Performance-based assessments for network analysis competencies

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The purpose of these assessments is for instructors to accurately measure the learning of their electronics students, in a way that melds theoretical knowledge with hands-on application. In each assessment, students are asked to predict the behavior of a circuit from a schematic diagram and component values, then they build that circuit and measure its real behavior. If the behavior matches the predictions, the student then simulates the circuit on computer and presents the three sets of values to the instructor. If not, then the student then must correct the error(s) and once again compare measurements to predictions. Grades are based on the number of attempts required before all predictions match their respective measurements.

You will notice that no component values are given in this worksheet. The *instructor* chooses component values suitable for the students' parts collections, and ideally chooses different values for each student so that no two students are analyzing and building the exact same circuit. These component values may be hand-written on the assessment sheet, printed on a separate page, or incorporated into the document by editing the graphic image.

This is the procedure I envision for managing such assessments:

1. The instructor hands out individualized assessment sheets to each student.
2. Each student predicts their circuit's behavior at their desks using pencil, paper, and calculator (if appropriate).
3. Each student builds their circuit at their desk, under such conditions that it is impossible for them to verify their predictions using test equipment. Usually this will mean the use of a multimeter only (for measuring component values), but in some cases even the use of a multimeter would not be appropriate.
4. When ready, each student brings their predictions and completed circuit up to the instructor's desk, where any necessary test equipment is already set up to operate and test the circuit. There, the student sets up their circuit and takes measurements to compare with predictions.
5. If any measurement fails to match its corresponding prediction, the student goes back to their own desk with their circuit and their predictions in hand. There, the student tries to figure out where the error is and how to correct it.
6. Students repeat these steps as many times as necessary to achieve correlation between all predictions and measurements. The instructor's task is to count the number of attempts necessary to achieve this, which will become the basis for a percentage grade.
7. (OPTIONAL) As a final verification, each student simulates the same circuit on computer, using circuit simulation software (Spice, Multisim, etc.) and presenting the results to the instructor as a final pass/fail check.

These assessments more closely mimic real-world work conditions than traditional written exams:

- Students cannot pass such assessments only knowing circuit theory or only having hands-on construction and testing skills – they must be proficient at both.
- Students do not receive the "authoritative answers" from the instructor. Rather, they learn to validate their answers through real circuit measurements.
- Just as on the job, the work isn't complete until *all errors* are corrected.
- Students must recognize and correct their own errors, rather than having someone else do it for them.
- Students must be fully prepared on exam days, bringing not only their calculator and notes, but also their tools, breadboard, and circuit components.

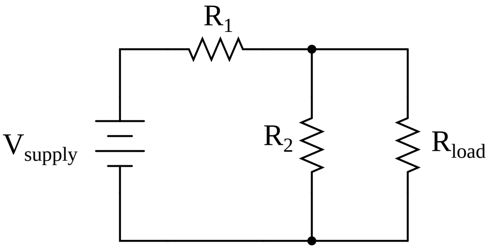
Instructors may elect to reveal the assessments before test day, and even use them as preparatory labwork and/or discussion questions. Remember that there is absolutely nothing wrong with "teaching to the test" *so long as the test is valid*. Normally, it is bad to reveal test material in detail prior to test day, lest students merely memorize responses in advance. With performance-based assessments, however, there is no way to pass without truly understanding the subject(s).

Question 1

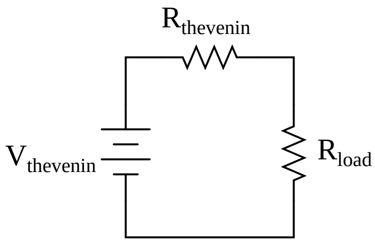
Competency: **Thevenin's theorem** Version:

Schematic

Original circuit



Thevenin equivalent circuit



Given conditions

V_{supply} = R_1 = R_2 = R_{load} =

Parameters

	Predicted
$V_{thevenin}$	
$R_{thevenin}$	

	Measured (in original circuit)	Measured (in Thevenin equivalent circuit)
V_{load}		

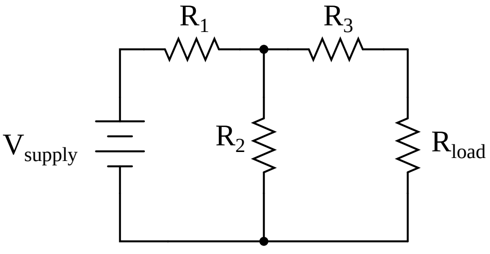
file 03225

Question 2

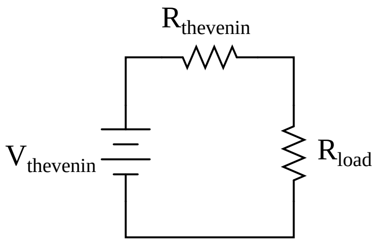
Competency: **Thevenin's theorem** Version:

Schematic

Original circuit



Thevenin equivalent circuit



Given conditions

V_{supply} =

R_1 =

R_2 =

R_3 =

R_{load} =

Parameters

Predicted

$V_{thevenin}$

$R_{thevenin}$

Measured (in original circuit)

Measured (in Thevenin equivalent circuit)

V_{load}

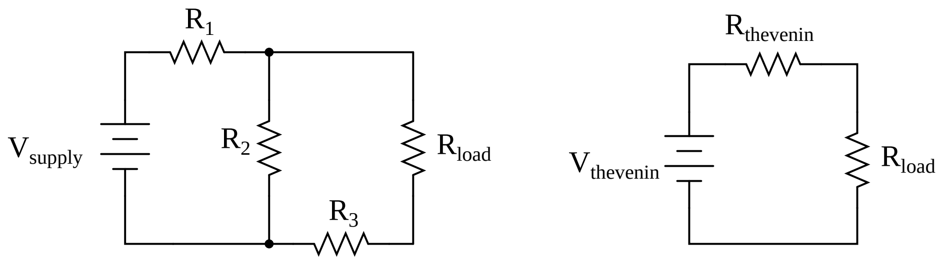
file 03469

Question 3

Competency: **Thevenin's theorem** Version:

Schematic

Original circuit *Thevenin equivalent circuit*



Given conditions

V_{supply} =

R_1 =

R_2 =

R_3 =

R_{load} =

Parameters

Predicted

$V_{thevenin}$

$R_{thevenin}$

Measured (in original circuit)

Measured (in Thevenin equivalent circuit)

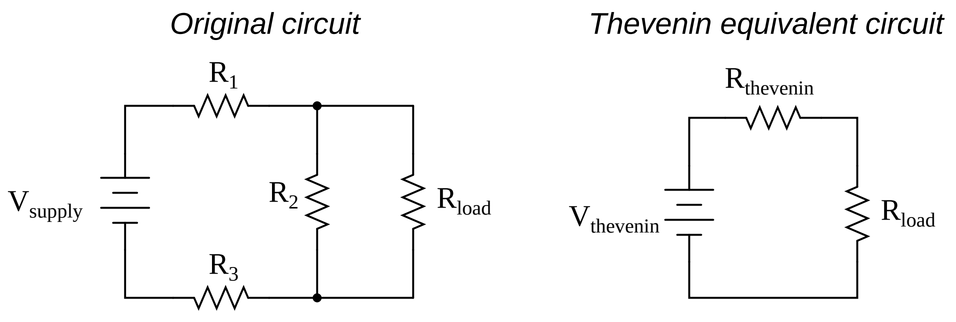
V_{load}

file 03471

Question 4

Competency: **Thevenin's theorem** Version:

Schematic



Given conditions

V_{supply} =

R_1 = R_2 =

R_3 = R_{load} =

Parameters

	Predicted
$V_{thevenin}$	
$R_{thevenin}$	

	Measured (in original circuit)	Measured (in Thevenin equivalent circuit)
V_{load}		

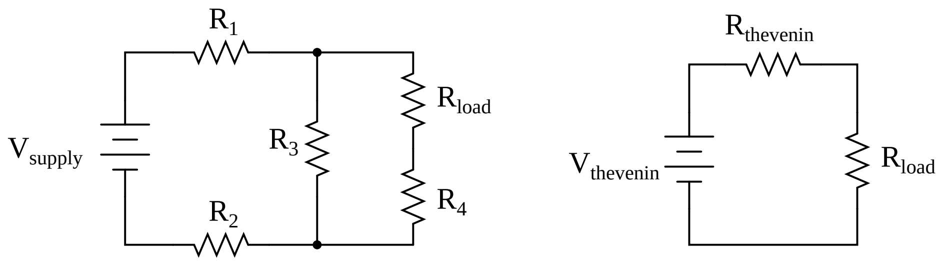
file 03470

Question 5

Competency: **Thevenin's theorem** Version:

Schematic

Original circuit *Thevenin equivalent circuit*



Given conditions

V_{supply} =

R_1 =

R_2 =

R_3 =

R_4 =

R_{load} =

Parameters

	Predicted
$V_{thevenin}$	
$R_{thevenin}$	

	Measured (in original circuit)	Measured (in Thevenin equivalent circuit)
V_{load}		

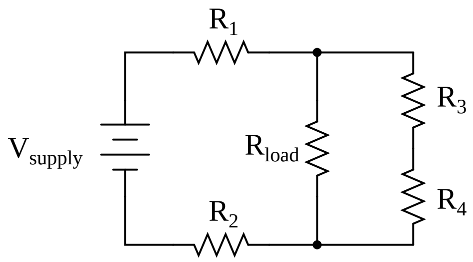
file 01933

Question 6

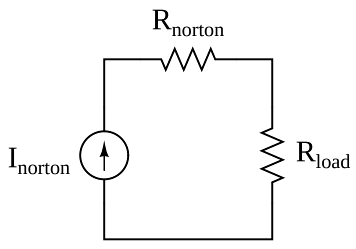
Competency: **Norton's theorem** Version:

Schematic

Original circuit



Norton equivalent circuit



Given conditions

V_{supply} =

R_1 = R_2 =

R_3 = R_4 =

R_{load} =

Parameters

Predicted

I_{norton}

$R_{thevenin}$

	Measured (in original circuit)	Measured (in Norton equivalent)
V_{load}		

file 01934

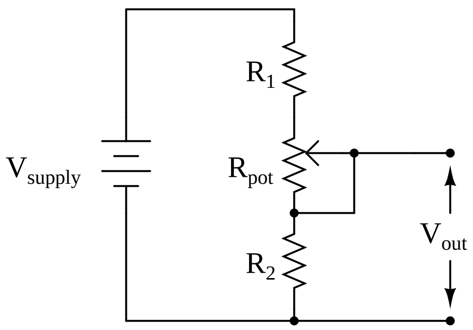
Question 7

Competency: **Voltage divider with limited range** Version:

Description

Use simultaneous equations to calculate values for resistors R_1 and R_2 that will limit the range of voltage adjustment to the specified minimum and maximum values.

Schematic



Given conditions

V_{supply} =

R_{pot} =

V_{out} (max) =

V_{out} (min) =

Parameters

	Calculated		Measured
R_1		V_{out} (min)	
R_2		V_{out} (max)	

Equations

file 03108

Answers

Answer 1

Use circuit simulation software to verify your predicted and measured parameter values.

Answer 2

Use circuit simulation software to verify your predicted and measured parameter values.

Answer 3

Use circuit simulation software to verify your predicted and measured parameter values.

Answer 4

Use circuit simulation software to verify your predicted and measured parameter values.

Answer 5

Use circuit simulation software to verify your predicted and measured parameter values.

Answer 6

Use circuit simulation software to verify your predicted and measured parameter values.

Answer 7

Use circuit simulation software to verify your predicted and measured parameter values.

Notes

Notes 1

Use a variable-voltage, regulated power supply for $V_{thevenin}$, and a fixed-voltage supply for V_{source}. Specify standard resistor values, all between 1 kΩ and 100 kΩ (1k5, 2k2, 2k7, 3k3, 4k7, 5k1, 6k8, 10k, 22k, 33k, 39k 47k, 68k, etc.) for resistors in the original circuit. A decade box or potentiometer will suffice for $R_{thevenin}$.

In case it is not already crystal-clear, I want students to build *two different circuits* for this exercise: the ”original” circuit and also a ”Thevenin equivalent” circuit, then plug the exact same load resistor into both circuits (one at a time) to see that the voltage across it is the same in both cases. Many students seem to struggle with the basic concept of equivalent circuits, and I have found this exercise (once successfully completed) to be excellent for ”making it real” to these students.

An extension of this exercise is to incorporate troubleshooting questions. Whether using this exercise as a performance assessment or simply as a concept-building lab, you might want to follow up your students' results by asking them to predict the consequences of certain circuit faults.

Notes 2

Use a variable-voltage, regulated power supply for $V_{thevenin}$, and a fixed-voltage supply for V_{source}. Specify standard resistor values, all between 1 kΩ and 100 kΩ (1k5, 2k2, 2k7, 3k3, 4k7, 5k1, 6k8, 10k, 22k, 33k, 39k 47k, 68k, etc.) for resistors in the original circuit. A decade box or potentiometer will suffice for $R_{thevenin}$.

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Notes 3

Use a variable-voltage, regulated power supply for $V_{thevenin}$, and a fixed-voltage supply for V_{source}. Specify standard resistor values, all between 1 kΩ and 100 kΩ (1k5, 2k2, 2k7, 3k3, 4k7, 5k1, 6k8, 10k, 22k, 33k, 39k 47k, 68k, etc.) for resistors in the original circuit. A decade box or potentiometer will suffice for $R_{thevenin}$.

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Notes 4

Use a variable-voltage, regulated power supply for $V_{thevenin}$, and a fixed-voltage supply for V_{source}. Specify standard resistor values, all between 1 kΩ and 100 kΩ (1k5, 2k2, 2k7, 3k3, 4k7, 5k1, 6k8, 10k, 22k, 33k, 39k 47k, 68k, etc.) for resistors in the original circuit. A decade box or potentiometer will suffice for $R_{thevenin}$.

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Notes 5

Use a variable-voltage, regulated power supply for $V_{thevenin}$, and a fixed-voltage supply for V_{source}. Specify standard resistor values, all between 1 kΩ and 100 kΩ (1k5, 2k2, 2k7, 3k3, 4k7, 5k1, 6k8, 10k, 22k, 33k, 39k 47k, 68k, etc.) for resistors in the original circuit. A decade box or potentiometer will suffice for $R_{thevenin}$.

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An extension of this exercise is to incorporate troubleshooting questions. Whether using this exercise as a performance assessment or simply as a concept-building lab, you might want to follow up your students' results by asking them to predict the consequences of certain circuit faults.

Notes 6

Use a variable-voltage, regulated power supply for I_{norton}, and a fixed-voltage supply for V_{source}. Specify standard resistor values, all between 1 kΩ and 100 kΩ (1k5, 2k2, 2k7, 3k3, 4k7, 5k1, 6k8, 10k, 22k, 33k, 39k 47k, 68k, etc.) for resistors in the original circuit. A decade box or potentiometer will suffice for R_{norton}.

An extension of this exercise is to incorporate troubleshooting questions. Whether using this exercise as a performance assessment or simply as a concept-building lab, you might want to follow up your students' results by asking them to predict the consequences of certain circuit faults.

Notes 7

The purpose of this exercise is for students to use simultaneous equations to arrive at values for fixed resistors R_1 and R_2 that will limit output voltage adjustment to the limits specified.

An extension of this exercise is to incorporate troubleshooting questions. Whether using this exercise as a performance assessment or simply as a concept-building lab, you might want to follow up your students' results by asking them to predict the consequences of certain circuit faults.