Title of Discipline:

Computer-Aided Analysis of Electronic Circuits

Laboratory Lecture 3

Bachelor : Telecommunication Technologies and Systems

Year of Study: 2

Computer-Aided Analysis of Electronic Circuits

Laboratory 3
The description of the passive analog devices supported by PSpice A/D

Analog Device Types

There are different types of analog devices supported by Pspice A/D.

- *analog primitives,*
- *independent and controlled sources,*
- *subcircuit calls.*

The device declaration begins with the name of the individual device.

The ***first letter*** *of the name determines the* ***device type****. What follows the name depends on the device type and its requested characteristics.*

Analog Device Summary

Passive device	Independent sources	Controlled sources	Controlled switch	Semiconductors
R – Resistor C – Capacitor L – Inductor K – Inductor coupling T – Transmission line	V – Independent voltage source I – Independent current source	E – Voltage-controlled voltage source G – Voltage-controlled current source F – Current-controlled current source H – Current-controlled voltage source	S – Voltage-controlled switch W – Current-controlled switch	D – Diode Q – Bipolar transistor J – Junction FET M – MOSFET B – GaAsFET

Passive Devices

Resistor

General form

R<name> <N+> <N-> [model name] <value> [TC = <TC1> [, <TC2>]]

Examples

Rs 12 0 1.5k
R3 2 9 7.5k TC=0.015,-0.003
Rfdbck 5 17 RMOD 5k

Model form

.MODEL <model name> RES [model parameters]

Passive Devices

Resistor model parameters

Model parameter	Description	Units	Default
R	resistance multiplier	-	1.0
TC1	linear temperature coefficient	$°C^{-1}$	0.0
TC2	quadratic temperature coefficient	$°C^{-2}$	0.0
TCE	exponential temperature coefficient	%/°C	0.0

Passive Devices

Arguments and options

<N+> <N-> are the nodes. Positive current flows from <N+> node through the resistor to the <N-> node.

Resistor value formulas

If [model name] is included and TCE is specified, then the resistance is given by:

$R_{total} = < value > \cdot \mathbf{R} \cdot 1.01^{\mathbf{TCE} \cdot (T - Tnom)}$

If [model name] is included and TCE is not specified, then the resistance is given by:

$R_{total} = < value > \cdot \mathbf{R} \cdot (1 + \mathbf{TC1} \cdot (T - Tnom) + \mathbf{TC2} \cdot (T - Tnom)^2)$

Where <value> is the one from the general form of the resistor. Tnom is the nominal temperature.

Resistor equation for noise

Noise is calculated assuming a 1.0-hertz bandwidth. The resistor generates thermal noise using the following spectral power density (per unit bandwidth):

$i^2 = 4 \cdot k \cdot T / R_{total}$

Passive Devices

Capacitor

General form

C<name> <N+> <N-> [model name] <value> [IC = <initial value>]

Examples

Cref 12 0 220u

C5 3 8 47nF IC=2.5V

Cfdbck 2 24 CMOD 100pF

Model form

.MODEL <model name> CAP [model parameters]

Passive Devices

Capacitor model parameters

Model parameter	Description	Units	Default
C	capacitance multiplier	-	1.0
TC1	linear temperature coefficient	$°C^{-1}$	0.0
TC2	quadratic temperature coefficient	$°C^{-2}$	0.0
VC1	linear voltage coefficient	$volt^{-1}$	0.0
VC2	quadratic voltage coefficient	$volt^{-2}$	0.0

Passive Devices

Arguments and options

<N+> <N-> are the nodes. The voltage across the component is defined as the first node voltage, less the second node voltage. If [model name] is left out, then <value> is the capacitance in farads.

The initial voltage across the capacitor during the bias point calculation. It can also be specified in a circuit file using a .IC command as follows:

.IC V(N+, N-) <initial value>

Capacitor value formula

If [model name] is specified, then the value is given by:

C_{total} = < value > · **C** · (1 + **VC1** · V + **VC2** · V^2) · (1 + **TC1** · (T-Tnom) + **TC2** · (T – Tnom $)^2$)

Where <value> is the one from the general form of the capacitor. Tnom is the nominal temperature.

Passive Devices

Inductor

General form:

L<name> <N+> <N-> [model name] <value> [IC = <initial value>]

Examples

Lload 16 0 22mH

L2 2 11 100uH IC=3mA

Lsec 13 17 LMOD 10uH

Model form

.MODEL <model name> IND [model parameters]

Passive Devices

Inductor model parameters

Model parameter	Description	Units	Default
L	inductance multiplier	-	1.0
TC1	linear temperature coefficient	$°C^{-1}$	0.0
TC2	quadratic temperature coefficient	$°C^{-2}$	0.0
IL1	linear current coefficient	amp^{-1}	0.0
IL2	quadratic current coefficient	amp^{-2}	0.0

Passive Devices

Arguments and options

<N+> <N-> are the nodes. The voltage across the component is defined as the first node voltage, less the second node voltage. If [model name] is left out, then <value> is the capacitance in farads.

<initial value> is the initial current through the inductor during the bias point calculation. It can also be specified in a circuit file using a .IC command as follows:

.IC I(L<name>) <initial value>

Inductor value formula

If [model name] is specified, then the effective value is given by:

$L_{total} = < value > \cdot \mathbf{L} \cdot (1 + \mathbf{IL1} \cdot I + \mathbf{IL2} \cdot I^2) \cdot (1 + \mathbf{TC1} \cdot (T - Tnom) + \mathbf{TC2} \cdot (T - Tnom)^2)$

Where <value> is the one from the general form of the inductor. Tnom is the nominal temperature.

Passive Devices

Inductor coupling

General form

K<name> L<inductor name> <L<inductor name>> * <coupling value>

K<name> <L<inductor name>>* <coupling value> <model name>

Examples

K12 L1 L2 0.95

Ktransf Lpr Lsec 1

Kcore L1 L2 L3 L4 0.98 MODCORE

Model form

.MODEL <model name> CORE [model parameters]

Passive Devices

Arguments and options

K<name> L <inductor name>

Couples two or more inductors.

<coupling value> This is the coefficient of mutual coupling, which must be between -1.0 and 1.0.

This coefficient is defined by the equation

$$< \text{coupling value} > = Mij/(Li \cdot Lj)^{1/2}$$

Where

Li, Lj = a coupled-[air of inductors

Mij = the mutual inductance between Li and Lj

Passive Devices

Transmission line

Description

The transmission line device is a bidirectional delay line with two ports, A and B.

Ideal transmission line

General form

T<name> < NA+> <NA-><NB+><NB-> [model name]

+ Z0 = <value> [TD = <value>] [F = <value> [NL =<value>]]

where

NA+, NA-, NB+, NB- are nodes of port A, respectively B.

Z0 is the characteristic impedance.

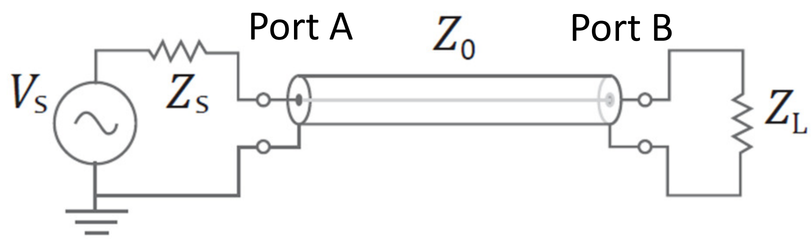


Figure 1: A typical transmission line circuit

The transmission line’s length can be specified either by TD, a delay in seconds, or by F and NL, a frequency and a relative wavelength at F.

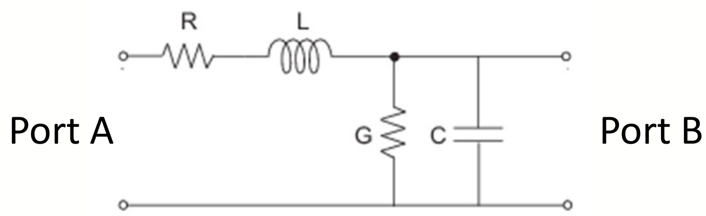
Passive Devices

Lossy transmission line

General form

T<name> < NA+> <NA-><NB+><NB-> [<model name> [electrical length value]]

+ LEN = <value> R = <value> L = <value> G = <value> C = <value>



where

NA+, NA-, NB+, NB- are nodes of port A, and B respectively.

LEN is the electrical length.

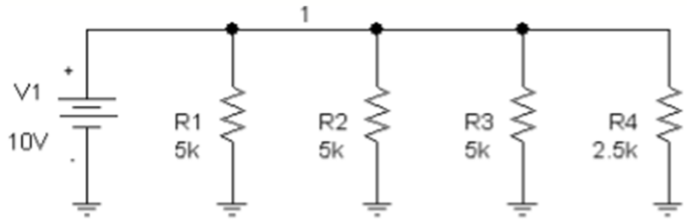
R, L, G, and C are the per unit length values of resistance, inductante, conductance, and capacitance, respectively.

Model form

.MODEL <model name> TRN [model parameters]

Applications

Application 1 – description and analysis of a circuit with different resistor models



Resistor model parameters:

R1: no variation with temperature

R2: TC1=0.01;

R3: TC1=0.01, TC2=-0.5e-3;

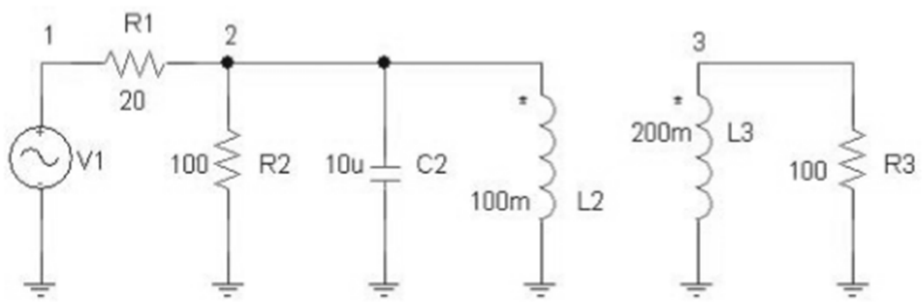
R4: R=2, TCE=2.

Activities:

- Describe the circuit into the SPICE circuit file (.cir). For each of resistors R2, R3 and R4 specify a model name and define them with .MODEL command.
- Add voltage source as follow: V1 1 0 10
- Add .DC command to perform a DC analysis when the temperature is swept in the interval -25ºC…75ºC with step size of 2ºC.
  .DC TEMP -25 75 2
- Perform the simulation
- In the ***Probe*** graphic analyzer plot the resistances of those four resistors by entering the following expressions:
  V(1)/I(R1), V(1)/I(R2), V(1)/I(R3), V(1)/I(R4)
- What is the temperature value at which all resistors have the same value?

Applications

Application 2 – description and analysis of a RLC circuit



Circuit details:
C2: initial condition = 0.5V
L2: initial condition = 0.3A
Coupling coefficient between L2 and L3 is 1
V1: V1 1 0 SIN(0 1 500)

Activities:

- Describe the circuit into the SPICE circuit file .cir
- Add the .TRAN command to perform a transient analysis
  .TRAN 0.1m 6m 0 50u
- Perform the simulation
- Show and inspect the waveforms of the voltages V(1), V(2) and V(3) in the ***Probe*** graphic analyzer. Determine the amplitude of V(2) and V(3).
- Show and inspect in a separate plot the waveforms of the currents through L2 and L3.