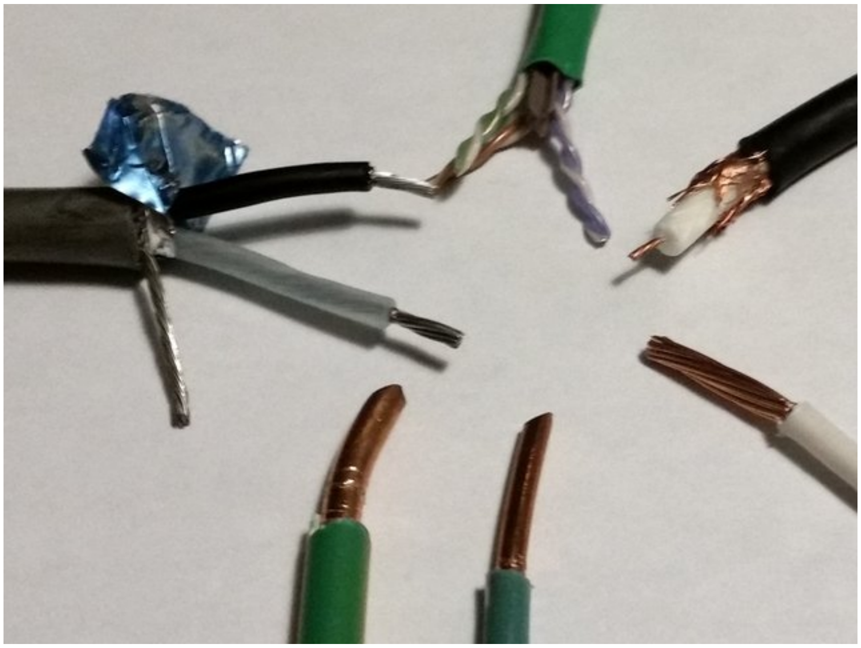

Wires and Connections

By Anne Barela
How to choose your next projects connections

Feedback? Corrections?

Wire Gauges

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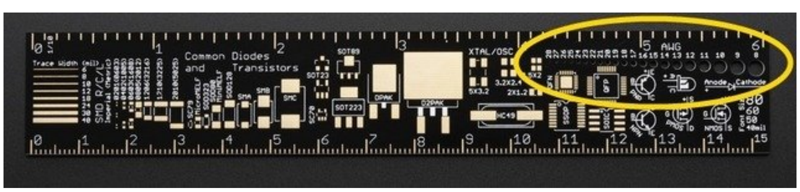
Size Matters

You'll probably have noticed wires come in many different sizes. Take apart a relay and the coil has fine coper wire thinner than human hair. On the other side are thick cables feeding power into homes and businesses.

With increasing size, wire can handle more electron flow (current, measured in Amperes). Just like a garden hose, a larger diameter hose carries more water in a given time over a given distance.

Wire sizes are most often measures in standardized *American Wire Guage* (AWG) sizes. The electronics industry uses the diameter of the wire in predefined sizes for manufacturability and known electrical characteristics.



The Adafruit Ruler has a handy wire gauge finder built in from 8 to 28 AWG

Below is a table of American Wire Gauge standard sizes and the characteristics of each wire size. For a particular gauge, it has a set diameter and cross-sectional area. When winding wire around for an inductor, coil, or transformer it is handy to know how thick the wire will stack up, which increases by wire gauge. An important measure is the electrical resistance of the wire which increases as the gauge goes higher and the diameter decreases. This is measured on ohms per kilometer or milliohms per meter. Finally the last column for Americans lists national electrical code current capacity for larger gauge wires - it is a good demonstration of current capacity changing as wire area changes.

AWG	Diameter (mm)	Turns of Wire, no insul. (per cm)	Area (mm^2)	Copper resistance (Ω/km)	Maximum Amperage for wiring

				(mΩ/m)	(amps)
0 (1/0)	8.251	1.21	53.5	0.3224	245
1	7.348	1.36	42.4	0.4066	211
2	6.544	1.53	33.6	0.5127	181
3	5.827	1.72	26.7	0.6465	158
4	5.189	1.93	21.2	0.8152	135
5	4.621	2.16	16.8	1.028	118
6	4.115	2.43	13.3	1.296	101
7	3.665	2.73	10.5	1.634	89
8	3.264	3.06	8.37	2.061	73
9	2.906	3.44	6.63	2.599	64
10	2.588	3.86	5.26	3.277	55
11	2.305	4.34	4.17	4.132	47
12	2.053	4.87	3.31	5.211	41
13	1.828	5.47	2.62	6.571	35
14	1.628	6.14	2.08	8.286	32
15	1.45	6.9	1.65	10.45	28
16	1.291	7.75	1.31	13.17	22
17	1.15	8.7	1.04	16.61	19
18	1.024	9.77	0.823	20.95	16
19	0.912	11	0.653	26.42	14
20	0.812	12.3	0.518	33.31	11
21	0.723	13.8	0.41	42.0	9
22	0.644	15.5	0.326	52.96	7, Common for breadboards
23	0.573	17.4	0.258	66.79	4.7
24	0.511	19.6	0.205	84.22	3.5
25	0.455	22	0.162	106.2	2.7
26	0.405	24.7	0.129	133.9	2.2
27	0.361	27.7	0.102	168.9	1.7
28	0.321	31.1	0.081	212.9	1.4
29	0.286	35	0.0642	268.5	1.2
30	0.255	39.3	0.0509	338.6	0.86
31	0.227	44.1	0.0404	426.9	0.70
32	0.202	49.5	0.032	538.3	0.53
33	0.18	55.6	0.0254	678.8	0.43
34	0.16	62.4	0.0201	856	0.33
35	0.143	70.1	0.016	1079	0.27
36	0.127	78.7	0.0127	1361	0.21
37	0.113	88.4	0.0100	1716	0.17
38	0.101	99.3	0.00797	2164	0.13
39	0.0897	111	0.00632	2729	0.11
40	0.0799	125	0.00501	3441	0.09

It is common to see the even size gauges in sizes 10 AWG and above. The smaller odd sizes are not seen as often.

For a majority of projects, getting the exact gauge of wire is not a critical factor - close enough is usually fine. Here are some things to consider for choosing a gauge:

1. Power - if you have high current requirements in a curcuit like large motors or many LED lights, select thicker wire starting at 18 AWG and lower. The size is based on handling the current while remaining cool plus providing lower resistance. This goes for wearables also - do not sew too many power hungry LEDs with the thinnest wire that cannot handle the current draw.

2. Breadboards - typically breadboard holes only handle a small range of wire gauges. Too small a wire and it falls out or makes a poor connection. Too large a wire will bend out a hole or just not fit. It is best to buy some wire specifically marketed for breadboards, most often 22 gauge. Alternatively, if you run accross some solid telephone wire from a recent installation, it's a tad smaller but works.

3. Resistance - Although much of the time you can design circuits thinking that wires have near zero electrical resistance to current flow, there are times where you must choose wire so that resistance is not a big factor. If temperature is a factor in resistance measurements, take the resistance per kilometer above (we'll label that R_0), and for copper wire, resistance related to temperature is $R = R_0 * (1 + 0.004 * (T - 20))$ where the temperature T is in Celcius. You can take resistance R and multiply by the number of kilometers for ohms, meters for milliohms.

Wire Cable

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