ALLUNITCONVERSIONS · PRINTABLE REFERENCE

Electrician and Electronics Reference Pack

Wire gauges, resistor codes, kVA to amps, electrical units, power and batteries in one printable PDF

For: Electricians, apprentices, electronics students, technicians and makers

allunitconversions.com/charts/packs
By Miguel Coelho · Edition 2.0
9 November 2026

Six reference sheets for the van, the workbench or the classroom: electrical units, Ohm’s law and watts-to-amps, the AWG wire size chart, transformer and generator currents in kVA and kW, the resistor and capacitor colour codes with E-series values, a power conversion chart and battery mAh to Wh with airline limits. Each sheet is also available on its own.

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Conversion values in this pack are generated by the AllUnitConversions conversion library and automatically checked against exact definitions (NIST SP 811, BIPM SI Brochure, 1959 International Yard and Pound Agreement) before the PDF is produced. Reference data taken from standards and regulations is cited to its source on each sheet. Free to print, copy and share with attribution (CC BY 4.0).

Printing tip: print double-sided and staple at the top left, or print single sheets from each chart’s own page.

Electrical Reference Chart

Watts to amps at common voltages, Ohm's law, electrical units and symbols, energy in kWh and mains supply by country

For: Electricians, engineers, campers and appliance buyers

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EXACT DEFINITION	FORMULA	REVERSE	WORKED EXAMPLE
1 W = 1 V × 1 A = 1 J/s; 1 kWh = 3.6 MJ	P = V × I; V = I × R	I = P ÷ V; R = V ÷ I	A 2,000 W kettle on 230 V draws 2,000 ÷ 230 = 8.70 A

Currents are rounded to 2 decimal places. Tables assume DC or resistive AC loads (power factor 1).

Watts to amps

Watts (W)	Amps at 12 V	Amps at 24 V	Amps at 120 V	Amps at 230 V	Amps at 240 V
5	0.42	0.21	0.04	0.02	0.02
10	0.83	0.42	0.08	0.04	0.04
25	2.08	1.04	0.21	0.11	0.10
40	3.33	1.67	0.33	0.17	0.17
60	5.00	2.50	0.50	0.26	0.25
100	8.33	4.17	0.83	0.43	0.42
150	12.50	6.25	1.25	0.65	0.63
200	16.67	8.33	1.67	0.87	0.83
300	25.00	12.50	2.50	1.30	1.25
500	41.67	20.83	4.17	2.17	2.08
750	62.50	31.25	6.25	3.26	3.13
1,000	83.33	41.67	8.33	4.35	4.17
1,200	100.00	50.00	10.00	5.22	5.00
1,500	125.00	62.50	12.50	6.52	6.25
1,800	150.00	75.00	15.00	7.83	7.50
2,000	166.67	83.33	16.67	8.70	8.33
2,500	208.33	104.17	20.83	10.87	10.42
3,000	250.00	125.00	25.00	13.04	12.50
3,500	291.67	145.83	29.17	15.22	14.58
5,000	416.67	208.33	41.67	21.74	20.83
7,000	583.33	291.67	58.33	30.43	29.17
10,000	833.33	416.67	83.33	43.48	41.67

Amps to watts (circuit and fuse ratings)

Current (A)	Watts at 12 V	Watts at 120 V	Watts at 230 V	Watts at 240 V
1	12	120	230	240
2	24	240	460	480
3	36	360	690	720
5	60	600	1,150	1,200
6	72	720	1,380	1,440
10	120	1,200	2,300	2,400
13	156	1,560	2,990	3,120
15	180	1,800	3,450	3,600
16	192	1,920	3,680	3,840
20	240	2,400	4,600	4,800
25	300	3,000	5,750	6,000

Current (A)	Watts at 12 V	Watts at 120 V	Watts at 230 V	Watts at 240 V
30	360	3,600	6,900	7,200
32	384	3,840	7,360	7,680
40	480	4,800	9,200	9,600
50	600	6,000	11,500	12,000
63	756	7,560	14,490	15,120

Energy use: watts and hours to kWh (units of electricity)

One unit on an electricity bill is 1 kWh. kWh = watts × hours ÷ 1000.

Watts (W)	kWh per hour	Hours per kWh	kWh per day (24 h)	kWh per month at 1 h/day	kWh per year at 1 h/day
5	0.005	200	0.12	0.15	1.8
10	0.01	100	0.24	0.3	3.7
40	0.04	25	0.96	1.2	14.6
60	0.06	16.67	1.44	1.8	21.9
100	0.1	10	2.4	3	36.5
150	0.15	6.67	3.6	4.5	54.8
500	0.5	2	12	15	182.5
1,000	1	1	24	30	365
1,500	1.5	0.67	36	45	547.5
2,000	2	0.5	48	60	730
2,500	2.5	0.4	60	75	912.5
3,000	3	0.33	72	90	1,095
7,000	7	0.14	168	210	2,555

Electrical quantities, symbols and SI units

Quantity	Symbol	Unit	Unit symbol	In other SI units
Electric current	I	ampere	A	SI base unit
Electric charge	Q	coulomb	C	A·s; 1 Ah = 3,600 C
Voltage (potential difference)	U or V	volt	V	W/A = J/C
Resistance	R	ohm	Ω	V/A
Conductance	G	siemens	S	A/V = 1/Ω
Resistivity	ρ	ohm metre	Ω·m	1 Ω·mm²/m = 10^{-6} Ω·m
Capacitance	C	farad	F	C/V
Inductance	L	henry	H	Wb/A = V·s/A
Active power	P	watt	W	J/s = V·A at power factor 1
Apparent power	S	volt-ampere	VA	V × A
Reactive power	Q	var	var	V × A × sin φ
Energy	E or W	joule	J	W·s; 1 kWh = 3.6 MJ
Frequency	f	hertz	Hz	1/s
Magnetic flux	Φ	weber	Wb	V·s
Magnetic flux density	B	tesla	T	Wb/m²
Electric field strength	E	volt per metre	V/m	N/C

Ohm's law and power formulas

Find	From V and I / R	From P and I / V	From P and R
Voltage V (volts)	V = I × R	V = P ÷ I	V = √(P × R)
Current I (amps)	I = V ÷ R	I = P ÷ V	I = √(P ÷ R)
Resistance R (ohms)	R = V ÷ I	R = V² ÷ P	R = P ÷ I²
Power P (watts)	P = V × I	P = I² × R	P = V² ÷ R

Find	From V and I / R	From P and I / V	From P and R
Three-phase power	P = √3 × V(line) × I × PF	I = P ÷ (√3 × V × PF)	PF = power factor (0–1)

Mains electricity by country (nominal)

Country / region	Voltage	Frequency
United Kingdom, Ireland	230 V	50 Hz
European Union	230 V	50 Hz
United States, Canada	120 V (240 V split-phase)	60 Hz
Mexico	127 V	60 Hz
Brazil	127 V or 220 V (varies by state)	60 Hz
Japan	100 V	50 Hz east / 60 Hz west
China	220 V	50 Hz
India	230 V	50 Hz
Australia, New Zealand	230 V	50 Hz
South Africa	230 V	50 Hz

Sources and method

- **BIPM SI Brochure, 9th edition** — Definitions of the SI units, including the kelvin (www.bipm.org/en/publications/si-brochure)
- **NIST Special Publication 811** — Guide for the Use of the International System of Units (www.nist.gov/pml/special-publication-811)
- **IEC 60038** — IEC standard voltages for electricity supply systems

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AWG Wire Size Chart

American Wire Gauge 4/0 to 40: diameter, area in mm² and kcmil, copper resistance and nearest metric size

For: Electricians, electronics engineers, installers, makers and students

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KEY RELATIONSHIP	FORMULA	REVERSE	WORKED EXAMPLE
AWG 36 = 0.005 in and AWG 4/0 = 0.46 in; 39 steps between them (ASTM B258)	d = 0.005 in × 92^((36 − n) ÷ 39)	n = 36 − 39 × $\log_{92}$(d ÷ 0.005 in)	AWG 12: 0.0808 in = 2.053 mm, 3.31 mm²

Solid round copper at 20 °C, 1/58 Ω·mm²/m (IEC 60028). Every 6 gauges halves the diameter; every 3 gauges halves the area.

AWG sizes, dimensions and copper resistance

Nearest metric size is the closest IEC 60228 cross-section by area. It is not a substitute for sizing a cable to your wiring code.

AWG	Diameter (in)	Diameter (mm)	Area (mm²)	Area (kcmil)	Ω per km	Ω per 1000 ft	Nearest mm²
4/0 (0000)	0.4600	11.684	107.2	211.6	0.1608	0.04901	120
3/0 (000)	0.4096	10.405	85.03	167.8	0.2028	0.0618	95
2/0 (00)	0.3648	9.266	67.43	133.1	0.2557	0.07793	70
1/0 (0)	0.3249	8.251	53.48	105.5	0.3224	0.09827	50
1	0.2893	7.348	42.41	83.69	0.4066	0.1239	50
2	0.2576	6.544	33.63	66.37	0.5127	0.1563	35
3	0.2294	5.827	26.67	52.63	0.6465	0.197	25
4	0.2043	5.189	21.15	41.74	0.8152	0.2485	25
5	0.1819	4.621	16.77	33.1	1.028	0.3133	16
6	0.1620	4.115	13.3	26.25	1.296	0.3951	16
7	0.1443	3.665	10.55	20.82	1.634	0.4982	10
8	0.1285	3.264	8.366	16.51	2.061	0.6282	10
9	0.1144	2.906	6.634	13.09	2.599	0.7921	6
10	0.1019	2.588	5.261	10.38	3.277	0.9989	6
11	0.0907	2.305	4.172	8.234	4.132	1.26	4
12	0.0808	2.053	3.309	6.53	5.211	1.588	4
13	0.0720	1.828	2.624	5.178	6.571	2.003	2.5
14	0.0641	1.628	2.081	4.107	8.286	2.525	2.5
15	0.0571	1.450	1.65	3.257	10.45	3.184	1.5
16	0.0508	1.291	1.309	2.583	13.17	4.016	1.5
17	0.0453	1.150	1.038	2.048	16.61	5.064	1
18	0.0403	1.024	0.823	1.624	20.95	6.385	0.75
19	0.0359	0.912	0.6527	1.288	26.42	8.051	0.75
20	0.0320	0.812	0.5176	1.022	33.31	10.15	0.5
21	0.0285	0.723	0.4105	0.8101	42	12.8	0.5
22	0.0253	0.644	0.3255	0.6424	52.96	16.14	—
23	0.0226	0.573	0.2582	0.5095	66.79	20.36	—
24	0.0201	0.511	0.2047	0.404	84.22	25.67	—
25	0.0179	0.455	0.1624	0.3204	106.2	32.37	—
26	0.0159	0.405	0.1288	0.2541	133.9	40.81	—
27	0.0142	0.361	0.1021	0.2015	168.9	51.47	—
28	0.0126	0.321	0.08098	0.1598	212.9	64.9	—
29	0.0113	0.286	0.06422	0.1267	268.5	81.84	—
30	0.0100	0.255	0.05093	0.1005	338.6	103.2	—
31	0.0089	0.227	0.04039	0.0797	426.9	130.1	—
32	0.0080	0.202	0.03203	0.06321	538.3	164.1	—
33	0.0071	0.180	0.0254	0.05013	678.8	206.9	—

AWG	Diameter (in)	Diameter (mm)	Area (mm²)	Area (kcmil)	Ω per km	Ω per 1000 ft	Nearest mm²
34	0.0063	0.160	0.02014	0.03975	856	260.9	—
35	0.0056	0.143	0.01597	0.03152	1,079	329	—
36	0.0050	0.127	0.01267	0.025	1,361	414.8	—
37	0.0045	0.113	0.01005	0.01983	1,716	523.1	—
38	0.0040	0.101	0.007967	0.01572	2,164	659.6	—
39	0.0035	0.090	0.006318	0.01247	2,729	831.8	—
40	0.0031	0.080	0.00501	0.009888	3,441	1,049	—

Metric cable sizes (IEC 60228) to AWG

Area (mm²)	Solid diameter (mm)	Area (kcmil)	Nearest AWG	Ω per km (copper)
0.5	0.80	0.9868	20	34.48
0.75	0.98	1.48	18	22.99
1	1.13	1.974	17	17.24
1.5	1.38	2.96	15	11.49
2.5	1.78	4.934	13	6.897
4	2.26	7.894	11	4.31
6	2.76	11.84	9	2.874
10	3.57	19.74	7	1.724
16	4.51	31.58	5	1.078
25	5.64	49.34	3	0.6897
35	6.68	69.07	2	0.4926
50	7.98	98.68	1/0 (0)	0.3448
70	9.44	138.1	2/0 (00)	0.2463
95	11.00	187.5	3/0 (000)	0.1815
120	12.36	236.8	4/0 (0000)	0.1437
150	13.82	296	4/0 (0000)	0.1149
185	15.35	365.1	4/0 (0000)	0.0932
240	17.48	473.6	4/0 (0000)	0.07184
300	19.54	592.1	4/0 (0000)	0.05747
400	22.57	789.4	4/0 (0000)	0.0431
500	25.23	986.8	4/0 (0000)	0.03448
630	28.32	1,243	4/0 (0000)	0.02737

Using this chart

Point	What to know
Stranded wire	A stranded conductor of the same gauge has about the same copper area but a slightly larger overall diameter.
Resistance and temperature	Copper resistance rises about 0.393% per °C above 20 °C; at 75 °C it is about 22% higher than shown.
Current rating	Ampacity depends on insulation, installation method, bundling and ambient temperature. Use NEC Table 310.16, BS 7671 or IEC 60364-5-52.
kcmil and MCM	1 kcmil = 1,000 circular mils = 0.5067 mm². Sizes above 4/0 are named in kcmil (250, 300, 350 …).
Voltage drop	Two-wire drop = 2 × length × current × Ω per unit length. Many codes recommend no more than 3% to 5%.

Sources and method

- **ASTM B258** — Standard nominal diameters and cross-sectional areas of AWG sizes of solid round wires
- **IEC 60028** — International standard of resistance for copper: 1/58 Ω·mm²/m at 20 °C (100% IACS)
- **IEC 60228** — Conductors of insulated cables: nominal cross-sectional areas

Diameters and areas are calculated from the AWG definition; resistance uses the IEC 60028 copper resistivity; the nearest metric size is the IEC 60228 cross-section closest in area. Interactive version, corrections and more charts: **allunitconversions.com/awg-wire-size-chart**

kVA and kW to Amps Chart

Full-load current for transformers and generators, single- and three-phase, 120 V to 600 V

For: Electricians, electrical engineers, generator and transformer installers, facilities managers

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KEY RELATIONSHIP
Apparent power S (kVA) = √3 × V(line) × I ÷ 1000 for three-phase; V × I ÷ 1000 for single-phase

FORMULA
I = kVA × 1000 ÷ (√3 × V); I = kW × 1000 ÷ (√3 × V × PF)

REVERSE
kVA = √3 × V × I ÷ 1000; kW = kVA × PF

WORKED EXAMPLE
500 kVA at 480 V three-phase: 500,000 ÷ (1.732 × 480) = 601.4 A

Amps to 1 decimal place. Voltages are line-to-line for three-phase. Generators are usually rated at power factor 0.8.

Three-phase kVA to amps

kVA	208 V	220 V	380 V	400 V	415 V	440 V	480 V	600 V
3	8.3	7.9	4.6	4.3	4.2	3.9	3.6	2.9
6	16.7	15.7	9.1	8.7	8.3	7.9	7.2	5.8
9	25.0	23.6	13.7	13.0	12.5	11.8	10.8	8.7
15	41.6	39.4	22.8	21.7	20.9	19.7	18.0	14.4
30	83.3	78.7	45.6	43.3	41.7	39.4	36.1	28.9
45	124.9	118.1	68.4	65.0	62.6	59.0	54.1	43.3
50	138.8	131.2	76.0	72.2	69.6	65.6	60.1	48.1
75	208.2	196.8	114.0	108.3	104.3	98.4	90.2	72.2
100	277.6	262.4	151.9	144.3	139.1	131.2	120.3	96.2
112.5	312.3	295.2	170.9	162.4	156.5	147.6	135.3	108.3
125	347.0	328.0	189.9	180.4	173.9	164.0	150.4	120.3
150	416.4	393.6	227.9	216.5	208.7	196.8	180.4	144.3
200	555.1	524.9	303.9	288.7	278.2	262.4	240.6	192.5
225	624.5	590.5	341.9	324.8	313.0	295.2	270.6	216.5
250	693.9	656.1	379.8	360.8	347.8	328.0	300.7	240.6
300	832.7	787.3	455.8	433.0	417.4	393.6	360.8	288.7
400	1,110.3	1,049.7	607.7	577.4	556.5	524.9	481.1	384.9
500	1,387.9	1,312.2	759.7	721.7	695.6	656.1	601.4	481.1
630	1,748.7	1,653.3	957.2	909.3	876.5	826.7	757.8	606.2
750	2,081.8	1,968.2	1,139.5	1,082.5	1,043.4	984.1	902.1	721.7
800	2,220.6	2,099.5	1,215.5	1,154.7	1,113.0	1,049.7	962.3	769.8
1,000	2,775.7	2,624.3	1,519.3	1,443.4	1,391.2	1,312.2	1,202.8	962.3
1,250	3,469.7	3,280.4	1,899.2	1,804.2	1,739.0	1,640.2	1,503.5	1,202.8
1,500	4,163.6	3,936.5	2,279.0	2,165.1	2,086.8	1,968.2	1,804.2	1,443.4
2,000	5,551.4	5,248.6	3,038.7	2,886.8	2,782.4	2,624.3	2,405.6	1,924.5
2,500	6,939.3	6,560.8	3,798.4	3,608.4	3,478.0	3,280.4	3,007.0	2,405.6
3,000	8,327.2	7,873.0	4,558.0	4,330.1	4,173.6	3,936.5	3,608.4	2,886.8

Single-phase kVA to amps

kVA	120 V	208 V	220 V	230 V	240 V	277 V
0.5	4.2	2.4	2.3	2.2	2.1	1.8
1	8.3	4.8	4.5	4.3	4.2	3.6
1.5	12.5	7.2	6.8	6.5	6.3	5.4
2	16.7	9.6	9.1	8.7	8.3	7.2

kVA	120 V	208 V	220 V	230 V	240 V	277 V
3	25.0	14.4	13.6	13.0	12.5	10.8
5	41.7	24.0	22.7	21.7	20.8	18.1
7.5	62.5	36.1	34.1	32.6	31.3	27.1
10	83.3	48.1	45.5	43.5	41.7	36.1
15	125.0	72.1	68.2	65.2	62.5	54.2
25	208.3	120.2	113.6	108.7	104.2	90.3
37.5	312.5	180.3	170.5	163.0	156.3	135.4
50	416.7	240.4	227.3	217.4	208.3	180.5
75	625.0	360.6	340.9	326.1	312.5	270.8
100	833.3	480.8	454.5	434.8	416.7	361.0
167	1,391.7	802.9	759.1	726.1	695.8	602.9

Three-phase kW to amps at power factor 0.8 (generators)

kW	kVA	208 V	400 V	415 V	480 V	600 V
10	12.5	34.7	18.0	17.4	15.0	12.0
20	25	69.4	36.1	34.8	30.1	24.1
25	31.3	86.7	45.1	43.5	37.6	30.1
30	37.5	104.1	54.1	52.2	45.1	36.1
40	50	138.8	72.2	69.6	60.1	48.1
50	62.5	173.5	90.2	87.0	75.2	60.1
60	75	208.2	108.3	104.3	90.2	72.2
75	93.8	260.2	135.3	130.4	112.8	90.2
80	100	277.6	144.3	139.1	120.3	96.2
100	125	347.0	180.4	173.9	150.4	120.3
125	156.3	433.7	225.5	217.4	187.9	150.4
150	187.5	520.4	270.6	260.9	225.5	180.4
200	250	693.9	360.8	347.8	300.7	240.6
250	312.5	867.4	451.1	434.8	375.9	300.7
300	375	1,040.9	541.3	521.7	451.1	360.8
400	500	1,387.9	721.7	695.6	601.4	481.1
500	625	1,734.8	902.1	869.5	751.8	601.4
600	750	2,081.8	1,082.5	1,043.4	902.1	721.7
750	937.5	2,602.2	1,353.2	1,304.3	1,127.6	902.1
800	1,000	2,775.7	1,443.4	1,391.2	1,202.8	962.3
1,000	1,250	3,469.7	1,804.2	1,739.0	1,503.5	1,202.8
1,500	1,875	5,204.5	2,706.3	2,608.5	2,255.3	1,804.2
2,000	2,500	6,939.3	3,608.4	3,478.0	3,007.0	2,405.6

Three-phase amps to kVA

Amps	kVA at 208 V	kVA at 400 V	kVA at 415 V	kVA at 480 V	kVA at 600 V
10	3.6	6.9	7.2	8.3	10.4
16	5.8	11.1	11.5	13.3	16.6
20	7.2	13.9	14.4	16.6	20.8
25	9.0	17.3	18.0	20.8	26.0
32	11.5	22.2	23.0	26.6	33.3
40	14.4	27.7	28.8	33.3	41.6
50	18.0	34.6	35.9	41.6	52.0
63	22.7	43.6	45.3	52.4	65.5

Amps	kVA at 208 V	kVA at 400 V	kVA at 415 V	kVA at 480 V	kVA at 600 V
80	28.8	55.4	57.5	66.5	83.1
100	36.0	69.3	71.9	83.1	103.9
125	45.0	86.6	89.9	103.9	129.9
160	57.6	110.9	115.0	133.0	166.3
200	72.1	138.6	143.8	166.3	207.8
250	90.1	173.2	179.7	207.8	259.8
400	144.1	277.1	287.5	332.6	415.7
630	227.0	436.5	452.8	523.8	654.7
800	288.2	554.3	575.0	665.1	831.4
1,000	360.3	692.8	718.8	831.4	1,039.2
1,250	450.3	866.0	898.5	1,039.2	1,299.0
1,600	576.4	1,108.5	1,150.1	1,330.2	1,662.8
2,000	720.5	1,385.6	1,437.6	1,662.8	2,078.5
2,500	900.7	1,732.1	1,797.0	2,078.5	2,598.1
3,200	1,152.9	2,217.0	2,300.2	2,660.4	3,325.5
4,000	1,441.1	2,771.3	2,875.2	3,325.5	4,156.9

kW, kVA and kvar at different power factors

For 100 kW of load. Lower power factor means more current for the same real power.

Power factor	kVA for 100 kW	kvar for 100 kW	Amps at 400 V 3-phase	Amps at 480 V 3-phase
0.60	166.7	133.3	240.6	200.5
0.70	142.9	102.0	206.2	171.8
0.75	133.3	88.2	192.5	160.4
0.80	125.0	75.0	180.4	150.4
0.85	117.6	62.0	169.8	141.5
0.90	111.1	48.4	160.4	133.6
0.95	105.3	32.9	151.9	126.6
1.00	100.0	0.0	144.3	120.3

Formulas

Motor full-load currents for conductor and protection sizing come from code tables (NEC 430.248–430.250) or the motor nameplate, not from these formulas.

To find	Single-phase	Three-phase	DC
Amps from kVA	I = kVA × 1000 ÷ V	I = kVA × 1000 ÷ (√3 × V)	—
Amps from kW	I = kW × 1000 ÷ (V × PF)	I = kW × 1000 ÷ (√3 × V × PF)	I = kW × 1000 ÷ V
kVA from amps	kVA = V × I ÷ 1000	kVA = √3 × V × I ÷ 1000	—
kW from amps	kW = V × I × PF ÷ 1000	kW = √3 × V × I × PF ÷ 1000	kW = V × I ÷ 1000
kW from kVA	kW = kVA × PF	kW = kVA × PF	—
Motor input kW	kW = hp × 0.7457 ÷ efficiency	kW = hp × 0.7457 ÷ efficiency	kW = hp × 0.7457 ÷ efficiency

Sources and method

- **IEEE Std 1459** — Definitions of apparent (VA), active (W) and reactive (var) power
- **IEC 60038** — Standard voltages (230/400 V; 120/208 V, 277/480 V and 347/600 V systems in North America)

Every current is calculated from the formulas above. No values are typed in. Interactive version, corrections and more charts: **allunitconversions.com/kva-to-amps-chart**

Resistor Color Code Chart

Colour bands, multipliers, tolerance and tempco, E-series values, SMD and capacitor codes

For: Electronics students, makers, technicians and repair engineers

allunitconversions.com/resistor-color-code-chart
By Miguel Coelho · Edition 2.0
9 November 2026

KEY RELATIONSHIP	FORMULA	REVERSE	WORKED EXAMPLE
Digits, then a power-of-ten multiplier, then tolerance (IEC 60062)	R = (digit bands as a number) × 10^(multiplier)	Write the value with 2 or 3 significant digits; the exponent is the multiplier colour	Yellow–violet–red–gold = 47 × 10^2 Ω = 4.7 kΩ ±5%

Read from the end nearest a band; the tolerance band is usually set apart. Colours as IEC 60062:2016.

Resistor colour code

Colour	Digit	Multiplier	Tolerance (letter)	Temp. coefficient (letter)
Pink	—	× 0.001	—	—
Silver	—	× 0.01	±10% (K)	—
Gold	—	× 0.1	±5% (J)	—
Black	0	× 1	—	250 ppm/K (U)
Brown	1	× 10	±1% (F)	100 ppm/K (S)
Red	2	× 100	±2% (G)	50 ppm/K (R)
Orange	3	× 1 k	±0.05% (W)	15 ppm/K (P)
Yellow	4	× 10 k	±0.02% (P)	25 ppm/K (Q)
Green	5	× 100 k	±0.5% (D)	20 ppm/K (Z)
Blue	6	× 1 M	±0.25% (C)	10 ppm/K (Z)
Violet	7	× 10 M	±0.1% (B)	5 ppm/K (M)
Grey	8	× 100 M	±0.01% (L)	1 ppm/K (K)
White	9	× 1 G	—	—
None	—	—	±20% (M)	—

Reading 4, 5 and 6 band resistors

A 3-band resistor has no tolerance band and is ±20%. On 6-band parts the last band can also be a reliability band.

Bands	Band 1	Band 2	Band 3	Band 4	Band 5	Band 6
3 bands	1st digit	2nd digit	Multiplier	—	—	—
4 bands	1st digit	2nd digit	Multiplier	Tolerance	—	—
5 bands	1st digit	2nd digit	3rd digit	Multiplier	Tolerance	—
6 bands	1st digit	2nd digit	3rd digit	Multiplier	Tolerance	Temp. coefficient

Worked examples

Bands	Resistance	Tolerance
Brown – Black – Black – Gold	10 Ω	±5%
Brown – Black – Red – Gold	1 kΩ	±5%
Red – Red – Brown – Gold	220 Ω	±5%
Yellow – Violet – Red – Gold	4.7 kΩ	±5%
Brown – Black – Orange – Gold	10 kΩ	±5%
Brown – Black – Yellow – Silver	100 kΩ	±10%
Green – Blue – Gold – Gold	5.6 Ω	±5%
Brown – Black – Black – Brown – Brown	1 kΩ	±1%
Yellow – Violet – Black – Brown – Brown	4.7 kΩ	±1%
Orange – Orange – Black – Red – Brown	33 kΩ	±1%

E-series preferred values (one decade)

Multiply by 1, 10, 100, 1 k, 10 k … to get every standard value, e.g. E12 4.7 → 4.7 Ω, 47 Ω, 470 Ω, 4.7 kΩ.

Series	Tolerance	Values
E6	±20%	1.0 1.5 2.2 3.3 4.7 6.8
E12	±10%	1.0 1.2 1.5 1.8 2.2 2.7 3.3 3.9 4.7 5.6 6.8 8.2
E24	±5%	1.0 1.1 1.2 1.3 1.5 1.6 1.8 2.0 2.2 2.4 2.7 3.0 3.3 3.6 3.9 4.3 4.7 5.1 5.6 6.2 6.8 7.5 8.2 9.1

E96 values (±1%) and EIA-96 SMD codes

The EIA-96 code is the position of the value in this list (01–96) followed by a multiplier letter.

Code	Value	Code	Value	Code	Value	Code	Value
01	100	25	178	49	316	73	562
02	102	26	182	50	324	74	576
03	105	27	187	51	332	75	590
04	107	28	191	52	340	76	604
05	110	29	196	53	348	77	619
06	113	30	200	54	357	78	634
07	115	31	205	55	365	79	649
08	118	32	210	56	374	80	665
09	121	33	215	57	383	81	681
10	124	34	221	58	392	82	698
11	127	35	226	59	402	83	715
12	130	36	232	60	412	84	732
13	133	37	237	61	422	85	750
14	137	38	243	62	432	86	768
15	140	39	249	63	442	87	787
16	143	40	255	64	453	88	806
17	147	41	261	65	464	89	825
18	150	42	267	66	475	90	845
19	154	43	274	67	487	91	866
20	158	44	280	68	499	92	887
21	162	45	287	69	511	93	909
22	165	46	294	70	523	94	931
23	169	47	301	71	536	95	953
24	174	48	309	72	549	96	976

EIA-96 multiplier letters

Letter	Multiplier	Example	Resistance
Z	× 0.001	01Z	100 mΩ
Y or R	× 0.01	68Y	4.99 Ω
X or S	× 0.1	30X	20 Ω
A	× 1	01A	100 Ω
B or H	× 10	01B	1 kΩ
C	× 100	01C	10 kΩ
D	× 1,000	01D	100 kΩ
E	× 10,000	01E	1 MΩ
F	× 100,000	01F	10 MΩ

SMD resistor 3- and 4-digit codes

Code	Rule	Resistance
103	10×10^{3}	10 kΩ
472	47×10^{2}	4.7 kΩ

Code	Rule	Resistance
100	10×10^{0}	10 Ω
4R7	R marks the decimal point	4.7 Ω
R47	R marks the decimal point	470 mΩ
000 or 0	Zero-ohm link (jumper)	0 Ω
1002	100×10^{2} (1% parts)	10 kΩ
4701	470×10^{1}	4.7 kΩ
2490	249×10^{0}	249 Ω

Capacitor codes (value in pF)

Two digits and a multiplier, in picofarads: 104 = 10×10^{4} pF = 100 nF. A third digit of 8 or 9 means × 0.01 or × 0.1.

Code	Capacitance	Code	Capacitance
101	100 pF	471	470 pF
102	1 nF	222	2.2 nF
103	10 nF	472	4.7 nF
104	100 nF	224	220 nF
105	1 µF	474	470 nF
106	10 µF	109	1 pF

Capacitor tolerance letters

Letter	Tolerance	Typical use
B	±0.1 pF	Small capacitors, below 10 pF
C	±0.25 pF	Small capacitors, below 10 pF
D	±0.5 pF (or ±0.5% above 10 pF)	Small capacitors and precision parts
F	±1%	Precision film and C0G/NP0 ceramic
G	±2%	Precision film and C0G/NP0 ceramic
J	±5%	Film, C0G/NP0 ceramic
K	±10%	Film, X7R ceramic
M	±20%	Electrolytic, X7R and Y5V ceramic
Z	+80% / −20%	Y5V and Z5U ceramic (decoupling)

Sources and method

- **IEC 60062:2016** — Marking codes for resistors and capacitors (colour code, letter and digit codes)
- **IEC 60063:2015** — Preferred number series for resistors and capacitors (E series)
- **EIA-96 marking code** — Three-character code for 1% surface-mount resistors (E96 index + multiplier letter)

Colour, tolerance and temperature-coefficient codes are transcribed from IEC 60062:2016 and cross-checked against a second published table; preferred values are from IEC 60063; every worked example and code table is calculated from those definitions. Interactive version, corrections and more charts: **allunitconversions.com/resistor-color-code-chart**

Power Conversion Chart

Watts, kilowatts, horsepower, BTU/h and tons of refrigeration

For: Engineers, HVAC technicians, electricians and mechanics

allunitconversions.com/power-conversion-chart
By Miguel Coelho · Edition 2.0
9 November 2026

EXACT DEFINITION	FORMULA	REVERSE	WORKED EXAMPLE
1 hp = 745.699 872 W; 1 BTU/h = 0.293 071 W; 1 RT = 12,000 BTU/h	kW = hp × 0.7457; W = BTU/h × 0.293 071	hp = kW ÷ 0.7457; BTU/h = W × 3.412 14	A 12,000 BTU/h air conditioner = 3.517 kW = 1 RT

Matrix values use 6 significant figures; tables are rounded as shown.

Factor matrix — 1 unit in every other unit

1 unit =	W	kW	MW	hp	PS	BTU/h	RT
1 W	1	0.001	1×10^{-6}	0.00134102	0.00135962	3.41214	2.84345×10^{-4}
1 kW	1,000	1	0.001	1.34102	1.35962	3,412.14	0.284345
1 MW	1×10^{6}	1,000	1	1,341.02	1,359.62	3.41214×10^{6}	284.345
1 hp	745.7	0.7457	7.457×10^{-4}	1	1.01387	2,544.43	0.212036
1 PS	735.499	0.735499	7.35499×10^{-4}	0.98632	1	2,509.63	0.209135
1 BTU/h	0.293071	2.93071×10^{-4}	2.93071×10^{-7}	3.93015×10^{-4}	3.98466×10^{-4}	1	8.33333×10^{-5}
1 RT	3,516.85	3.51685	0.00351685	4.71618	4.78159	12,000	1

Horsepower to kilowatts

Horsepower (mech.) (hp)	Kilowatts (kW)	Horsepower (mech.) (hp)	Kilowatts (kW)	Horsepower (mech.) (hp)	Kilowatts (kW)	Horsepower (mech.) (hp)	Kilowatts (kW)
1	0.75	**12**	8.95	**35**	26.10	**90**	67.11
2	1.49	**13**	9.69	**40**	29.83	**95**	70.84
3	2.24	**14**	10.44	**45**	33.56	**100**	74.57
4	2.98	**15**	11.19	**50**	37.28	**150**	111.85
5	3.73	**16**	11.93	**55**	41.01	**200**	149.14
6	4.47	**17**	12.68	**60**	44.74	**250**	186.42
7	5.22	**18**	13.42	**65**	48.47	**300**	223.71
8	5.97	**19**	14.17	**70**	52.20	**350**	260.99
9	6.71	**20**	14.91	**75**	55.93	**400**	298.28
10	7.46	**25**	18.64	**80**	59.66	**450**	335.56
11	8.20	**30**	22.37	**85**	63.38	**500**	372.85

BTU per hour to watts and tons of refrigeration

BTU per hour (BTU/h)	Watts (W)	Tons of refrigeration (RT)	BTU per hour (BTU/h)	Watts (W)	Tons of refrigeration (RT)
1,000	293	0.08	**18,000**	5,275	1.50
2,000	586	0.17	**24,000**	7,034	2.00
5,000	1,465	0.42	**30,000**	8,792	2.50
6,000	1,758	0.50	**36,000**	10,551	3.00
8,000	2,345	0.67	**42,000**	12,309	3.50
9,000	2,638	0.75	**48,000**	14,067	4.00
10,000	2,931	0.83	**60,000**	17,584	5.00
12,000	3,517	1.00	**100,000**	29,307	8.33
15,000	4,396	1.25			

Sources and method

- **NIST Special Publication 811** — Guide for the Use of the International System of Units (www.nist.gov/pml/special-publication-811)

Conversion values on this sheet are generated by the AllUnitConversions conversion library and automatically checked against the exact definitions above before the PDF is produced; reference tables are taken from the sources listed. Interactive version, corrections and more charts: **allunitconversions.com/power-conversion-chart**

mAh to Wh Battery Chart

Milliamp-hours to watt-hours for phone cells, power banks and battery packs, with airline limits

For: Travellers, drone and camera users, makers, e-bike and solar users

allunitconversions.com/mah-to-wh-chart
By Miguel Coelho · Edition 2.0
9 November 2026

KEY RELATIONSHIP	FORMULA	REVERSE	WORKED EXAMPLE
Energy (Wh) = charge (Ah) × nominal voltage (V)	Wh = mAh × V ÷ 1000	mAh = Wh × 1000 ÷ V	A 20,000 mAh power bank at 3.7 V = 74 Wh (under the 100 Wh airline limit)

Wh to 1 decimal place. Use the nominal cell voltage printed on the battery (3.6 V, 3.7 V or 3.85 V for most lithium-ion cells).

Phone cells and power banks: mAh to Wh

mAh	Wh at 3.6 V	Wh at 3.7 V	Wh at 3.85 V	mAh	Wh at 3.6 V	Wh at 3.7 V	Wh at 3.85 V
1,000	3.6	3.7	3.9	**10,000**	36.0	37.0	38.5
2,000	7.2	7.4	7.7	**12,000**	43.2	44.4	46.2
2,500	9.0	9.3	9.6	**15,000**	54.0	55.5	57.8
3,000	10.8	11.1	11.6	**20,000**	72.0	74.0	77.0
3,500	12.6	13.0	13.5	**25,000**	90.0	92.5	96.3
4,000	14.4	14.8	15.4	**26,800**	96.5	99.2	103.2
4,500	16.2	16.7	17.3	**27,000**	97.2	99.9	104.0
5,000	18.0	18.5	19.3	**30,000**	108.0	111.0	115.5
6,000	21.6	22.2	23.1	**40,000**	144.0	148.0	154.0
8,000	28.8	29.6	30.8	**50,000**	180.0	185.0	192.5

Airline category at 3.7 V

Categories by watt-hour rating; the rules for each category are in the table below.

mAh at 3.7 V	Wh	Category
10,000	37.0	Up to 100 Wh
20,000	74.0	Up to 100 Wh
25,000	92.5	Up to 100 Wh
26,800	99.2	Up to 100 Wh
27,000	99.9	Up to 100 Wh
30,000	111.0	100–160 Wh
40,000	148.0	100–160 Wh
43,000	159.1	100–160 Wh
45,000	166.5	Over 160 Wh

Battery packs: Ah to Wh

Ah	7.4 V	11.1 V	12 V	12.8 V	14.8 V	24 V	36 V	48 V
1	7.4	11.1	12	12.8	14.8	24	36	48
2	14.8	22.2	24	25.6	29.6	48	72	96
2.5	18.5	27.8	30	32	37	60	90	120
3	22.2	33.3	36	38.4	44.4	72	108	144
4	29.6	44.4	48	51.2	59.2	96	144	192
5	37	55.5	60	64	74	120	180	240
6	44.4	66.6	72	76.8	88.8	144	216	288
7	51.8	77.7	84	89.6	103.6	168	252	336
9	66.6	99.9	108	115.2	133.2	216	324	432

Ah	7.4 V	11.1 V	12 V	12.8 V	14.8 V	24 V	36 V	48 V
10	74	111	120	128	148	240	360	480
12	88.8	133.2	144	153.6	177.6	288	432	576
18	133.2	199.8	216	230.4	266.4	432	648	864
20	148	222	240	256	296	480	720	960
35	259	388.5	420	448	518	840	1,260	1,680
50	370	555	600	640	740	1,200	1,800	2,400
100	740	1,110	1,200	1,280	1,480	2,400	3,600	4,800
200	1,480	2,220	2,400	2,560	2,960	4,800	7,200	9,600

Watt-hours to mAh

Wh	mAh at 3.6 V	mAh at 3.7 V	mAh at 3.85 V
5	1,389	1,351	1,299
10	2,778	2,703	2,597
20	5,556	5,405	5,195
27	7,500	7,297	7,013
37	10,278	10,000	9,610
50	13,889	13,514	12,987
60	16,667	16,216	15,584

Wh	mAh at 3.6 V	mAh at 3.7 V	mAh at 3.85 V
74	20,556	20,000	19,221
90	25,000	24,324	23,377
99	27,500	26,757	25,714
100	27,778	27,027	25,974
120	33,333	32,432	31,169
160	44,444	43,243	41,558

Lithium batteries in passenger baggage (ICAO and IATA, 2026)

Power banks must not be recharged on board, and should not be used to charge devices in flight. Many airlines are stricter (for example one power bank only). Check your airline before you fly.

Rating	Item	Carry-on	Checked	Airline approval
Up to 100 Wh	In a device (phone, laptop, camera)	Yes	Yes, switched fully off	No
Up to 100 Wh	Spare battery	Yes, terminals protected	No	No
Up to 100 Wh	Power bank	Yes, at most 2 per person	No	No
100–160 Wh	In a device	Yes	Yes	Yes
100–160 Wh	Spare battery	Yes, at most 2	No	Yes
100–160 Wh	Power bank	Only with approval until 31 Dec 2026; not allowed from 1 Jan 2027	No	Yes
Over 160 Wh	Any	No: cargo only, under the Dangerous Goods Regulations	No	—

Useful battery formulas

To find	Formula	Example
Watt-hours	Wh = mAh × V ÷ 1000	5,000 mAh × 3.85 V ÷ 1000 = 19.25 Wh
Milliamp-hours	mAh = Wh × 1000 ÷ V	99 Wh × 1000 ÷ 3.7 V = 26,757 mAh
Runtime	hours ≈ Wh × efficiency ÷ load (W)	100 Wh × 0.85 ÷ 20 W = 4.25 h
Power-bank output at 5 V	mAh(5 V) ≈ mAh × 3.7 ÷ 5 × efficiency	20,000 mAh × 3.7 ÷ 5 × 0.85 = 12,580 mAh
Charge time	hours ≈ Ah ÷ charge current (A) × 1.2	5 Ah ÷ 2 A × 1.2 = 3 h

Sources and method

- **ICAO Doc 9284 Technical Instructions 2025–2026, Addendum No. 1 (27 March 2026)** — Power banks: carry-on only, at most two per person, not recharged on board
- **IATA, Changes Regarding Power Banks: guidance for operators (31 March 2026)** — Passenger table for lithium batteries; 100–160 Wh power-bank approval not carried into the 68th edition DGR (1 January 2027) (www.iata.org/en/programs/cargo/dgr/lithium-batteries/)

Watt-hours are calculated from Wh = mAh × V ÷ 1000; airline rules are summarised from the ICAO addendum and IATA guidance listed, current at the edition date. Interactive version, corrections and more charts: **allunitconversions.com/mah-to-wh-chart**