Technology

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http://denisemeeks.com/science/notebooks/notebook_technology.pdf

Technology: Base 2 and Base 10

IEC prefix		representations				customary prefix	
name	sym-bol	base 2	base 1024	value	base 10	name	sym-bol
kibi	Ki	2^{10}	1024^1	1024	≈ 1.02×10^3	kilo	k or K
mebi	Mi	2^{20}	1024^2	1048576	≈ 1.05×10^6	mega	M
gibi	Gi	2^{30}	1024^3	1073741824	≈ 1.07×10^9	giga	G
tebi	Ti	2^{40}	1024^4	1099511627776	≈ 1.10×10^{12}	tera	T
pebi	Pi	2^{50}	1024^5	1125899906842624	≈ 1.13×10^{15}	peta	P
exbi	Ei	2^{60}	1024^6	1152921504606846976	≈ 1.15×10^{18}	exa	E
zebi	Zi	2^{70}	1024^7	1180591620717411303424	≈ 1.18×10^{21}	zetta	Z
yobi	Yi	2^{80}	1024^8	1208925819614629174706176	≈ 1.21×10^{24}	yotta	Y

Technology: Electric Force and Charge

q_1/q_2 charges	force on q_1 charge	force on q_2 charge	result
- / -	←⊖	⊖→	repulsion
+ / +	←⊕	⊕→	repulsion
- / +	⊖→	←⊕	attraction
+ / -	⊕→	←⊖	attraction

particle	charge (C)	charge (e)
Electron	1.602×10^{-19} C	*-e*
Proton	1.602×10^{-19} C	*+e*
Neutron	0 C	0

Technology: Coulomb's Law

Coulomb's law $F = \frac{kq_1q_2}{r^2}$

F = force in newtons (N)

k = 8.988×10^9 N·m²/C²

q_1 = first charge in coulombs (C).

q_2 = second charge in coulombs (C).

r = distance between the 2 charges in meters (m)

1 C = 6.242×10^{18} electrons

Technology: Ohm's Law, Power, and DC Circuits

Direct current (DC) is used to power electronics and other digital equipment, smartphones, tablets, electric vehicles, LED and LCD TVs, and is generated by a constant voltage source like a battery or other DC voltage source.

$V_R = I_R x R$ power $P = IV = I^2R$

V_R = voltage drop in volts (V)

I_R = current in amps (A)

R = resistance in ohms (Ω)

Technology: Voltage and Current in DC Circuits

voltage in series $V_S = V_1 + V_2 + V_3 + \ldots$

voltage in parallel $V_P = V_1 = V_2 = V_3 = \ldots$

voltage divider for loads in series $V_i = V_{total} \dfrac{R_i}{R_{total}}$

current in series $I_S = I_1 = I_2 = I_3 = \ldots$

current in parallel $I_P = I_1 + I_2 + I_3 + \ldots$

current divider of resistors in parallel $I_i = I_P \dfrac{R_P}{R_i + R_P}$

Technology: Resistance and Capacitance in DC Circuits

resistance in series $R_{total} = R_1 + R_2 + R_3 + \ldots$

resistance in parallel $R_{total} = \dfrac{1}{1/R_1 + 1/R_2 + 1/R_3 + \ldots}$

capacitance in parallel $C_P = C_1 + C_2 + C_3 + \ldots$

capacitance in series $C_S = \dfrac{1}{1/C_1 + 1/C_2 + 1/C_3 + \ldots}$

inductance in parallel $L_P = \dfrac{1}{1/L_1 + 1/L_2 + 1/L_3 + \ldots}$

inductance in series $L_S = L_1 + L_2 + L_3 + \ldots$

Technology: Capacitance in DC Circuits

charge on a capacitor $q_{flow}(t) = Q_{\max}(1 - e^{-tRC})$

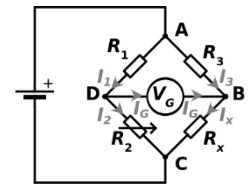
$Q_{\max} = CV_0$ $\qquad C = \dfrac{Q}{V_c}$

capacitors in series $\dfrac{1}{C_{total}} = \dfrac{1}{C_1} + \dfrac{1}{C_2} + \dfrac{1}{C_3} + \ldots$

capacitors in parallel $C_{total} = C_1 + C_2 + C_3 + \ldots$

Technology: Wheatstone Bridge

$R_x = \dfrac{R_2}{R_1} x R_3$



$I_3 - I_x + I_G = 0 \qquad I_1 - I_2 - I_G = 0$

$I_3 R_3 - I_G R_G - I_1 R_1 = 0$

$I_x R_x - I_2 R_2 + I_G R_G = 0$

when bridge balanced $I_G = 0 \quad I_3 R_3 = I_1 R_1 \quad I_x R_x = I_2 R_2$

$V_G = \left(\dfrac{R_2}{R_1 + R_2} - \dfrac{R_x}{R_x + R_3} \right) V_S$

(Image source: https://en.wikipedia.org/wiki/Wheatstone_bridge#/media/File:Wheatstonebridge_current.svg, Rhdv and cmglee, CC BY SA 3.0)

Technology: RC Transient Response in DC Circuits with Switches

series, RC charging	series, RC discharging
$\tau = RC$	$\tau = RC$
$e^{-N} = e^{-t/\tau} = e^{-t/RC}$	$e^{-N} = e^{-t/\tau} = e^{-t/RC}$
$V_{bat} = V_R(t) + V_C(t)$	$0 = V_R(t) + V_C(t)$
$I(t) = \dfrac{V_{bat} - V_0}{R} e^{-N}$	$I(t) = \dfrac{V_0}{R} e^{-N}$
$V_R(t) = I(t)R = (V_{bat} - V_0)e^{-N}$	$V_R(t) = -V_0 e^{-N}$
$V_C(t) = V_0 + (V_{bat} - V_0)(1 - e^{-N})$	$V_C(t) = V_0 e^{-N}$
$Q_C(t) = C[V_0 + (V_{bat} - V_0)(1 - e^{-N})]$	$Q_C(t) = CV_0 e^{-N}$

Technology: RL Transient Response in DC Circuits with Switches

series, RL charging	series, RL discharging
$\tau = L/R$	$\tau = L/R$
$e^{-N} = e^{-t/\tau} = e^{-tR/L}$	$e^{-N} = e^{-t/\tau} = e^{-tR/L}$
$V_{bat} = V_R(t) + V_L(t)$	$0 = V_R(t) + V_L(t)$
$I(t) = I_0 e^{-N} + \dfrac{V_{bat}}{R}(1 - e^{-N})$	$I(t) = I_0 e^{-N}$
$V_R(t) = I(t)R = I_0 \mathrm{R} e^{-N} + V_{bat}(1 - e^{-N})$	$V_R(t) = I_0 \mathrm{R} e^{-N}$
$V_L(t) = (V_{bat} - I_0 R)e^{-N}$	$V_L(t) = -I_0 \mathrm{R} e^{-N}$

Technology: Voltage in AC Circuits

voltage $V(t) = V_{\max} \sin(\omega t) = \dfrac{I_{\max}}{\omega C} \sin(\omega t) = \dfrac{I_{\max}}{2\pi f} \sin(\omega t)$

$V(t)$ = voltage at time t (volts)

$V_{\max}$ = maximal voltage (amplitude of sine)

ω = angular frequency in radians per second (rad/s)

t = time in seconds (s)

f = frequency in Hz

$V_{RMS} = V_{\max} / \sqrt{2} = 0.707 V_{\max}$

peak-to-peak voltage $V_{P-P} = V_{\max}$

average power $P_{avg} = I_{RMS}^2 R$

Technology: Capacitors in AC Circuits

$I_{RMS} = \dfrac{V_{RMS}}{X_C}$

capacitive reactance $X_C = \dfrac{1}{\omega C} = \dfrac{1}{2\pi f C}$

f = frequency in Hz

ω = angular frequency in radians per second (rad/s)

C = capacitance in farads (F)

Technology: RC Circuits

capacitance reactance $X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C}$ in ohms (Ω)

$$Z = \sqrt{R^2 + X_C^2} = \sqrt{R^2 + \left(\frac{1}{\omega C}\right)^2} = \frac{V_{RMS}}{I_{RMS}}$$

phase angle $\cos\phi = \frac{R}{Z}$ Z = impedence in ohms (Ω)

R = resistance in ohms (Ω) C = capacitance in farads (F)

$$V_{\max} = I_{\max}\sqrt{R^2 + X_C^2} = I_{\max} Z$$

$$V_{RMS} = I_{RMS}\sqrt{R^2 + X_C^2} = \sqrt{V_{RMS,R}^2 + V_{RMS,C}^2} = I_{RMS} Z$$

average power $P_{avg} = I_{RMS} V_{RMS} \cos\phi$

Technology: Inductors in AC Circuits

inductive reactance $X_L = \omega L = 2\pi f L$

$$Z = \sqrt{R^2 + X_L^2} = \sqrt{R^2 + (\omega L)^2} = \frac{V_{RMS}}{I_{RMS}}$$

phase angle $\cos\phi = \frac{R}{Z}$ Z = impedence in ohms (Ω)

R = resistance in ohms (Ω) L = capacitance in farads (F)

$$V_{\max} = I_{\max}\sqrt{R^2 + X_L^2} = I_{\max} Z$$

$$V_{RMS} = I_{RMS}\sqrt{R^2 + X_L^2} = \sqrt{V_{RMS,R}^2 + V_{RMS,L}^2} = I_{RMS} Z$$

Technology: Current in AC Circuits

instantaneous current $I(t) = I_{\max}\sin(\omega t)$

$I(t)$ = current at time t in amps (A).

$I_{\max}$ = maximal current (amplitude of sine)

ω = angular frequency in radians per second (rad/s)

t = time in seconds (s)

RMS current $I_{RMS} = \frac{V_{RMS}}{X_C} = V_{RMS}\omega C$

peak-to-peak current $I_{P-P} = I_{peak}$

Technology: RLC Circuits and Resonance

$$Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}$$

$$\omega_0 = \frac{1}{\sqrt{LC}} = 2\pi f_0$$

f_0 = resonant frequency, frequency at which $X_L = X_C$

Technology: Resistivity

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

for metallic conductors, the resistivity and resistance vary linearly with changes in temperature

$$\rho = \rho_0\left[1 + \alpha(T - T_0)\right]$$

$$R = R_0\left[1 + \alpha(T - T_0)\right]$$

ρ_0 = resistivity at T_0

R_0 = resistance at T_0

α = temperature coefficient

Technology: Boolean Algebra (1)

x	y	¬x	¬y	x^y	¬x^y	x^¬y	xᵛy	¬xᵛy	xᵛ¬y
0	0	1	1	0	0	0	0	1	1
1	0	0	1	0	0	1	1	0	1
0	1	1	0	0	1	0	1	1	0
1	1	0	0	1	0	0	1	1	1

x	y	x → y	x ⊕ y	¬x ⊕ ¬y	x≡y	¬x≡¬y
0	0	1	0	0	1	0
1	0	0	1	1	0	1
0	1	1	1	1	0	1
1	1	1	0	0	1	0

Technology: Boolean Algebra (2)

x^y = x AND y xᵛy = x OR y x ⊕ y = x EXCLUSIVE OR y

¬x = NOT x x≡y = x EQUALS y

x^y = ¬(¬xᵛ¬y) = xy = min(x,y)

xᵛy = ¬(¬x^¬y) = x + y – xy = max(x,y)

x → y = ¬xᵛy x ⊕ y = (xᵛy)^¬(x^y)

¬x = 1-x x≡y = ¬(x ⊕ y)

Demorgan's laws:

¬x^¬y = ¬(xᵛy)

¬xᵛ¬y = ¬(x^y)