

Electrical Principles – Data Sheet

Constants

Constant	Code	Value	Unit
Speed of light in a vacuum	c	3×10^8	m s^{-1}
Permeability of free space	μ_0	$4\pi \times 10^{-7}$	H m^{-1}
Permittivity of free space	ϵ_0	8.85×10^{-12}	F m^{-1}
Charge of an electron	e	-1.602×10^{-19}	C
Charge of a proton	e	$+1.602 \times 10^{-19}$	C
Mass of an electron	m_e	9.11×10^{-31}	kg

Basic Electricity

Charge	$Q = It$
Ohm's Law	$V = IR$
Conductance	$G = \frac{1}{R}$
Power	$P = IV$
	$P = I^2R$
	$P = \frac{V^2}{R}$
Resistivity	$R = \frac{\rho l}{A}$

Capacitors

Charge	$Q = CV$
Energy	$E = \frac{1}{2}CV^2$
	$E = \frac{1}{2}\frac{Q^2}{C}$

Inductors

EMF	$\mathcal{E} = -L\frac{dI}{dt}$
Energy	$E = \frac{1}{2}LI^2$

Simple Circuits

Series resistors	$R_T = R_1 + R_2 + \dots$
Parallel resistors	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$
Voltage divider	$V_{\text{out}} = V_{\text{in}} \left(\frac{R_2}{R_1 + R_2} \right)$
Kirchhoff I	$I_T = I_1 + I_2 + \dots$
Kirchhoff II	$\mathcal{E} = V_1 + V_2 + \dots$
Energy	$E = VIt = VQ$
Internal Resistance	$\mathcal{E} = I(R + r)$

Circuits

Parallel Capacitors	$C_T = C_1 + C_2 + \dots$
Series Capacitors	$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \dots$

Circuits

Series inductors	$L_T = L_1 + L_2 + \dots$
Parallel inductors	$\frac{1}{L_T} = \frac{1}{L_1} + \frac{1}{L_2} + \dots$

AC Theory (Sinusoidal Waves)

Peak Voltage	$V_0 = \frac{V_{pk\ topk}}{2}$	Angular velocity	$\omega = 2\pi f$
RMS voltage	$V_{RMS} = \frac{V_0}{\sqrt{2}}$	Average value	$0.637 \times \text{max value}$
Instantaneous value	$V = V_0 \sin(\omega t)$ $I = I_0 \sin(\omega t)$	RMS value	$0.707 \times \text{max value}$
(with phase angle)	$V = V_0 \sin[(\omega t) \pm \phi]$		

AC values for non-sinusoidal wave-forms

Average value = $\frac{\text{area under the graph}}{\text{Length of base}}$ Form Factor = $\frac{\text{RMS value}}{\text{Average value}}$

RMS value: $V_{RMS} = \sqrt{\left(\frac{V_1^2 + V_2^2 + \dots + V_n^2}{n}\right)}$ Peak factor = Maximum value \div RMS value

AC Theory (Reactive Circuits)

Reactance of a capacitor	$X_C = \frac{1}{2\pi fC}$	Phase angle*	$\tan \phi = \frac{V_C}{V_R} = \frac{X_C}{R}$
Reactance of an inductor	$X_L = 2\pi fL$	Power factor	$\cos \phi = \frac{R}{Z}$
Reactance	$X = \frac{V}{I}$	Apparent power	$S = VI$
Impedance	$Z = \frac{V}{I}$	True power	$P = VI \cos \phi$
Series Impedance	$Z^2 = X^2 + R^2$	Reactive power	$Q = VI \sin \phi$
Parallel Impedance	$\left(\frac{1}{Z}\right)^2 = \left(\frac{1}{R}\right)^2 + \left(\frac{1}{X_L}\right)^2$		

* This formula also applies to an inductor.

AC Theory (Resonance)

Resonant frequency	$f = \frac{1}{2\pi\sqrt{LC}}$	Impedance (series circuit)	$Z = R$
Q factor	$Q = \frac{V_L}{V}$	Q factor	$Q = \frac{1}{2\pi fCR}$
Q factor	$Q = \frac{1}{R} \sqrt{\left(\frac{L}{C}\right)}$	Q factor	$Q = \frac{2\pi fL}{R}$
Current in parallel Resistor	$I_R = \frac{VRC}{L}$	Parallel resonance in LCR	$f = \frac{1}{2\pi} \sqrt{\left(\frac{1}{LC} - \frac{R^2}{L^2}\right)}$

Transformers

Equation $\frac{N_{prim}}{N_{sec}} = \frac{V_{prim}}{V_{sec}} = \frac{I_{sec}}{I_{prim}}$ Turns ratio

$$\text{turns ratio} = \sqrt{\left(\frac{\text{source resistance}}{\text{load resistance}}\right)}$$

3-phase supplies

Quantity	Star	Delta
Voltage	$V_L = \sqrt{3}V_P$	$V_L = V_P$
Current	$I_L = I_P$	$I_L = \sqrt{3}I_P$
Power	$P = \sqrt{3}V_L I_L \cos \phi$	$P = \sqrt{3}V_L I_L \cos \phi$
Apparent Power	$S = \sqrt{3}V_L I_L$	$S = \sqrt{3}V_L I_L$
Reactive Power	$Q = \sqrt{3}V_L I_L \sin \phi$	$Q = \sqrt{3}V_L I_L \sin \phi$

Reactive Transients with DC (Capacitors)

Time Constant	$\tau = RC$	Discharge	$V = V_0 e^{-\frac{t}{RC}}$
Half-life	$t_{\frac{1}{2}} = 0.69 RC$	Charge	$V = V_0 \left(1 - e^{-\frac{t}{RC}}\right)$
		Current	$I = I_0 e^{-\frac{t}{RC}}$

Reactive Transients with DC (Inductors)

Time Constant	$\tau = \frac{L}{R}$	Inductive voltage rise	$V = V_0 \left(1 - e^{-\frac{tR}{L}}\right)$
Half-life	$t_{\frac{1}{2}} = 0.69 \frac{L}{R}$	Inductive current rise	$I = I_0 \left(1 - e^{-\frac{tR}{L}}\right)$
		Inductive voltage fall	$V = V_0 e^{-\frac{tR}{L}}$
		Inductive current fall	$I = I_0 e^{-\frac{tR}{L}}$