Al-Anbar University
College of engineering
Electrical Engineering Department

fundamental of Electric Circuit 1
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Stage 1
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LECTURE 04
SERIES AND PARALLEL CONNECTIONS
EQUIVALENT RESISTANCE-CONDUCTANCE

Topics

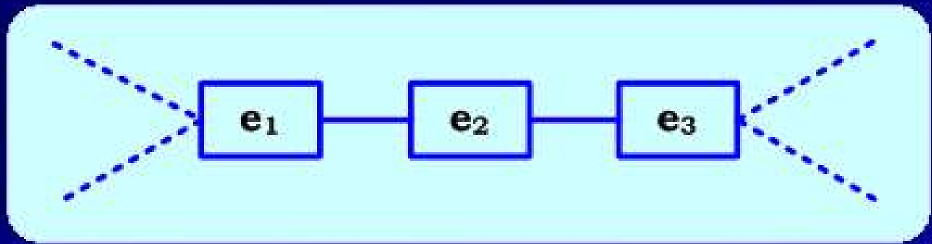
- Series connection
- Parallel connection
- Equivalent resistance
- Conductance
- Power absorbed by a resistor

Objectives

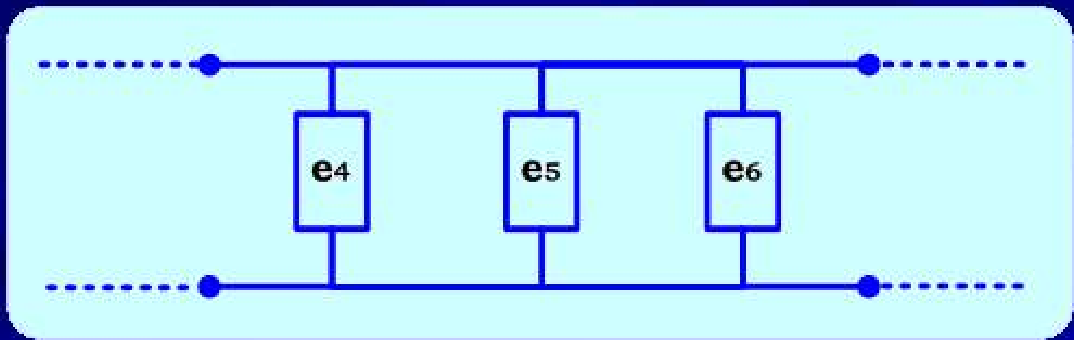
- Recognize series connections
- Recognize parallel connections
- Understand the meaning of series and parallel connections
- Calculate the equivalent resistance
- Relate conductance to resistance
- Understand power absorption by a resistor

Series and Parallel Connections

The electric elements e_1, e_2 *and* e_3 are connected in series



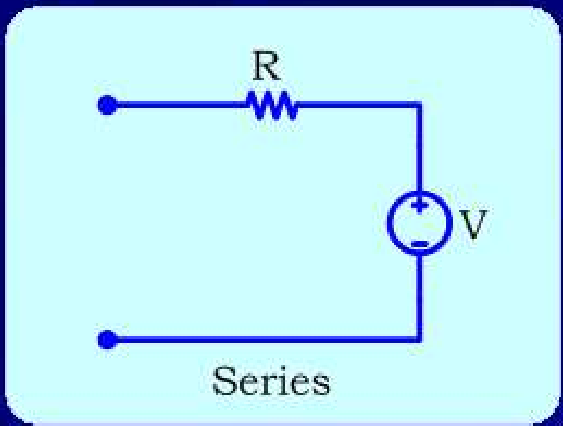
The electric elements e_4, e_5 *and* e_6 are connected in parallel

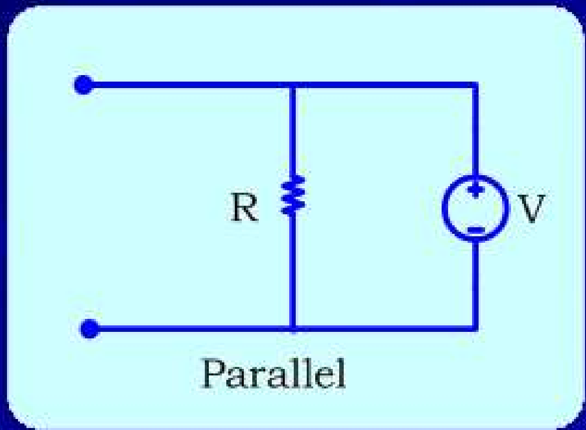


Example

Any two terminal electric element can be connected in series or in parallel to *any other* element

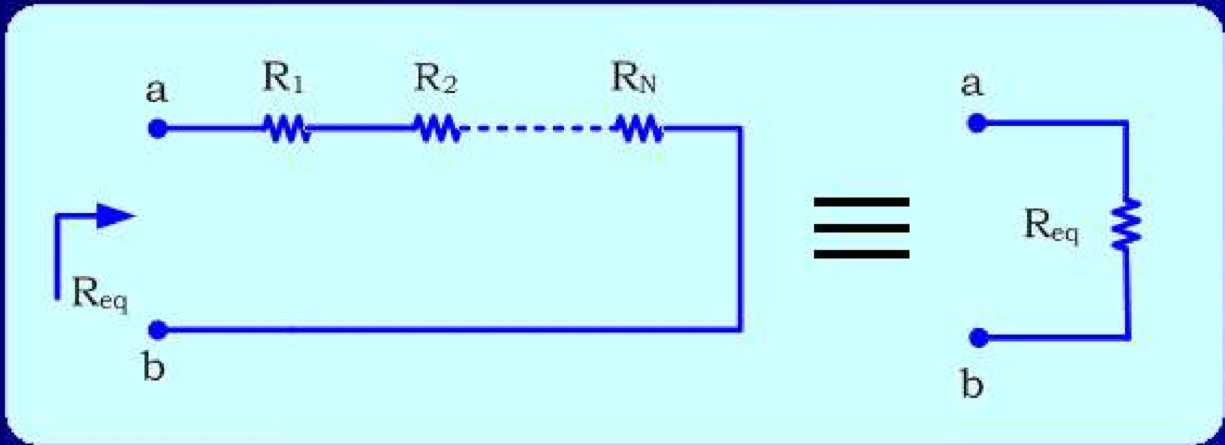
For example, a voltage source can be connected in series or in parallel to a resistor





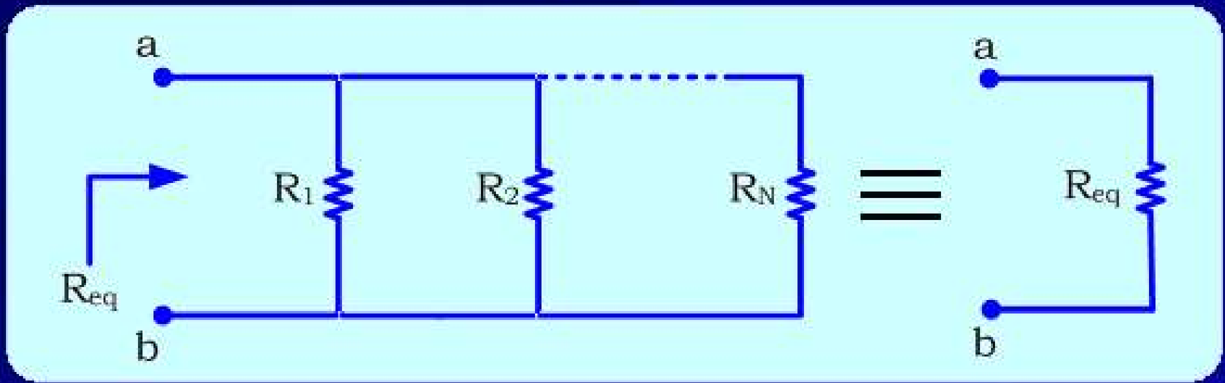
Equivalent Resistance of N Resistors in Series

$$R_{eq} = R_1 + R_2 + \ldots + R_N = \sum_{i=1}^{N} R_i$$



Equivalent Resistance of N Resistors in Parallel

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots + \frac{1}{R_N} = \sum_{i=1}^{N} \frac{1}{R_i}$$

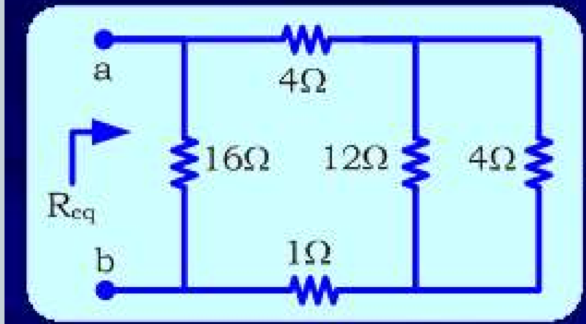


Special Case: If two resistors R_1 and R_2 are in parallel

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{R_1 + R_2}{R_1 R_2} \Rightarrow R_{eq} = \frac{R_1 R_2}{R_1 + R_2} \Rightarrow R_{eq} = \frac{\text{Product}}{\text{Sum}}$$

Example 1

Calculate the equivalent resistance seen to the right of a-b



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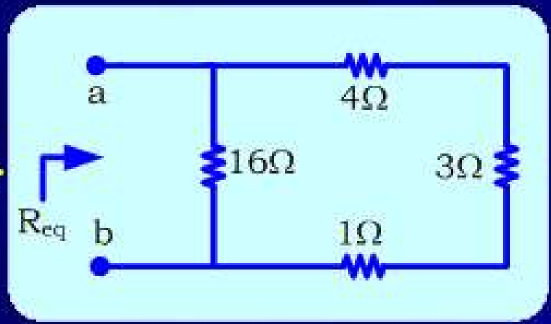

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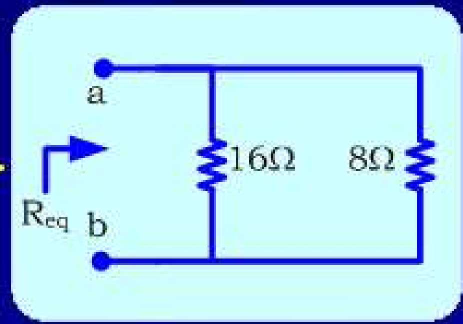


12Ω and 4Ω in parallel

$$\frac{12\times 4}{12+4}=\frac{48}{16}=3\Omega$$

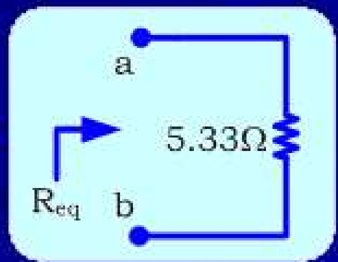
4Ω, 3Ω and 1Ω in series

$$4+3+1=8\Omega$$

16Ω and 8Ω in parallel

$$\frac{16\times 8}{16+8}=\frac{16\times 8}{24}=\frac{16}{3}=5.33\Omega$$

⇒



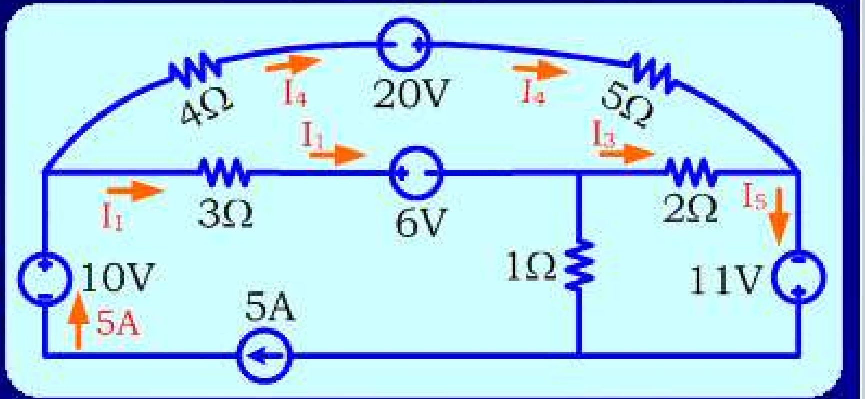
$$\therefore R_{eq}=5.33\Omega$$

Series and Parallel Connections

Why?

(a) 3Ω and 6V source are in series
10V and 5A sources are in series
4Ω, 20V source and 5Ω are in series

(b) 6V source and 2Ω are not in series
2Ω and 11V source are not in series



Solution

(a) 3Ω and 6V are in series ⟹ the *same current* I_1 passes through them
10V and 5A sources are in series ⟹ the *same current* 5A passes through them
4Ω, 20V source and 5Ω are in series ⟹ the *same current* I_4 passes through them

(b) 6V source and 2Ω are not in series ⟹ *different* currents I_1 and I_3 passes through them
2Ω and 11V source are not in series ⟹ *different* currents I_3 and I_5 passes through them

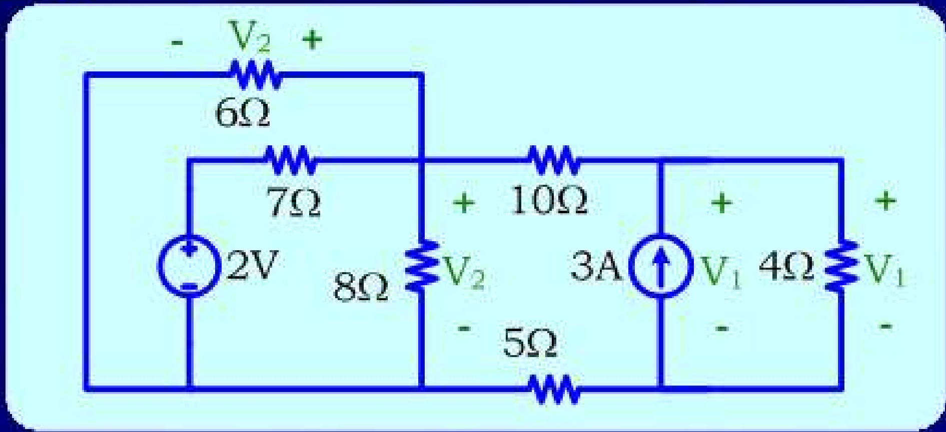
Series and Parallel Connections

3A source and 4Ω are in parallel

6Ω and 8Ω are in parallel

2V source and 8Ω are not in parallel

Why?



Solution

the *same voltage* V_1 appears across 3A and 4Ω ⇒ they are in parallel

the *same voltage* V_2 appears across 6Ω and 8Ω ⇒ they are in parallel

different voltages appear across 2V and 8Ω ⇒ they are not in parallel

Conductance

The conductance *G* of a resistor is the reciprocal of the resistance R

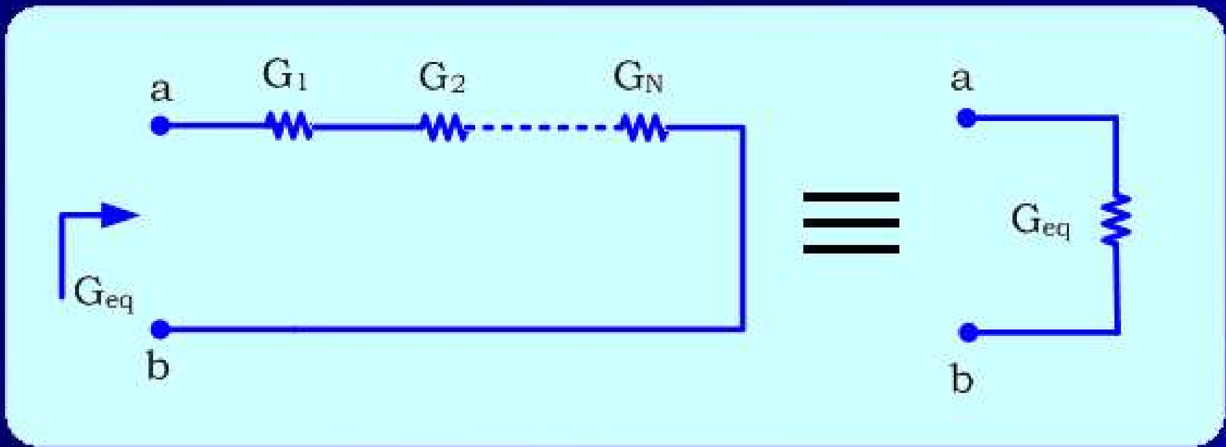
$$G = \frac{1}{R}$$

Unit of G is $\frac{1}{\Omega}$ or *Siemens* $[S]$ $\Rightarrow$ $\frac{1}{\Omega} \equiv S$

Conductance

N conductances in series

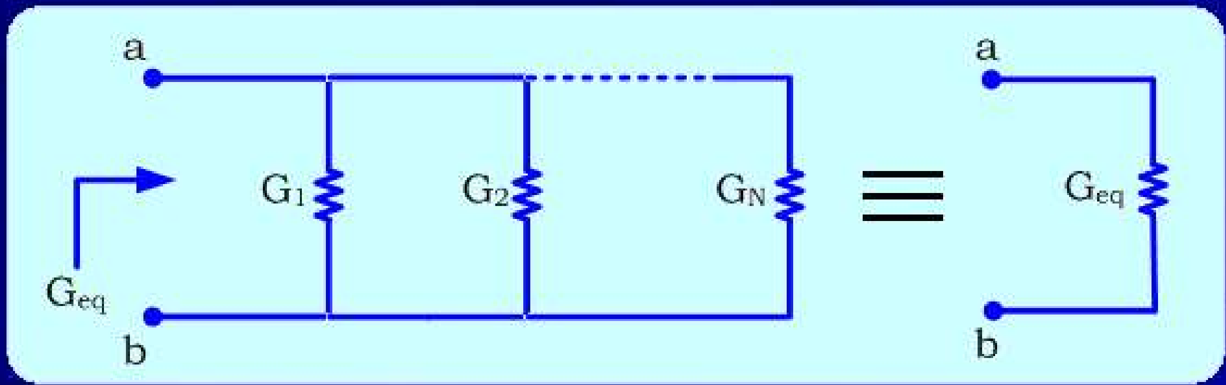
$$\frac{1}{G_{eq}} = \frac{1}{G_1} + \frac{1}{G_2} + \ldots + \frac{1}{G_N} = \sum_{i=1}^{N} \frac{1}{G_i}$$



Conductance

N conductances in parallel

$$G_{eq} = G_1 + G_2 + \ldots + G_N = \sum_{i=1}^{N} G_i$$



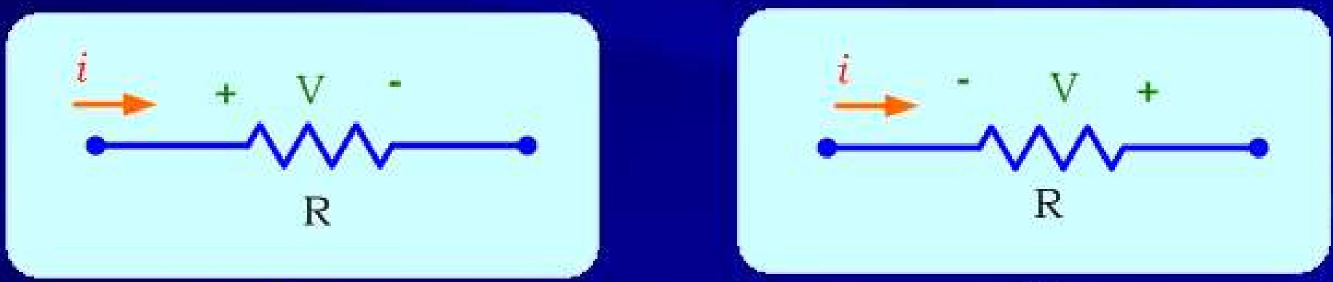
Power Absorbed by a Resistor

Using circuit (a) $p_R = +iv = +i(iR) = i^2R = \frac{v^2}{R}$

Using circuit (b) $p_R = -iv = -i(-iR) = i^2R = \frac{v^2}{R}$

$\therefore p_R = \frac{v^2}{R} = i^2R$ (regardless of the direction of i and polarity of v)

$\therefore p_R \geq 0 \Longrightarrow$ a resistor does not generate electric power, it always absorbs it



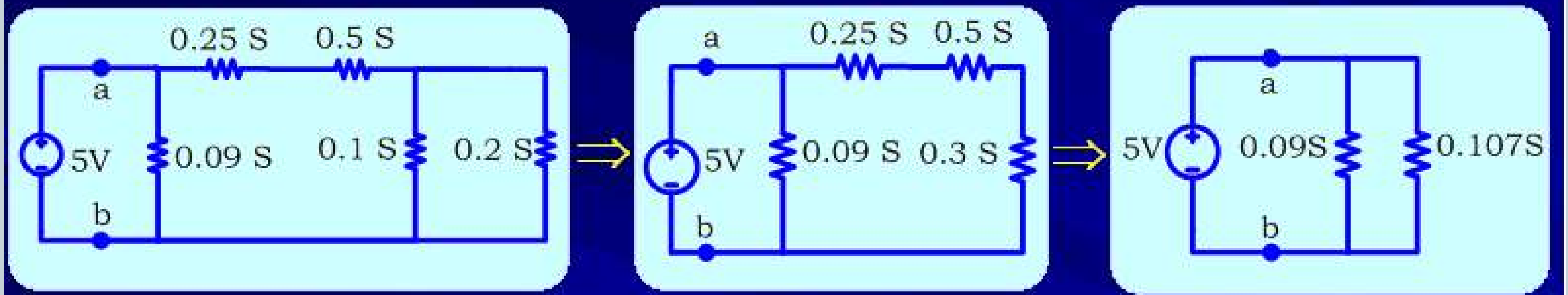
(a) (b)

Example 2

In the given circuit calculate

(a) Geq seen by the voltage source

(b) Req (c) the power absorbed by the load



(a) 0.1S and 0.2S in parallel

$$0.1+0.2=0.3S$$

0.25S, 0.5S, 0.3S in series

$$\frac{1}{0.25}+\frac{1}{0.5}+\frac{1}{0.3}=4+2+3.33=9.33$$

$$\Rightarrow \frac{1}{9.33}=0.107S$$

0.107 & 0.09 in parallel

$$0.107+0.09=0.197S$$

$$\therefore G_{eq}=0.197S$$

(b) $R_{eq}=\dfrac{1}{Geq}=\dfrac{1}{0.197}=5.08\Omega$

(c) $p_{5.08\Omega}=\dfrac{v^2}{R}=\dfrac{(5)^2}{5.08}=4.97W$

Example 3

Calculate

(a) the power absorbed by the 3Ω resistor

(b) the equivalent resistance seen by the 10V source

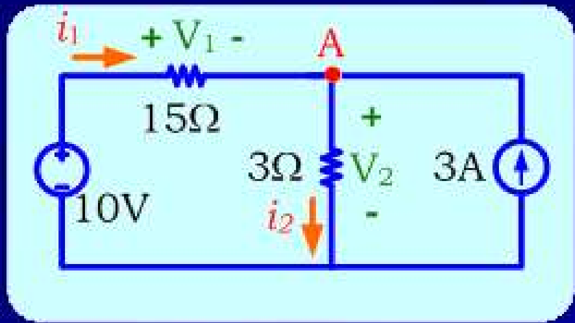
(a) KVL $\Rightarrow -10 + v_1 + v_2 = 0$

Ohm's Law $\Rightarrow -10 + 15i_1 + 3i_2 = 0 \cdots\cdots (1)$

KCL $\Rightarrow i_1 + 3 = i_2 \cdots\cdots\cdots\cdots\cdots (2)$

Solving (1) and (2) $\Rightarrow -10 + 15(i_2 - 3) + 3i_2 = 0$

$\Rightarrow 18i_2 = 55 \Rightarrow i_2 = \frac{55}{18} = 3.056\text{A}$



$\therefore p_{3\Omega} = 3i_2^2 = 3(3.056)^2 = 28.02\text{W}$

(b) Using (2) $\Rightarrow i_1 = i_2 - 3 = 3.056 - 3 = 0.056\text{A}$

$\therefore R_{eq} = +\frac{v}{i_1} = +\frac{10}{0.056} = 178.57\Omega$