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2

4

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Lecture 5

- Series and Parallel Resistors
- Voltage and Current Divider
- Ammeters and Voltmeters
- Series and Parallel Capacitors
- 2-Capacitor Circuit
- Useful insights and tips to avoid dumb mistakes





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Correct if nothing else connected to nodes

because R_5 removes condition of resistors in series $I_3 \neq I$

MEASURING CURRENT

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To measure current in a circuit, insert DMM (in current mode) into circuit, in series with measured element.

But ammeters change the circuit. Ammeters are characterized by their "ammeter input resistance," R_{in}. Ideally this should be very low. Typical value 1Ω .



11

9

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12

10

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MEASURING CURRENT Potential measurement error due to non-zero input resistance: Imeas 🔸 ammeter Rı Rı ∣ ≩ R_{in} R_2 [≷] R₂ undisturbed circuit with ammeter $I = \frac{V}{R_1 + R_2} \qquad I_{meas} = \frac{V}{R_1 + R_2 + R_{in}}$ Example: V = 1 V, $R_1 = R_2 = 500 \Omega$, $R_{in} = 1\Omega$ $I = \frac{1V}{500\Omega + 500\Omega} = 1$ mA, $I_{meas} = \frac{1V}{500\Omega + 500\Omega + 1\Omega} \cong 0.999$ mA ₁₃ EECS 40 Spring 2003 Lecture 5 Copyright, Regents University of California S. Ross and W. G. Oldham EECS 40 Spring 2003 Lecture 5 S. Ross and W. G. Oldham Copyright, Regents University of California PARALLEL ELEMENTS KVL tells us that any set of elements which are connected at both ends carry the same voltage. We say these elements are in parallel. KVL clockwise. start at top: + + Vb - Va = 0Va Vb Va = Vb

15

16

14

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RESISTORS IN PARALLEL

Resistors in parallel can be made into one equivalent resistor



- Voltage over R_{eq} is the sum of the voltages over the original resistors
- For resistors in parallel:
 - Current through ${\rm R}_{\rm eq}$ is equal to the sum of the currents through each of the original resistors
 - Voltage over $R_{\rm eq}$ is equal to the voltage over the original resistors (all have same voltage)

18

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CURRENT DIVIDER

There is a simple equation for the way current splits between two parallel resistors: \mathbf{x}



21

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22

REAL VOLTMETERS

How is voltage measured? Digital multimeter (DMM) in parallel with measured element.

Connecting a real voltmeter across two nodes changes the circuit. The voltmeter may be modeled by an ideal voltmeter (open circuit) in parallel with a resistance: "voltmeter input resistance," R_{in} . Typical value: 10 M Ω



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REAL VOLTMETERS



