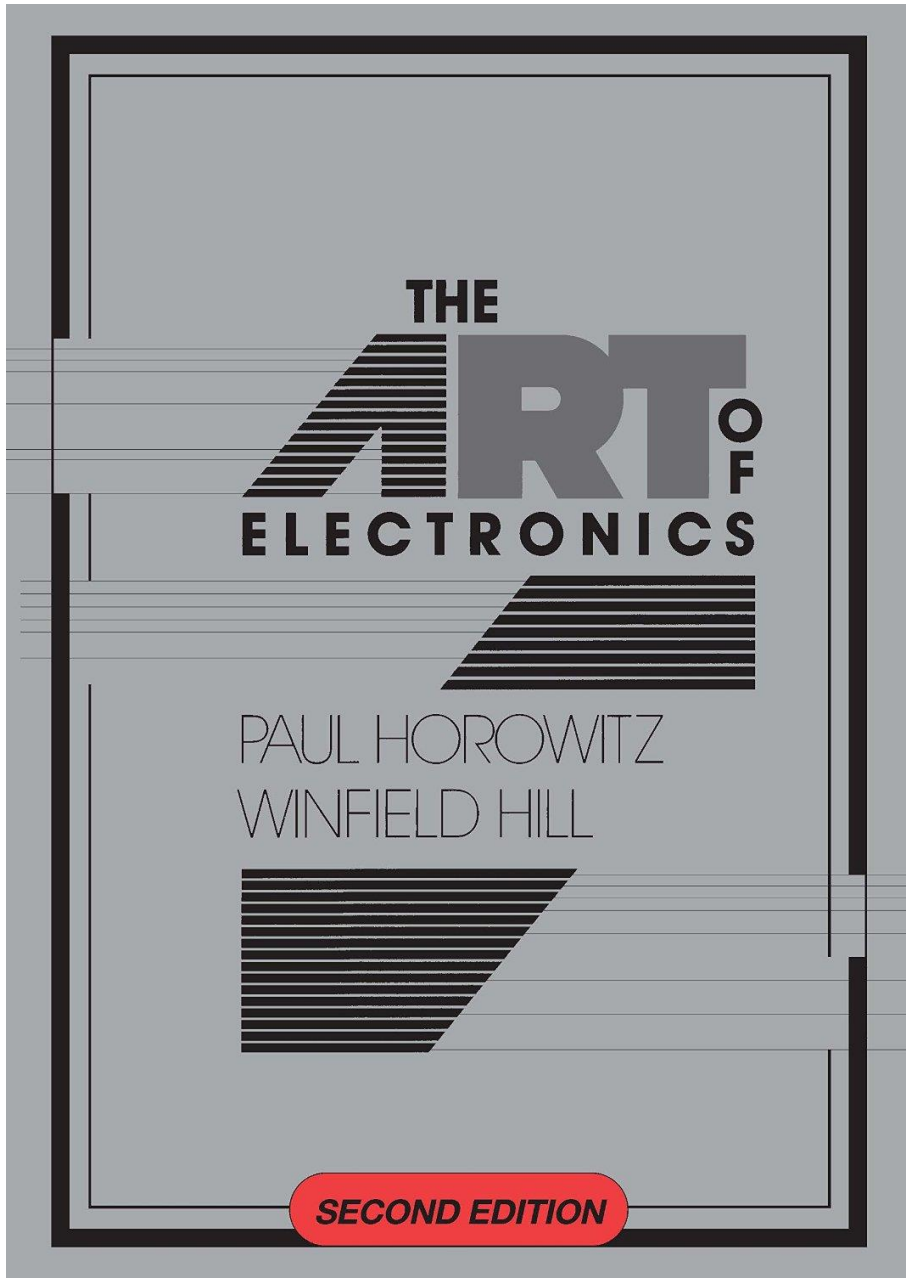
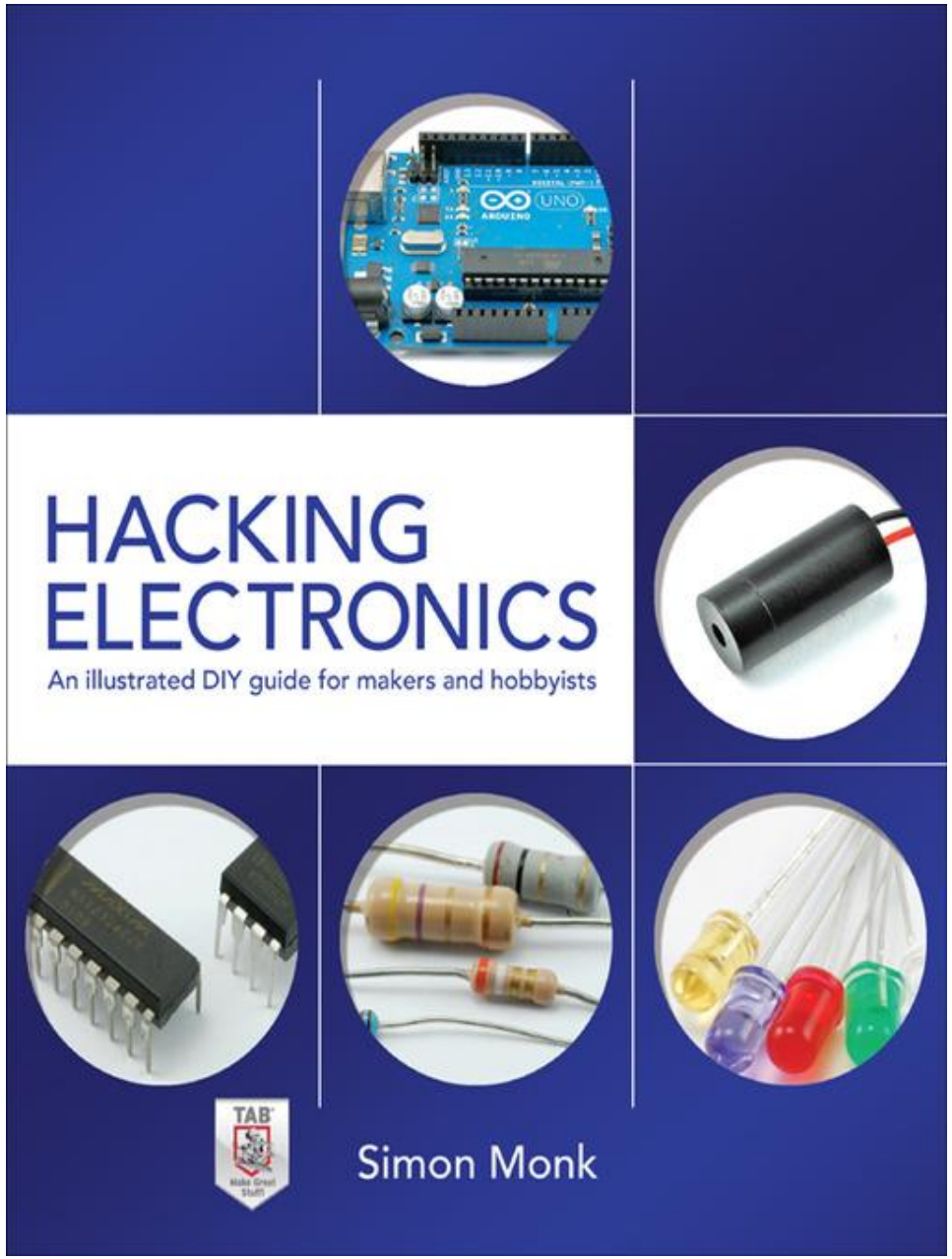
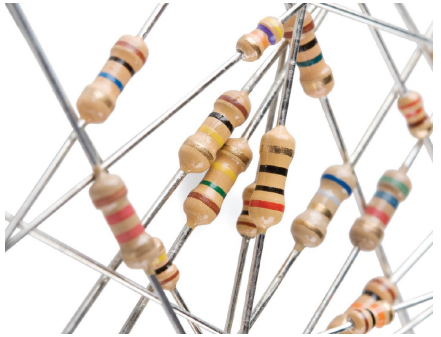
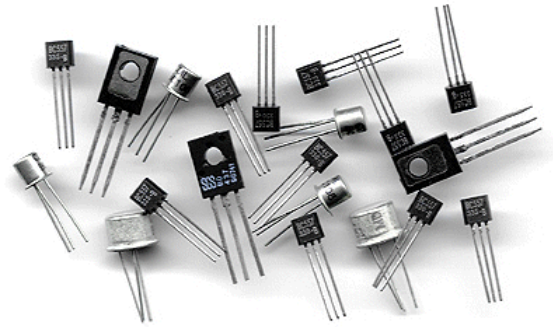

THE
ART OF
ELECTRONICS
PAUL HOROWITZ
WINFIELD HILL
SECOND EDITION

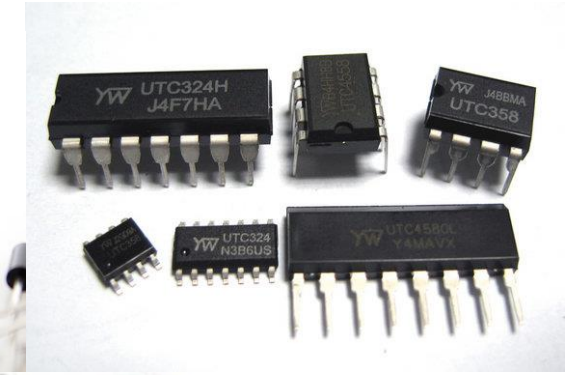

HACKING
ELECTRONICS
An illustrated DIY guide for makers and hobbyists
TAB
Simon Monk

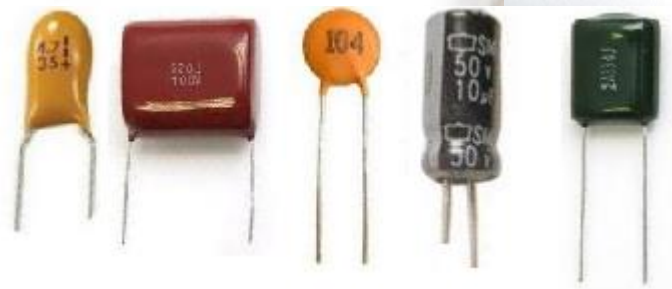
How to identify electronic components?

- Appearance → Name/type
- Value
- Function
- Purpose (applications)
- Limitations/constraints
- +++

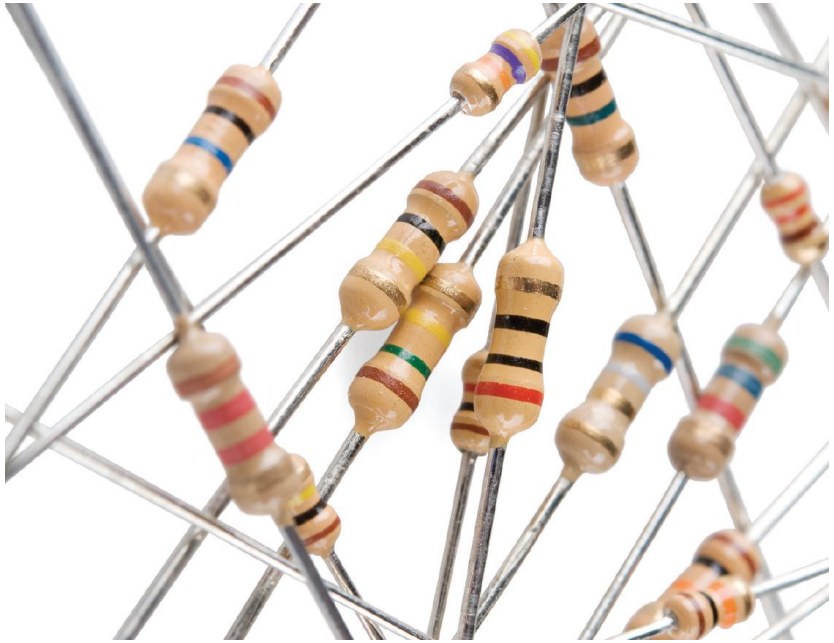




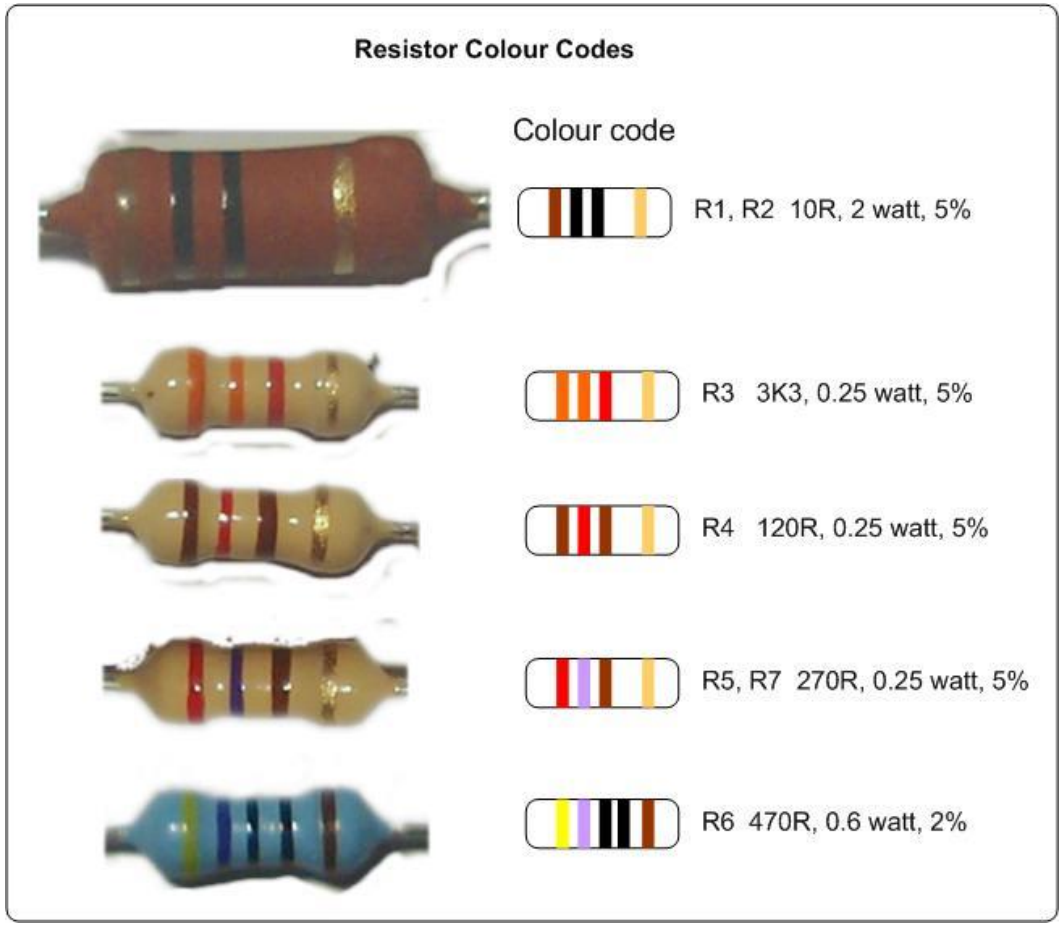




Resistor

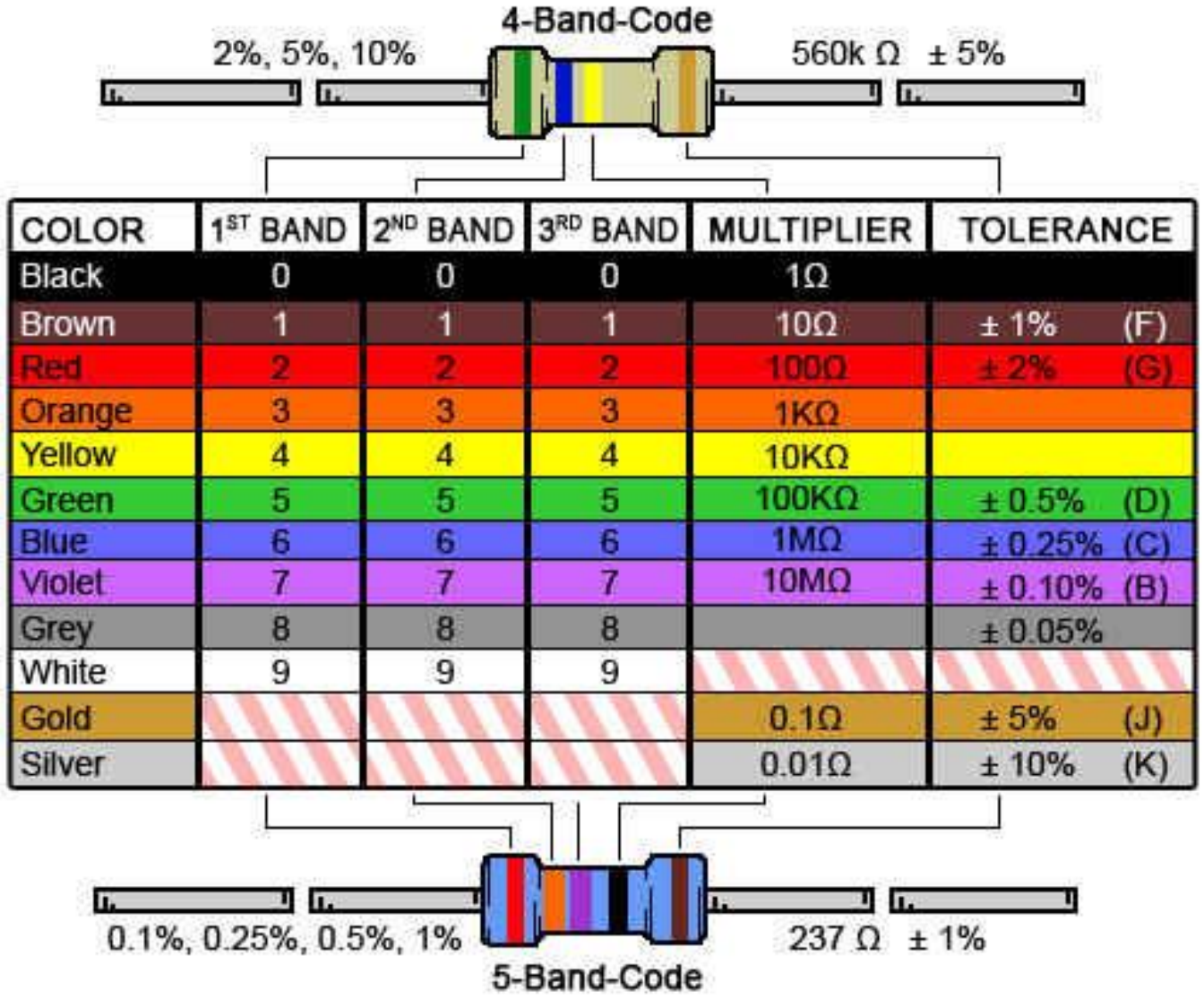


[What is a resistor?]
https://www.youtube.com/channel/UC3s7JLsNEf_TEBYnl3uzSxw



180 ohm, 5%
4K7, 5%
3M9, 5%

1.2 ohm, 10%
5K47, 1%
0.15 ohm, 5%



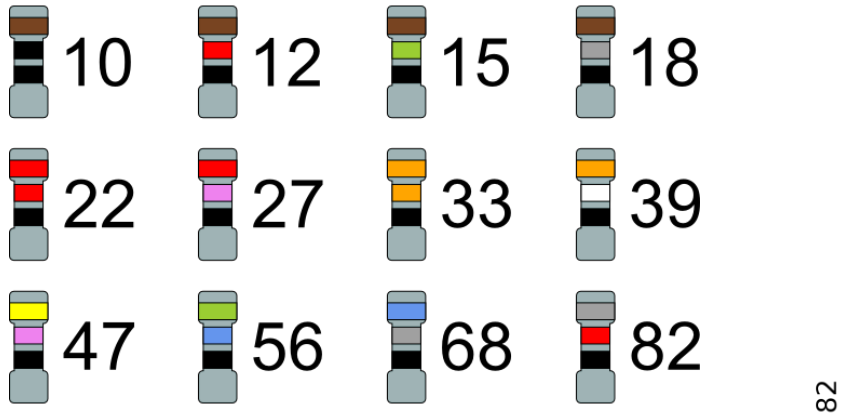
COLOR	1ST BAND	2ND BAND	3RD BAND	MULTIPLIER	TOLERANCE
Black	0	0	0	1Ω	
Brown	1	1	1	10Ω	± 1% (F)
Red	2	2	2	100Ω	± 2% (G)
Orange	3	3	3	1KΩ	
Yellow	4	4	4	10KΩ	
Green	5	5	5	100KΩ	± 0.5% (D)
Blue	6	6	6	1MΩ	± 0.25% (C)
Violet	7	7	7	10MΩ	± 0.10% (B)
Grey	8	8	8		± 0.05%
White	9	9	9		
Gold				0.1Ω	± 5% (J)
Silver				0.01Ω	± 10% (K)

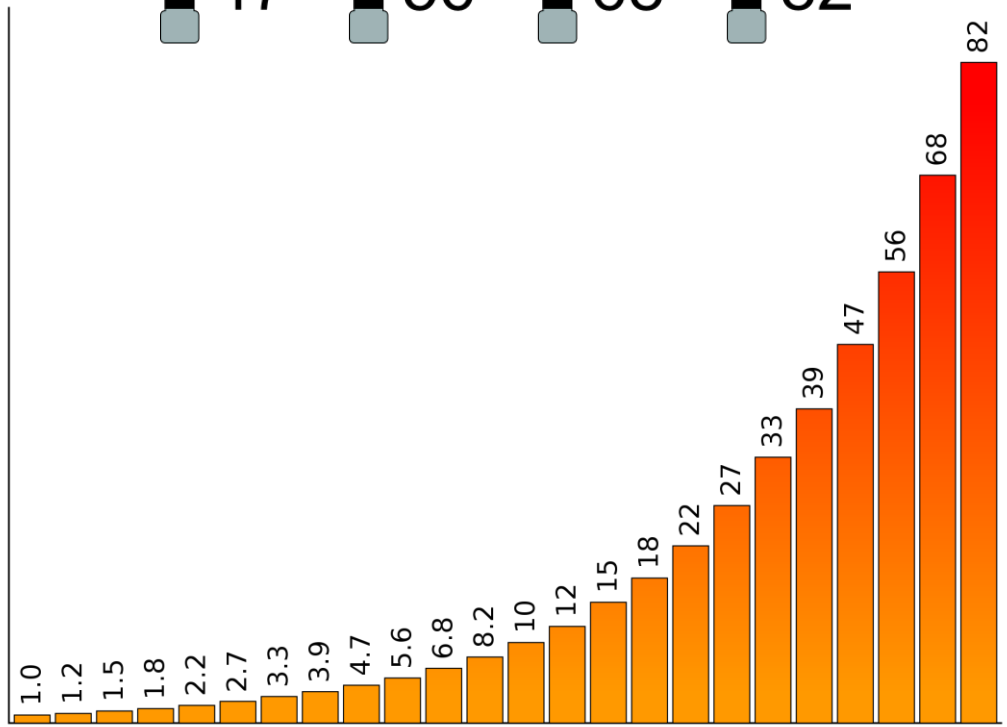
[How to read resistance with an analog multimeter?](http://youtube.com/watch?v=syHIbU7Q0yk)

http://youtube.com/watch?v=syHIbU7Q0yk

Resistor standard series values

E.g. E12 series



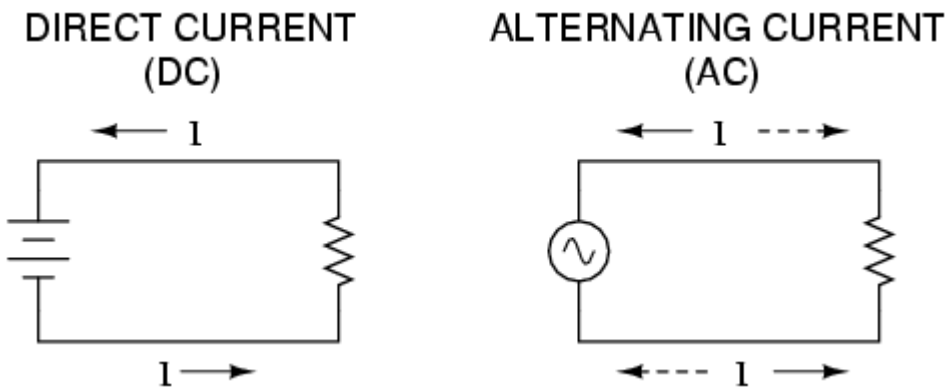


E6 (20%)	E12 (10%)	E24 (5%)	E48 (2%)	E96 (1%)	E192 (0.5%, 0.25%, 0.1%)
100	100	100	100	100	100
					101
				102	102
					104
			105	105	105
					106
				107	107
					109
		110	110	110	110
					111
				113	113
					114
			115	115	115
					117
				118	118
					120
	120	120	121	121	121
					123
				124	124
					126
			127	127	127
					129
				130	130
					132
		130	133	133	133
					135
				137	137
					138
			140	140	140
					142
				143	143
					145
150	150	150	147	147	147
					149
				150	150
					152
			154	154	154
					156
				158	158
					160
		160	162	162	162
					164
				165	165
					167
			169	169	169
					172
				174	174
					176
		180	178	178	178
					180
				182	182
					184
			187	187	187
					189
				191	191
					193
		200	196	196	196
					198
				200	200
					203
			205	205	205
					208
				210	210
					213

E6 (20%)	E12 (10%)	E24 (5%)	E48 (2%)	E96 (1%)	E192 (0.5%, 0.25%, 0.1%)
220	220	220	215	215	215
					218
				221	221
					223
			226	226	226
					229
				232	232
					234
		240	237	237	237
					240
				243	243
					246
			249	249	249
					252
				255	255
					258
	270	270	261	261	261
					264
				267	267
					271
			274	274	274
					277
				280	280
					284
		300	287	287	287
					291
				294	294
					298
			301	301	301
					305
				309	309
					312
330	330	330	316	316	316
					320
				324	324
					328
			332	332	332
					336
				340	340
					344
		360	348	348	348
					352
				357	357
					361
			365	365	365
					370
				374	374
					379
		390	383	383	383
					388
				392	392
					397
			402	402	402
					407
				412	412
					417
		430	422	422	422
					427
				432	432
					437
			442	442	442
					448
				453	453
					459

E6 (20%)	E12 (10%)	E24 (5%)	E48 (2%)	E96 (1%)	E192 (0.5%, 0.25%, 0.1%)
470	470	470	464	464	464
					470
				475	475
					481
			487	487	487
					493
				499	499
					505
		510	511	511	511
					517
				523	523
					530
			536	536	536
					542
				549	549
					556
	560	560	562	562	562
					569
				576	576
					583
			590	590	590
					597
				604	604
					612
		620	619	619	619
					626
				634	634
					642
			649	649	649
					657
				665	665
					673
680	680	680	681	681	681
					690
				698	698
					706
			715	715	715
					723
				732	732
					741
		750	750	750	750
					759
				768	768
					777
			787	787	787
					796
				806	806
					816
	820	820	825	825	825
					835
				845	845
					856
			866	866	866
					876
				887	887
					898
		910	909	909	909
					920
				931	931
					942
			953	953	953
					965
				976	976
					988

Voltage, current, and power



A simulation tool

Circuit Construction Kit (AC+DC), Virtual Lab

http://phet.colorado.edu/en/simulations/category/physics

[AC vs. DC]

http://youtube.com/watch?v=BcIDRet787k

[What is an amp?]

https://www.youtube.com/watch?v=8gvJzrjwjds

[Current and Voltage]

https://www.youtube.com/watch?v=1xPjES-sHwg

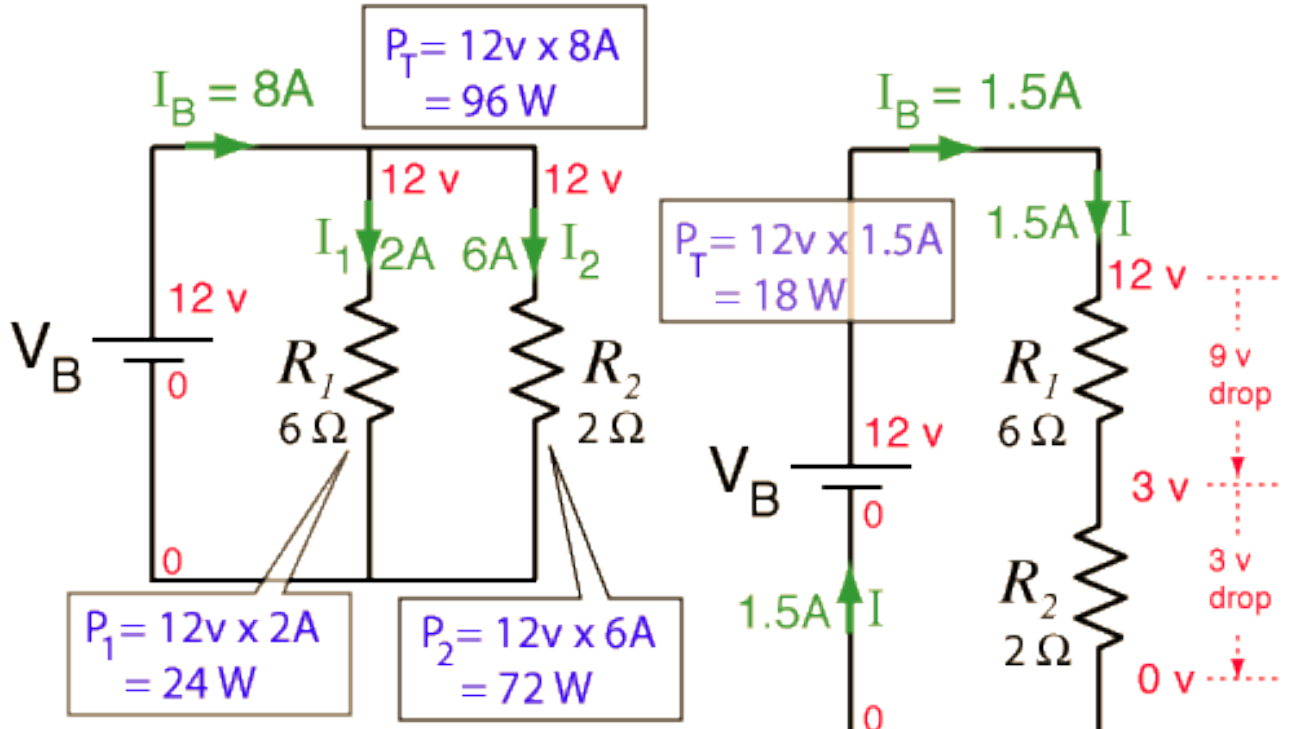
[Using and Oscilloscope]

https://www.youtube.com/watch?v=8VEg6L2QG5o

[“It's not the volts that kill you, it's the amps”]

https://www.youtube.com/watch?v=8gvJzrjwjds

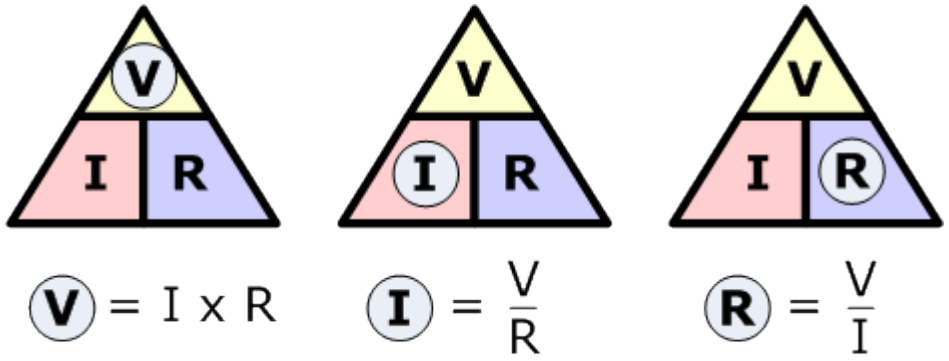
Voltage, current, and power in DC circuits



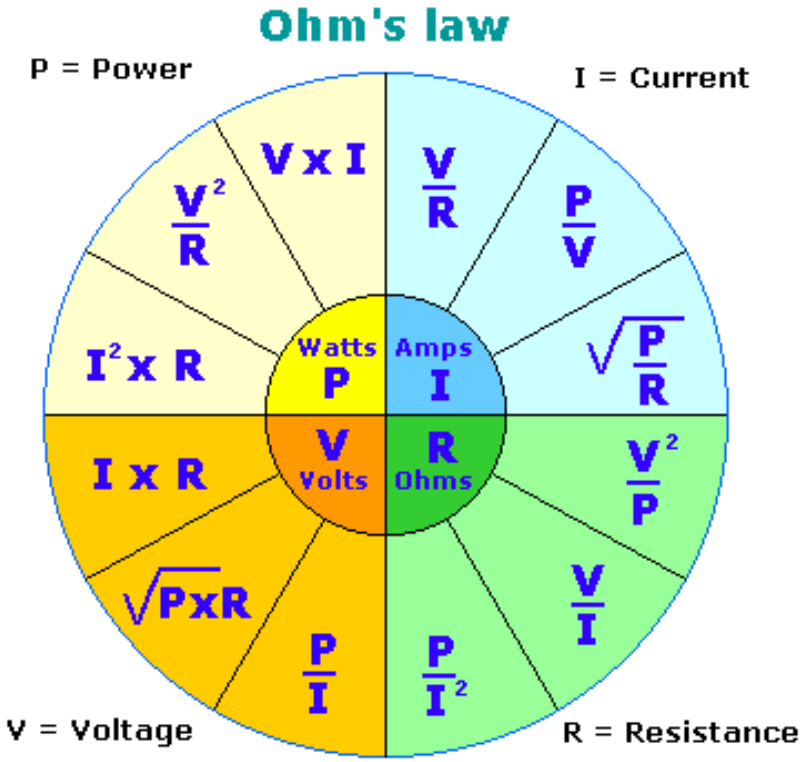
The powers for individual parallel elements can be calculated from the voltage across the element times the current through it. The sum of those powers will equal the power supplied by the battery.

For a series combination, the current is the same at any point in the circuit . Multiplying that current times the voltage drop across the resistor gives the power dissipated.

Resistor formulas



$V = I \times R$ $\quad I = \frac{V}{R}$ $\quad R = \frac{V}{I}$



Series

$$R_{equivalent} = R_1 + R_2 + R_3 + \ldots$$

$$R_{equivalent} = \frac{V}{I} = \frac{V_1 + V_2 + V_3 + \ldots}{I} = \frac{V_1}{I_1} + \frac{V_2}{I_2} + \frac{V_3}{I_3} + \ldots = R_1 + R_2 + R_3 + \ldots$$

Series key idea: The current is the same in each resistor by the current law.

Parallel

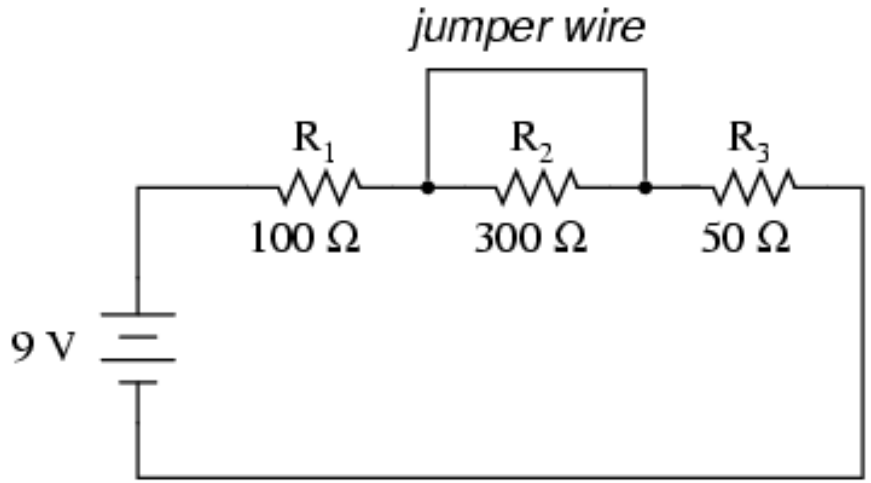
$$\frac{1}{R_{equivalent}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$$

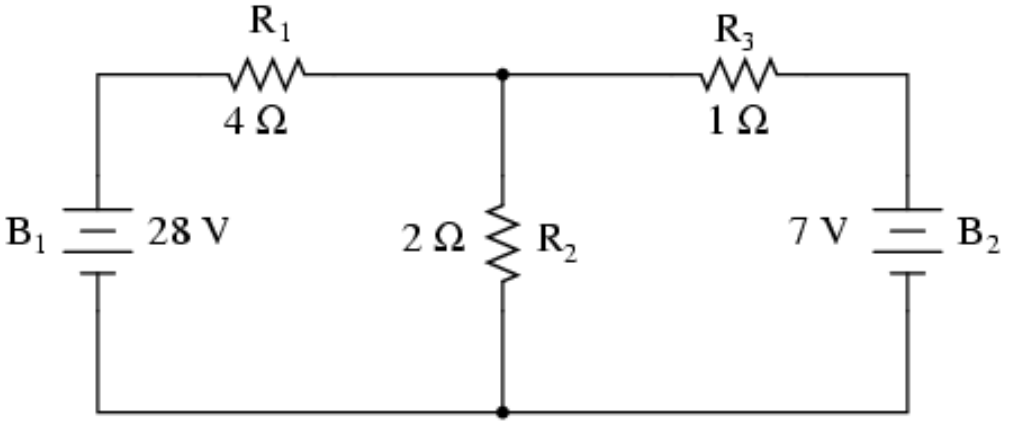
Parallel: $$\frac{V}{R_{equivalent}} = I = I_1 + I_2 + I_2 + \ldots = \frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3} + \ldots$$

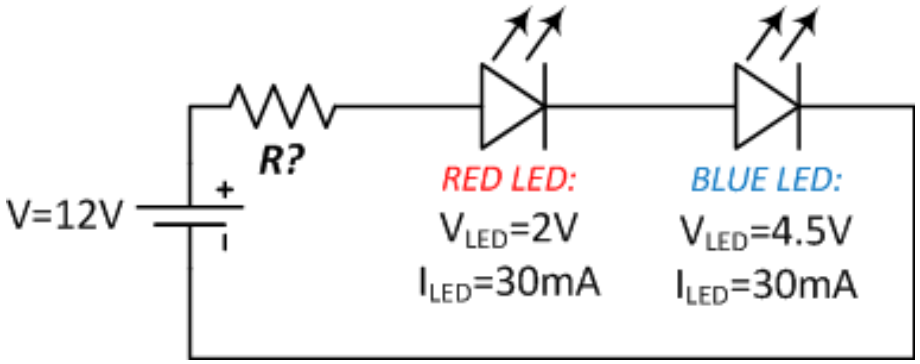
$$\frac{1}{R_{equivalent}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$$

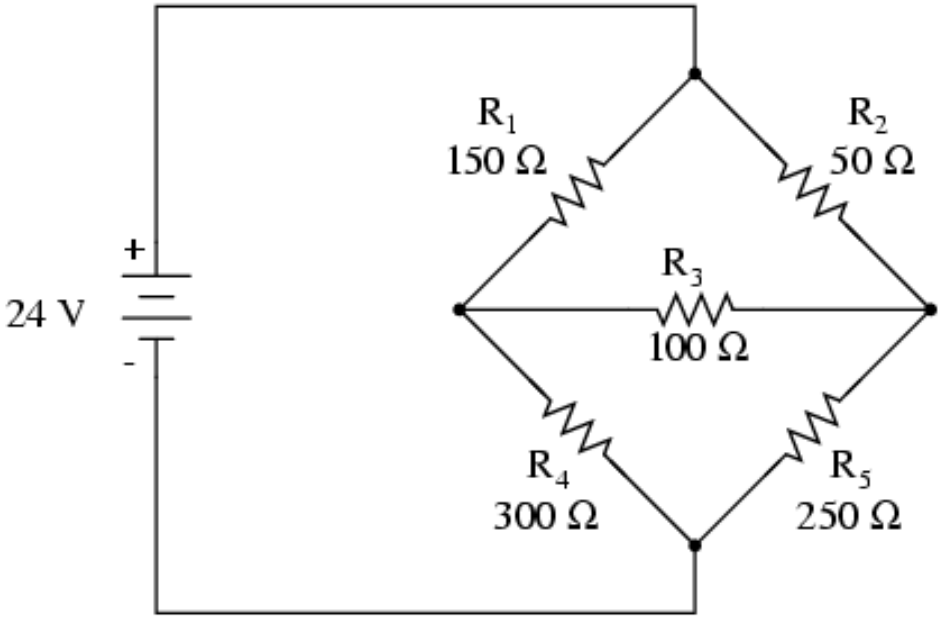
Parallel key idea: The voltage is the same across each resistor by the voltage law.

More circuits

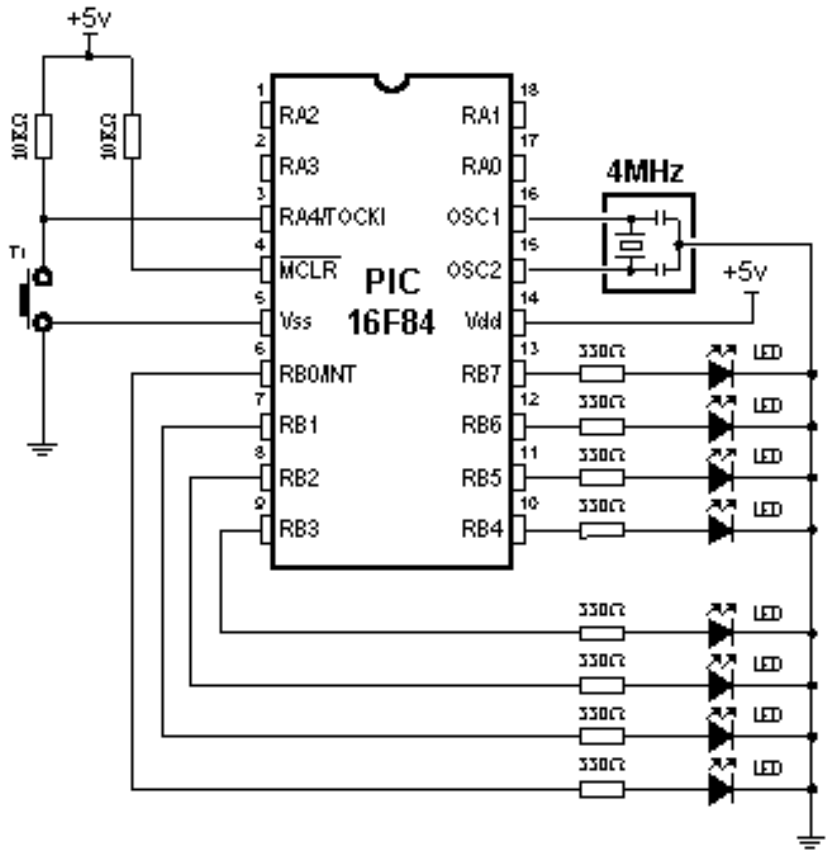


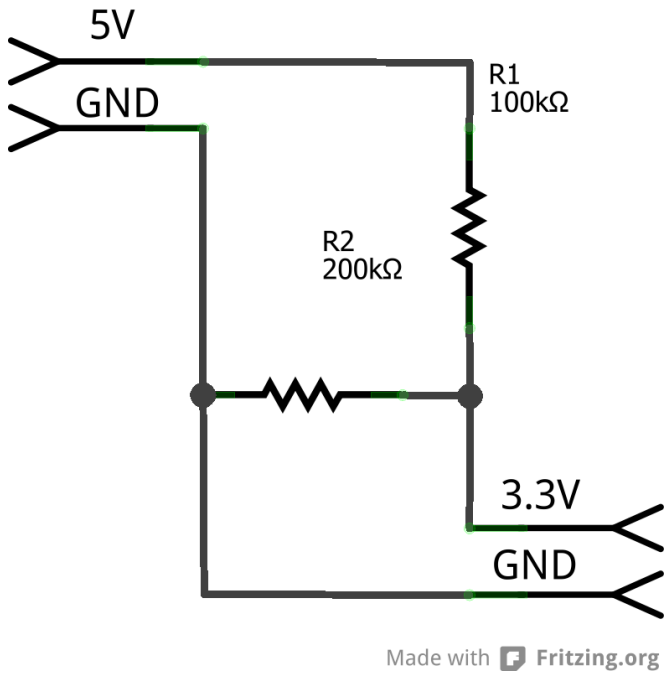






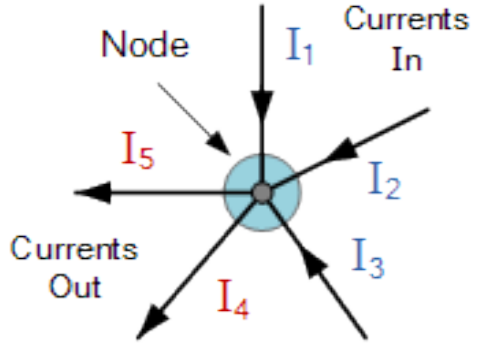
Applications in microcontroller circuits





Kirchhoff Laws

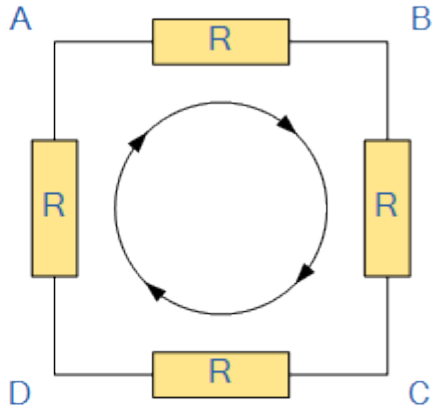
Currents Entering the Node
Equals
Currents Leaving the Node



$$I_1 + I_2 + I_3 + (-I_4 + -I_5) = 0$$

"total current or charge entering a junction or node is exactly equal to the charge leaving the node…"
Conservation of charge

The sum of all the Voltage Drops around the loop is equal to Zero



$$V_{AB} + V_{BC} + V_{CD} + V_{DA} = 0$$

"in any closed loop network, the total voltage around the loop is equal to the sum of all the voltage drops within the same loop"
Conversation of energy

Example