**Series Circuit**

**5.2 SERIES CIRCUITS**

Two elements are in series if:

1. They have only one terminal in common
2. The common point between them is not connected to another current carrying element.

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| In the circuit *E*, *R1* and *R2* are in series.All elements in the circuit are in series: $⟹$ Series CircuitThe current is the same through series elements.A branch of a circuit is any portion of the circuit having one or more elements in series. |  |

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| *R1* and *R2* are not in series because at point (b) the common between them is connected to *R3* which carries a current |  |

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| ***The total resistance of a series circuit is the sum of the resistance levels.***If *R1*= *R2*= *R3*= …..= *RN* = *R* $⟹$ $$R\_{T}=N∙R$$ |  |

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| Once *RT* is known the circuit can be replaced by the one shown: and thenE is fixed: $⟹$ *Is* depends on *RT*.$V\_{1}=I\_{s}∙R\_{1}$ $V\_{2}=I\_{s}∙R\_{2}$ , ….$P\_{1}=V\_{1}∙I\_{1}=I\_{1}^{2}∙R\_{1}=\frac{V\_{1}^{2}}{R\_{1}}$ , ……$P\_{del}=E∙I\_{s}$ ***The total power delivered to a resistive circuit is equal to the total power dissipated by the resistive elements.*** |  |

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**5.3 VOLTAGE SOURCES IN SERIES**

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| Voltage sources can be connected in series to increase or decrease the total voltage applied:The net voltage is determined simply by summing the sources with the same polarity and subtracting the total of the sources with the opposite polarity.Net polarity ≡ polarity of the larger sum. |  |

**5.4 KIRCHHOFF’S VOLTAGE LAW**

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| **Kirchhoff’s voltage law *(KVL) states that the algebraic sum of the potential rises and drops around a closed loop (or path) is zero.***A **closed loop** is any continuous path that leaves a point in one direction and returns to that same point from another direction without leaving the circuit. The applied voltage of a series circuit equals the sum of the voltage drops across the series elements: | abcda ≡ closed loop$+E-V\_{1}-V\_{2}=0$ $⟹$ $E=V\_{1}+V\_{2}$ |

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| ***The application of Kirchhoff’s voltage law need not follow a path that includes current-carrying elements.***$+12V-V\_{x}-8V=0$ $⟹$ $V\_{x}=4V$ |  |

**!!!!! Polarity is very important when applying KVL !!!!!**

**EXAMPLE 5.4** Determine the unknown voltages for the networks of the Figures.

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| Application of Kirchhoff’s voltage law in clockwise direction results in:$$+E\_{1}-V\_{1}-V\_{2}-E\_{2}=0$$$$V\_{1}=E\_{1}-V\_{2}-E\_{2}=0$$$$V\_{1}=16V-4.2V-9V=2.8V$$ |  |
| 1. $E-V\_{1}-V\_{x}=0$ $⟹$

$$V\_{x}=E-V\_{1}=32V-12V=20V$$or 1. $V\_{x}-V\_{2}-V\_{3}=0$ $⟹$

$$V\_{x}=V\_{2}+V\_{3}=6V+14V=20V$$ |  |

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**5.5 INTERCHANGING SERIES ELEMENTS**

The elements of a series circuit can be interchanged without affecting the total resistance, current, or power to each element.

**5.6 VOLTAGE DIVIDER RULE**

***In a series circuit: the voltage across the resistive elements will divide as the magnitude of the resistance levels.***

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| *R1* = 2*R2* $⟹$ *V1* = 2*V2* *R2* = 3*R3* $⟹$ *V2* = 3*V3* The current *I* change by the values of *R*’s, but the voltage remain the same. |  |  |

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| *R1* = 1000 *R2* $⟹$ *V1* = 1000 *V2* *R1* = 10000*R3* $⟹$ *V1* = 10000*V3* $I=\frac{E}{R\_{T}}=\frac{100}{1001100}≅99.89 μA$ $V\_{1}=IR\_{1}=99.89 V$ $V\_{2}=IR\_{2}=99.89 mV$ $V\_{3}=IR\_{3}=9.989 mV$  |  |

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| *RT* = *R1* + *R2* $⟹$ $I=\frac{E}{R\_{T}}$$V\_{1}=IR\_{1}= \frac{E}{R\_{T}}R\_{1}=\frac{R\_{1}}{R\_{T}}∙E$ $V\_{2}=IR\_{2}= \frac{E}{R\_{T}}R\_{2}=\frac{R\_{2}}{R\_{T}}∙E$ In General:$V\_{x}=IR\_{x}=\frac{R\_{x}}{R\_{T}}∙E$ (Voltage Divider Rule) |  |

***The voltage across a resistor in a series circuit is equal to the value of that resistor times the total impressed voltage across the series elements divided by the total resistance of the series elements.***

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**5.7 NOTATION**

**Voltage Sources and Ground:**

 

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**Double-Subscript Notation**

Voltage is always **across** (between) two points resulted in a double –subscript notation that defines the first subscript as the higher potential



***The double-subscript notation Vab specifies point “a” as the higher potential. If this is not the case, a negative sign must be associated with the magnitude of Vab.***

***The voltage Vab is the voltage at point “a” with respect to (w.r.t.) point “b”.***

**Single-Subscript Notation:**

If one of the point is specified as ground (reference) then a single subscript is employed, that provide the voltage with respect to ground.

***If the voltage is less than zero volts, a negative sign must be associated with the magnitude of Va .***

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| In general: |  |