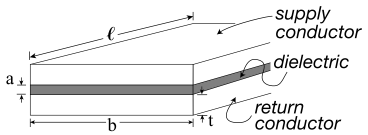
Standard Formulas for Basic Electrical Properties of Power Distribution Systems.

LAMINAR BUS BARS



Where:
a = Dielectric Thickness
b = Conductor Width
ℓ = Conductor Length
t = Conductor Thickness

*All dimensions in inches

VOLTAGE DROP

$V_d = 2R_C\, I$

$R_C\ \rho\ell/tb$

So: $V_d = 2\rho\ 1\ell/tb$

Where: R_C = Conductor resistance (Ω)
I = Current (A)
ρ = Conductor resistivity (Ω in)

INDUCTANCE

$$L = 31.9\,\ell\,\frac{a}{d}\ \text{(nH)}$$

Assumption: conductors are non-ferromagnetic and frequency effects can be neglected.

CAPACITANCE

$$C = \frac{.2225\,\ell b E_r}{a}\ \text{(pF)}$$

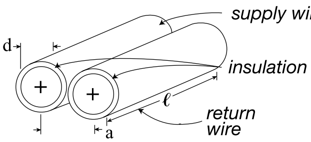
Er = Relative dielectric constant

CHARACTERISTIC IMPEDANCE

$Z_o = \sqrt{L/C}\ (\Omega)$ Where: L = Inductance (H), C = Capacitance (F)

Assumption: Effective Loss less conductors and dielectric.

WIRING HARNESSES



Where:
a = Centerline Spacing
d = Wire Diameter
ℓ = Wire Length

*All dimensions in inches

VOLTAGE DROP

$V_d = 2R_C\, I$

$R_C\ 4\rho\ell/\pi d^2$

So: $V_d = 8\rho\ell I/\pi d^2$

Where: R_C = Conductor resistance (Ω)
I = Current (A)
ρ = Conductor resistivity (Ω in)

INDUCTANCE

$$L = 20.3\,\ell\,\ln\left(\frac{a}{d} + \sqrt{\left(\tfrac{a}{d}\right)^2 - 1}\right)\ \text{(nH)}$$

Assumption: Conductors are non-ferromagnetic and frequency effects can be neglected.

CAPACITANCE

$$C = \left[\ell\,\frac{0.707}{\ln\left(\frac{a+\sqrt{a^2+2d^2}}{d}\right)}\right]\ \text{(pF)}$$

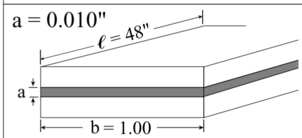
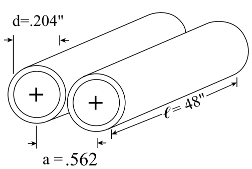
Assumption: Effective dielectric constant is close to 1 due to conductor spacing.

CHARACTERISTIC IMPEDANCE

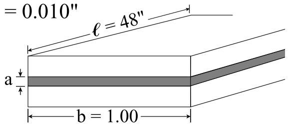
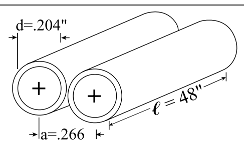
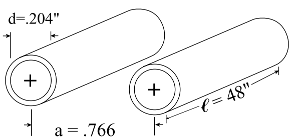
$Z_o = \sqrt{L/C}\ (\Omega)$ Where: L = Inductance (H), C = Capacitance (F)

Assumption: Loss less conductors and dielectric.

Sample Calculations for 100 A Systems

	CAPACITANCE	INDUCTANCE	IMPEDANCE
a = 0.010" 	$C = \frac{.2225\ell b\,E_r}{a}$(pF) $C = \frac{.2225\,(48)\,(1.00)\,(5)}{(0.010)}$ C = 5,340 pF	$L = 31.9\,\ell\,\frac{a}{d}$ (nH) $L = 31.9\,(48)\,(\frac{0.010}{1.00})$ (nH) L = 15.3 nH	$Z_o = \sqrt{L/C}\ (\Omega)$ $Z_o = \sqrt{\frac{(15.3 \times 10^{-9})\ (H)}{(5{,}400 \times 10^{-12})\ (F)}}$ Z_o = 1.68 Ω
ln = .32893 	$C = \ell\frac{0.707}{\ln\frac{(a+\sqrt{a^2+2d^2})}{d}}$ (pF) $C = 48\left(\frac{0.707}{\ln\frac{((.562)+\sqrt{(.562)^2+2(.204)^2})}{(.204)}}\right)$ $C = 48\left(\frac{0.707}{\ln(5.8516)}\right)$ (pF) C = 17.63pF	$L = 20.3\,\ell\,\ln(\frac{a}{d} + \sqrt{(\frac{a}{d})^2 - 1})$ (nH) $L = 20.3\,(48)\ln\left(\frac{(.562)}{(.204)}+\sqrt{\left(\frac{(.562)}{(.204)}\right)^2 - 1}\right)$(nH) L = 974.4 ln(5.322) nH L = 1,705 nH	$Z_o = \sqrt{L/C}\ (\Omega)$ $Z_o = \sqrt{\frac{(1{,}629 \times 10^{-9})\ (H)}{(21.9 \times 10^{-12})\ (F)}}$ Z_o = 273 Ω

Electrical Performance Comparison Chart

CASES	C	L	Zo
a = 0.010"  1	5,340 pF	15.3 nH	1.7Ω
 2	31.97 pF	686 nH	160Ω
 3	13.28 pF	2,364 nH	338Ω

Impedance Comparison Chart