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Modelling Electronic Diode Networks with PSPICE Simulation

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Abstract

The dual of Thevenin, Norton equivalent circuit is used in place of any circuit/network of linear sources and immittances at at a given frequency. Both Thevenin with Norton theorem is useful for analyses and modification of circuits, to study /obtain network's steady state response and initial condition. Methods to represent different circuits with Thevenin/Norton impedances connected at desired nodes are given using Spice/Pspice. The Thevenin/Norton impedances connected are of other networks which are independent with non-linear elements (diode etc). The Thevenin/Norton impedances are scaled to the desired level after obtaining small –signal equivalents for non-linear elements (diode). Circuit analyses and simulation methods with SPICE /OrCAD software to obtain Norton and Thevenin equivalent circuits for networks containing non-linear elements such as diodes are described to simulate other different networks with scalar multiples of previous equivalent circuit parameters (Thevenin and Norton). Using Spice/Pspice simulator the non-linear circuit is described in two ways, (I) to obtain Thevenin open circuit voltage(ac), (ii) to obtain AC Thevenin without changing DC bias of non-linear element. Here, the individual parameters are from a different circuit (Thevenin/Norton equivalents) are implemented in other networks.

Keywords: Analog network theory, non- linear circuits, complex variables, circuit simulation and modelling, rf and microwave circuits, computer aided design

INTRODUCTION

Working with electrical circuits can lead to some complex situations. Thevenin's and Norton's theorems are frequently used by engineers to facilitate analysis. Norton utilizes a current source and resistance, while Thevenin uses a voltage source and resistance. Both techniques reduce a complicated circuit to a simpler model. This allows engineers to comprehend the behavior of the circuit without having to handle each individual component.

However, diodes and other non-linear components used in many circuits don't react in straightforward, predictable ways. We deal with this by employing small-signal models, which are approximations that continue to apply Thevenin's and Norton's theorems despite the presence of non-linear circuit components.

Thevenin's/Norton's theorem is not applicable to non-linear circuits for due to the following reasons:

a. *Linearity requirement:* In Thevenin's theorem the principle of superposition, which holds true only for linear components is used. Since linear components, resistors, capacitors, and inductors have a constant relationship between voltage and currantlike, the output is directly proportional to the input. Non-linear components, diodes, transistors, HEMTs, and certain types of nonlinear voltage-current loads, due to change with operating conditions, the superposition theorem should not be used and is invalid.

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b. *Variable parameters:* In non-linear circuits, the values of the components (like resistance) can change with the voltage or current. So, the equivalent circuit cannot be accurately represented by a voltage/current source and resistance although analog behavioral model can be applied to represent them.
c. *Variable operating points*: Non-linear circuits can have multiple operating points for the same input conditions with different responses. As Thevenin's theorem uses linear circuit theory and cannot be used.
d. *Circuit behavior*: Clipping, Clamping occurs in non-linear circuits, which are not accounted for in Thevenin's theorem.
e. For non-linear circuits, other methods should be employed, such as numerical simulation or piecewise linear approximations (small signal analyses), are often needed for analysis and simulation.

Circuit analyses and simulation methods with SPICE software to obtain Norton and Thevenin equivalent circuits with SCALAR multiples of original Norton/Thevenin networks are described with examples. The circuits consist of linear and non-linear elements(diodes). Individual sub-circuits whose Thevenin/Norton equivalents are to be determined are obtained from original circuits. Useful separate method, which is spice compatible, for Norton/Thevenin equivalents are determined. The technique could be applied to a circuit or network consisting of resistors, independent DC sources (current and voltage), and dependent sources and can be for different energy excitations non-linear element and can be analyzed for currents and voltages in all branches and nodes. Also, it could be broken into several small individual circuits applying superposition theorem. Alterations such as increase or decrease in the main network by altering individual energy sources could be manipulated (compensated) by obtaining exact values for some DC energy sources using PSpice software network description.

For different circuits/networks Spice, OrCAD [1-10]. compatible methods to determine the Thevenin and Norton equivalent circuit parameters have been described. The Thevenin open circuit voltage and impedance thus determined could be verified by different computer simulation software's. In this work, two networks are considered which use Thevenin/Norton immittances of different circuits (with linear elements and non-linear element diode). Procedures to incorporate these immittances (scalar multiples of immittances) is described with examples. Different exampleas are mentioned in the table (1-36)

CIRCUIT EXAMPLES IMPLEMENTING SCALAR MULTIPLES

Thevenin's theorem is often used to replace/represent a multiple element circuit with a single voltage source and resistor while Norton's theorem is used to replace/represent a multiple element circuit with a single current source and resistor (both AC and DC applications) [11-16]. Accurate Thevenin's theorem defined as:" Any linear electrical network containing only voltage sources, current sources and resistances can be replaced at terminals R–S by an equivalent combination of a voltage source Voc in a series connection with a resistance Ro." Norton's theorem (dual of Thevenin) is almost the same and identical except that the replacement is a single current source Isc in parallel with a resistor R_0. The resistor Ro is the same value for both the Thevenin and Norton equivalent circuits. The active voltage and current sources are either independent or dependent sources. An independent source is one where the value (voltage/current) does not depend on anything else in the circuit. The above circuit can be replaced with either the Thevenin Equivalent or the Norton Equivalent shown Figure 1(I-II).

Finding thevenin impedance: An arbitrary voltage Vx can be applied to port R-S, voltage source(s) current source(s) resistor(s) Circuit with R S, Ix Vx Zero all independent sources The Thevenin/Norton resistance is then Ro = Vx/ Ix When finding Ix, all independent sources should be set to zero. This is equivalent to shorting all independent voltage sources and opening all independent current sources. However, dependent sources remain in the circuit while finding Ix.

Finding thevenin open circuit voltage: To find the value, find the open-circuit voltage at port R-S. In other words, disconnect any other elements connected to port R-S [(Figure I(b-c)]

ISC computation: To find the value of Isc, find the short-circuit current at port R-S. In other words, short port (zero resistance) R-S and find the short-circuit current flowing through the shorting wire from R to S. [Figure 1(d-e)]

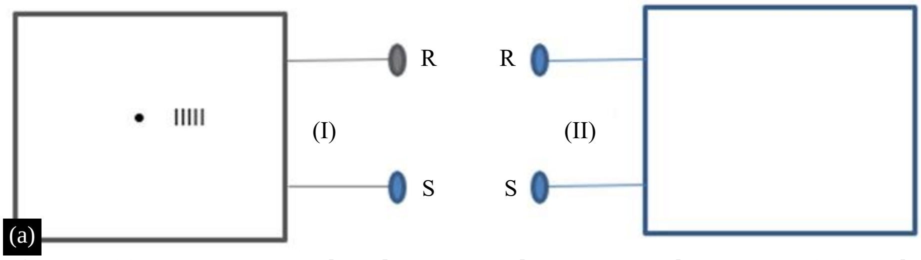

Figure 1(I). Active Network Split into two linear networks Figure 1(II) to obtain Thevenin equivalent circuit variables.

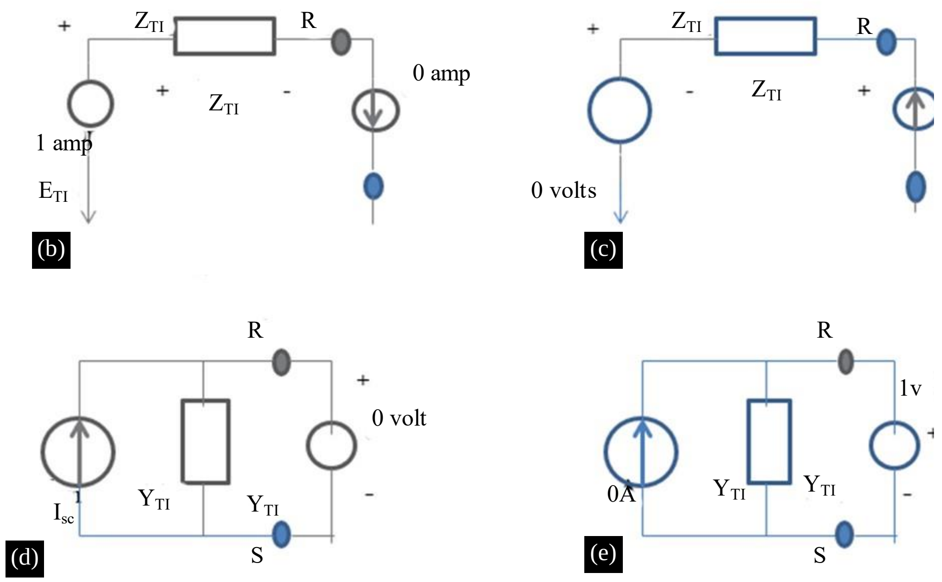

Figure (1b-e). shows circuit terminations required to obtain Thevenin/Norton equivalent circuit parameters with Pspice software.

- *Type I:* Consider the circuit Figure 2. The Thevenin open circuit voltage and impedance of this network are to be incorporated (scalar multiples) into different circuits using SPICE simulation program.
- *Type 2:* Consider the circuit Figure 3. The Thevenin open circuit voltage and impedance of this network also should be substituted (with scalar multiples) in a different network.

Figures 2(a-b) and 3(a-b) describe two such active circuits. Figure 3(a-b) is same as Figure 2(a-b) except that a 10 Ohm resistor is added in series with diode.

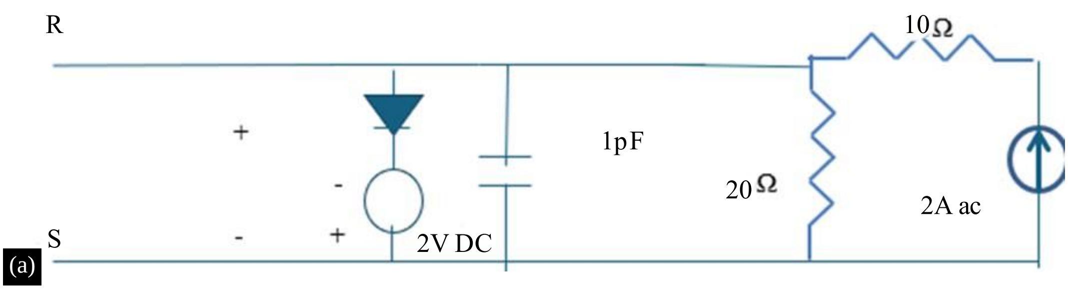

Figure 2. a Active Network I of figure 1 for which Thevenin/Norton equivalent is to be obtained

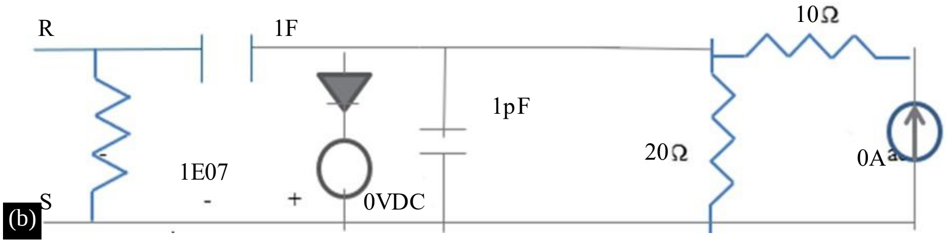

Figure 2. b Active Network II of figure 1 for which Thevenin/Norton equivalent is to be obtained

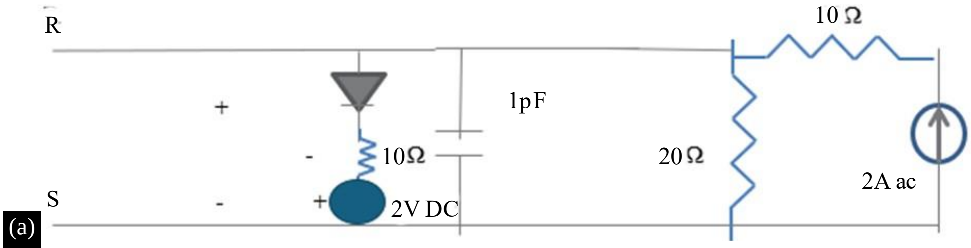

Figure 3. a Second example of Active Network I of Figure 1 for which Thevenin/Norton equivalent is to be obtained.

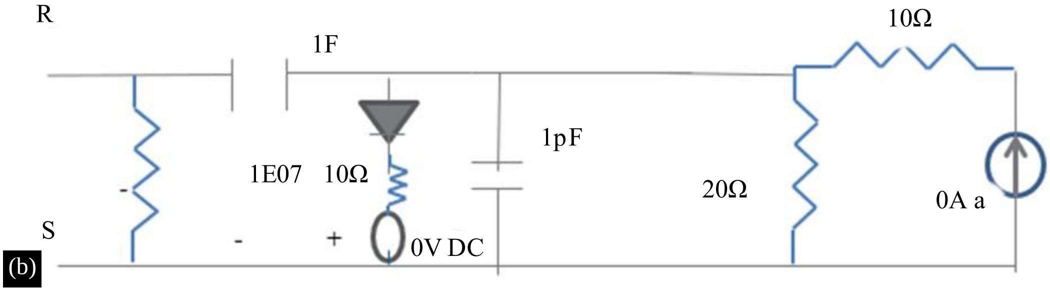

Figure 3. b Second example of Active Network II of Figure 1 for which Thevenin/Norton equivalent is to be obtained

Different networks utilizing various linear circuits employ Thevenin/Norton equivalent parameters (scalar multiples) obtained from Figures 2 and 3. The Thevenin AC impedance from Figure 1a is integrated into the network while maintaining the original bias conditions of the diode

Table Pspice Thevenin Circuit Description (Example I) To Describe a New Circuit

**** 09/24/24 17:32:51 **** PSpice Lite (October 2012) ****** ID# 10813 ****
Diode test circuit for Thevenin circuit determination

Circuit Description
Description for Thevenin open circuit voltage (See figure 2)

IO1 0 1 AC 2
R12 1 2 10
C20 2 0 1PF
R20 2 0 20
V30 3 0 DC -2
D 7 3 DNAME
R27 2 7 0.000001
C719 7 19 1000UF
R190 19 0 1E15

Description for Thevenin Impedance by AC Option (see Figure 2)
IO5 0 5 AC 0
R65 6 5 10
C60 6 0 2PF
R60 6 0 20
D1 6 8 DNAME
V80 8 0 DC -2
F06 0 18 V1314 1
C718 6 18 1000UF
R180 18 0 1E14

Conventional Method for Thevenin Impedance of Figure 2.

AC Resistance of Diode is incorporated value= 0.54 ohms
IT is added to Series resistance of diode value= 6 ohms

I09 0 9 AC 0
R910 9 10 10
C100 10 0 2PF
R100 10 0 20
R1011 10 11 0.000001
R1112 11 12 6.54
V120 12 0
I011 0 10 AC 1

***V (10) Gives Thevenin/Norton Impedance by conventional technique**
*An AC circuit which uses scalar multiples of Thevenin AC voltage and impedance
EAC 13 0 19 0 1
R130 13 0 20
C130 13 0 1PF
V1314 13 20
R1420 14 20 0.0000001
E1415 14 15 18 0 1
E1516 15 16 18 0 0.2
E1617 16 17 18 0 0.5
R170 17 0 20
C170 17 0 1PF

.MODEL DNAME D (IS=1E-14 RS=6)

.AC LIN 10 1GHZ 2GHZ
.PRINT AC VM (1) VP (1) VM(2) VP(2) VM(10) VP(10)
.PRINT AC VM(14,15) VP(14,15) IM(V1314) IP(V1314)
.PRINT AC VM (15,16) VP(15,16) vM(16,17) VP(16,17)
.OP
.end

Diode Model Parameters

	DNAME
IS	10.000000E-15
RS	6

Small Signal Bias Solution Temperature = 27.000 Deg C

Table- 1. Node Voltage Node Voltage Node Voltage Node Voltage.

Node	Voltage	Node	Voltage	Node	Voltage	Node	Voltage
(1)	-.9576	(2)	-.9576	(3)	-2.0000	(5)	-.9576
(6)	-.9576	(7)	-.9576	(8)	-2.0000	(9)	0.0000
(10)	0.0000	(11)	0.0000	(12)	0.0000	(13)	0.0000
(14)	0.0000	(15)	0.0000	(16)	0.0000	(17)	0.0000
(18)	0.0000	(19)	0.0000	(20)	0.0000		

Table 2. Voltage Source Currents.

Name	Current
V30	4.788E-02
V80	4.788E-02
V120	0.000E+00
V1314	0.000E+00

*Total Power Dissipation: 1.92e-01 Watts **** 09/24/24 17:32:51 ****** PSpice Lite (October 2012) ****** ID# 10813 ****Operating Point Information Temperature = 27.000 Deg C*

Table 3. Voltage-Controlled Voltage Sources.

Name	EAC	E1415	E1516	E1617
V-SOURCE	0.000E+00	0.000E+00	0.000E+00	0.000E+00
I-SOURCE	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Table 4. Current-Controlled Current Sources.

Name	F06
I-SOURCE	0.000E+00

Table 5. Diodes.

Name	D	D1
MODEL	DNAME	DNAME
ID	4.79E-02	4.79E-02
VD	1.04E+00	1.04E+00
REQ	5.40E-01	5.40E-01
CAP	0.00E+00	0.00E+00

AC Analysis Temperature = 27.000 Deg C

Table 6. Diode Test Circuit For Thevenin Circuit Determination Case -I.

FREQ	VM (1)	VP (1)	VM (2)	VP (2)	VM (10)
1.000E+09	2.985E+01	-5.854E-01	9.852E+00	-1.774E+00	4.919E+00
1.111E+09	2.985E+01	-6.503E-01	9.851E+00	-1.971E+00	4.917E+00
1.222E+09	2.985E+01	-7.152E-01	9.850E+00	-2.168E+00	4.914E+00
1.333E+09	2.984E+01	-7.801E-01	9.849E+00	-2.364E+00	4.912E+00
1.444E+09	2.984E+01	-8.449E-01	9.847E+00	-2.561E+00	4.909E+00
1.556E+09	2.984E+01	-9.097E-01	9.846E+00	-2.758E+00	4.906E+00
1.667E+09	2.984E+01	-9.744E-01	9.844E+00	-2.955E+00	4.902E+00
1.778E+09	2.983E+01	-1.039E+00	9.842E+00	-3.151E+00	4.899E+00
1.889E+09	2.983E+01	-1.104E+00	9.840E+00	-3.348E+00	4.895E+00
2.000E+09	2.983E+01	-1.168E+00	9.838E+00	-3.544E+00	4.891E+00

AC Analysis Temperature = 27.000 Deg C

Table 7. Diode Test Circuit for Thevenin Circuit Determination Case -Ii.

FREQ	VP (10)
1.000E+09	-3.544E+00
1.111E+09	-3.937E+00
1.222E+09	-4.329E+00
1.333E+09	-4.721E+00
1.444E+09	-5.112E+00
1.556E+09	-5.503E+00
1.667E+09	-5.893E+00
1.778E+09	-6.283E+00
1.889E+09	-6.672E+00
2.000E+09	-7.061E+00

Ac Analysis Temperature = 27.000 Deg C

Table 8. Diode Test Circuit for Thevenin Circuit Determination Case -III.

FREQ	VM(14,15)	VP(14,15)	IM(V1314)	IP(V1314)
1.000E+09	1.719E+00	7.722E-01	3.494E-01	4.316E+00
1.111E+09	1.721E+00	8.510E-01	3.499E-01	4.788E+00
1.222E+09	1.722E+00	9.278E-01	3.505E-01	5.257E+00
1.333E+09	1.724E+00	1.002E+00	3.511E-01	5.723E+00
1.444E+09	1.726E+00	1.074E+00	3.517E-01	6.186E+00
1.556E+09	1.729E+00	1.143E+00	3.524E-01	6.646E+00
1.667E+09	1.731E+00	1.210E+00	3.531E-01	7.103E+00
1.778E+09	1.734E+00	1.273E+00	3.539E-01	7.556E+00
1.889E+09	1.736E+00	1.333E+00	3.547E-01	8.005E+00
2.000E+09	1.739E+00	1.390E+00	3.556E-01	8.451E+00

Diode Test Circuit for Thevenin Circuit Determination AC Analysis Temperature = 27.000 Deg C

Table 9. Diode Test Circuit For The vnin Circuit Determination Case -IV.

FREQ	VM (15,16)	VP (15,16)	VM (16,17)	VP (16,17)
1.000E+09	3.438E-01	7.722E-01	8.595E-01	7.722E-01
1.111E+09	3.441E-01	8.510E-01	8.603E-01	8.510E-01
1.222E+09	3.445E-01	9.278E-01	8.612E-01	9.278E-01
1.333E+09	3.449E-01	1.002E+00	8.622E-01	1.002E+00
1.444E+09	3.453E-01	1.074E+00	8.632E-01	1.074E+00
1.556E+09	3.457E-01	1.143E+00	8.643E-01	1.143E+00
1.667E+09	3.462E-01	1.210E+00	8.655E-01	1.210E+00
1.778E+09	3.467E-01	1.273E+00	8.668E-01	1.273E+00
1.889E+09	3.473E-01	1.333E+00	8.682E-01	1.333E+00
2.000E+09	3.478E-01	1.390E+00	8.696E-01	1.390E+00

JOB CONCLUDED

Shows the Norton impedance incorporated into the network with results.
PSPICE NORTON CIRCUIT DESCRIPTION (EXAMPLE I) TO DESCRIBE A NEW CIRCUIT
**** 09/24/24 17:56:25 ***** PSpice Lite (October 2012) ****** ID# 10813 ****
Diode Test Circuit for Norton Circuit Determination (Norton short circuit current)
Description for Norton short circuit current (Figure 2)
IO1 0 1 AC 2
R12 1 2 10
C20 2 0 1PF
R20 2 0 20
V30 3 0 DC -2


```
D 7 3 DNAME
R27 2 7 1E-10
C719 7 19 1000UF
R190 19 0 1E17
V190 19 0
```

Description for Thevenin impedance by AC option (See Figure 2)

```
IO5 0 5 AC 0
R65 6 5 10
C60 6 0 2PF
R60 6 0 20
D1 6 8 DNAME
V80 8 0 DC -2
EF06 21 0 14 0 1
C718 6 18 1000UF
R180 18 0 1E17
V1821 18 21
```

Conventional method for Norton impedance of figure 2.
AC resistance of diode is incorporated value= 0.54 ohms
IT is added to Series resistance of diode value= 6 ohms

```
I09 0 9 AC 0
R910 9 10 10
C100 10 0 2PF
R100 10 0 20
R1011 10 11 1E-10
R1112 11 12 6.54
V120 12 0
V011 0 10 AC -1
```

*V(10) gives Thevenin/Norton impedance by conventional technique
An AC circuit which uses scalar multiples of Thevenin AC voltage and impedance

```
FVEAC 0 13 V190 1
R130 13 0 15
C130 13 0 0.5PF
V1314 13 14

FE1415 14 22 V1821 -1
FE1516 14 23 V1821 -0.2
FE1617 14 24 V1821 -0.5

V220 22 0
V230 23 0
V240 24 0

.MODEL DNAME D(IS=1E-14 RS=6)
.AC LIN 10 1GHZ 2GHZ
.PRINT AC VM(1) VP(1) VM(2) VP(2) IM(V011) IP(V011)
*ADD 180 DEGREES TO I(V1821) TO OBTAIN CORRECT NORTON ADMITTANCE
```

```
.PRINT AC VM(14) VP(14) IM(V1821) IP(V1821)
.PRINT AC IM(V190) IP(V190)
.PRINT AC IM(V1314) IP(V1314)
.PRINT AC IR(V1821) II(V1821) IR(V1314) II(V1314)
.PRINT AC IM(V220) IP(V220) IM(V230) IP(V230) IM(V240) IP(V240)
.OP
.end
```

**** 09/24/24 17:56:25 ****** PSpice Lite (October 2012) ****** ID# 10813 ****

Diode test circuit for Norton circuit determination (AC analysis Temperature)

Table 10. Diode model parameters.

DNAME	
IS	10.000000E-15
RS	6

Small Signal Bias Solution Temperature = 27.000 Deg C

Table-11. Diode Test Circuit For Thevnin Circuit Determination Case -V.

Node	Voltage	Node	Voltage	Node	Voltage	Node	Voltage
(1)	-.9576	(2)	-.9576	(3)	-2.0000	(5)	-.9576
(6)	-.9576	(7)	-.9576	(8)	-2.0000	(9)	0.0000
(10)	0.0000	(11)	0.0000	(12)	0.0000	(13)	0.0000
(14)	0.0000	(18)	0.0000	(19)	0.0000	(21)	0.0000
(22)	0.0000	(23)	0.0000	(24)	0.0000		

Table 12. Voltage Source Currents.

Name	Current
V30	4.788E-02
V190	0.000E+00
V80	4.788E-02
V1821	0.000E+00
V120	0.000E+00
V011	0.000E+00
V1314	0.000E+00
V220	0.000E+00
V230	0.000E+00
V240	0.000E+00

Total Power Dissipation = 1.92e-01 Watts Diode test circuit for Norton circuit determination Operating point information temperature = 27.000 deg c

Table 13. Voltage-controlled voltage sources.

Name	EF06
V-Source	0.000E+00
I-Source	0.000E+00

Table 14. Current-Controlled Current Sources.

Name	FVEAC	FE1415	FE1516	FE1617
I-SOURCE	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Table 15. Diodes.

Name	D	D1
Model	DNAME	DNAME
ID	4.79E-02	4.79E-02
VD	1.04E+00	1.04E+00
REQ	5.40E-01	5.40E-01
CAP	0.00E+00	0.00E+00

Diode Test Circuit for Norton Circuit Determination AC analysis temperature = 27.000 deg C

Table 16. Diode Test Circuit for The vnin Circuit Determination Case -VI.

FREQ	VM(1)	VP(1)	VM(2)	VP(2)	IM(V011)
1.000E+09	2.000E+01	-9.119E-07	3.183E-07	-8.996E+01	2.033E-01
1.111E+09	2.000E+01	-8.207E-07	2.865E-07	-8.996E+01	2.034E-01
1.222E+09	2.000E+01	-7.461E-07	2.604E-07	-8.996E+01	2.035E-01
1.333E+09	2.000E+01	-6.839E-07	2.387E-07	-8.995E+01	2.036E-01
1.444E+09	2.000E+01	-6.313E-07	2.204E-07	-8.995E+01	2.037E-01
1.556E+09	2.000E+01	-5.862E-07	2.046E-07	-8.994E+01	2.038E-01
1.667E+09	2.000E+01	-5.471E-07	1.910E-07	-8.994E+01	2.040E-01
1.778E+09	2.000E+01	-5.129E-07	1.791E-07	-8.994E+01	2.041E-01
1.889E+09	2.000E+01	-4.828E-07	1.685E-07	-8.993E+01	2.043E-01
2.000E+09	2.000E+01	-4.559E-07	1.592E-07	-8.993E+01	2.045E-01

Diode Test Circuit for Norton Circuit Determination AC Analysis Temperature = 27.000 DEG C

Table 17. Diode Test Circuit For Thevnin Circuit Determination Case -VII.

FREQ	IP(V011)
1.000E+09	3.544E+00
1.111E+09	3.937E+00
1.222E+09	4.329E+00
1.333E+09	4.721E+00
1.444E+09	5.112E+00
1.556E+09	5.503E+00
1.667E+09	5.893E+00
1.778E+09	6.283E+00
1.889E+09	6.672E+00
2.000E+09	7.061E+00

Diode test circuit for Norton circuit determination AC Analysis Temperature = 27.000 Deg C

Table 18. Diode Test Circuit For Thevnin Circuit Determination Case -VIII.

FREQ	VM(14)	VP(14)	IM(V1821)	IP(V1821)
1.000E+09	4.851E+00	- 3.407E+00	9.861E-01	-1.799E+02
1.111E+09	4.849E+00	- 3.785E+00	9.861E-01	-1.798E+02
1.222E+09	4.846E+00	- 4.162E+00	9.861E-01	-1.798E+02
1.333E+09	4.844E+00	-4.539E+00	9.862E-01	-1.798E+02
1.444E+09	4.841E+00	-4.915E+00	9.862E-01	-1.798E+02
1.556E+09	4.838E+00	-5.291E+00	9.863E-01	-1.798E+02
1.667E+09	4.835E+00	-5.667E+00	9.863E-01	-1.798E+02
1.778E+09	4.832E+00	-6.042E+00	9.864E-01	-1.798E+02
1.889E+09	4.829E+00	-6.416E+00	9.864E-01	-1.797E+02
2.000E+09	4.825E+00	-6.790E+00	9.865E-01	-1.797E+02

Diode Test Circuit for Norton Circuit Determination AC Analysis Temperature = 27.000 Deg C

Table 19. Diode Test Circuit for Thevenin Circuit Determination Case -IX.

FREQ	IM(V190)	IP(V190)
1.000E+09	2.000E+00	1.850E-06
1.111E+09	2.000E+00	1.665E-06
1.222E+09	2.000E+00	1.514E-06
1.333E+09	2.000E+00	1.388E-06
1.444E+09	2.000E+00	1.281E-06
1.556E+09	2.000E+00	1.189E-06
1.667E+09	2.000E+00	1.110E-06
1.778E+09	2.000E+00	1.041E-06
1.889E+09	2.000E+00	9.795E-07
2.000E+09	2.000E+00	9.250E-07

Diode Test Circuit for Norton Circuit Determination AC Analysis Temperature = 27.000 Deg C

Table 20. Diode Test Circuit For Thevnin Circuit Determination Case -X.

FREQ	IM(V1314)	IP(V1314)
1.000E+09	1.676E+00	1.369E-01
1.111E+09	1.676E+00	1.520E-01
1.222E+09	1.676E+00	1.671E-01
1.333E+09	1.676E+00	1.821E-01
1.444E+09	1.677E+00	1.970E-01
1.556E+09	1.677E+00	2.119E-01
1.667E+09	1.677E+00	2.267E-01
1.778E+09	1.677E+00	2.415E-01
1.889E+09	1.677E+00	2.562E-01
2.000E+09	1.677E+00	2.709E-01

Diode Test Circuit for Norton Circuit Determination AC Analysis Temperature = 27.000 Deg C

Table 21. Diode Test Circuit for Thevnin Circuit Determination Case -XI.

FREQ	IR(V1821)	II(V1821)	IR(V1314)	II(V1314)
1.000E+09	-9.861E-01	-2.357E-03	1.676E+00	4.006E-03
1.111E+09	-9.861E-01	-2.616E-03	1.676E+00	4.448E-03
1.222E+09	-9.861E-01	-2.875E-03	1.676E+00	4.888E-03
1.333E+09	-9.862E-01	-3.134E-03	1.676E+00	5.327E-03
1.444E+09	-9.862E-01	-3.391E-03	1.677E+00	5.765E-03
1.556E+09	-9.863E-01	-3.648E-03	1.677E+00	6.201E-03
1.667E+09	-9.863E-01	-3.903E-03	1.677E+00	6.635E-03
1.778E+09	-9.864E-01	-4.158E-03	1.677E+00	7.068E-03
1.889E+09	-9.864E-01	-4.411E-03	1.677E+00	7.499E-03
2.000E+09	-9.865E-01	-4.664E-03	1.677E+00	7.929E-03

Diode Test Circuit for Norton Circuit Determination AC Analysis Temperature = 27.000 Deg C

Table 22. Diode Test Circuit For Thevnin Circuit Determination Case -XII.

Freq	IM(V220)	IP(V220)	IM(V230)	IP(V230)	IM(V240)
1.000E+09	9.861E-01	1.369E-01	1.972E-01	1.369E-01	4.930E-01
1.111E+09	9.861E-01	1.520E-01	1.972E-01	1.520E-01	4.930E-01
1.222E+09	9.861E-01	1.671E-01	1.972E-01	1.671E-01	4.931E-01
1.333E+09	9.862E-01	1.821E-01	1.972E-01	1.821E-01	4.931E-01
1.444E+09	9.862E-01	1.970E-01	1.972E-01	1.970E-01	4.931E-01
1.556E+09	9.863E-01	2.119E-01	1.973E-01	2.119E-01	4.931E-01
1.667E+09	9.863E-01	2.267E-01	1.973E-01	2.267E-01	4.932E-01
1.778E+09	9.864E-01	2.415E-01	1.973E-01	2.415E-01	4.932E-01
1.889E+09	9.864E-01	2.562E-01	1.973E-01	2.562E-01	4.932E-01
2.000E+09	9.865E-01	2.709E-01	1.973E-01	2.709E-01	4.932E-01

Diode Test Circuit for Norton Circuit Determination AC Analysis Temperature = 27.000 Deg C

Table 23. Diode Test Circuit for Thevnin Circuit Determination Case -XIII.

Freq	IP(V240)
1.000E+09	1.369E-01
1.111E+09	1.520E-01
1.222E+09	1.671E-01
1.333E+09	1.821E-01
1.444E+09	1.970E-01
1.556E+09	2.119E-01
1.667E+09	2.267E-01
1.778E+09	2.415E-01
1.889E+09	2.562E-01
2.000E+09	2.709E-01

JOB CONCLUDED

Table III shows Thevenin impedance incorporated into a network with different bias applied to the diode.

TABLE III Pspice Thevenin circuit description (example 3) to describe a new circuit

```
**** 09/24/24 18:13:45 ****** PSpice Lite (October 2012) ****** ID# 10813 ****

Diode Test Circuit for Norton Circuit Determination (Open Circuit Voltage)
Figure 3 Description for Thevenin Open Circuit Voltage
IO1 0 1 AC 2
R12 1 2 10
C20 2 0 1PF
R20 2 0 20
V30 3 21 DC -2
R210 21 0 10
D 7 3 DNAME
R27 2 7 0.000001
C719 7 19 1000UF
R190 19 0 1E15

*Figure 3 description for thevenin impedance by AC option
IO5 0 5 AC 0
R65 6 5 10
C60 6 0 2PF
R60 6 0 20
D1 6 8 DNAME
V80 8 22 DC -2
R220 22 0 10
F06 0 18 V1314 1
C718 6 18 1000UF
R180 18 0 1E14

*Conventional Method for Thevenin Impedance of Figure 2
AC Resistance of Diode is incorporated value= 0.54 ohms
IT is added to Series resistance of diode value= 6 ohms
I09 0 9 AC 0
R910 9 10 10
C100 10 0 2PF
R100 10 0 20
```

```
R1011 10 11 0.000001
R1112 11 23 6.743
R230 23 0 10
V120 12 0
I011 0 10 AC 1
```

V(10) gives Thevenin/Norton impedance by conventional technique
An AC circuit which uses scalar multiples of Thevenin AC voltage and impedance

```
EAC 13 0 19 0 1
R130 13 0 20
C130 13 0 1PF
V1314 13 20
R1420 14 20 0.0000001
E1415 14 15 18 0 1
E1516 15 16 18 0 0.2
E1617 16 17 18 0 0.5
R170 17 0 20
C170 17 0 1PF

.MODEL DNAME D(IS=1E-14 RS=6)
.AC LIN 10 1GHZ 2GHZ

.PRINT AC VM(1) VP(1) VM(2) VP(2) VM(10) VP(10)
.PRINT AC VM(14,15) VP(14,15) IM(V1314) IP(V1314)
.PRINT AC VM(15,16) VP(15,16) vM(16,17) VP(16,17)
.OP
.end
```

Diode Test Circuit for Norton Circuit Determination

Table 24. Diode Model Parameters.

DNAME	
IS	10.000000E-15
RS	6

Diode Test Circuit for Norton Circuit Determination Small Signal Bias Solution Temperature = 27.000 Deg C

Table-25. Diode Test Circuit For Thevnin Circuit Determination Case-XIV.

Node	Voltage	Node	Voltage	Node	Voltage	Node	Voltage
(1)	-.6962	(2)	-.6962	(3)	-1.6519	(5)	-.6962
(6)	-.6962	(7)	-.6962	(8)	-1.6519	(9)	0.0000
(10)	0.0000	(11)	0.0000	(12)	0.0000	(13)	0.0000
(14)	0.0000	(15)	0.0000	(16)	0.0000	(17)	0.0000
(18)	0.0000	(19)	0.0000	(20)	0.0000	(21)	.3481
(22)	.3481	(23)	0.0000				

Table 26. Voltage Source Currents.

Name	Current
V30	3.481E-02
V80	3.481E-02
V120	0.000E+00
V131	0.000E+00

TOTAL POWER DISSIPATION 1.39E-01 WATTS Diode Test Circuit for Norton Circuit Determination Operating Point Information Temperature = 27.000 Deg C

Table 27. Voltage-Controlled Voltage Sources.

Name	EAC	E1415	E1516	E1617
V-SOURCE	0.000E+00	0.000E+00	0.000E+00	0.000E+00
I-SOURCE	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Table 28. Current-Controlled Current Sources.

Name	F06
I-SOURCE	0.000E+00

Table 29.

Name	D	D1
Model	DNAME	DNAME
ID	3.48E-02	3.48E-02
VD	9.56E-01	9.56E-01
REQ	7.43E-01	7.43E-01
CAP	0.00E+00	0.00E+00

Diode Test Circuit for Norton Circuit Determination AC Analysis Temperature = 27.000 Deg C.

Table 30. Diode Test Circuit For Thevnin Circuit Determination Case-XV.

FREQ	VM(1)	VP(1)	VM(2)	VP(2)	VM(10)
1.000E+09	3.818E+01	-1.561E+00	1.820E+01	-3.277E+00	9.054E+00
1.111E+09	3.817E+01	-1.734E+00	1.819E+01	-3.641E+00	9.041E+00
1.222E+09	3.816E+01	-1.906E+00	1.818E+01	-4.003E+00	9.026E+00
1.333E+09	3.815E+01	-2.079E+00	1.817E+01	-4.366E+00	9.009E+00
1.444E+09	3.813E+01	-2.250E+00	1.817E+01	-4.728E+00	8.991E+00
1.556E+09	3.812E+01	-2.422E+00	1.816E+01	-5.090E+00	8.972E+00
1.667E+09	3.810E+01	-2.593E+00	1.814E+01	-5.452E+00	8.952E+00
1.778E+09	3.808E+01	-2.764E+00	1.813E+01	-5.813E+00	8.930E+00
1.889E+09	3.807E+01	-2.934E+00	1.812E+01	-6.173E+00	8.908E+00
2.000E+09	3.805E+01	-3.104E+00	1.811E+01	-6.533E+00	8.884E+00

Diode Test Circuit for Norton Circuit Determination AC Analysis Temperature = 27.000 Deg C.

Table 31. Diode Test Circuit For Thevenin Circuit Determination Case -XVI.

FREQ	VP(10)
1.000E+09	-6.533E+00
1.111E+09	-7.252E+00
1.222E+09	-7.968E+00
1.333E+09	-8.682E+00
1.444E+09	-9.393E+00
1.556E+09	-1.010E+01
1.667E+09	-1.081E+01
1.778E+09	-1.151E+01
1.889E+09	-1.221E+01
2.000E+09	-1.290E+01

Diode Test Circuit for Norton Circuit Determination AC Analysis Temperature = 27.000 Deg C

Table 32. Diode Test Circuit For Thevnin Circuit Determination Case -XVII.

FREQ	VM(14,15)	VP(14,15)	IM(V1314)	IP(V1314)
1.000E+09	4.676E+00	-2.923E+00	5.164E-01	3.610E+00
1.111E+09	4.675E+00	-3.248E+00	5.171E-01	4.004E+00
1.222E+09	4.674E+00	-3.574E+00	5.179E-01	4.395E+00

1.333E+09	4.673E+00	-3.899E+00	5.187E-01	4.783E+00
1.444E+09	4.672E+00	-4.225E+00	5.196E-01	5.168E+00
1.556E+09	4.670E+00	-4.550E+00	5.205E-01	5.551E+00
1.667E+09	4.669E+00	-4.876E+00	5.215E-01	5.930E+00
1.778E+09	4.667E+00	-5.202E+00	5.226E-01	6.306E+00
1.889E+09	4.665E+00	-5.528E+00	5.237E-01	6.678E+00
2.000E+09	4.663E+00	-5.855E+00	5.249E-01	7.046E+00

Diode Test Circuit for Norton Circuit Determination AC Analysis Temperature = 27.000 Deg C

Table 33. Diode Test Circuit for Thevnin Circuit Determination Case -XVIII.

FREQ	VM (15,16)	VP (15,16)	VM (16,17)	VP (16,17)
1.000E+09	9.352E-01	-2.923E+00	2.338E+00	-2.923E+00
1.111E+09	9.350E-01	-3.248E+00	2.338E+00	-3.248E+00
1.222E+09	9.348E-01	-3.574E+00	2.337E+00	-3.574E+00
1.333E+09	9.346E-01	-3.899E+00	2.336E+00	-3.899E+00
1.444E+09	9.343E-01	-4.225E+00	2.336E+00	-4.225E+00
1.556E+09	9.340E-01	-4.550E+00	2.335E+00	-4.550E+00
1.667E+09	9.337E-01	-4.876E+00	2.334E+00	-4.876E+00
1.778E+09	9.334E-01	-5.202E+00	2.333E+00	-5.202E+00
1.889E+09	9.330E-01	-5.528E+00	2.333E+00	-5.528E+00
2.000E+09	9.327E-01	-5.855E+00	2.332E+00	-5.855E+00

Table shows Norton impedance realization into the network by different bias applied to the diode
TABLE PSPICE NORTON CIRCUIT DESCRIPTION (EXAMPLE 3) TO DESCRIBE A NEW CIRCUIT
Diode Test Circuit for Norton Circuit Determination
Circuit Description
*Figure 3 (See) Description for Norton Short Circuit Current
IO1 0 1 AC 2
R12 1 2 10
C20 2 0 1PF
R20 2 0 20
V30 3 25 DC -2
R250 25 0 10
D 7 3 DNAME
R27 2 7 1E-10
C719 7 19 1000UF
R190 19 0 1E17
V190 19 0

Figure 3 Description for Thevenin Impedance by AC Option
IO5 0 5 AC 0
R65 6 5 10
C60 6 0 2PF
R60 6 0 20
D1 6 8 DNAME
V80 8 26 DC -2
R260 26 0 10
EF06 21 0 14 0 1
C718 6 18 1000UF
R180 18 0 1E17


```
V1821 18 21

Conventional method for Norton Impedance of figure 3
AC Resistance of Diode is incorporated value=0.743 ohms
IT is added to Series resistance of diode value= 6 ohms
I09 0 9 AC 0
R910 9 10 10
C100 10 0 2PF
R100 10 0 20
R1011 10 11 1E-10
R1112 11 27 6.743
R270 27 0 10
V120 12 0
V011 0 10 AC -1

V(10) gives Thevenin/Norton impedance by conventional technique

An AC Circuit Which Uses Scalar Multiples of Thevenin AC Voltage and Impedance
FVEAC 0 13 V190 1
R130 13 0 15
C130 13 0 0.5PF
V1314 13 14
FE1415 14 22 V1821 -1
FE1516 14 23 V1821 -0.2
FE1617 14 24 V1821 -0.5
V220 22 0
V230 23 0
V240 24 0
.MODEL DNAME D(IS=1E-14 RS=6)
.AC LIN 10 1GHZ 2GHZ
.PRINT AC VM(1) VP(1) VM(2) VP(2) IM(V011) IP(V011)
Add 180 Degrees to I(V1821) to obtain correct Norton Admittance
.PRINT AC VM(14) VP(14) IM(V1821) IP(V1821)
.PRINT AC IM(V190) IP(V190)
.PRINT AC IM(V1314) IP(V1314)

.PRINT AC IR(V1821) II(V1821) IR(V1314) II(V1314)

.PRINT AC IM(V220) IP(V220) IM(V230) IP(V230) IM(V240) IP(V240)
.OP
.end
```

Diode Test Circuit for Norton Circuit Determination

Diode Model Parameters

DNAME	
IS	10.000000E-15
RS	6

Small Signal Bias Solution Temperature = 27.000 Deg C

In Table 34, nodes 1, 2, 6, and 7 exhibit a voltage of −0.6962 V−0.6962V, while node 22 has a voltage of 0.3481 V0.3481V.

Table 34. Diode Test Circuit For Thevnin Circuit Determination Case -XIX.

Node	Voltage	Node	Voltage	Node	Voltage	Node	Voltage
(1)	-.6962	(2)	-.6962	(3)	-1.6519	(5)	-.6962
(6)	-.6962	(7)	-.6962	(8)	-1.6519	(9)	0.0000
(10)	0.0000	(11)	0.0000	(12)	0.0000	(13)	0.0000
(14)	0.0000	(15)	0.0000	(16)	0.0000	(17)	0.0000
(18)	0.0000	(19)	0.0000	(20)	0.0000	(21)	.3481
(22)	.3481	(23)	0.0000				

In Table 35 V30, V80 has a current of 3.481E-02 & 3.481E-02., while another voltage sources have a current of 0.000E+00.

Table 35. Voltage Source Currents.

Name	Current
V30	3.481E-02
V190	0.000E+00
V80	3.481E-02
V1821	0.000E+00
V120	0.000E+00
V011	0.000E+00
V1314	0.000E+00
V1314	0.000E+00
V220	0.000E+00
V230	0.000E+00
V240	0.000E+00

TOTAL POWER DISSIPATION 1.39E-01 WATTS

The PSpice simulation results are presented in Table 36, detailing the diode's performance under test conditions. The measured diode current was 3.48m Awith a forward voltage of 0.956V and an equivalent resistance of 0.743Ω

Table 36. The PSpice simulation Results.

**** 09/24/24 18:31:17 ****** PSpice Lite (October 2012) ****** ID# 10813 ****
DIODE TEST CIRCUIT FOR NORTON CIRCUIT DETERMINATION
**** OPERATING POINT INFORMATION TEMPERATURE = 27.000 DEG C
****
**** VOLTAGE-CONTROLLED VOLTAGE SOURCES
NAME EF06
V-SOURCE 0.000E+00
I-SOURCE 0.000E+00
**** CURRENT-CONTROLLED CURRENT SOURCES
NAME FVEAC FE1415 FE1516 FE1617
I-SOURCE 0.000E+00 0.000E+00 0.000E+00 0.000E+00
**** DIODES
NAME D D1
MODEL DNAME DNAME
ID 3.48E-02 3.48E-02
VD 9.56E-01 9.56E-01
REQ 7.43E-01 7.43E-01
CAP 0.00E+00 0.00E+00
**** 09/24/24 18:31:17 ****** PSpice Lite (October 2012) ****** ID# 10813 ****
DIODE TEST CIRCUIT FOR NORTON CIRCUIT DETERMINATION
**** AC ANALYSIS TEMPERATURE = 27.000 DEG C
****

FREQ VM(1) VP(1) VM(2) VP(2) IM(V011)
1.000E+09 2.000E+01 -9.119E-07 3.183E-07 -8.996E+01 1.104E-01
1.111E+09 2.000E+01 -8.207E-07 2.865E-07 -8.996E+01 1.106E-01
1.222E+09 2.000E+01 -7.461E-07 2.604E-07 -8.996E+01 1.108E-01
1.333E+09 2.000E+01 -6.839E-07 2.387E-07 -8.995E+01 1.110E-01
1.444E+09 2.000E+01 -6.313E-07 2.204E-07 -8.995E+01 1.112E-01
1.556E+09 2.000E+01 -5.862E-07 2.046E-07 -8.994E+01 1.115E-01
1.667E+09 2.000E+01 -5.471E-07 1.910E-07 -8.994E+01 1.117E-01
1.778E+09 2.000E+01 -5.129E-07 1.791E-07 -8.994E+01 1.120E-01
1.889E+09 2.000E+01 -4.828E-07 1.685E-07 -8.993E+01 1.123E-01
2.000E+09 2.000E+01 -4.559E-07 1.592E-07 -8.993E+01 1.126E-01
**** 09/24/24 18:31:17 ****** PSpice Lite (October 2012) ****** ID# 10813 ***
DIODE TEST CIRCUIT FOR NORTON CIRCUIT DETERMINATION
**** AC ANALYSIS TEMPERATURE = 27.000 DEG C
****
FREQ IP(V011)
1.000E+09 6.533E+00
1.111E+09 7.252E+00
1.222E+09 7.968E+00
1.333E+09 8.682E+00
1.444E+09 9.393E+00
1.556E+09 1.010E+01
1.667E+09 1.081E+01
1.778E+09 1.151E+01
1.889E+09 1.221E+01
2.000E+09 1.290E+01
**** 09/24/24 18:31:17 ****** PSpice Lite (October 2012) ****** ID# 10813 ****
DIODE TEST CIRCUIT FOR NORTON CIRCUIT DETERMINATION
**** AC ANALYSIS TEMPERATURE = 27.000 DEG C
****
FREQ VM(14) VP(14) IM(V1821) IP(V1821)
1.000E+09 7.862E+00 -5.528E+00 8.683E-01 -1.790E+02
1.111E+09 7.854E+00 -6.138E+00 8.687E-01 -1.789E+02
1.222E+09 7.844E+00 -6.746E+00 8.691E-01 -1.788E+02
1.333E+09 7.834E+00 -7.353E+00 8.695E-01 -1.787E+02
1.444E+09 7.823E+00 -7.958E+00 8.700E-01 -1.786E+02
1.556E+09 7.811E+00 -8.561E+00 8.705E-01 -1.785E+02
1.667E+09 7.798E+00 -9.163E+00 8.711E-01 -1.784E+02
1.778E+09 7.784E+00 -9.762E+00 8.717E-01 -1.783E+02
1.889E+09 7.770E+00 -1.036E+01 8.723E-01 -1.782E+02
2.000E+09 7.755E+00 -1.095E+01 8.730E-01 -1.781E+02
**** 09/24/24 18:31:17 ****** PSpice Lite (October 2012) ****** ID# 10813 ****
DIODE TEST CIRCUIT FOR NORTON CIRCUIT DETERMINATION
**** AC ANALYSIS TEMPERATURE = 27.000 DEG C
****

FREQ	IM(V190)	IP(V190)		
1.000E+09	2.000E+00	1.001E-06		
1.111E+09	2.000E+00	9.005E-07		
1.222E+09	2.000E+00	8.186E-07		
1.333E+09	2.000E+00	7.504E-07		
1.444E+09	2.000E+00	6.927E-07		
1.556E+09	2.000E+00	6.432E-07		
1.667E+09	2.000E+00	6.003E-07		
1.778E+09	2.000E+00	5.628E-07		
1.889E+09	2.000E+00	5.296E-07		
2.000E+09	2.000E+00	5.002E-07		
**** 09/24/24 18:31:17 ****** PSpice Lite (October 2012) ****** ID# 10813 ****				
DIODE TEST CIRCUIT FOR NORTON CIRCUIT DETERMINATION				
**** AC ANALYSIS TEMPERATURE = 27.000 DEG C				
**				
FREQ	IM(V1314)	IP(V1314)		
1.000E+09	1.476E+00	1.006E+00		
1.111E+09	1.477E+00	1.114E+00		
1.222E+09	1.477E+00	1.222E+00		
1.333E+09	1.478E+00	1.329E+00		
1.444E+09	1.479E+00	1.435E+00		
1.556E+09	1.480E+00	1.540E+00		
1.667E+09	1.481E+00	1.644E+00		
1.778E+09	1.482E+00	1.746E+00		
1.889E+09	1.483E+00	1.847E+00		
2.000E+09	1.484E+00	1.947E+00		
**** 09/24/24 18:31:17 ****** PSpice Lite (October 2012) ****** ID# 10813 ****				
DIODE TEST CIRCUIT FOR NORTON CIRCUIT DETERMINATION				
**** AC ANALYSIS TEMPERATURE = 27.000 DEG C				
**				
FREQ	IR(V1821)	II(V1821)	IR(V1314)	II(V1314)
1.000E+09	-8.682E-01	-1.524E-02	1.476E+00	2.591E-02
1.111E+09	-8.685E-01	-1.689E-02	1.477E+00	2.872E-02
1.222E+09	-8.689E-01	-1.854E-02	1.477E+00	3.152E-02
1.333E+09	-8.693E-01	-2.017E-02	1.478E+00	3.429E-02
1.444E+09	-8.698E-01	-2.179E-02	1.479E+00	3.704E-02
1.556E+09	-8.702E-01	-2.340E-02	1.479E+00	3.977E-02
1.667E+09	-8.707E-01	-2.498E-02	1.480E+00	4.247E-02
1.778E+09	-8.713E-01	-2.656E-02	1.481E+00	4.515E-02
1.889E+09	-8.719E-01	-2.811E-02	1.482E+00	4.779E-02
2.000E+09	-8.725E-01	-2.965E-02	1.483E+00	5.041E-02
**** 09/24/24 18:31:17 ****** PSpice Lite (October 2012) ****** ID# 10813 ****				
DIODE TEST CIRCUIT FOR NORTON CIRCUIT DETERMINATION				
**** AC ANALYSIS TEMPERATURE = 27.000 DEG C				
**				

FREQ	IM(V220)	IP(V220)	IM(V230)	IP(V230)	IM(V240)
1.000E+09	8.683E-01	1.006E+00	1.737E-01	1.006E+00	4.342E-01
1.111E+09	8.687E-01	1.114E+00	1.737E-01	1.114E+00	4.343E-01
1.222E+09	8.691E-01	1.222E+00	1.738E-01	1.222E+00	4.346E-01
1.333E+09	8.695E-01	1.329E+00	1.739E-01	1.329E+00	4.348E-01
1.444E+09	8.700E-01	1.435E+00	1.740E-01	1.435E+00	4.350E-01
1.556E+09	8.705E-01	1.540E+00	1.741E-01	1.540E+00	4.353E-01
1.667E+09	8.711E-01	1.644E+00	1.742E-01	1.644E+00	4.356E-01
1.778E+09	8.717E-01	1.746E+00	1.743E-01	1.746E+00	4.358E-01
1.889E+09	8.723E-01	1.847E+00	1.745E-01	1.847E+00	4.362E-01
2.000E+09	8.730E-01	1.947E+00	1.746E-01	1.947E+00	4.365E-01
**** 09/24/24 18:31:17 ****** PSpice Lite (October 2012) ****** ID# 10813 ****					
DIODE TEST CIRCUIT FOR NORTON CIRCUIT DETERMINATION					
**** AC ANALYSIS TEMPERATURE = 27.000 DEG C					
**					
FREQ	IP(V240)				
1.000E+09	1.006E+00				
1.111E+09	1.114E+00				
1.222E+09	1.222E+00				
1.333E+09	1.329E+00				
1.444E+09	1.435E+00				
1.556E+09	1.540E+00				
1.667E+09	1.644E+00				
1.778E+09	1.746E+00				
1.889E+09	1.847E+00				
2.000E+09	1.947E+00				
JOB CONCLUDED					

CONCLUSIONS

In Table I, the Thevenin equivalent parameters, (Figure 2) are described and implemented in a different network. Both the Figure 2 and a new circuit using (Thevenin voltage, three scalar multiples of Thevenin impedance) are described here. Table II describes Norton equivalent parameters of Figure 2 implemented in a different circuit (scalar multiples of Norton admittance). The scalar multiple values are 1, 0.2, 0.5, respectively in both the cases. Table III and IV describe another example (figure 3) where bias (with same scalar multiples) of the diode is changed. Here also in two different networks the Thevenin/Norton scalar multiple equivalents are implemented.

Different circuits with independent sources and linear (non-linear) circuit elements are broken into two separate portions for the Thevenin/Norton equivalent circuit parameters and are evaluated/obtained. The Thevenin/Norton equivalent circuit parameters thus obtained are used (as it is or scalar multiples) in other networks by Spice compatible techniques. This approach (method of solving presented) would also serve as a useful exercise for tutorial sessions in electrical circuits with simulation tools.

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