P&Q are not perpendicular

The Instantaneous Power

The instantaneous power is given by the product of the instantaneous voltage and current.

The instantaneous power = $V(t) \cdot I(t)$

For an inductive load, $I(t) = I_{max} \operatorname{Sin}(\omega t - \varphi)$

$$V(t) \cdot I(t) = V_{max} \operatorname{Sin}(\omega t) \cdot I_{max} \operatorname{Sin}(\omega t - \varphi)$$

$$V(t) \cdot I(t) = \underbrace{VI \cos\varphi \, \{1 - \cos 2\omega t\} - VI \sin\varphi \, \sin(2\omega t)}_{\text{Existing equation for power}}$$

We replace $\{1 - \cos 2\omega t\}$ with $\{2 \operatorname{Sin}^2 \omega t\}$

$$V(t) \cdot I(t) = 2V.I \operatorname{Cos} \varphi \operatorname{Sin}^2 \omega t + V.I \operatorname{Sin}\varphi . \operatorname{Sin}(-2\omega t)$$

$$V(t) \cdot I(t) = K \operatorname{Sin}^2 \omega t + K` \operatorname{Sin}(2\omega t)$$

$$V(t) \cdot I(t) = \text{PART 1} + \text{PART 2}$$

PART 1 has a square factor $\{\operatorname{Sin}^2 \omega t\}$ that implies a unidirectional energy flow from the source to the load, which is defined as an instantaneous active power or simply *Active power* P(t).

PART 2 has an oscillating factor $\{\operatorname{Sin}(2\omega t)\}$ that implies a bidirectional energy flow with an average of nil. We note it Q(t) as instantaneous reactive power or simply *Reactive Power* Q(t).

the result is the following substantial power equation. We note it by T(t).

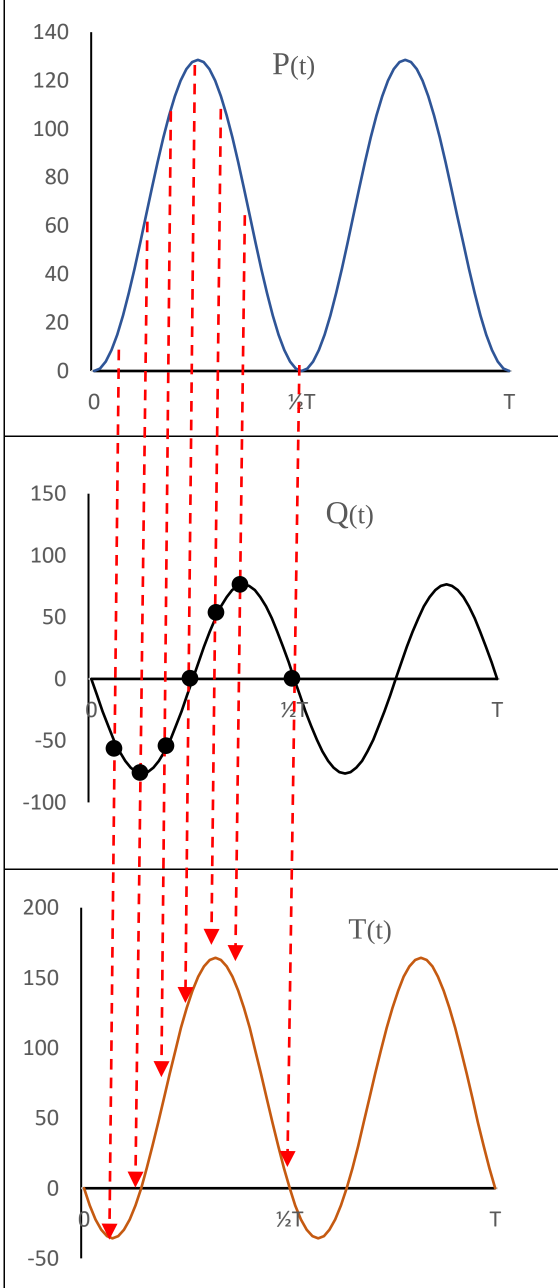
$$T(t) = P(t) + Q(t)$$

The waveforms in Table 1 and plus sign (+) in (3) show that the active and reactive power are added algebraically and **are not perpendicular.**

There are three power components, three equations, three waveforms, and three concepts.

Table 1. The illustration of $\{P(t) + Q(t)\}$.

Waveforms show the algebraically addition of $P(t) + Q(t)$



- $P(t) = K \operatorname{Sin}^2 \omega t$
- $Q(t) = K` \operatorname{Sin} 2\omega t$
- $T(t) = K \operatorname{Sin}^2 \omega t + K` \operatorname{Sin} 2\omega t$