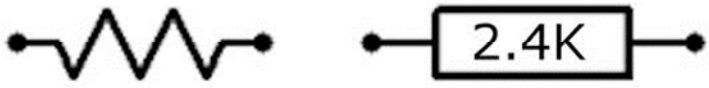
We can now apply some of what we've already learned to some practical situations. But first, an art lesson!

## Schematic Diagrams

When developing electronic circuitry, engineers ordinarily create a *schematic diagram*, which shows the all the components of the circuit, their values, and how they are connected to each other. On that diagram, the parts are shown using standard, generally accepted, symbols, rather than in their physical form.

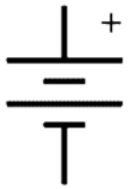
Resistors, for example, may be shown in either one of two ways:




The squiggly version was originally used mostly in the U.S. The rectangular version was used in Europe and elsewhere. Since the

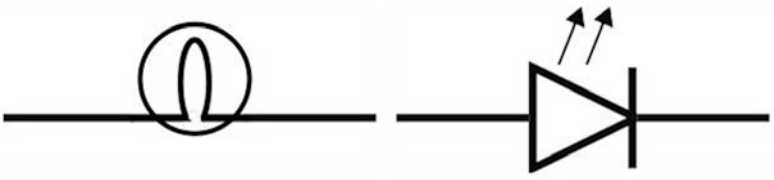
European version is easier to draw, and can neatly include the value within the symbol, it is often favored.

Batteries of any kind can be represented like this:

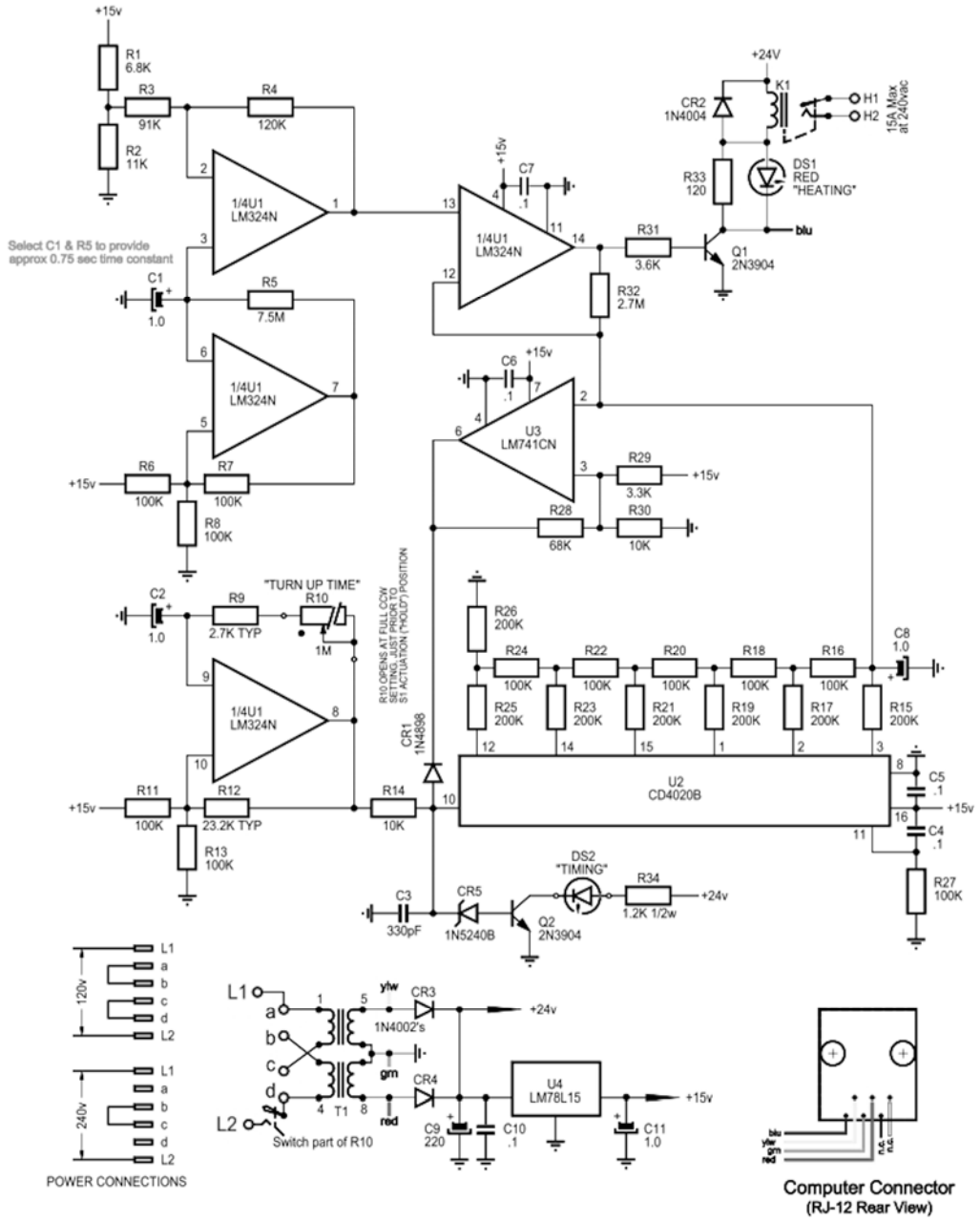


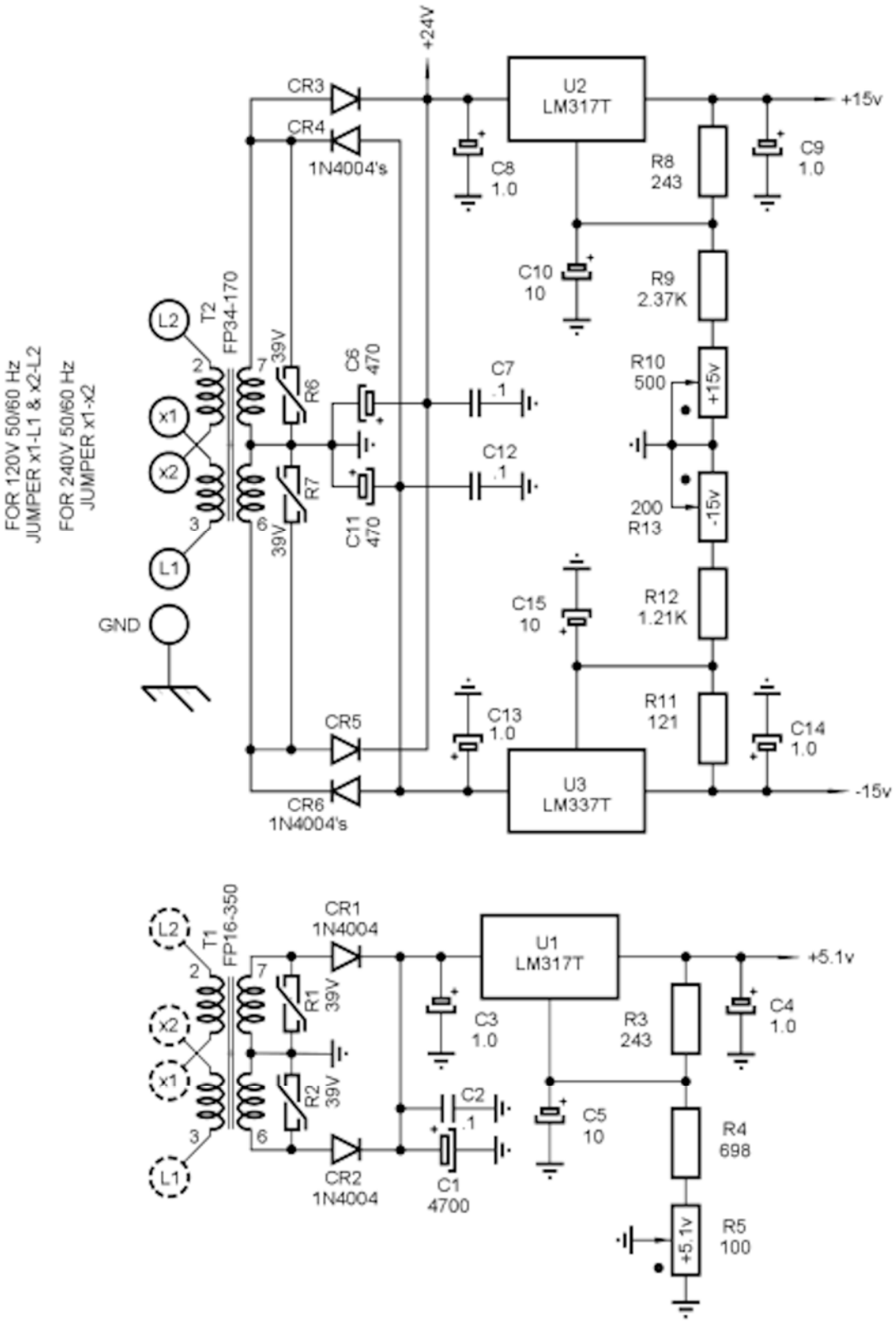

The polarity need not be marked; the larger end-plate is always presumed to be the battery's positive end.

Incandescent bulbs and light-emitting diodes (LEDs) are generally drawn like this:



That's it for now. We'll learn about more circuit symbols as we encounter additional types of components during the next several lectures. Meanwhile, here are some examples of schematic diagrams …


+15v
R1 6.8K
R2 11K
R3 91K
R4 120K
1/4U1 LM324N
Select C1 & R5 to provide approx 0.75 sec time constant
C1 1.0
R5 7.5M
R6 100K
R7 100K
R8 100K
C2 1.0
R9 2.7K TYP
R10 1M
"TURN UP TIME"
R10 OPENS AT FULL CCW SETTING, JUST PRIOR TO S1 ACTUATION ("HOLD") POSITION
R11 100K
R12 23.2K TYP
R13 100K
R14 10K
CR1 1N4898
C3 330pF
CR5 1N5240B
Q2 2N3904
DS2 "TIMING"
R34 1.2K 1/2w
+24v
C7 .1
C6 .1
U3 LM741CN
R29 3.3K
R28 68K
R30 10K
R31 3.6K
R32 2.7M
Q1 2N3904
CR2 1N4004
K1
H1
H2
15A Max at 240vac
R33 120
DS1 RED "HEATING"
blu
R26 200K
R24 100K
R22 100K
R20 100K
R18 100K
R16 100K
C8 1.0
R25 200K
R23 200K
R21 200K
R19 200K
R17 200K
R15 200K
U2 CD4020B
C5 .1
C4 .1
R27 100K
L1
a
b
c
d
L2
120v
240v
POWER CONNECTIONS
y/w
CR3
1N4002's
gm
CR4
red
T1
Switch part of R10
U4 LM78L15
C9 220
C10 .1
C11 1.0
Computer Connector
(RJ-12 Rear View)


FOR 120V 50/60 Hz
JUMPER x1-L1 & x2-L2
FOR 240V 50/60 Hz
JUMPER x1-x2
L2
X1
X2
L1
GND
T2
FP34-170
2
7
6
3
39V
R6
R7
C6
470
C11
470
C7
.1
C12
.1
+24V
CR3
CR4
1N4004's
CR5
CR6
1N4004's
U2
LM317T
U3
LM337T
C8
1.0
C9
1.0
C10
10
C15
10
C13
1.0
C14
1.0
R8
243
R9
2.37K
R10
500
+15v
200
R13
-15v
R12
1.21K
R11
121
+15v
-15v
T1
FP16-350
CR1
1N4004
CR2
1N4004
R1
R2
C2
.1
C1
4700
U1
LM317T
C3
1.0
C4
1.0
C5
10
R3
243
R4
698
R5
100
+5.1v
+5.1v

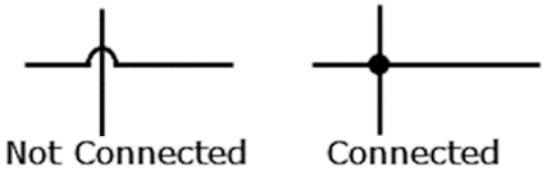
## Crossovers and Connections

The logical organization of components and a neat layout make for a very helpful schematic diagram. Careful preliminary planning is very helpful in achieving that result.

The schematic will necessarily include a lot of lines representing conductors that are connected between the various components. These lines are typically drawn horizontally and vertically. Lines drawn on angles or curves are rarely, if ever appropriate.

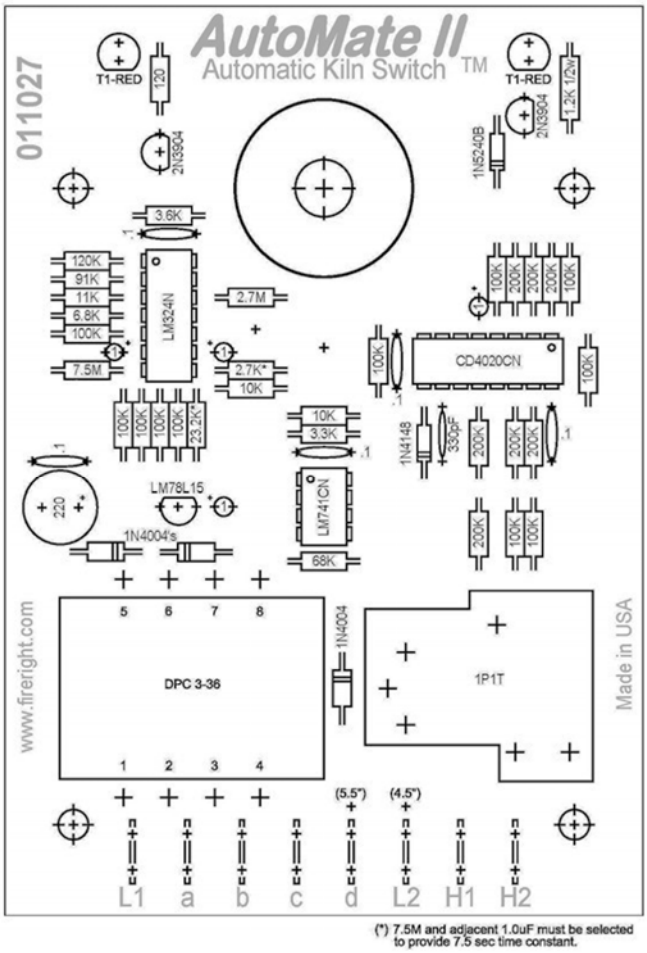
Careful planning helps to ensure the fewest number of crossovers — meaning places where unconnected lines cross.

Nevertheless, this can almost never be avoided completely, so for the sake of disambiguation, crossing lines are (almost) always rendered like this …



## Component Layout Diagrams

While we're on the subject of electronic diagrams — the component layout diagram is a scaled drawing showing the physical layout of circuit components, usually on a printed circuit board.



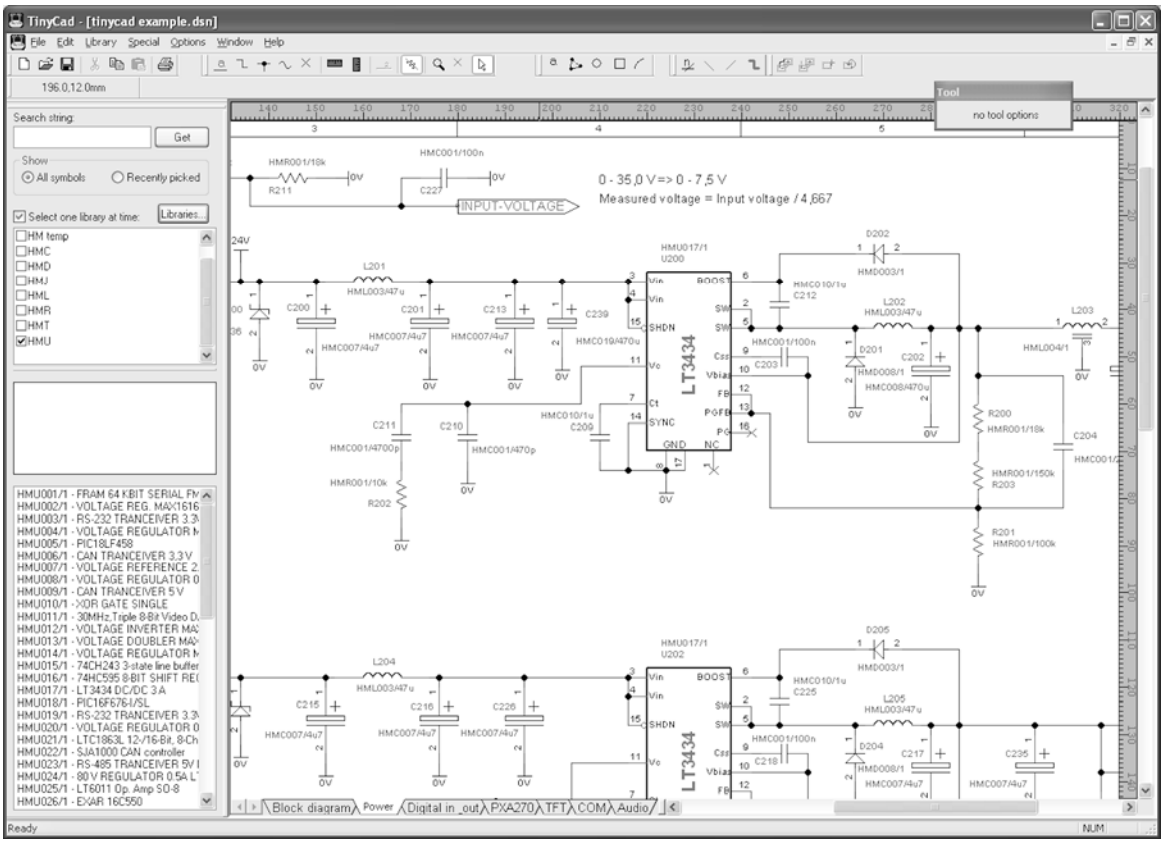

Component layout is an important engineering task in most applications, and is the first step in printed circuit board design.

This set of drawings, the schematic and the comp layout, are also an essential tool for assembly and service personnel.

## CAD Tools

Engineering drawings always used to be created by draftsmen working on drawing boards. Whenever you saw an old guy all bent over with osteoporosis, it was a safe bet that he'd been a draftsman.

CAD tools (Computer Aided Design) now make easy work of schematic and layout



drawings. An example is a highly rated open source (free) program called *TinyCAD*.

Training in the use of TinyCAD or any other such tool isn't included in this course, but if and when you ever need to become seriously involved in producing electronic diagrams of this type, most of the simple CAD programs are intuitive enough that you won't have much trouble quickly learning how to use them and, in the case of TinyCAD at least, there's a lot of helpful information readily available online.

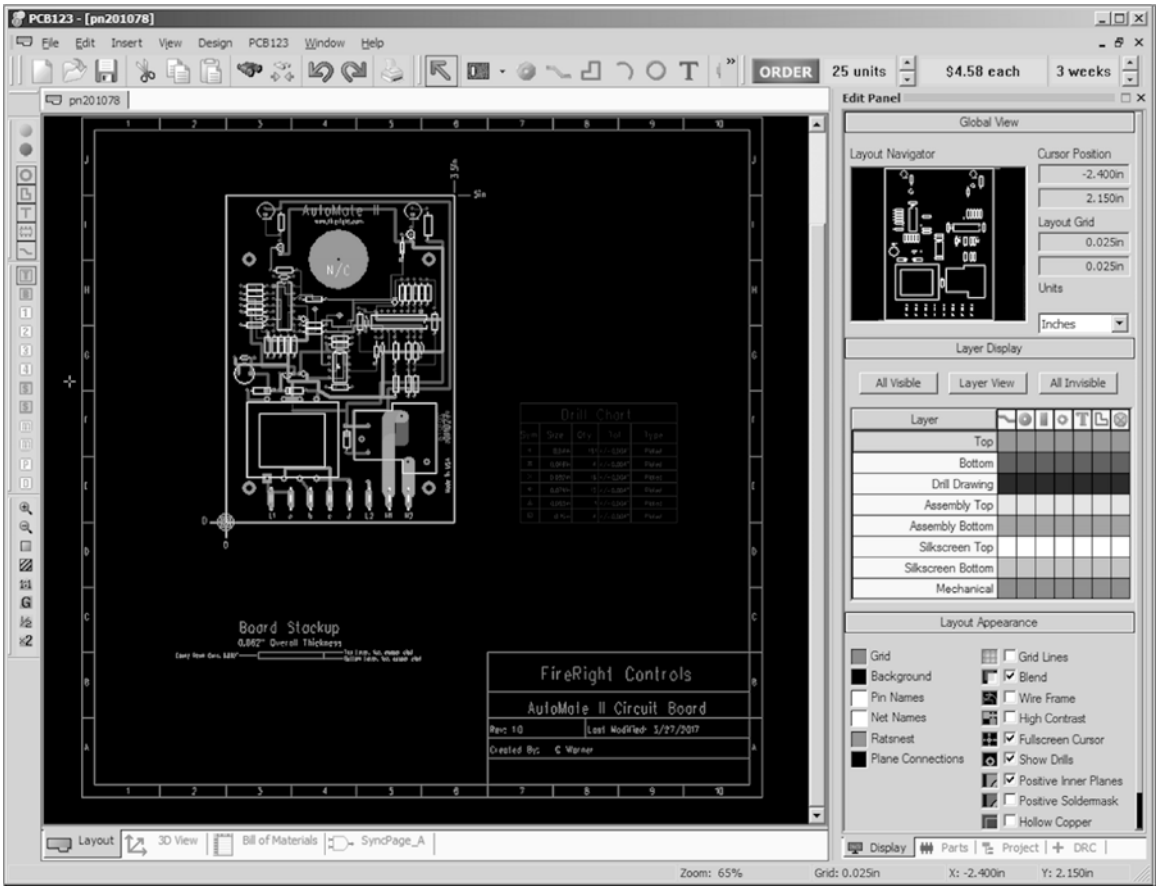
### Printed Circuit Boards

At the risk of straying even further from the subject at hand, but just in case you are interested, printed circuit board manufacturing, even on a small scale, is now highly automated.

In the old days, PCB layouts used to be done by hand on Mylar sheets, using precision cut crepe paper tapes and "doughnut" pads.

It’s not done like that anymore.

There are several online companies that will make printed circuits according to your design. They provide their own free printed circuit layout software, which is highly integrated with their manufacturing process.




You can design your circuit board according to accepted industry standards using that software, the program checks your work automatically for errors and

potential manufacturing problems, and then provides instant price quotations for whatever quantity you need.

When ready to order, the design can be uploaded, along with your order details, from within the same program. If you're in a hurry (and willing to spend the money) you can even have prototype boards in your hands the very next day!

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Getting back to business, let's have a quick look at resistor color codes, and then we'll do some real circuit analysis.

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