Electronics formulas

The formulas you'll use most, from Ohm's law to resonance, on one page.

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CHEAT SHEET

Ohm's law

$V = I \times R$
voltage across a resistor

$I = V \div R$
current through it

$R = V \div I$
resistance that sets a current

V = mA × kΩ
the same, with no conversions

Power

$P = V \times I$
watts from volts and amps

$P = I^2 \times R$
from current and resistance

$P = V^2 \div R$
from voltage and resistance

$P_{rating} \geq 2 \times P$
keep parts at half their rating

Series and parallel

R = R1 + R2 + …
resistors in series

1 ÷ R = 1 ÷ R1 + 1 ÷ R2 + …
resistors in parallel

R = (R1 × R2) ÷ (R1 + R2)
two in parallel: product over sum

C = C1 + C2 + …
capacitors in parallel

1 ÷ C = 1 ÷ C1 + 1 ÷ C2 + …
capacitors in series

V = V1 + V2 + …
cells in series

Kirchhoff's laws

$\Sigma I_{in} = \Sigma I_{out}$
current in = current out at a junction

$\Sigma V_{rises} = \Sigma V_{drops}$
the drops round a loop add up

Dividers

$V_{out} = V_{in} \times R2 \div (R1 + R2)$
voltage divider (R2 to 0 V)

$I_1 = I \times R2 \div (R1 + R2)$
how current splits between two

LEDs

$R = (V_{supply} - V_{LED}) \div I$
series resistor for one LED

$R = (V_{supply} - n \times V_{LED}) \div I$
one resistor for n in series

V_{LED} at 20 mA: about 2.0 V red, 2.1 V yellow, 2.2 V green, 3.2 V blue or white

Capacitors

$Q = C \times V$
charge stored

$E = \frac{1}{2} \times C \times V^2$
energy stored

$\tau = R \times C$
RC time constant, in seconds

$V = V_s \times (1 - e^{-t/\tau})$
charging: 63% after 1 τ, about 99% after 5 τ

$V = V_0 \times e^{-t/\tau}$
discharging: 37% left after 1 τ

Inductors

$V = L \times \Delta I \div \Delta t$
voltage when the current changes

$\tau = L \div R$
RL time constant

$E = \frac{1}{2} \times L \times I^2$
energy in the magnetic field

AC and filters

$f = 1 \div T$
frequency from the period

$V_{rms} = V_{peak} \div \sqrt{2} \approx 0.707 \times V_{peak}$
RMS of a sine wave

$X_C = 1 \div (2\pi \times f \times C)$
a capacitor's reactance

$X_L = 2\pi \times f \times L$
a coil's reactance

$|Z| = \sqrt{(R^2 + X^2)}$
impedance

$f_c = 1 \div (2\pi \times R \times C)$
RC filter cutoff (−3 dB)

$f_0 = 1 \div (2\pi \times \sqrt{(L \times C)})$
LC resonant frequency

Decibels

$dB = 10 \times \log_{10}(P_{out} \div P_{in})$
a power ratio

$dB = 20 \times \log_{10}(V_{out} \div V_{in})$
a voltage ratio

−3 dB ≈ half the power (0.707 × the voltage). +6 dB ≈ 2 × the voltage, +20 dB = 10 × the voltage.

Transistors and op-amps

$I_C = \beta \times I_B$
collector current (active region)

$R_B = (V_{in} - 0.7\ V) \div I_B$
base resistor for a switch

$G = 1 + R_f \div R_g$
non-inverting amplifier gain

$G = -R_f \div R_{in}$
inverting amplifier gain

Batteries and digital

hours = mAh ÷ mA
battery life

n bits → 2^n values
8 bits: 0 to 255

duty = value ÷ 255
PWM from analogWrite

Symbols, units and prefixes

V volt (V) · **I** amp (A) · **R** ohm (Ω) · **P** watt (W) · **C** farad (F) · **L** henry (H) · **f** hertz (Hz) · **t**, **T**, **τ** second (s) · **Q** coulomb (C) · **E** joule (J)

p × 10^{-12} · **n** × 10^{-9} · **μ** × 10^{-6} · **m** × 10^{-3} · **k** × 10^{3} · **M** × 10^{6} · **G** × 10^{9}. Convert to base units before you substitute: 4.7 kΩ = 4700 Ω, 100 μF = 0.0001 F.