**Continuity of Learning - Part 4**

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| **Name:** |  | **Group:** |  |

The purpose of the last block of learning [[**BLOCK 3**: **Steps 1 -** **6]** was to try to get you to demonstrate an understanding of CAPACITANCE, and that when combined with RESISTANCE AND INDUCTANCE, to be able to explain the resulting effects. This included the term **POWER FACTOR**.

The purpose of this block of learning [**BLOCK 4**: **Steps 1 -** **6]** is to try to get you to demonstrate an understanding of **POWER FACTOR** and its relationship with Power in single and three phase systems.

This sheet contains a study plan with **Step**s that must be followed in the order laid out; skipping steps or undertaking them in the wrong order **will not help at all**.

References for study including **Text** and YouTube video links, are shown below each answer box.

**Step 1**

By now you should be immediately familiar with the basic Power formula shown in the memory prompting triangle below:



1. Write out the basic formula and the S.I. units (in brackets below each symbol)

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When used for a **d.c.** circuit, this formula will **always** give the **TRUE POWER** of the circuit.

When used for an **a.c.** circuit, this formula will **only** give the **TRUE POWER** when there is no reactance i.e. when the circuit is purely resistive.

1. Give an example of a purely resistive circuit or item of electrical equipment.

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1. Give an example of an inductive reactive item of electrical equipment (not purely resistive).

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To summarise, in an **a.c. circuit**:

* **Volts** × **Amps** only equals **TRUE POWER** when the Volts and Amps are in phase **(RESISTIVE)**.
* **Volts** × **Amps** × **PF** equals the **TRUE POWER** when the Volts and Amps are not in phase **(REACTIVE)**.
1. What does **PF** stand for?

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1. What is the S.I. unit for TRUE Power?

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1. Explain the meaning of the following interval (math term): **0 < PF ≤ 1**

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**Step 2**

As with the Impedance Triangle that you were introduced to in the previous two workbooks, there is a **Power Triangle** that shows the relationship between the products of Current, Voltage and Power Factor.

1. Using the following **eight** quantities, units and symbols label the Power Triangle below:

**True Power Voltamps Voltamps-Reactive CosƟ=power factor (W) (VAR) (VA) Watts**

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| Power Triangle (for leading p.f.) |
| **References:*** **Text Book B Chapter ELTK 08 page 333**
* **YouTube videos:** [Drawing Power Triangles](https://www.youtube.com/watch?v=6YC2_Ir-d2w&list=TLPQMDYwNzIwMjAKHEcENd04DA&index=2)
 |

**Step 2 (continued)**

In relation to the terms used in the Power Triangle:

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| 1. Explain what is meant by True Power.
 |
| 1. Explain what is meant by Reactive Power.
 |
| 1. Explain what is meant by Apparent Power.
 |
| 1. Using the symbols **VA**, **VAR** and **W**, produce a formula that shows the relationship between them?
 |
| 1. Using only **TWO** of the symbols **VA**, **VAR** and **W**, produce a formula that would allow you to calculate the power factor (cos Ɵ) from the Power Triangle.
 |
| **References:*** **Text Book B Chapter ELTK 08 pages 333-334**
* **YouTube videos:** [Drawing Power Triangles](https://www.youtube.com/watch?v=6YC2_Ir-d2w&list=TLPQMDYwNzIwMjAKHEcENd04DA&index=2) [Power Factor](https://www.youtube.com/watch?v=xp6Rv5cUQG8)
 |

**Step 2 (continued)**

In relation to the terms used in the Power Triangle:

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| 1. Explain the importance of the angle between the side labelled (**W**) and the side labelled (**VA**).
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| 1. Explain why on a scientific calculator when you enter **Cos** **Zero**, you get an answer **1**.
 |
| 1. Explain why on a scientific calculator when you enter **Cos** **90**, you get an answer **0**.
 |
| 1. What is the best Power Factor that you can hope to get? **(0 < PF ≤ 1)**
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| 1. What electrical component is used to correct the poor power factor created by a motor?
 |
| 1. From a large commercial or industrial consumer’s point, what are the disadvantages of not correcting a poor power factor caused by electrical equipment in their installation?
 |
| **References:*** **Text Book B Chapter ELTK 08 pages 333-334**
* **YouTube videos:**  [Power Factor](https://www.youtube.com/watch?v=xp6Rv5cUQG8)
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**Step 3**

As was stated earlier, the formula **P = V × I** is limited to d.c. circuits or purely resistive a.c. circuits.

Using the relevant symbols from the following seven, state the formula that allows you to calculate the Power in the following situations: P √3 I V p.f. = ×

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| 1. A single-phase night storage heater
 |
| 1. A 3-phase industrial immersion heater
 |
| 1. A single-phase induction motor
 |
| 1. A 3-phase induction motor
 |
| **References:*** **Text Book B Chapter ELTK 08 page 343**
* **YouTube videos:** [Calculating Power](https://www.youtube.com/watch?v=9omx07AKH5Q)
 |

1. A panel heater is connected to a single-phase supply. The voltage at the heater is measured as 244.3V and the current measured on the supply flex is 4.2A. Calculate the power taken by the heater and determine if this is in line with the nominal stated appliance power rating of 1 kW.

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| **Show all your working out**. |
| **References:*** **Text Book B Chapter ELTK 08 page 343**
* **YouTube videos:** [Calculating Power](https://www.youtube.com/watch?v=9omx07AKH5Q)
 |

**Step 3 (continued)**

1. For the question above, which of the following electrical quantities **DO NOT** make any difference whatsoever to the capacitive reactance produced by the capacitor?

Capacitance (0.05 μF) Voltage (230 V) Frequency (100 kHz)

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**Step 4 (continued)**

1. Explain what it means when the Capacitive Reactance (XC) is being described as being **inversely proportional** to the frequency.

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| **References:*** **Text Book B Chapter ELTK 08 page 326**
* **YouTube videos:** [Calculating Capacitive Reactance](https://www.youtube.com/watch?v=mqECFI_dCvg)
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Below is a **RESISTOR** in series with a **CAPACITOR,** this is usually referred to as a RC circuit.



1. In a similar way to how RESISTANCE (Ohms) and INDUCTIVE REACTANCE (Ohms) was combined to produce the total circuit IMPEDANCE (Ohms), show the formula that allows the RESISTANCE (Ohms) and CAPACITIVE REACTANCE (Ohms) to be combined to produce the total IMPEDANCE.

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| **References:*** **Text Book B Chapter ELTK 08 page 326**
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1. A 50 microfarad capacitor is connected in series with a 40 Ohm resistor which is connected to a 12V 60Hz a.c. supply. Calculate:
2. the capacitive reactance produced by the capacitor (**XC**)
3. the total circuit impedance (**Z**)
4. The circuit current (**I**)
5. The voltage across the resistor (**VR**)
6. The voltage across the capacitor (**VC**)

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| **Capacitive Reactance (XC)**  **Show all your working out**. |
| **Circuit Impedance (Z)**  **Show all your working out**. |
| **Circuit Current (I)**  **Show all your working out**. |
| **Voltage across the resistor (VR) Show all your working out**. |
| **Voltage across the capacitor (VC) Show all your working out**. |
| **References:*** **Text Book B Chapter ELTK 08 page 326**
* **YouTube videos:** [RC calculation](https://www.youtube.com/watch?v=ZOn0L42cyFE)
 |

1. A 160 microfarad capacitor is connected in series with a 15 Ohm resistor which is connected to a 250V 50Hz supply. Calculate:
2. the capacitive reactance produced by the capacitor (**XC**)
3. the total circuit impedance (**Z**)
4. the circuit current (**I**)
5. the voltage across the resistor (**VR**)
6. the voltage across the capacitor (**VC**)

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| **Capacitive Reactance (XC)**  **Show all your working out**. |
| **Circuit Impedance (Z)**  **Show all your working out**. |
| **Circuit Current (I)**  **Show all your working out**. |
| **Voltage across the resistor (VR) Show all your working out**. |
| **Voltage across the capacitor (VC) Show all your working out**. |
| **References:*** **Text Book B Chapter ELTK 08 page 326**
* **YouTube videos:** [RC calculation](https://www.youtube.com/watch?v=ZOn0L42cyFE)
 |

1. Explain what happens to the relationship between the **Voltage** ‘across’ and the **Current** ‘through’ the Capacitor when it is connected to an **a.c. supply**

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| **References:*** **Text Book B Chapter ELTK 08 page 320**
* **YouTube videos:** [Phase shift](https://www.youtube.com/watch?v=SGel5QNSkIQ)
 |

1. With the aid of diagrams, show the relationship between the **Voltage** ‘across’ and the **Current** ‘through’ a Capacitor when it is connected to an **a.c. supply**

|  |  |
| --- | --- |
| **Wave diagram** | **Phasor diagram** |
| **References:*** **Text Book B Chapter ELTK 08 page 320**
* **YouTube videos:** [Phase shift](https://www.youtube.com/watch?v=SGel5QNSkIQ) [Wave diagrams](https://www.youtube.com/watch?v=_XNvQ44feqA)
 |

1. Explain what happens when BOTH Inductive Reactance (**XL**) OHMs and Capacitive Reactance (**XC**) OHMs are in the same a.c. circuit.

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| **References:*** **Text Book B Chapter ELTK 08 page 327**
* **YouTube videos:** [Impedance in RLC circuit](https://www.youtube.com/watch?v=1bIRwZtSurg)
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**Step 5**

By now you should have become aware that, individually, a **RESISTOR (R)**, a **CAPACITOR (C)**, or an **INDUCTOR** (**L**) each affect the Voltage/ Current relationship in different ways.

Remember, the Current is the constant through the series connected components (**RLC**)



**For the following 3 questions you may want to remember this useful memory aid:**  **C I V I L**

1. For a **purely resistive** circuit, which one of the following statements is **TRUE**?

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| --- | --- |
|  | **Tick 🗸** |
| The Voltage (**VR**) across the resistor lags the current (**I**) through the resistor |  |
| The Voltage (**VR**) across the resistor is in phase with the current (**I**) through the resistor |  |
| The Voltage (**VR**) across the resistor leads the current (**I**) through the resistor |  |
| **References:*** **Text Book B Chapter ELTK 08 page 316**
 | * **YouTube videos:** [Phasor diagrams and CIVIL](https://www.youtube.com/watch?v=_F1jzaGgtXw)
 |

1. For a **purely inductive** circuit, which one of the following statements is **TRUE**?

|  |  |
| --- | --- |
|  | **Tick 🗸** |
| The Voltage (**VL**) across the inductor lags the current (**I**) through the inductor |  |
| The Voltage (**VL**) across the inductor is in phase with the current (**I**) through the inductor |  |
| The Voltage (**VL**) across the inductor leads the current (**I**) through the inductor |  |
| **References:*** **Text Book B Chapter ELTK 08 page 317**
 | * **YouTube videos:** [Phasor diagrams and CIVIL](https://www.youtube.com/watch?v=_F1jzaGgtXw)
 |

1. For a **purely capacitive** circuit, which one of the following statements is **TRUE**?

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| --- | --- |
|  | **Tick 🗸** |
| The Voltage (**VC**) across the capacitor lags the current (**I**) through the capacitor |  |
| The Voltage (**VC**) across the capacitor is in phase with the current (**I**) through the capacitor |  |
| The Voltage (**VC**) across the capacitor leads the current (**I**) through the capacitor |  |
| **References:*** **Text Book B Chapter ELTK 08 page 320**
 | * **YouTube videos:** [Phasor diagrams and CIVIL](https://www.youtube.com/watch?v=_F1jzaGgtXw)
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**Step 5 (continued)**

1. A 15 microfarad capacitor is connected in series with a 150 Ohm resistor and a 750 milliHenry inductor, which are all connected to a 230 V 55 Hz supply.

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| Calculate:1. (i) the capacitive reactance (**XC**)
2. (ii) the inductive reactance (**XL**)
3. (iii) the total circuit impedance (**Z**)
 | 1. (iv) the circuit current (**I**)
2. (v) the voltage across the resistor (**VR**)
3. (vi) the voltage across the capacitor (**VC**)

(vii) the voltage across the inductor (**VL**) |
| **Capacitive Reactance (XC)**  **Show all your working out**. |
| **Inductive Reactance (XL)**  **Show all your working out**. |
| **Circuit Impedance (Z)**  **Show all your working out**. |
| **Circuit Current (I)**  **Show all your working out**. |
| **Voltage across the resistor (VR) Show all your workin g out**. |
| **Voltage across the capacitor (VC) Show all your working out**. |
| **Voltage across the inductor (VL) Show all your working out**. |
| **References:** * **Text Book B Chapter ELTK 08 page 328**
 | * **YouTube videos:** [RLC calculation](https://www.youtube.com/watch?v=1bIRwZtSurg)
 |

**Step 6**

A 150 microfarad capacitor is connected in series with a 5 Ohm resistor and a 20 milli-Henry inductor, which are all connected to a 230 V 50 Hz supply.

Calculate:

1. the total circuit impedance (Z)
2. the circuit current (I)
3. the power factor

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| **Show all your working out**. |