How to Read a Schematic Diagram
Simple Electrical Circuit

pictorial
Simple Electrical Circuit

schematic
A voltage divider used for volume control.
Standard symbol for a dc voltage source.
electrical schematic of flashlight
Resistance symbol and notation.
Film resistors:

- Carbon-film (1/2 W)
- Metal-film (2 W)
- Metal-oxide film (2 W)
FIG. 3.25  Color coding for fixed resistors.
Color-code bands on a resistor

- 1\textsuperscript{st} band is the first digit of the resistance value
- 2\textsuperscript{nd} band is the second digit of the resistance value
- 3\textsuperscript{rd} band is the multiplier (number of zeros)
- 4\textsuperscript{th} band indicates the tolerance
Color coding.

<table>
<thead>
<tr>
<th>Number</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Black</td>
</tr>
<tr>
<td>1</td>
<td>Brown</td>
</tr>
<tr>
<td>2</td>
<td>Red</td>
</tr>
<tr>
<td>3</td>
<td>Orange</td>
</tr>
<tr>
<td>4</td>
<td>Yellow</td>
</tr>
<tr>
<td>5</td>
<td>Green</td>
</tr>
<tr>
<td>6</td>
<td>Blue</td>
</tr>
<tr>
<td>7</td>
<td>Violet</td>
</tr>
<tr>
<td>8</td>
<td>Gray</td>
</tr>
<tr>
<td>9</td>
<td>White</td>
</tr>
</tbody>
</table>

- **±5%** (0.1 multiplier if 3rd band) Gold
- **±10%** (0.01 multiplier if 3rd band) Silver
### Standard Values of Resistors

<table>
<thead>
<tr>
<th>Ohms (Ω)</th>
<th>Kilohms (kΩ)</th>
<th>Megohms (MΩ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.10</td>
<td>1.0</td>
<td>10</td>
</tr>
<tr>
<td>0.11</td>
<td>1.1</td>
<td>11</td>
</tr>
<tr>
<td>0.12</td>
<td>1.2</td>
<td>12</td>
</tr>
<tr>
<td>0.13</td>
<td>1.3</td>
<td>13</td>
</tr>
<tr>
<td>0.15</td>
<td>1.5</td>
<td>15</td>
</tr>
<tr>
<td>0.16</td>
<td>1.6</td>
<td>16</td>
</tr>
<tr>
<td>0.18</td>
<td>1.8</td>
<td>18</td>
</tr>
<tr>
<td>0.20</td>
<td>2.0</td>
<td>20</td>
</tr>
<tr>
<td>0.22</td>
<td>2.2</td>
<td>22</td>
</tr>
<tr>
<td>0.24</td>
<td>2.4</td>
<td>24</td>
</tr>
<tr>
<td>0.27</td>
<td>2.7</td>
<td>27</td>
</tr>
<tr>
<td>0.30</td>
<td>3.0</td>
<td>30</td>
</tr>
<tr>
<td>0.33</td>
<td>3.3</td>
<td>33</td>
</tr>
<tr>
<td>0.36</td>
<td>3.6</td>
<td>36</td>
</tr>
<tr>
<td>0.39</td>
<td>3.9</td>
<td>39</td>
</tr>
<tr>
<td>0.43</td>
<td>4.3</td>
<td>43</td>
</tr>
<tr>
<td>0.47</td>
<td>4.7</td>
<td>47</td>
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<tr>
<td>0.51</td>
<td>5.1</td>
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<td>0.68</td>
<td>6.8</td>
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</tr>
<tr>
<td>0.75</td>
<td>7.5</td>
<td>75</td>
</tr>
<tr>
<td>0.82</td>
<td>8.2</td>
<td>82</td>
</tr>
<tr>
<td>0.91</td>
<td>9.1</td>
<td>91</td>
</tr>
</tbody>
</table>

100 | 1000 | 10.0 |
110 | 1100 | 11.0 |
120 | 1200 | 12.0 |
130 | 1300 | 13.0 |
150 | 1500 | 15.0 |
160 | 1600 | 16.0 |
180 | 1800 | 18.0 |
200 | 2000 | 20.0 |
220 | 2200 | 22.0 |
240 | 2400 | 24.0 |
270 | 2700 | 27.0 |
300 | 3000 | 30.0 |
330 | 3300 | 33.0 |
360 | 3600 | 36.0 |
390 | 3900 | 39.0 |
430 | 4300 | 43.0 |
470 | 4700 | 47.0 |
510 | 5100 | 51.0 |
560 | 5600 | 56.0 |
620 | 6200 | 62.0 |
680 | 6800 | 68.0 |
750 | 7500 | 75.0 |
820 | 8200 | 82.0 |
910 | 9100 | 91.0 |
Potentiometer control of voltage levels.
Potentiometer and rheostat symbols and basic construction of one type of potentiometer.

(a) Potentiometer
(b) Rheostat
(c) Potentiometer connected as a rheostat
(d) Basic construction (simplified)
Typical potentiometers and two construction views.
Common Ground Symbol
Circuit Ground

- Voltage is relative
- The voltage at one point in a circuit is always measured relative to another point
- This reference point in a circuit is usually the ground point
Notation

Voltage sources and grounds

Ground symbol

Voltage source symbol
A simple circuit with ground connections.
Connections or NODES
The voltage divider as a bias circuit for a transistor amplifier.
Symbol for the inductor.
Typical Inductors
Symbols for the capacitor: (a) fixed; (b) variable.
(a) Film/foil polyester radial lead; (b) metalized polyester-film axial lead; (c) surface-mount polyester-film; (d) polypropylene-film, radial lead.
Capacitors

Variable Capacitors

Most common are shown in the figure below. The dielectric for each is air. The capacitance is changed by turning the shaft at one end to vary the common area of the movable and fixed plates. The greater the common area the larger the capacitance.
Symbol for a sinusoidal voltage source.
Function generator.
Transistors

(a) Bipolar
(b) JFET
(c) D-MOSFET
(d) E-MOSFET
Transistor ratings

$h_{fe} = 100$

$h_{ie} = 4 \text{k}\Omega$

$f_T = 400 \text{ MHz}$

$C_{bc} = 9 \text{ pF}$
Amplifier Output stage
Timers

LM-555

Experiment
LM555 Timer

The LM555 is a highly stable device for generating accurate time delays or oscillation. Additional terminals are provided for triggering or resetting if desired.
LM555 Timer pin-outs

8-Pin SOIC, MSOP, MDIP

- Ground (1)
- Trigger (2)
- Output (3)
- Reset (4)
- V+ (8)
- Discharge (7)
- Threshold (6)
- Control Voltage (5)

R = 100kΩ

Top View
555 Timer Modes
Astable (free-running)
Astable Operation (free-run)
ASTABLE OPERATION

If the circuit is connected as shown in Figure 4 (pins 2 and 6 connected) it will trigger itself and free run as a multivibrator. The external capacitor charges through $R_A + R_B$ and discharges through $R_B$. Thus the duty cycle may be precisely set by the ratio of these two resistors.
(a) The 555 timer connected to implement an astable multivibrator. (b) Waveforms of the circuit in (a).
Astable Operation (free-run)

\[
W = 0.693(R_1 + R_2)C \\
T = 0.693(R_1 + 2R_2)C \\
f = \frac{1.44}{(R_1 + 2R_2)C} \\
D = \frac{R_1 + R_2}{R_1 + 2R_2}
\]
The period of the output equals:

\[ T = 0.693(R_1 + 2R_2)C \]

The reciprocal of the period is the frequency:

\[ f = \frac{1.44}{(R_1 + 2R_2)C} \]
Upper threshold trip point

Lower threshold trip point

R-S Flip-Flop (reset - set)
Astable Operation (free-run)
Elect. Lab.
Ball Hall rm. 424
Sampling Scope
Scope CRT – Soft Keys
Inputs & Controls
Scope Probe, 1 - 10meg. Ohms have to be used for all scope measurements
1X – 10X Probe
Manual Scope Setting