structures for which segmentations are done automatically it can also accept user defined structures *Modeling Multiconductor Transmission Lines Using the Finite Difference Time Domain Method* John R. St. Peter,1993

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