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	$R = \frac{\rho l}{A}$

Simple Circuits

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

Capacitors

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

Circuits

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

Inductors

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

Circuits

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

AC Theory (Sinusoidal Waves)

Peak Voltage	$V_0 = \frac{V_{pktopk}}{2}$	Angular velocity	$\omega = 2\pi f$
RMS voltage	$V_{RMS} = \frac{V_0}{\sqrt{2}}$	Average value	0.637 × max value
Instantaneous value	$V = V_0 \sin(\omega t)$	RMS value	0.707 × max value
	$I = I_0 \sin(\omega t)$		
(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: $V_{RMS} = \sqrt{\left(\frac{V_1^2+V_2^2+\cdots+V_n^2}{n}\right)}$

Peak factor = Maximum value ÷ RMS value

AC Theory (Reactive Circuits)

Reactance of a capacitor	$X_C = \frac{1}{2\pi f C}$	Phase angle*	$\tan\phi = \frac{V_C}{V_R} = \frac{X_C}{R}$
Reactance of an inductor	$X_L = 2\pi f L$	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	$Q = \frac{1}{2\pi f C R}$
Q factor	$Q = \frac{1}{R}\sqrt{\left(\frac{L}{C}\right)}$	Q factor	$Q = \frac{2\pi f L}{R}$
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	$V_{\mathrm{L}} = \sqrt{3}V_{\mathrm{P}}$	$V_{\mathrm{L}} = V_{\mathrm{P}}$
Current	$I_{\mathrm{L}} = I_{\mathrm{P}}$	$I_{\mathrm{L}} = \sqrt{3}I_{\mathrm{P}}$
Power	$P = \sqrt{3}\, V_{\mathrm{L}}I_{\mathrm{L}} \cos\phi$	$P = \sqrt{3}\, V_{\mathrm{L}}I_{\mathrm{L}} \cos\phi$
Apparent Power	$S = \sqrt{3}V_{\mathrm{L}}I_{\mathrm{L}}$	$S = \sqrt{3}V_{\mathrm{L}}I_{\mathrm{L}}$
Reactive Power	$Q = \sqrt{3}\, V_{\mathrm{L}}I_{\mathrm{L}} \sin\phi$	$Q = \sqrt{3}\, V_{\mathrm{L}}I_{\mathrm{L}} \sin\phi$

Reactive Transients with DC (Capacitors)

Time Constant $\tau = RC$

Half-life $t_{\frac{1}{2}} = 0.69\, RC$

Discharge $V = V_0 e^{-\frac{t}{RC}}$

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 $\tau = \frac{L}{R}$

Half-life $t_{\frac{1}{2}} = 0.69\frac{L}{R}$

Inductive voltage rise $V = V_0\left(1 - e^{-\frac{tR}{L}}\right)$

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 $I = I_0 e^{-\frac{tR}{L}}$