A two port network biology essay

A two-port network a kind of four-terminal network or quadripole is an electrical network circuit or device with two pairs of terminals to connect to external circuits. Two terminals constitute a port if the currents applied to them satisfy the essential requirement known as the port condition: the electric current entering one terminal must equal the current emerging from the other. The ports constitute interfaces where the network connects to other networks, the points where signals are applied or outputs are taken. In a two-port network, often port 1 is considered the input port and port 2 is considered the output port.

The two-port network model is used in mathematical circuit analysis techniques to isolate portions of larger circuits. A two-port network is regarded as a " black box" with its properties specified by a matrix of numbers. This allows the response of the network to signals applied to the ports to be calculated easily, without solving for all the internal voltages and currents in the network. It also allows similar circuits or devices to be compared easily. For example, transistors are often regarded as two-ports, characterized by their h-parameters (see below) which are listed by the manufacturer. Any linear circuit with four terminals can be regarded as a two-port network provided that it does not contain an independent source and satisfies the port conditions.

Examples of circuits analysed as two-ports are filters, matching networks, transmission lines, transformers, and small-signal models for transistors (such as the hybrid-pi model). The analysis of passive two-port networks is an outgrowth of reciprocity theorems first derived by Lorentz. In two-port mathematical models, the network is described by a 2 by 2 square

matrix of complex numbers. The common models that are used are referred to as z-parameters, y-parameters, h-parameters, g-parameters, and ABCD-parameters, each described individually below. These are all limited to linear networks since an underlying assumption of their derivation is that any given circuit condition is a linear superposition of various short-circuit and open circuit conditions. They are usually expressed in matrix notation, and they establish relations between the variables" (Two-Port Networks. (n. d.).
In Wikipedia. Retrieved October 25, 20012, from http://en. wikipedia. org/wiki/Two-port_network)

The experiment is divided into two parts: Part 1 is focused on determining two-port network parameters (admittance and transmission parameters only). The process of measurement and calculations will be briefly illustrated in Theoretical Supplement part. We are aiming to investigate the relationships between the individual parameters and the parameters of two-port networks in cascade and parallel. Part 2 is focused on finding out the transient responses in two-port networks containing capacitive and inductive reactances.

Theoretical Supplements:

Measurement of Admittance (Y-) Parameters:

The equations to determine the parameters are:

I1 = y11V1 + y12V2

I2 = y21V1 + y22V2

i. e. [I] = [Y].[V]

[Y] =

y11 y12

y21 y22

where

are the Y parameters of the two-port network. Experimentally these parameters can be determined by short circuiting the ports, one at a time. Hence these parameters are also termed as short-circuit admittance parameters.

The following diagrams show the method to calculate the parameters:

When output port is shorted (as shown in Figure 2 below):

V2 = 0. 1

Figure 2

y11 = I1 / V1

y21 = I2 / V1

When input port is shorted (as shown in Figure 3 below):

V1 = 0

2

Figure3

y12 = I1 / V2

y22 = I2 / V2

Measurement of Transmission Parameters:

The equations to determine the parameters are:

V1 = AV2 – BI2

I1 = CV2 – DI2

Or3

Where [t] is the transmission parameters of the two-port network.

Experimentally, the t-parameters can be obtained by short circuiting and open circuiting the output one at a time.

The following procedure shows how to calculate the parameters:

Output port is open-circuited:

i. e. I2 = 0

4

Figure4

A = V1 / V2

C = I1 / V2

Output port is short-circuited:

i. e. V2 = 0

1

Figure5

B = – V1 / I2

D = – I1 / I2

Cascade Interconnection of two 2-port Networks:

Considering the 2 networks A and B which are connected in cascade, as shown in Figure 6 below. From this the transmission parameters of the combined cascaded network (N) is obtained. The method is demonstrated below.

5

Figure 6

[t]N = [t]A.[t]B

7

Hence, the following result is obtained.

8

Parallel Interconnection of two 2-Port Networks:

Considering the two networks A and B which connected in parallel, as shown in Figure 7 below. The overall y-parameters of the combined network N can be obtained as follows:

6

Figure 7

I1 = I1A + I1B

I2 = I2A + I2B

V1 = V1A = V1B

V2 = V2A = V2B;

And

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It can be seen that the overall Y-parameters can be obtained by summing the corresponding Y-parameters of individual networks A and B, when the A and B networks are not altered by the parallel connection.

Transient Responses of Two-Port Networks:

Damping Ratio 🚹 º is defined as the ratio of the actual resistance in damped harmonic motion to that necessary to produce critical damping. It is also known as relative damping ratio. We divide the transient responses into three types on the basis of damping ratio 🚹 º,

Over damped response (🚹 º > 1),

Under damped response (🚹 º < 1) and

Critically damped response (🚹 º = 1).

The various conditions stated above are described in detail below.

Over damped Response: In this case the roots of the characteristic equation are real and distinct. The solution to the input signal is a decaying exponential function with no oscillations and the transient response will be over damped. The response to the input signal is slow and has no overshoots or undershoots.

Under damped: The roots are complex in this case. The transient response will be under damped when 🚹º <1. In this case the solution is a decaying exponential function which has an oscillatory portion in between. Overshoots and undershoots will be produced.

Critically damped: When 🚹º = 1, the roots are real and equal, and the transient response to the input signal will be critically damped. There will be no oscillations whatsoever. This case is a desirable outcome in many industries.

In this experiment, we are mainly using the second type, which is the under damped response.

And the characteristic equation is given by:

S2 + 2🚹ºÏ‰nS + Ï‰n2

where

Ï‰n = undamped natural frequency = 1/âˆš(LC)

Ï‰n âˆš (1 – 🚹º2) = damped natural frequency

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º = damping ratio =

Further critical details have been illustrated in the Appendix B of Laboratory manual of Experiment L212.

Objectives:

To measure the admittance-parameters and transmission parameters of two-port network

To investigate the relationships between individual network parameters and two-port networks in cascade and parallel connections

To study the transient response of a two-port network containing capacitive and inductive reactances.

Equipment:

Digital Storage Oscilloscope

Function Generator (50Î©)

Digital Multimeter

Inductor with 2 inductance steps

Capacitors: 22Î¼F, 100Î¼F

Resistors: 33Î©, 100Î© (2 numbers), 220Î©, 330Î©, 560Î©, 680Î©, 3. 9kÎ©, 4. 7kÎ© (2 numbers), 5. 6kÎ©, 6. 8kÎ©

Bread-board

Procedure:

Measurement of Admittance-Parameters and Transmission Parameters and to investigate the relationships between individual network parameters and two port networks in cascade and parallel connections

Setup A

Connect the resistive network A as shown in Figure 8 below.

With the network connected in the circuit, apply a sinusoidal voltage of 1 kHz, and amplitude 10 volts from peak to peak at:

Port 1 with port 2 open-circuited

Port 1 with port 2 short-circuited

Port 2 with port 1 short-circuited

In each case measure the voltage and current at the input and output terminals

The input voltage is measured by observing the peak to peak value on the scope of the oscilloscope while the output voltage is measured with the digital meter.

Tabulate the results in Table 1. (all the values measured should be in rms)

Figure 8: The resistive network A{DA60CACE-9B44-4522-A111-F57AC9F95897}

Setup B:

Connect the resistive network as shown in the Figure 9 below.

With the network connected in the circuit, apply an identical sinusoidal voltage as in Setup A at:

Port 1 with port 2 open-circuited

Port 1 with port 2 short-circuited

Port 2 with port 1 short-circuited

Measure the identical reading as in Setup A in the same way.

Tabulate the results in the same Table 1.{0536D217-3D48-4F28-B37B-77F1CB823EEA}

Figure 9: The Resistive Network B

Cascaded Setup:

Connect the networks A and B in cascade as shown in the Figure 10 below.

Measure the identical parameters with the identical voltage and applying the voltage at the same positions as was done in the previous two setups A & B.

Tabulate the readings in Table 1 again.{32E83E0D-6633-4D97-A59B-4374AF22F541}

Figure 10: The Cascaded Network of Networks A & B

Parallel Setup:

Reconnect the individual networks A & B in parallel as shown in Figure 12 below.

Repeat the same procedures above with the same voltage as above to this network.

Tabulate the readings in Table 1.{591F8FFC-7083-4E49-88AD-96E019FAD63C}

Figure 12: The Parallel Network of Networks A & B

Table 1: (All values in rms)

Results

I2 = 0

V2 = 0

V1 = 0

I1 (mA)

V1 (V)

V2 (V)

I1 (mA)

I2 (mA)

V1 (V)

I1 (mA)

I2 (mA)

V2 (V)

Network A

(measured)

2. 38

3. 45

2. 52

5. 09

3. 82

3. 45

4. 00

5. 65

3. 46

Network B

(measured)

0. 72

3. 49

3. 22

3. 27

2. 82

3. 45

2. 89

3. 18

3. 45

Cascaded

(measured)

2. 66

3. 47

2. 07

3. 42

1. 31

3. 44

Parallel

(measured)

13. 28

11. 59

3. 46

10. 34

12. 55

3. 46

Questions:

The voltages V1 and V2 should not be connected to channel 1 and 2 of the scope simultaneously. Why?

It can be observed from the circuit that both the ports V1 and V2 have different grounds. If V1 and V2 are connected simultaneously to channel 1 and 2 of oscilloscope respectively, then the ground terminals of V1 and V2 will be short-circuited as they are connected through the oscilloscope. This would change the circuit's configuration and would give us the readings for a completely different circuit which would differ a great deal from the accurate values.

What should you do to the readings of peak to peak voltage in order to make them compatible with the currents measured by the digital meter?

The relationship between peak to peak values and its respective rms values is:

peak to peak voltage = 2 x âˆš2 x rms voltage

The current measured by the digital meter is in root-mean-square value (rms). So it is mandatory to convert the peak to peak voltages to its rms value in order to be compatible with the currents measured by the digital meter. Hence the peak to peak value is divided by 2 x âˆš2 to so that it is compatible with the currents measured by the digital meter.

Compare the theoretical results with the measurement readings recorded in Table 1 for the interconnected two-port networks. Explain any of the differences in the two sets of results.

Two kinds of parameters' values are calculated and shown in Table 2 and Table 3. With this parameter values we can compare the difference in values of the measurement and theoretical readings.

The parameter values in Table 2 shown below are defined as

When the output-port is open, $I2 = 0$

Then:

$A = V1 / V2$

$C = I1/V2$

When the output port is shorted, $V2 = 0$

Hence:

$B = V1/I2$

$D = I1/I2$

And Cascade (theoretical) is obtained by [t]N = [t]A . [t]B

Transmission parameters

A

B

C

D

Network A

(measured)

1. 36

677. 80

0. 00094

1. 33

Network B

(measured)

1. 08

1223. 40

0. 00022

1. 16

Cascade

(theoretical) (Network A

*****

Network B)

1. 62

2450. 07

0. 0013

2. 69

Cascade

(measured)

1. 68

2625. 95

0. 00129

2. 61

Percentage difference between cascade (measured) and (theoretical)

3. 70%

6. 69%

0. 78%

3. 07%

Table 2

As it can be seen from the Table 2 above that there are slight differences between the theoretical and experimental results of the transmission parameters of the individual network and the interconnected two-port networks. The difference is observed due to the experimental human errors, tolerance levels of resistors in networks and slight deviation due to the slight inaccuracy of equipment.

The parameter values in Table 3 shown below are defined as

When the output port is shorted, V2 = 0. Then:

y11 = I1 /V1

y21 = I2/V1

When the input port is shorted, V1= 0. Then:

y12 = I1/V2

y22 = I2/V2

And Parallel (theoretical) is obtained by Network A values + Network B values

Table 3: Admittance Parameters

Admittance parameters

y11

y12

y21

y22

Network A

(measured)

0. 00148

0. 00156

0. 00107

0. 00163

Network B

(measured)

0. 00095

0. 00084

0. 00082

0. 00092

Parallel (theoretical)

(Network A

+

Network B)

0. 00243

0. 00240

0. 00189

0. 00255

Parallel

(measured)

0. 00384

0. 00299

0. 00335

0. 00363

Percentage difference between Parallel

(measured) and Parallel (theoretical)

36. 72%

19. 73%

43. 58%

29. 75%

From Table 3, it can be observed that the difference between experimental and theoretical admittance parameters are quite large. The large difference is due to the same experimental errors and small tolerance of resistors or the existing voltage drop of the multimeter.

Measurement of Transient Response of Two-Port Networks:

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Figure 13

Connect the circuit as shown in the Figure 13 above with C = 22 F

Using a storage scope and with the inductor setting at position 1, inject 10V peak to peak square wave at V1. Choose frequency f of the input voltage such that the square wave's leading edge simulate a step input with the transient response completed before the next voltage change. The frequency f is chosen to be about 4 Hz.

Record the output waveform V2 with the storage oscilloscope. Sketch the waveforms and when the waveforms have been captured, use the oscilloscope cursor to measure the oscillation period T and the voltages Va and Vb as shown in the Figure 14 below.

The waveform is shown in Figure i) below.

{71B3E9F8-C513-4F5A-9441-0C73C0A0C9B8}

V1 – Input Voltage V2 – Output Voltage

Tin – Input signal period T – Transient Oscillation

Va / Vb – Transient Oscillation Voltage Ratio Period

Figure 14

Repeat the above procedure for the inductor setting at position 2. The waveform is shown as in Figure ii) below.

Repeat the procedure for the two inductor settings with the capacitor changed to 100Î¼F. The waveforms are show as Figure iii) and iv) below respectively.

Add a resistor R2 of 33 Î© in series with inductor L as shown in Figure 15 below and select the inductor setting at position 1 with the capacitor = 100 Î¼F. The waveform is shown as in Figure v) below.

Repeat all the procedures with R2 values of 100 Î© and 220 Î©. The waveform with R2 as 100 Î© is shown in Figure vi) below.

All measurements are recorded in Table 4 below. H: DropboxCamera Uploads2012-10-25 06. 12. 32. jpg

Figure 15

Figure a

Figure b

Figure c

Figure d

Figure e

Figure f

Figure g

Condition

C= 22Î¼F

L = 1H

C= 22Î¼F

L = 200mH

C= 100Î¼F

L = 1H

C= 100Î¼F

L = 200mH

C= 100Î¼F

L = 1H and add R2= 33Î©

C= 100Î¼F

L = 1H and add R2= 100Î©

C= 100Î¼F

L = 1H and add R2= 220Î©

T(ms)

48. 0

19. 0

38. 5

94. 5

80. 20

Period = 253. 0

Î” t1 = 130. 0

Î” t2 = 46. 00

V2 = 2. 531

Va(v)

3. 00

1. 46

0. 791

1. 80

1. 687

1. 250

Vb(v)

0. 633

0. 700

0. 408

0. 516

0. 3750

0. 5000

Table 4

Waveform Figures:

L: AAADS0001. BMP

Figure i)

L: AAADS0003. BMP

Figure ii)

L: AAADS0006. BMP

Figure iii)

Figure iv)L: AAADS0007. BMP

L: AAADS0008. BMP

Figure v)

Figure vi)

L: AAADS0009. BMP

Questions:

Why are square waves at a higher frequency not used as input?

Square waves at higher frequencies are not used as input because frequency is related to time period by the relationship f = 1/T. So as the frequency is increased, the time period will become shorter and shorter. So it will take shorter time for the output power levels to stabilize after the input circuit stops drawing power. Hence the waveform obtained from the oscilloscope will not be clear enough for proper distinction.

What causes the step input voltage to become an oscillating output voltage?

The oscillating output voltage is caused due to the presence of the two reactive elements in the circuit, the inductor and the capacitor. The effect of charging and discharging of the capacitor and inductor causes the output to become an oscillating voltage.

What are the effects of increasing the values of L and C?

The undamped natural frequency Ï‰n equals to 1/âˆš(LC). If the values of L and C are increased, the undamped natural frequency will reduce simultaneously. Hence the oscillations will become more damped. Thus the number of output oscillations will reduce.

Calculate the theoretical frequencies of oscillation and compare with the experimental results.

The theoretical frequency is given by the relation ft = 1/ (2 ðŸ° âˆš(LC)) Hz and the oscillation frequency is given by the relation f = 1/T. Using this relation we can tabulate the values.

Figure a

Figure b

Figure c

Figure d

T(ms)

48. 0

19. 0

38. 5

94. 5

1/T(Hz)

20. 83

52. 63

25. 97

10. 58

ft (Hz)

33. 93

75. 87

35. 59

15. 92

Percentage difference

38. 60%

30. 63%

27. 03%

33. 54%

The difference in the values is caused by the tolerance levels of the reactive elements used in the circuit i. e. the inductor and the capacitor.

Consider the circuit shown in Figure 13. Obtain the expression for the damping ratio of the circuit.{A484D667-ABED-4193-B38C-40120C378004}

Damping Ratio is given by the formula, ɸº =

The natural undamped frequency is given by the relation Ï‰n = 1/âˆš (LC). Since

R2 = 0, R1 = 330 â„¦ and R3 = 100 â„¦, deriving the damping ratio of the circuit as shown in Figure 13, the result is:

🚺º = âˆš(L/C)/860.

Obtain the condition for the underdamped response in Figure 13.

From the derived result obtained above, 🚺º = âˆš(L/C)/860. For an underdamped response, the damping ratio, Î¾, should be less than 1, thus âˆš(L/C)/860 < 1, which gives the condition for the underdamped response in Figure 13 as âˆš(L/C) < 860.

What is the effect of adding resistance R2 in the LC circuit?

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According to the formula of damping ratio 🚺º =

When R2 is added, the total value of 🚺º increases. Depending on the value of R2, 🚺º < = 1and as a result the total number of overshoots and undershoots will reduce. Thus it will increase the speed of system response. If 🚺º > 1, even if the number of undershoots and overshoots is reduced, the response will be slower.

Conclusion:

The parameters of the two-port network, especially the Y-parameters and Transmission parameters (A, B, C, D) were determined experimentally. They can also be calculated theoretically. This experiment is aimed at comparing the differences between the experimental and theoretical values. The relationship between individual network parameters and two-port networks in cascade and parallel connections were also investigated. The results obtained for these were shown in the calculations in the Questions answered previously. Hence if every individual parameter of the networks can be determined, the parameter of the combined system can be determined.

Part 2 was focused on studying the transient responses of the experiment. The responses to the change of values in the RLC circuit in the two-port networks were recorded. By varying the values of the capacitor, resistor and inductor, it was observed that increase in the capacitor and inductor values decrease the oscillating frequency and also reduce the number of undershoots and overshoots in the response signal. By adding a resistor in series with the inductor, it was observed that the resistor increases the damping ratio of the circuit but the effect is still dependent on the final damping ratio of the circuit, 🚹º.

To summarize the conclusion, all the objectives as stated earlier were met in course of the experiment and a lot of important observations came to light in the area of two-port networks.