Application Guide

Power Equations

This note brings together a number of equations and conversion factors that are useful when applying a power supply.

General

Voltage & Current

$$V_P = \left(\frac{1}{0.707}\right) \times V_{RMS}$$

$$V_P = \sqrt{2}V_{RMS} = 1.414\ V_{RMS}$$

$$V_{PP} = 2V_P$$

$$V_{RMS} = \sqrt{0.5}\ V_P \approx 0.707\ V_P$$

$$V_{AVG} = \left(\frac{2}{\pi}\right) V_P \approx 0.637\ V_P$$

$$I_P = \sqrt{2}I_{RMS} \approx 1.414\ I_{RMS}$$

$$I_{PP} = 2I_P$$

$$I_{RMS} = \sqrt{0.5}\ I_P \approx 0.707\ I_P$$

$$I_{AVG} = \left(\frac{2}{\pi}\right) I_P \approx 0.637\ I_P$$

Where:
- V_P = Peak Voltage
- V_{PP} = Peak to Peak Voltage
- V_{AVG} = Average Voltage
- V_{rms} = RMS (root mean square) Voltage
- I_P = Peak Curent
- I_{PP} = Peak to Peak Current
- I_{AVG} = Average Current
- I_{RMS} = RMS (root mean square) Current

Frequency & Time

Duty Cycle: The ratio of "on" time to "off" time of the semi-conductor switch (in PWM systems) or clock signal.

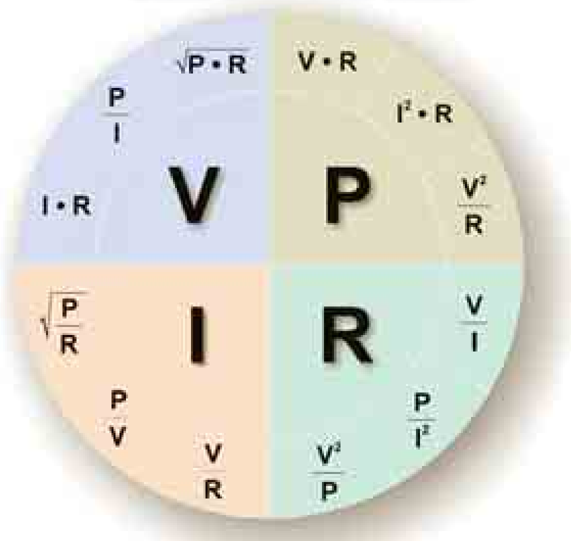
$$F = \left(\frac{1}{T}\right)$$

$$T = \left(\frac{1}{F}\right)$$

$$\text{Duty Cycle} = \left(\frac{\text{Pulse Width}}{\text{Cycle Time}}\right) \times 100$$

Where:
- F = Frequency
- T = Time

Ohms Law/Power Wheel



Reactance

$$X_C = \left(\frac{1}{2\pi FC}\right)$$

$$X_L = 2\pi FL$$

Where:
- X_c = Reactance, in ohms, of a capacitance
- X_L = Reactance, in ohms, of an inductance
- F = Frequency in Hertz)
- C = Capacitance in Farads
- L = Inductance in Henrys

Decibal

Decibel (dB): A decibel (**dB**) is the fundamental measurement unit used in EMI measurements.

$$dB = 10\ Log_{10}\left(\frac{P_{OUT}}{P_{IN}}\right)$$

$$dB = 20\ Log_{10}\left(\frac{V_{OUT}}{V_{IN}}\right)$$

$$PR = 10^{(dB/10)}$$

$$VR = 10^{(dB/20)}$$

Where:
- P_{OUT} = Output Power
- P_{IN} = Input Power
- V_{OUT} = Output Voltage
- V_{IN} = Input Voltage
- PR = Power Ratio
- VR = Voltage Ratio (Current ratio is the same)

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Specifications

Efficiency

Efficiency (η): The ratio of total output power to input power. Typically expressed as a percentage, efficiency is derived by the equation:

$$\text{Efficiency (\%)} = \frac{P_{OUT}}{P_{IN}} \times 100$$

Where: P_{OUT} = Output Power
P_{IN} = Input Power

Power

Average Power: In an ac circuit, the average value of ac power. For resistive circuits, this equals the square of the rms current times the circuit resistance, as given by:

$$P_A = (I_{RMS})^2 R$$

Where: I_{RMS} = rms value of the circuit current
R = Circuit resistance in ohms

True Power: The actual power consumed by an ac circuit. It is given by:

$$P_T = V_{RMS} \times I_{RMS} \cos(\varphi)$$

Where: I_{RMS} = rms value of the circuit current
V_{RMS} = rms value of the circuit voltage

Power Factor: For an ac input power supply, the ratio of true input power to apparent input power.

$$PF = \cos\theta$$

$$PF = \left(\frac{P_T}{P_{App}}\right)$$

Thermal

Internal Power Dissipation: Power dissipated as heat within the power supply during normal operation.

$$P_D = P_{IN} - P_{OUT}$$

$$P_D = \left(\frac{P_{OUT}}{\eta}\right) - P_{OUT}$$

Where: P_D = Internal power dissipated
P_{IN} = Input Power
P_{OUT} = Output Power
η = Efficiency

Thermal Resistance: (θ) A measure of the opposition a material will have to the flow of heat. Used to calculate the temperature drop that occurs when power flows through a material or across the junction of two materials.

$$\theta\ (^{\circ}C/W) = \frac{L}{KA}$$

$$\theta\ (^{\circ}C/W) = \frac{\Delta T}{P_D}$$

Where: L = Length of material
K = Thermal conductivity of material
A = Cross sectional area of material
ΔT = Temp drop across material
P_D = Power flowing through material

Regulation

$$\text{Line Regulation (\%)} = \frac{\%V_L \Delta}{\%V_{IN} \Delta} \times 100$$

$$\text{Load Regulation (\%)} = \frac{NLV_{OUT} - FLV_{OUT}}{FLV_{OUT}} \times 100$$

Where: V_L = Load Voltage
V_{IN} = Input Voltage (Line)
NLV_{OUT} = Load Voltage @ No Load
FLV_{OUT} = Load Voltage @ Full Load

Conversion Factors

Common Conversions

LFM	=	$\frac{CFM}{Area}$
CFM	=	Area x LFM
°C	=	$\frac{(°F-32)}{1.8}$
°F	=	1.8 x °C + 32
°K	=	$\frac{°F + 459.67}{1.8}$
°K	=	°C + 273.15
1 Inch	=	25.4 mm
1 mm	=	0.03937 Inches
1 m	=	39.7 Inches
1 Ampere-Hour	=	3,600 Coulombs
1 IB	=	453.4924 Grams
1 Ounce	=	28.3495 Grams
1 Gram	=	0.0357 Ounces
1 kGram	=	2.205 Pounds
1 Pound	=	0.4523 kgrams
1 Watt	=	1 Joule/Second
1 BTU/Sec	=	1,054.8 Joules/Sec
1 Joule	=	0.000948 BTU