

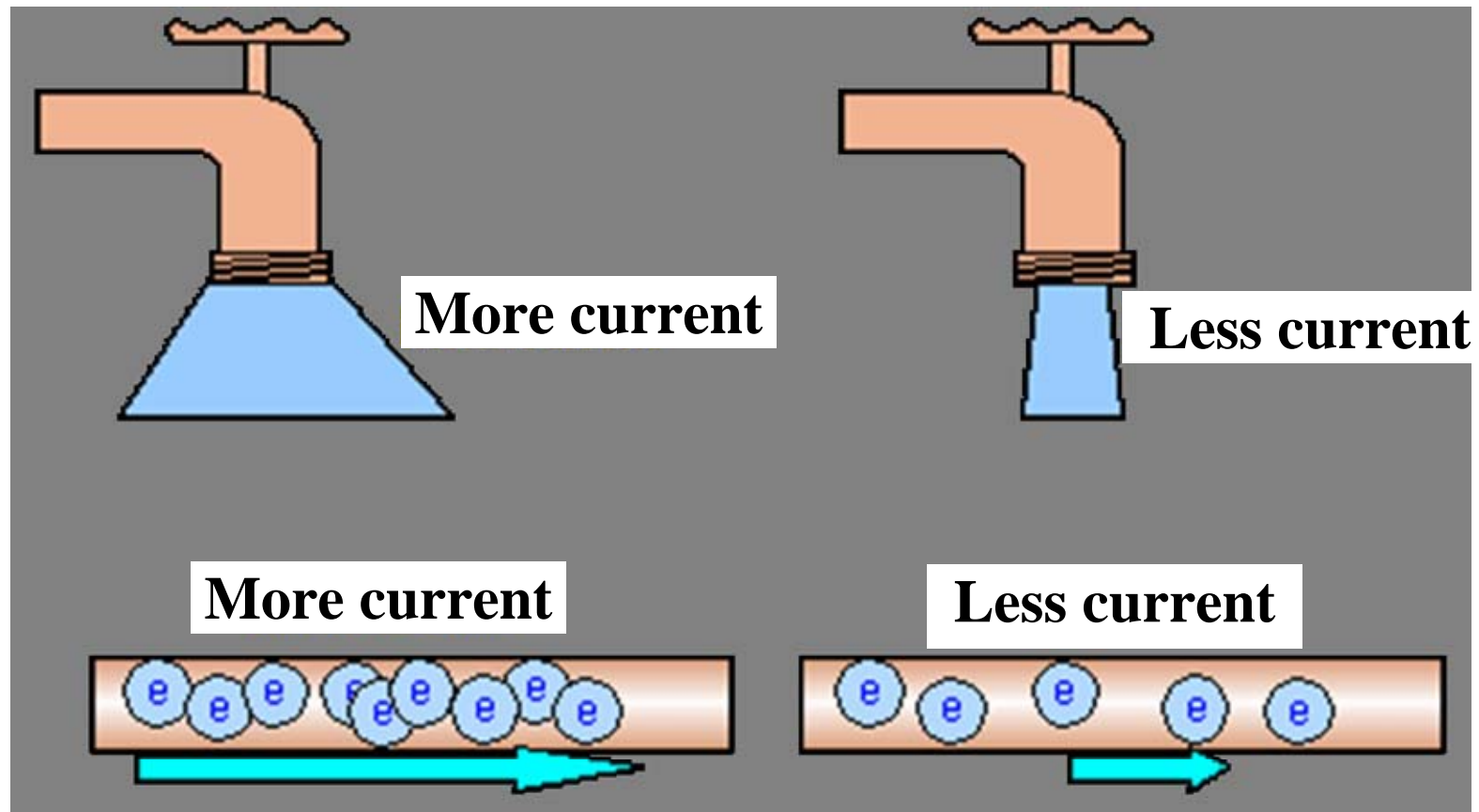
Lecture 1

Resistor

What is Current?

- A flow of electrically charged particles
- Carried by small negatively-charged particles, called **electrons**
- Represented by the symbol **I** , and is measured in **amperes**, or '**amps**', **A**
- Most often measured in **milliamps**, **mA**
- Like water flow

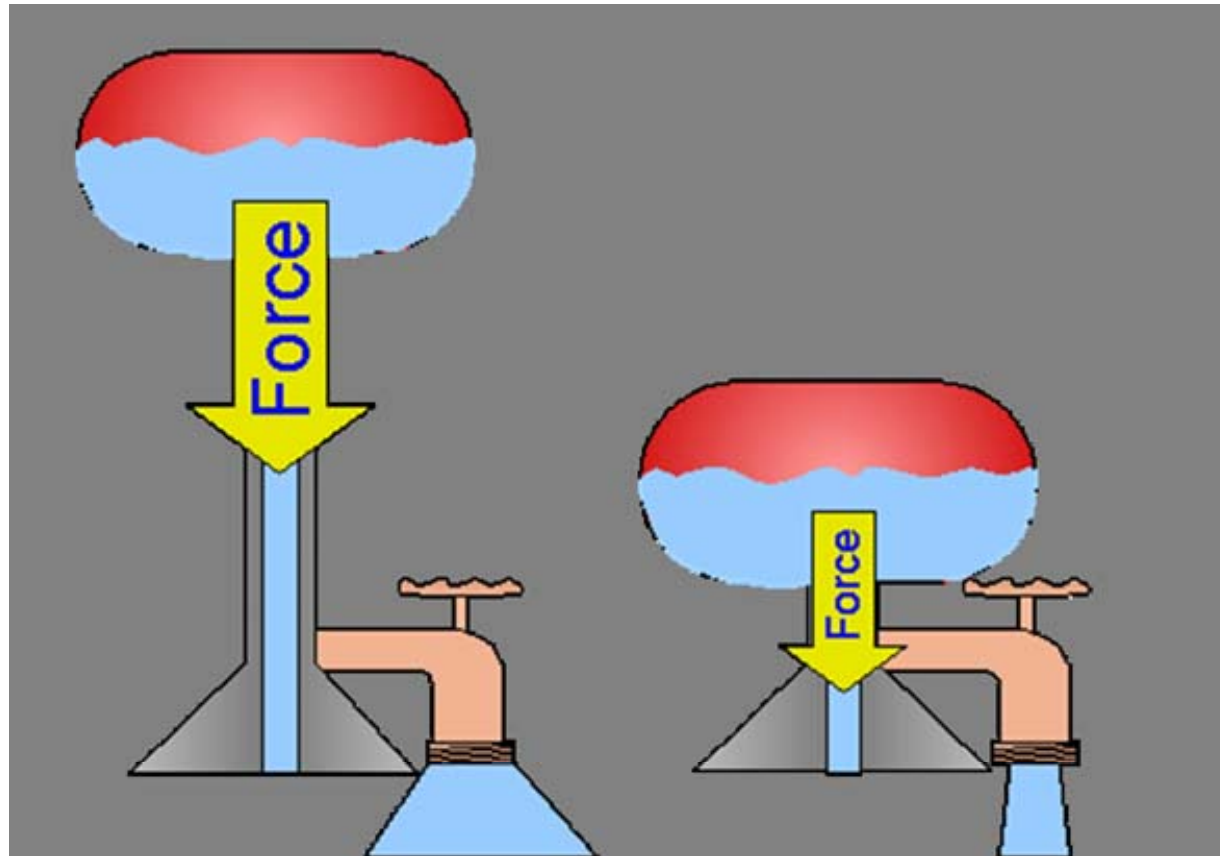
Water Analogy



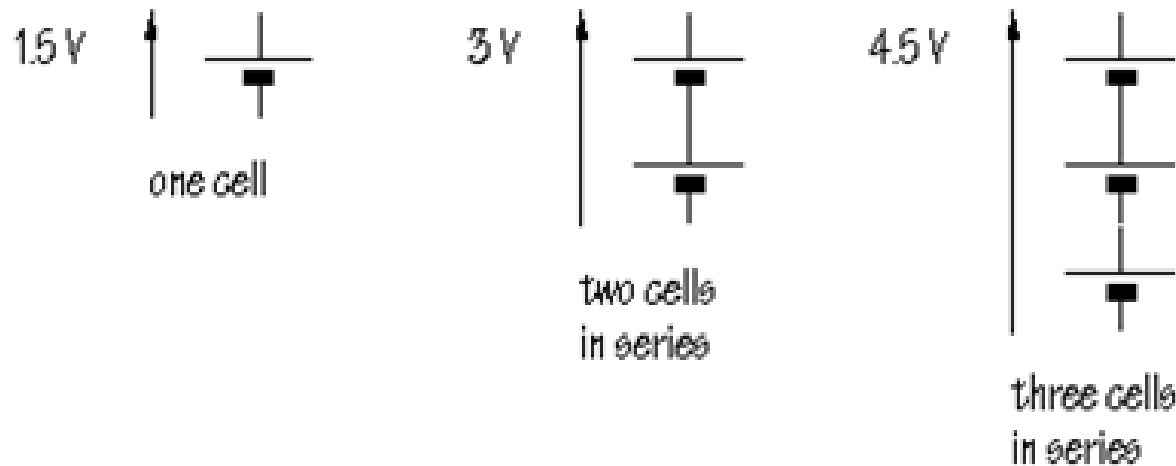
What is Voltage?

- **Potential difference**
- Represented by the symbol V , and is measured in **volts, V**
- Like potential energy at water fall

Water Analogy

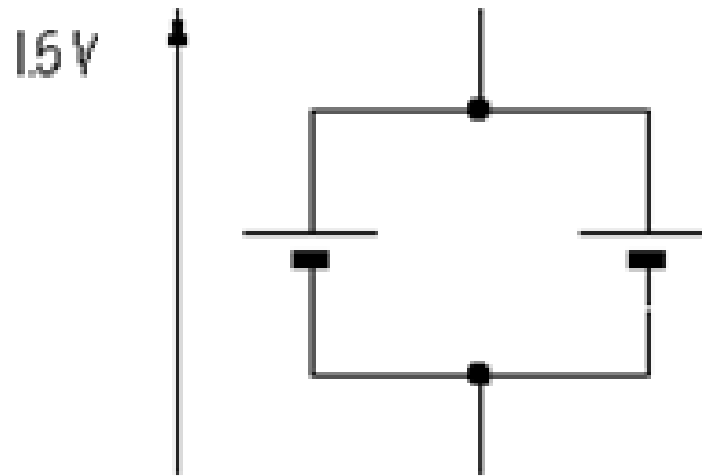


Series Connection of Cells



- Each cell provides 1.5 V
- Two cells connected one after another, **in series**, provide 3 V, while three cells would provide 4.5 V
- Polarities matter

Parallel Connection of Cells



- If the cells are connected in parallel, the voltage stays at 1.5 V, but now you can draw a larger current

DC and AC

- A cell provides a steady voltage, so that current flow is always in the same direction
 - This is called **direct current**, or **d.c**
- The domestic mains provides a constantly changing voltage which reverses in polarity 60 times every second
 - This gives rise to **alternating current**, or **a.c**

Power Supply

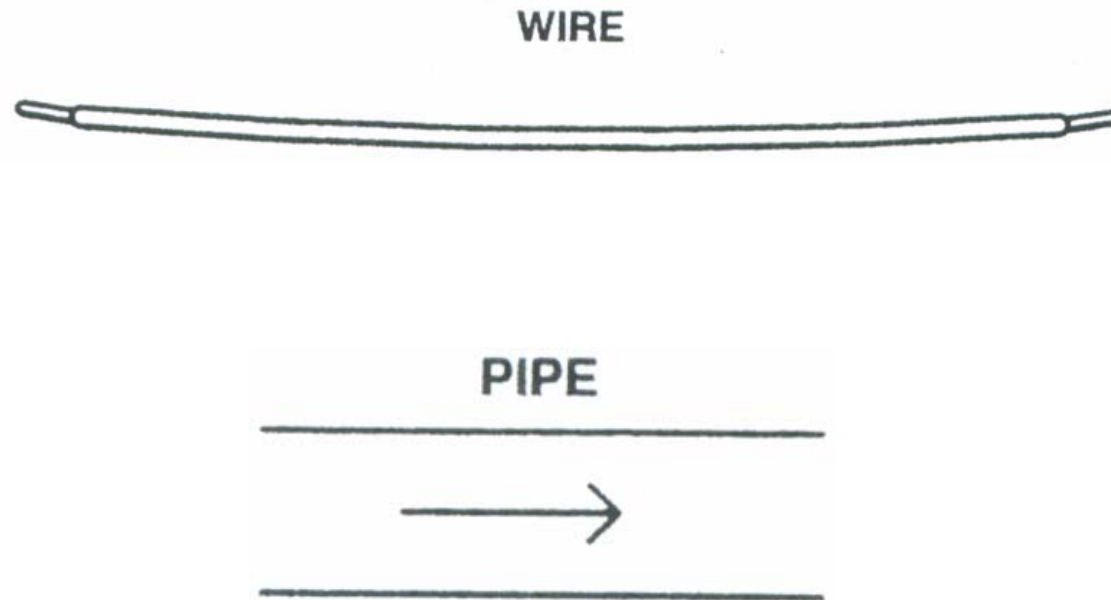


Digital



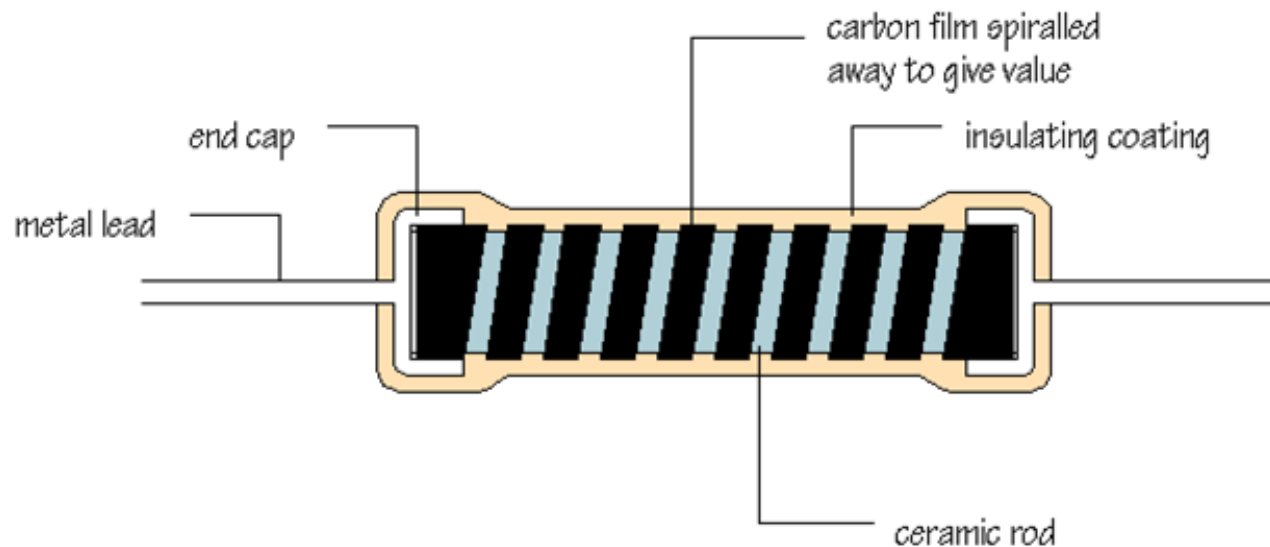
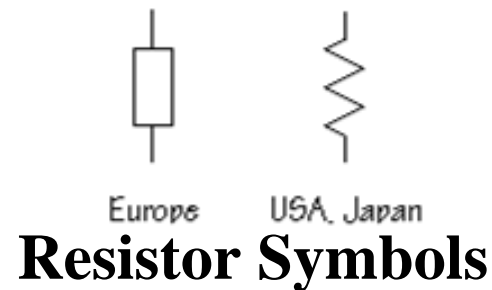
Analog

Water Analogy of Wires



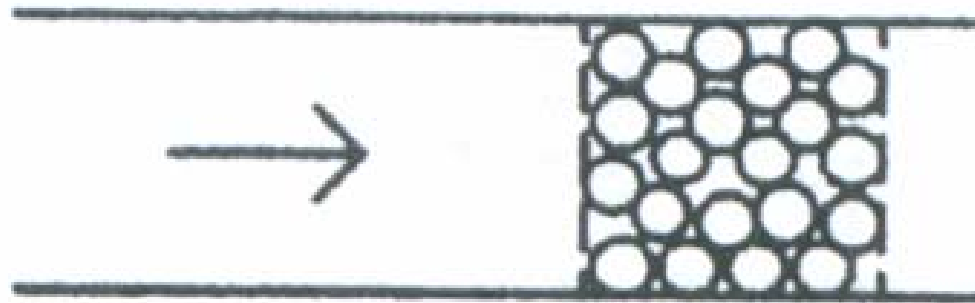
Resistors

- Dissipative elements that convert electrical energy into heat
- Resistors limit current
- Unit is **ohms**, Ω



Water Analogy of Resistor

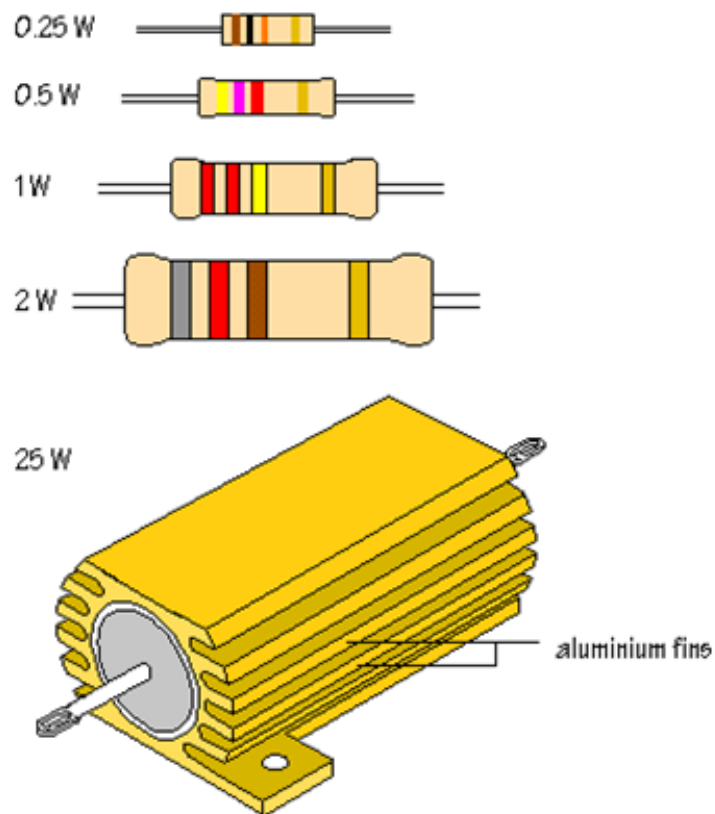
ROCKS IN THE PIPE



Resistor Applications

- Resistors are used for
 - Limiting current
 - Lowering voltage (voltage divider)
 - As current divider
 - As a sensor (potentiometers, photoresistors, strain gauge)
 - As pull-up or pull down elements

Resistors of Different Sizes

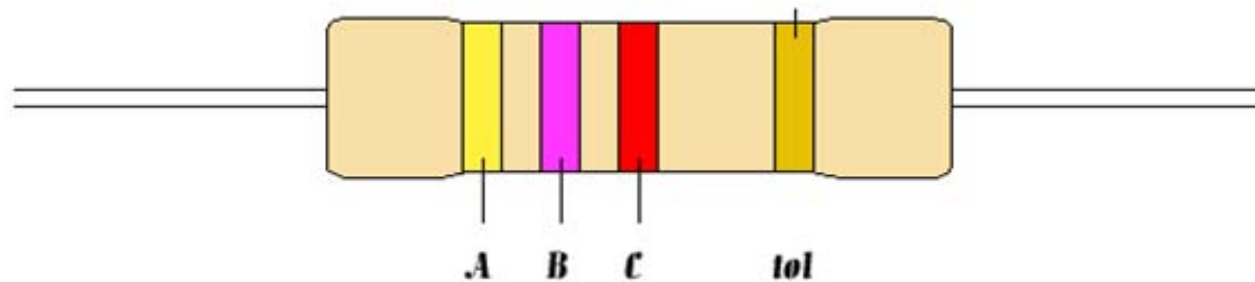


How to Read Resistor Values 1

1. By color code
2. By digital multi meter (DMM)

How to Read Resistor Values 2

By color code



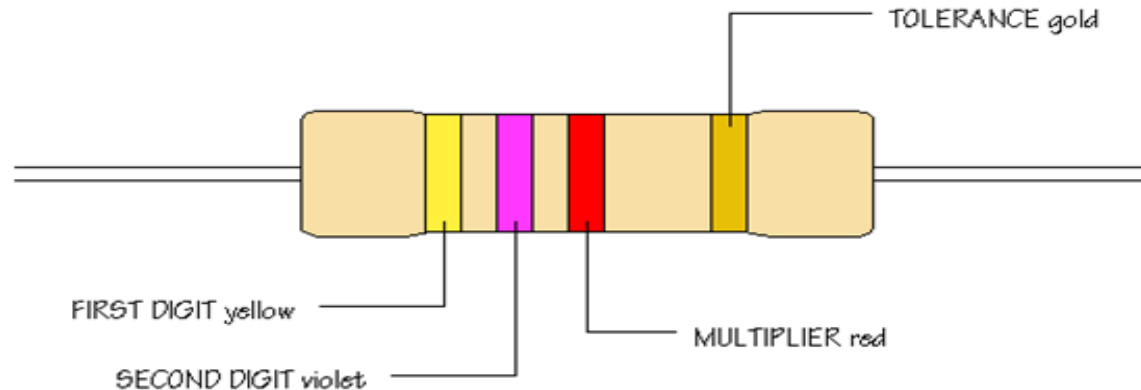
$$\text{Resistor value} = AB \times 10^C \pm \text{tol} \% (\Omega)$$

Resistance Color Code

<i>Number</i>	<i>Color</i>
0	black
1	brown
2	red
3	orange
4	yellow
5	green
6	blue
7	violet
8	grey
9	white

<i>Tolerance</i>	<i>Color</i>
$\pm 1\%$	brown
$\pm 2\%$	red
$\pm 5\%$	gold
$\pm 10\%$	silver

Example

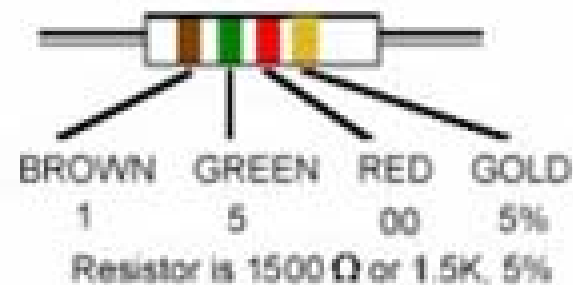
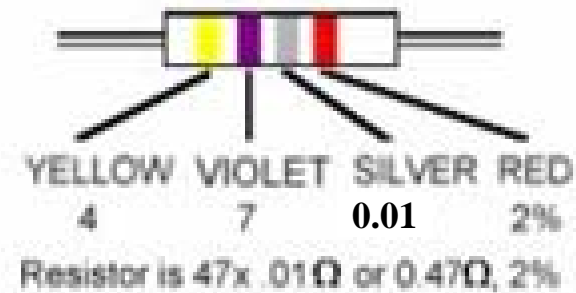
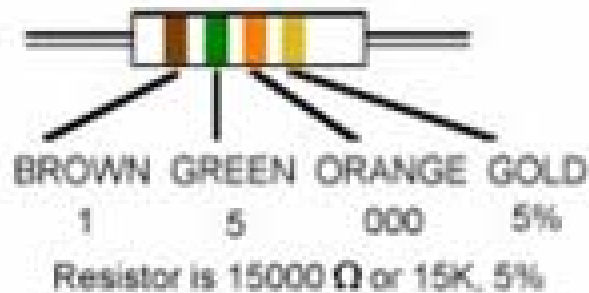


- The first band is yellow, so the first digit is 4
- The second band is violet, so the second digit is 7
- The third band is red, so the multiplier is 10^2
- Resistor value is $47 \times 10^2 \pm 5\% (\Omega)$

Metric Units and Conversions

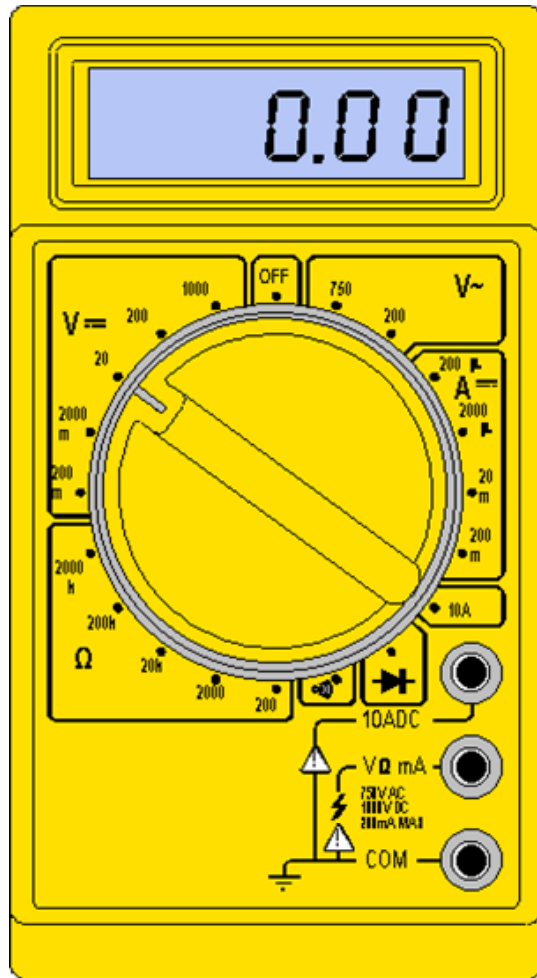
Abbreviation	Means	Multiply unit by	Or
p	pico	.000000000000001	10^{-12}
n	nano	.0000000001	10^{-9}
μ	micro	.0000001	10^{-6}
m	milli	.001	10^{-3}
.	Unit	1	10^0
k	kilo	1,000	10^3
M	mega	1,000,000	10^6
G	giga	1,000,000,000	10^9

Examples



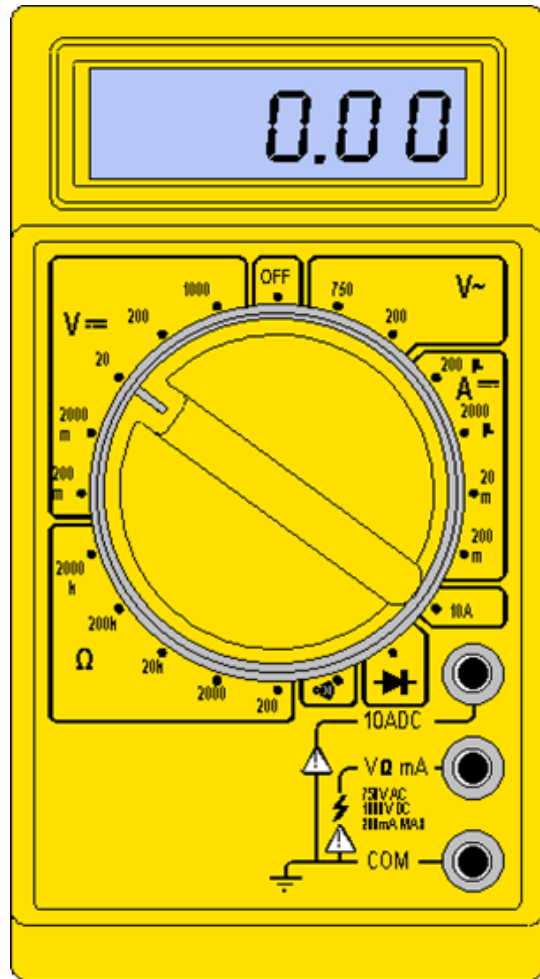
http://www.electrician.com/resist_calc/resist_calc.htm

Digital Multimeter 1



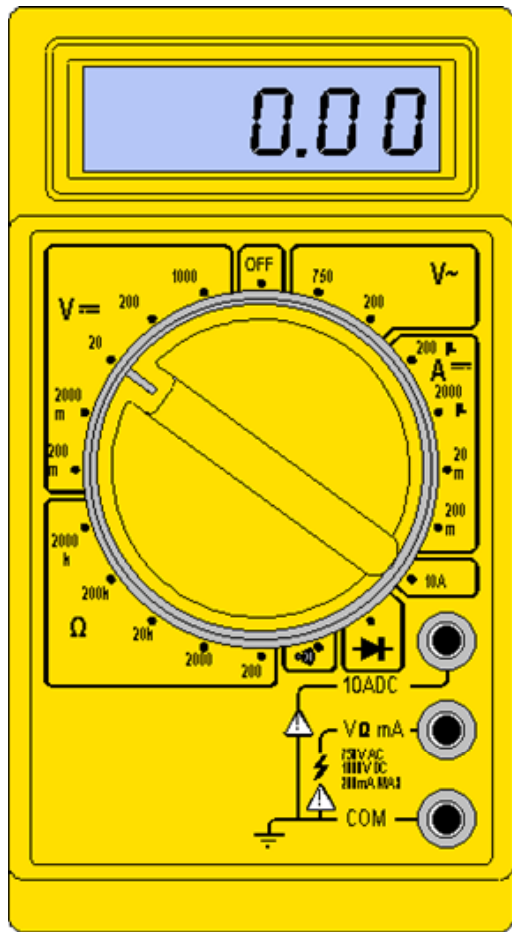
- DMM is a measuring instrument
- An **ammeter** measures current
- A **voltmeter** measures the potential difference (voltage) between two points
- An **ohmmeter** measures resistance
- A **multimeter** combines these functions, and possibly some additional ones as well, into a single instrument

Digital Multimeter 2

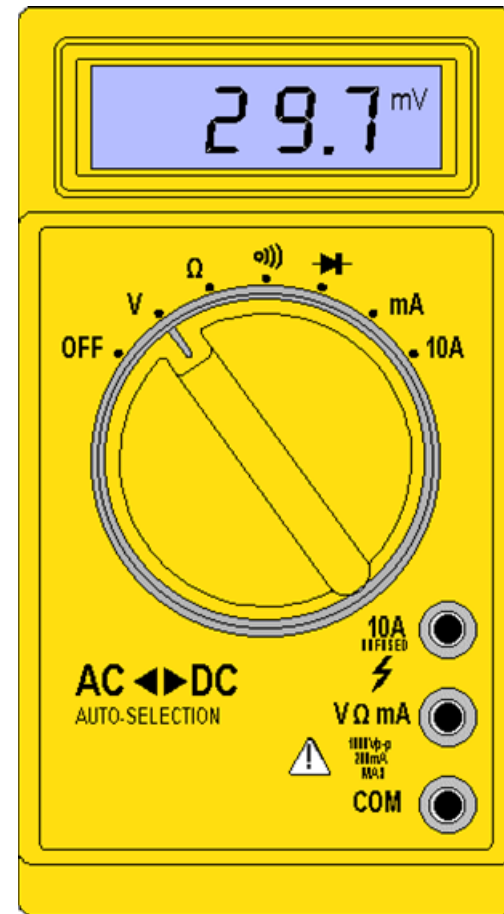


- Voltmeter
 - Parallel connection
- Ammeter
 - Series connection
- Ohmmeter
 - Without any power supplied
- Adjust range (start from highest limit if you don't know)

Digital Multimeter 3

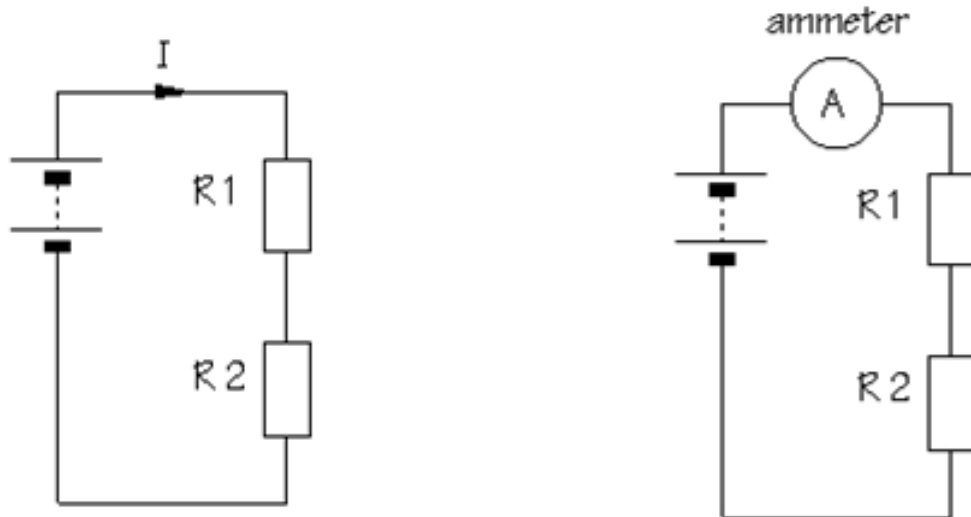


Switched Ranging DMM



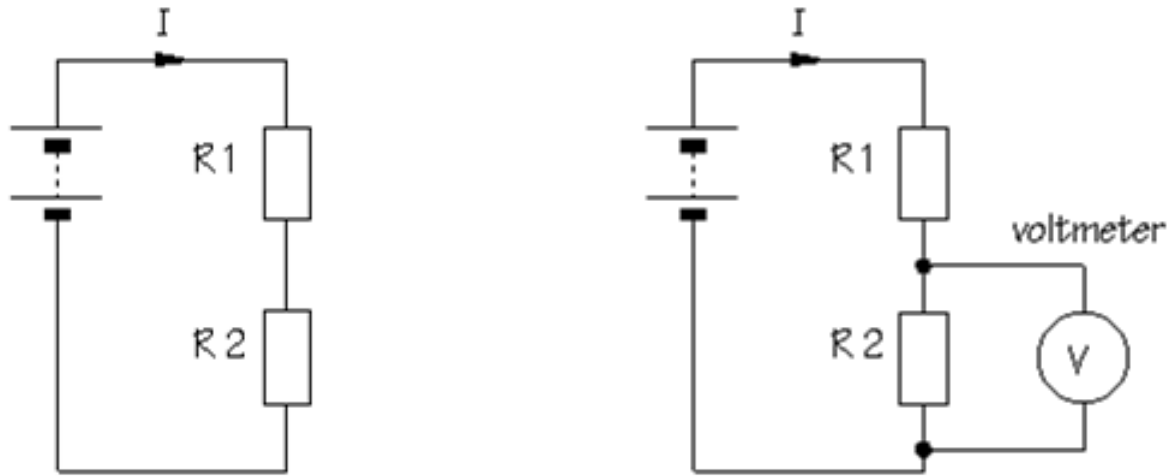
Auto Ranging DMM

Ammeter Connection



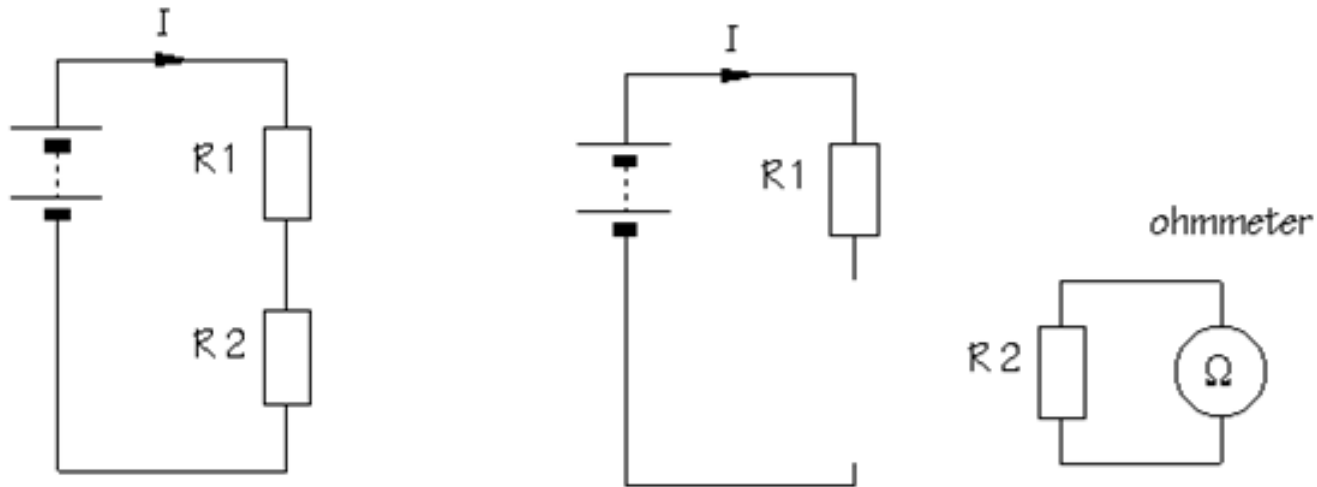
- Break the circuit so that the ammeter can be connected in series
- All the current flowing in the circuit must pass through the ammeter
- An ammeter must have a very **LOW** input impedance

Voltmeter Connection



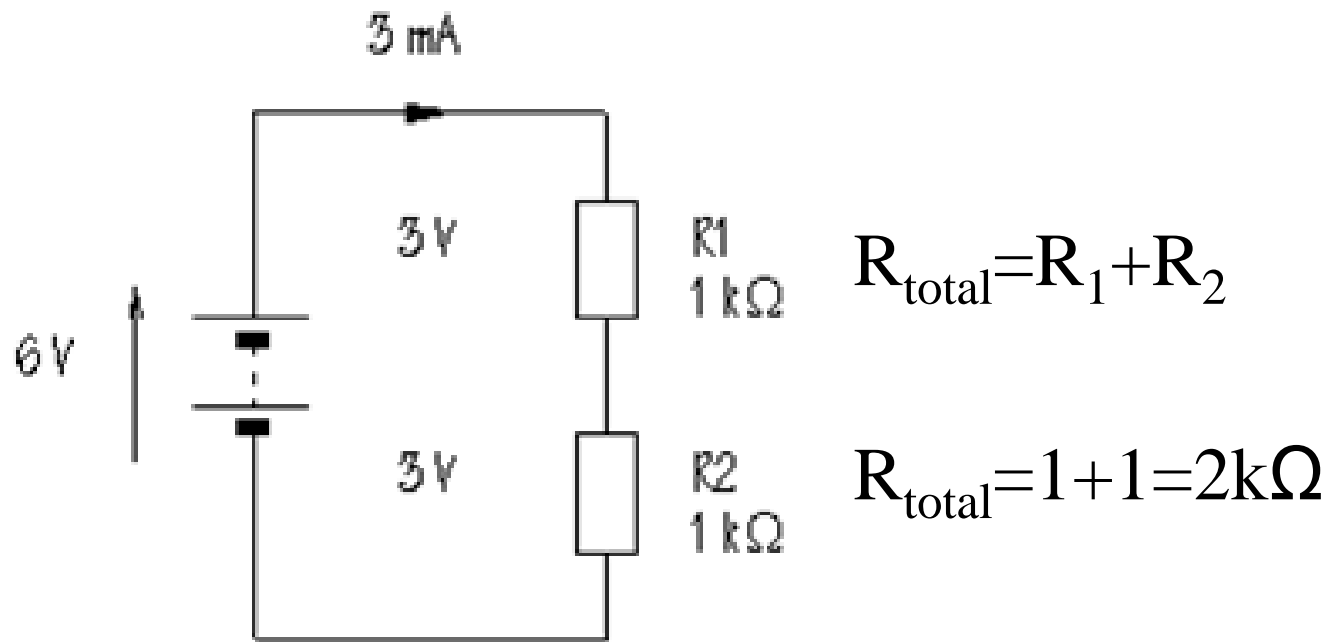
- The voltmeter is connected in parallel between two points of circuit
- A voltmeter should have a very **HIGH** input impedance

Ohmmeter Connection

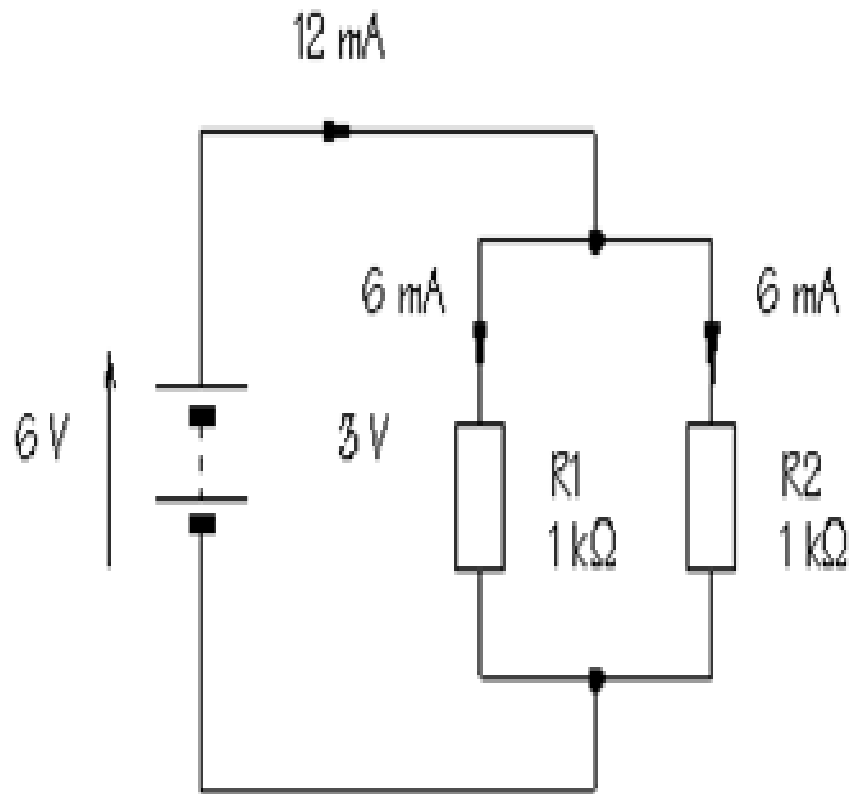


- An ohmmeter does not function with a circuit connected to a power supply
- Must take it out of the circuit altogether and test it separately

Resistors in Series



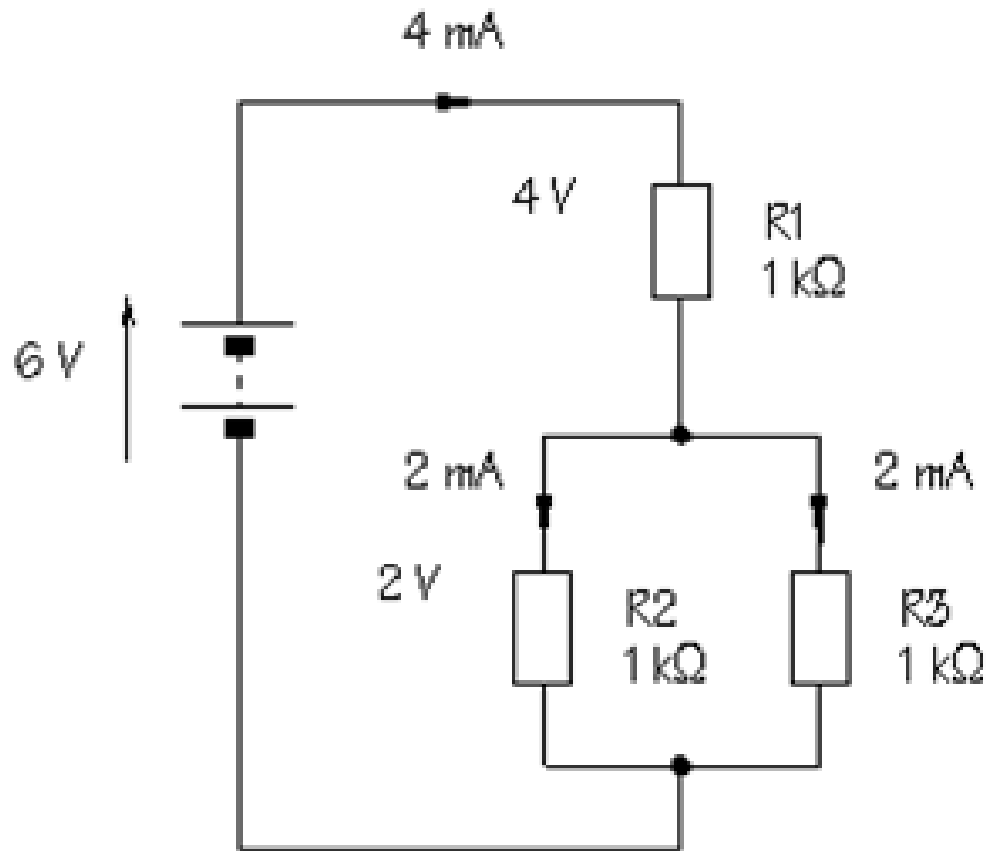
Resistors in Parallel



$$R_{total} = \frac{R_1 \times R_2}{R_1 + R_2}$$

$$R_{total} = \frac{1 \times 1}{1 + 1} = \frac{1}{2} = 0.5\text{ k}\Omega$$

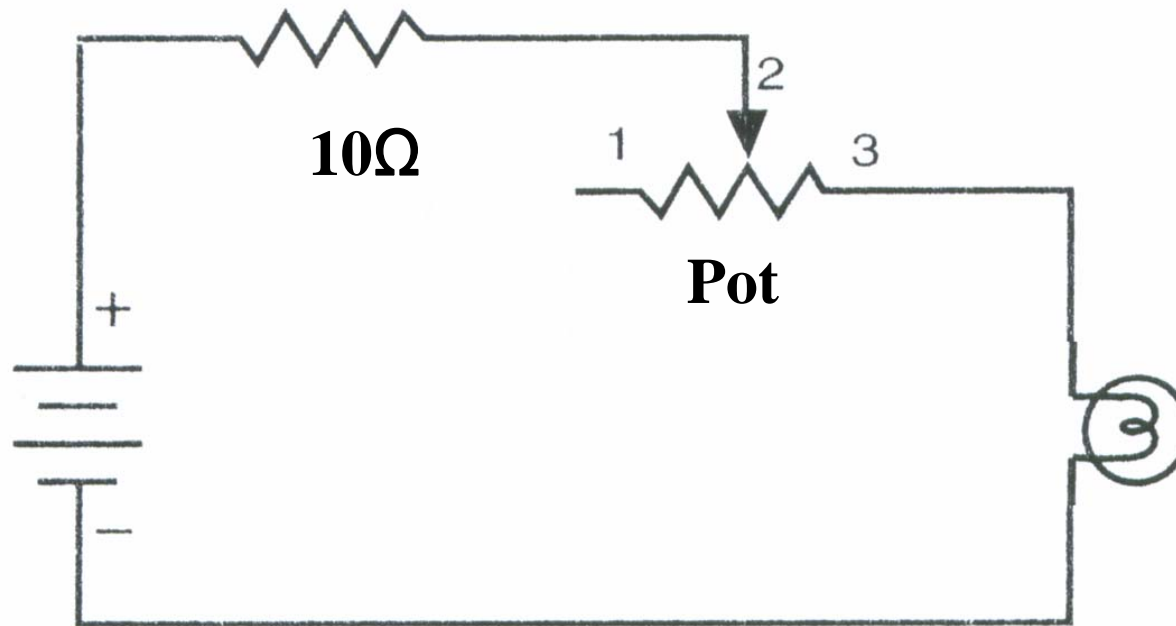
Exercise 1



$$R_{total} = R_1 + \frac{R_2 \times R_3}{R_2 + R_3}$$

$$R_{total} = 1 + \frac{1 \times 1}{1 + 1} = \frac{3}{2} = 1.5k\Omega$$

Exercise 2

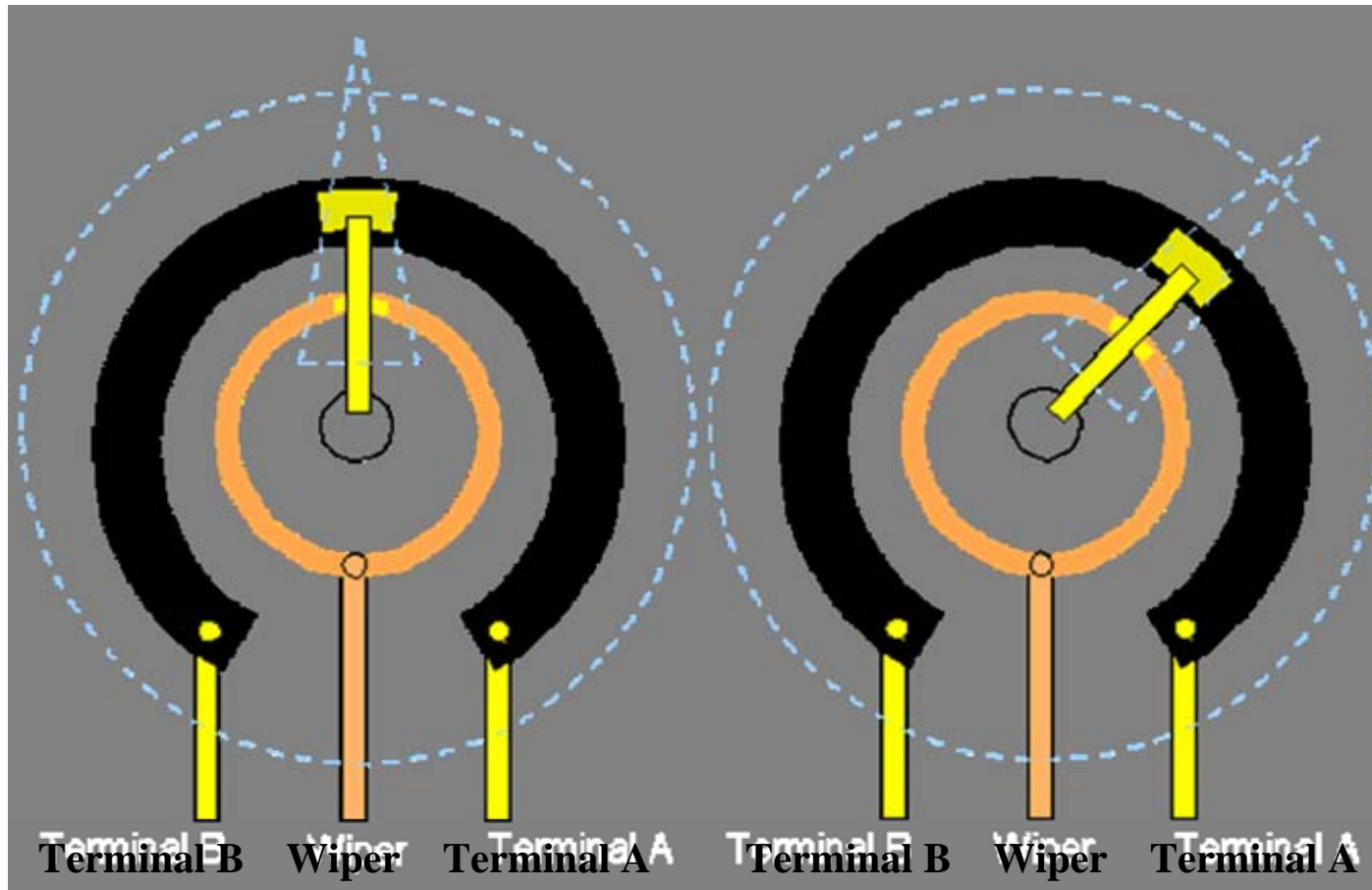


Potentiometer 1

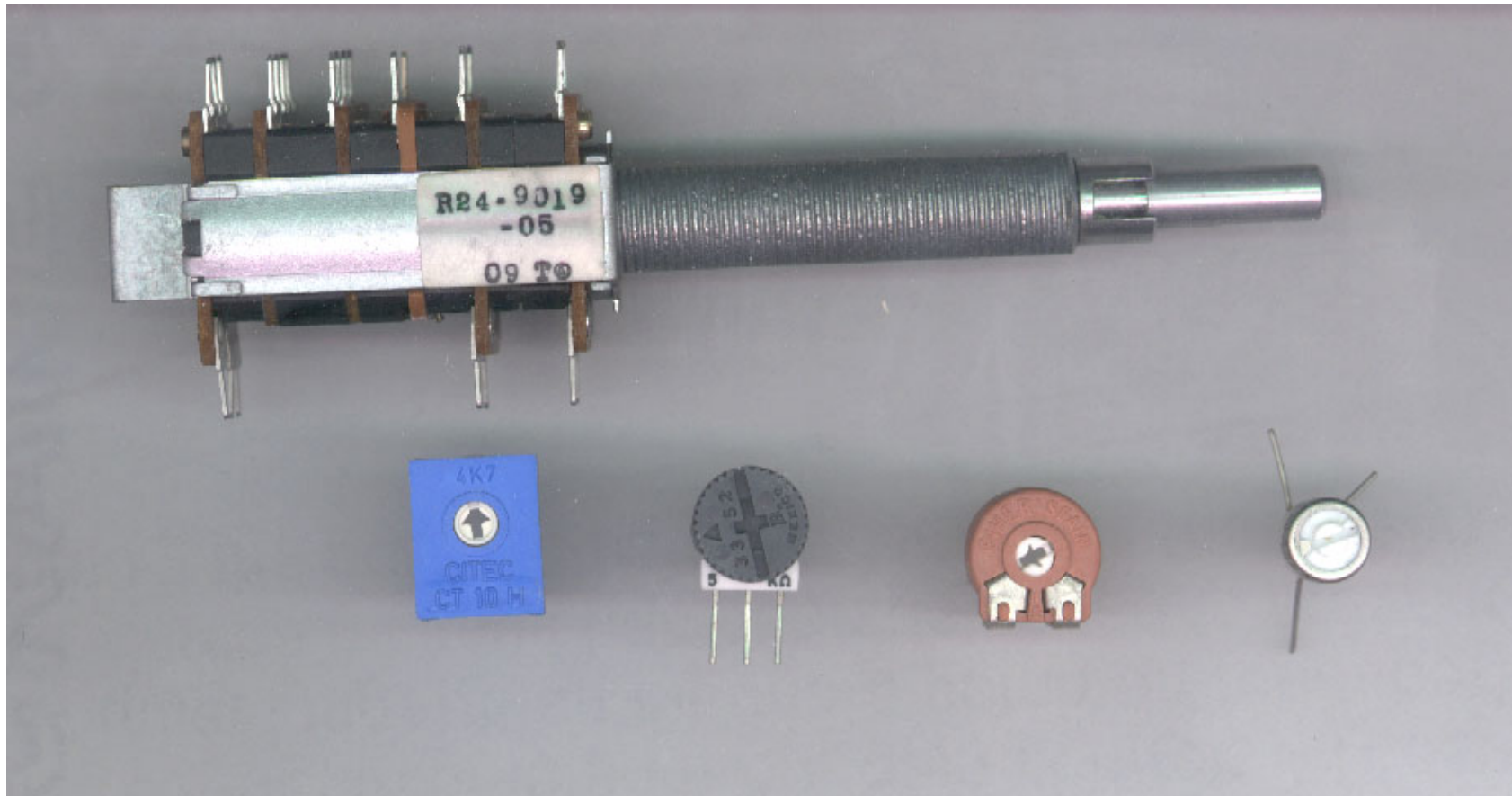


- Has an adjustable resistance
- Rotary potentiometer
- Linear potentiometer
- Use as a position sensor

Potentiometer 2



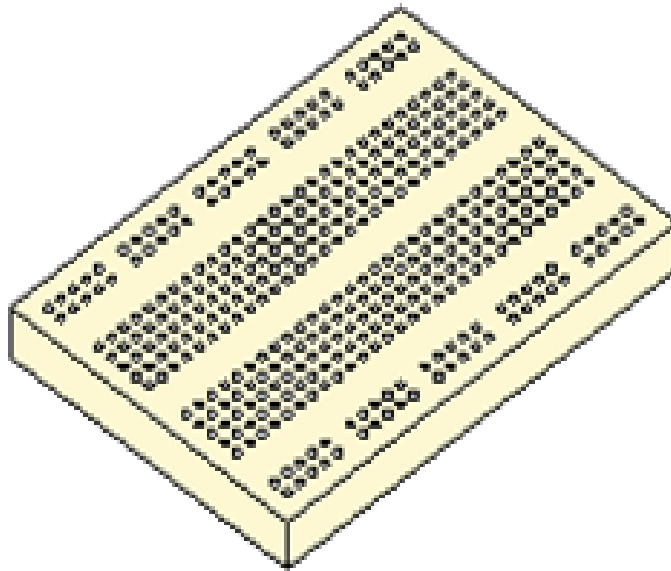
Rotary Potentiometers



Linear Potentiometer



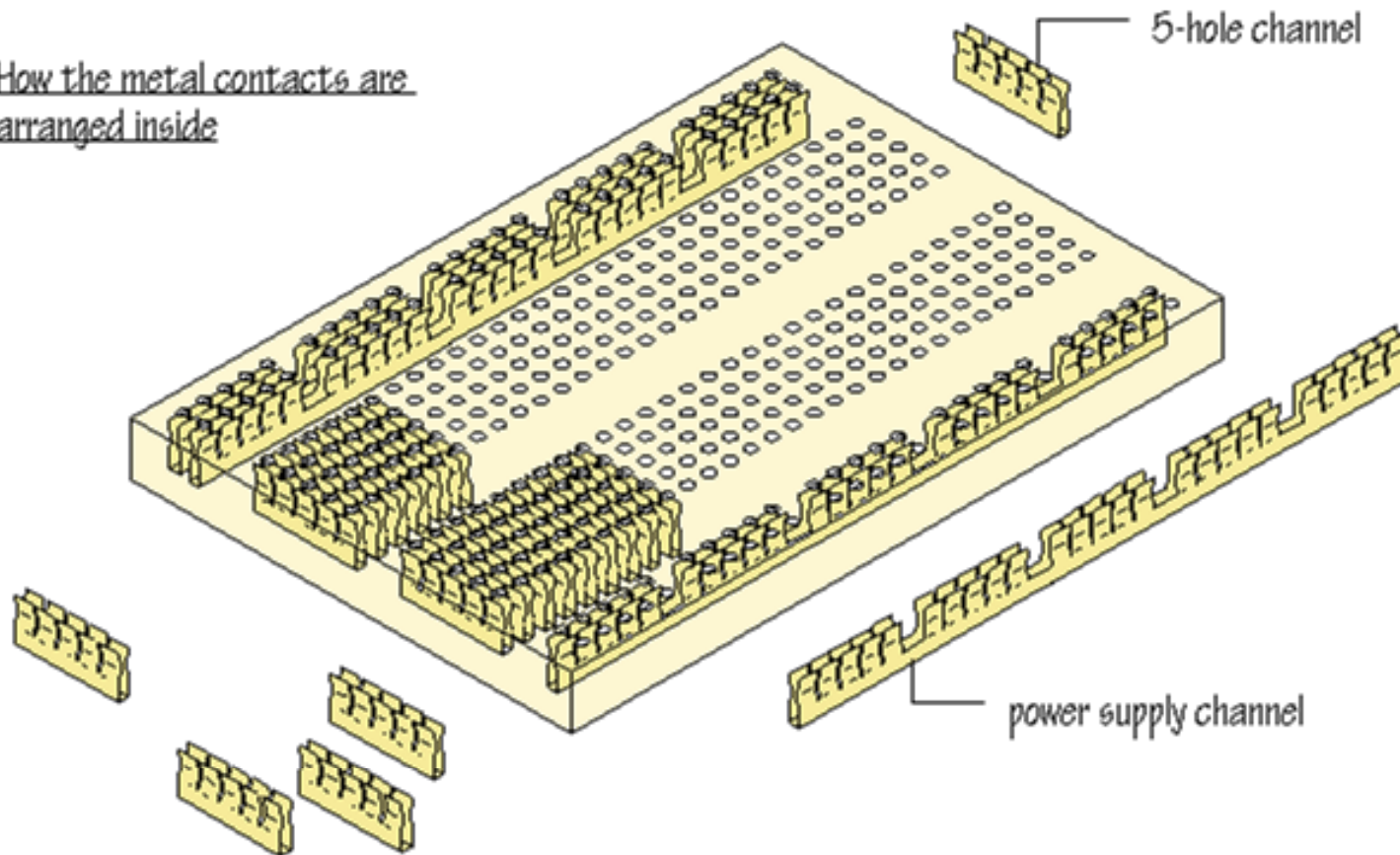
Breadboard 1



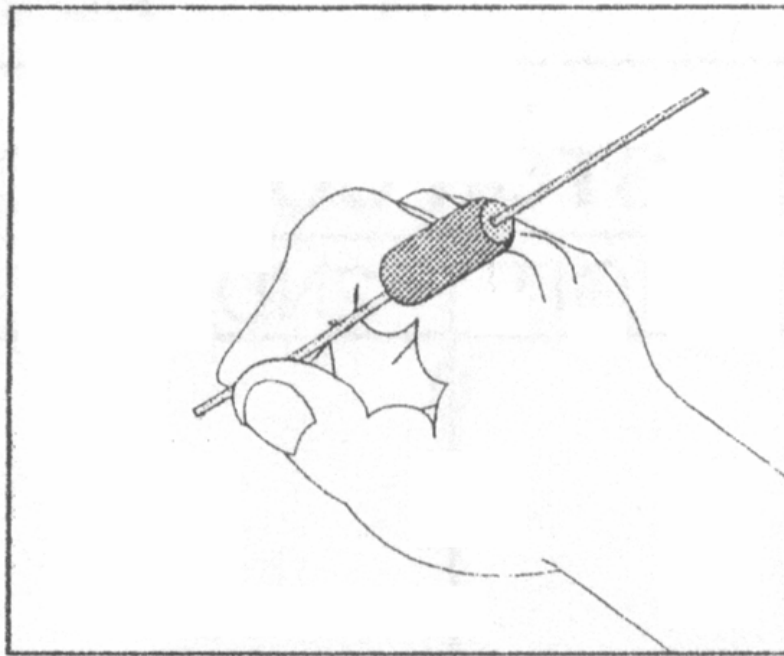
Prototype board is used for building temporary circuits, without soldering. Component leads are pushed into the holes in the board to make connections.

Breadboard 2

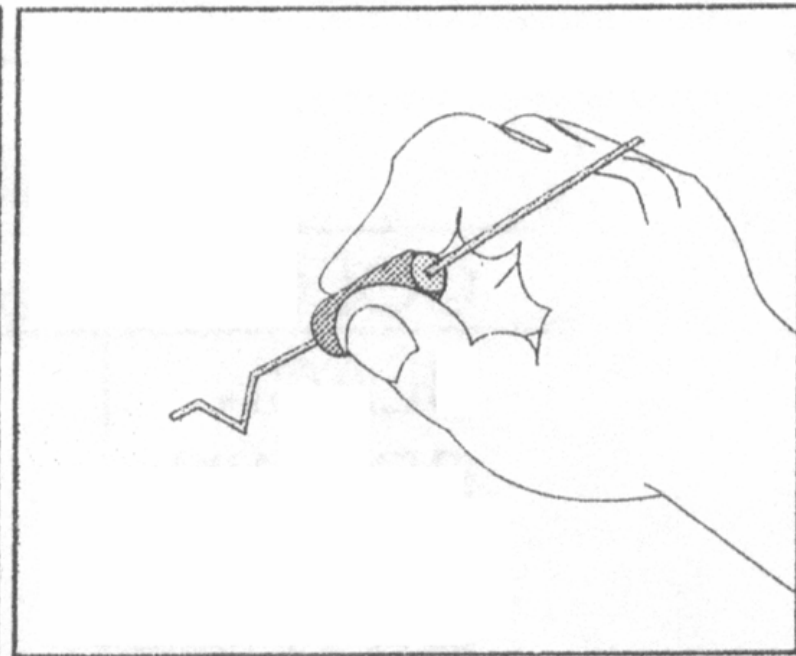
How the metal contacts are
arranged inside



How to Insert a Component into a Breadboard



RIGHT



WRONG

Resistor Experiments

Experiments	Chapters
What's micro controller	
Basic A and D	
Earth measurements	
Robotics	
StampWorks	
Others	On coming slides

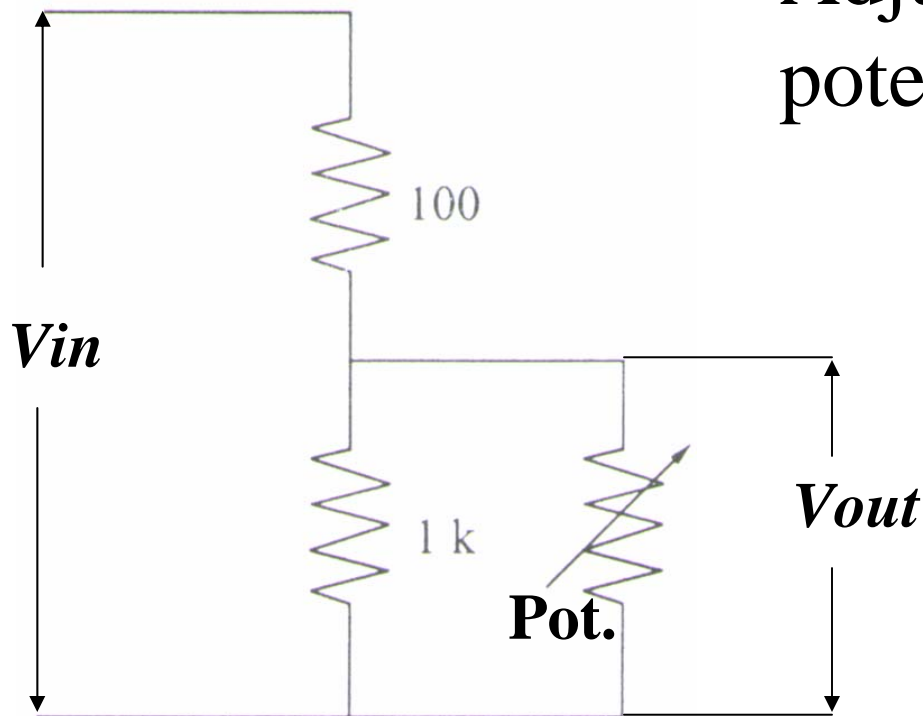
Experiment Details 1

- 1. Read resistors' nominal values using color code**
- 2. Determine resistors' values using an Ohmmeter**
- 3. Determine resistors' values using DMM (Voltmeter and Ammeter) and compare with results from 1 and 2**
- 4. Make serial connection with two resistors**
 - 1) Repeat 1, 2, and 3**
- 5. Make parallel connection with two resistors**
 - 1) Repeat 1, 2, and 3**
- 6. Make combination of serial and parallel connection with three resistors**
 - 1) Repeat 1, 2, and 3**

Experiment Details 2

- Adjust and Determine the potentiometer value such that

$$V_{out} = \frac{5}{6} V_{in}$$



Lecture 2

Mechatronics

Mechatronics 1

- Synergistic integration of
 - Mechanical engineering
 - Control theory
 - Computer science
 - Electronics
- To manage complexity, uncertainty, and communication in engineered systems

Mechatronics 2

- Typical knowledgebase for optimal design and operation of mechatronic systems comprises of
 - Dynamic system modeling and analysis
 - Decision and control theory
 - Sensors and signal conditioning
 - Actuators and power electronics
 - Hardware interfacing
 - Rapid control prototyping
 - Embedded computing

Mechatronic Applications

- **Smart consumer products:** home security, camera, microwave oven, toaster, dish washer, laundry washer-dryer, climate control units, etc.
- **Medical:** implant-devices, assisted surgery, haptic, etc.
- **Defense:** unmanned air, ground, and underwater vehicles, smart munitions, jet engines, etc.
- **Manufacturing:** robotics, machines, processes, etc.
- **Automotive:** climate control, antilock brake, active suspension, cruise control, air bags, engine management, safety, etc.
- **Network-centric, distributed systems:** distributed robotics, tele-robotics, intelligent highways, etc.

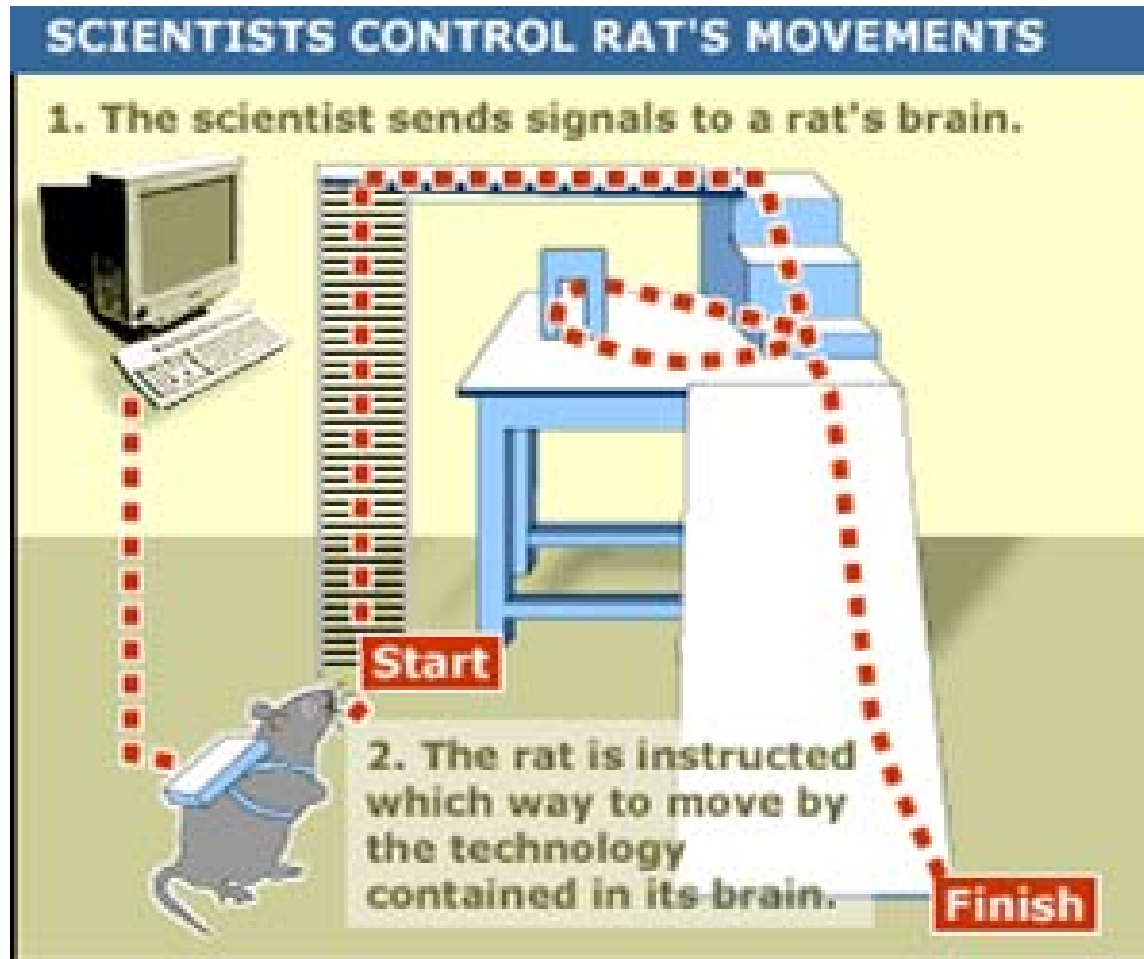
Roborat 1



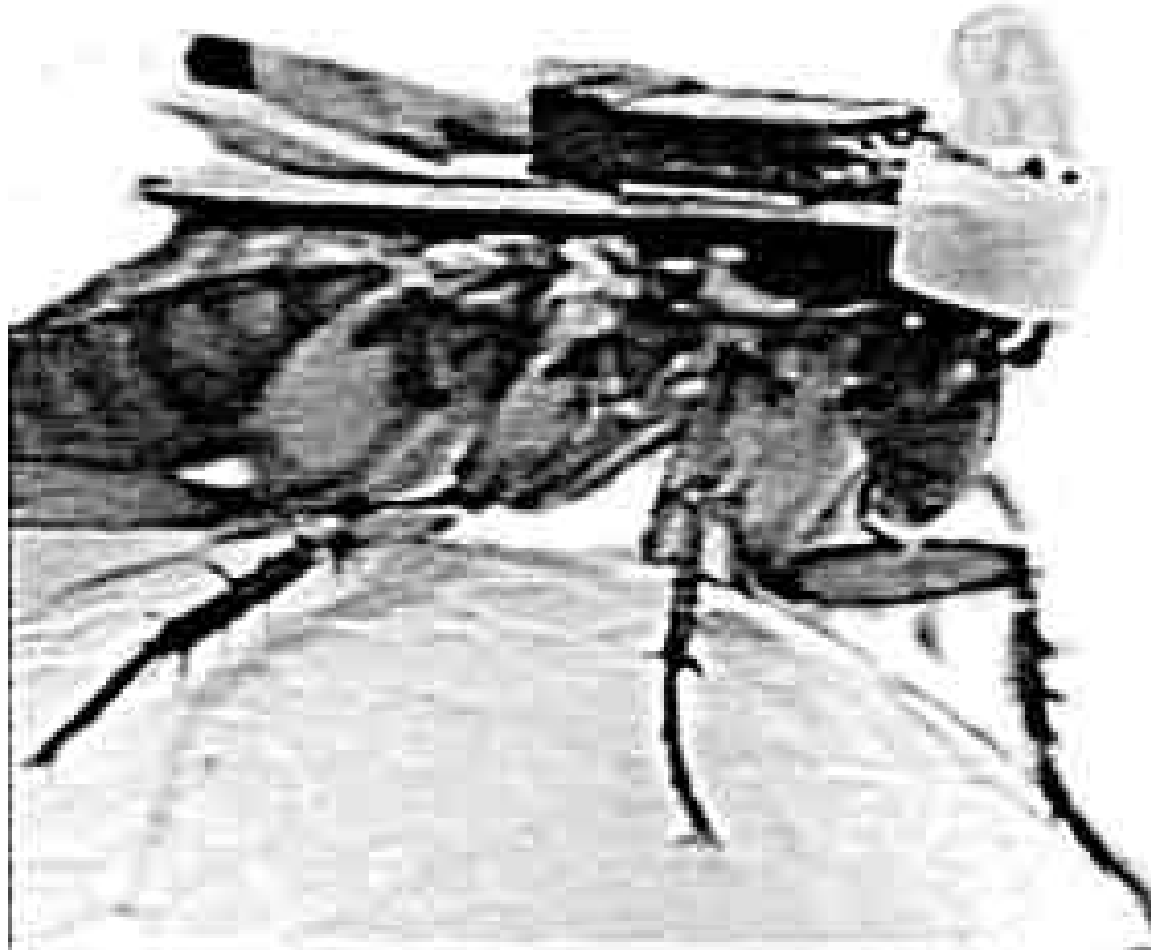
Roborat 2



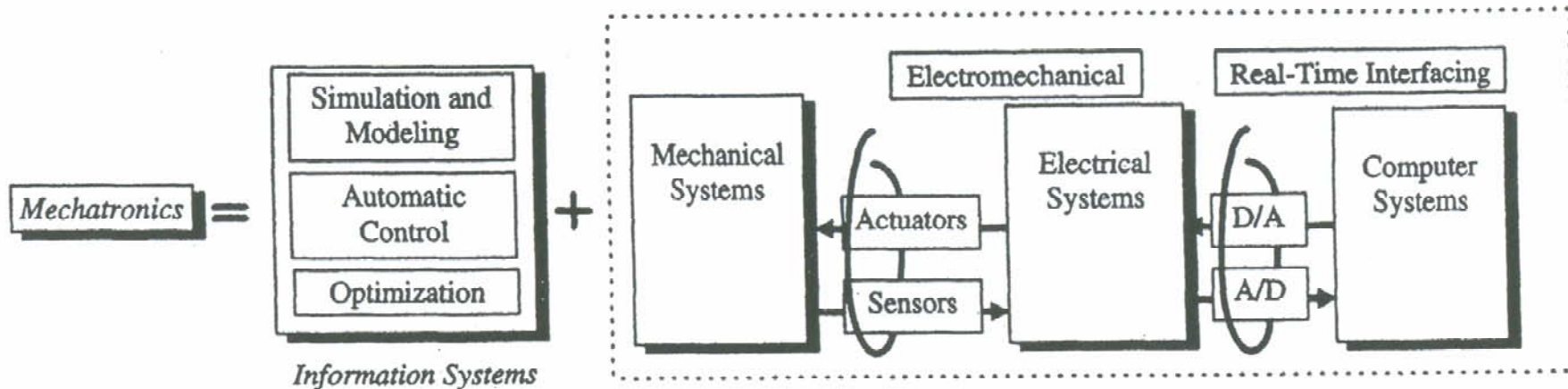
Roborat 3



Robocockroach



Key Elements of Mechatronics



Elements of Mechatronics 1

- Mechanical elements



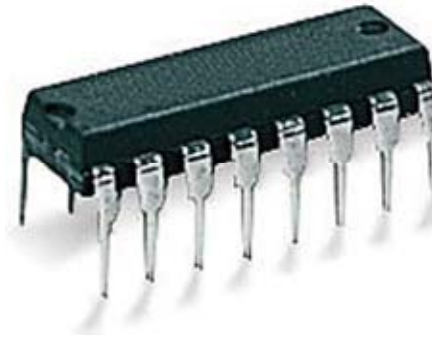
Elements of Mechatronics 2

- Electromechanical elements



Elements of Mechatronics 3

- Electrical/Electronic elements



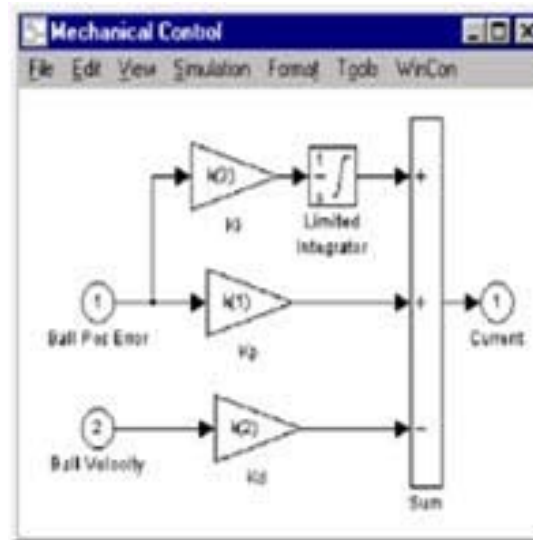
Elements of Mechatronics 4

- Control interface/computing hardware elements



Elements of Mechatronics 4

- Computer elements



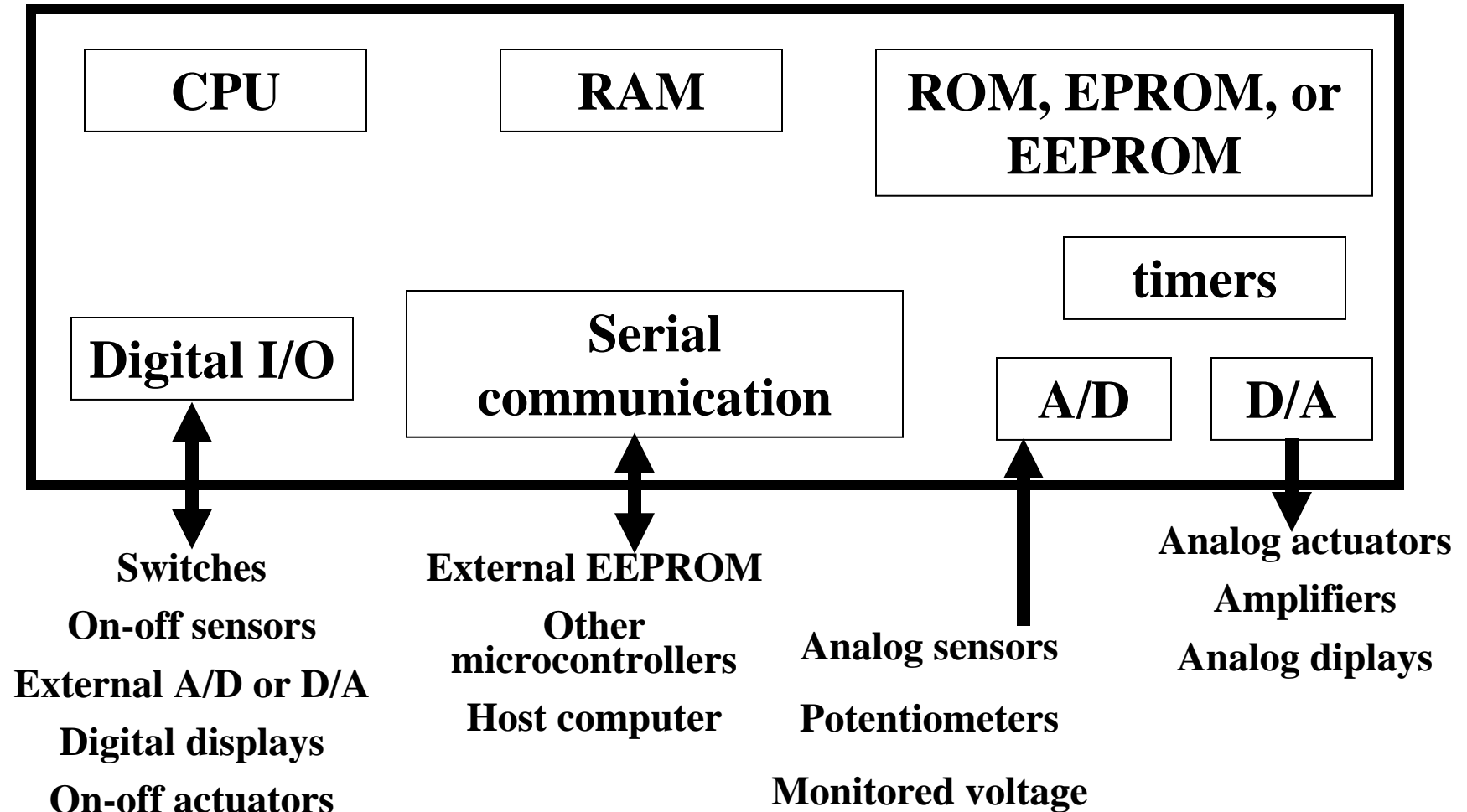
Microprocessors

- Perform arithmetic, logic, communication, and control function
- Arithmetic/logic unit(ALU)
- Instruction registers and decoders
- Data registers
- Control unit
- Intel 4004 (4bit microprocessor),
Intel 8080 (8bit microprocessor)

Microcontrollers

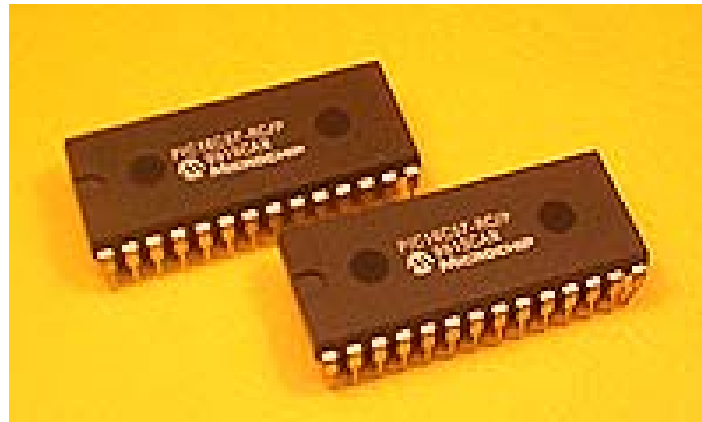
- Special purpose miniaturized computers
- Single integrated circuit containing many specialized and sophisticated circuits and functions
- Two primary components
 - RAM
 - CPU with instruction set

Microcontroller Architecture

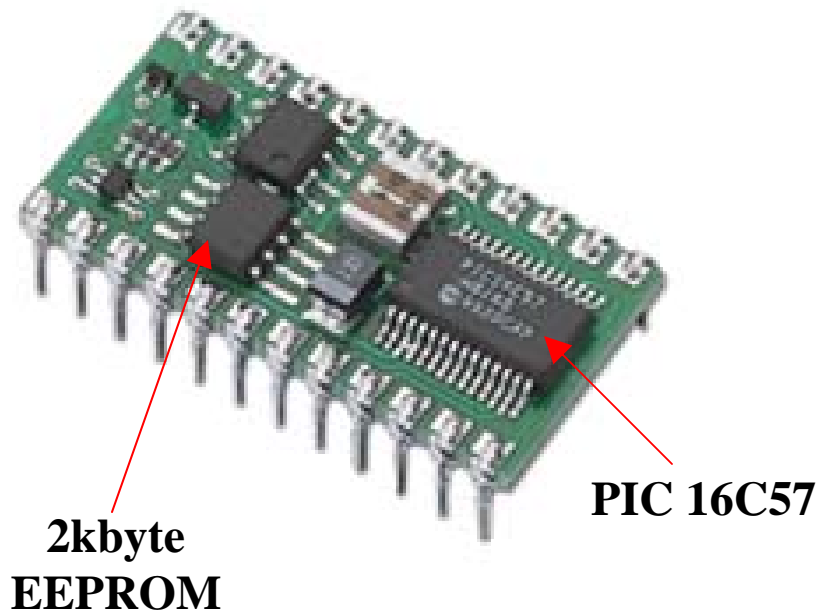


PIC Microcontrollers

- PIC 16C57 (unit price: \$7.50 in single quantities, \$3.50 in quantities of 1000 or more)



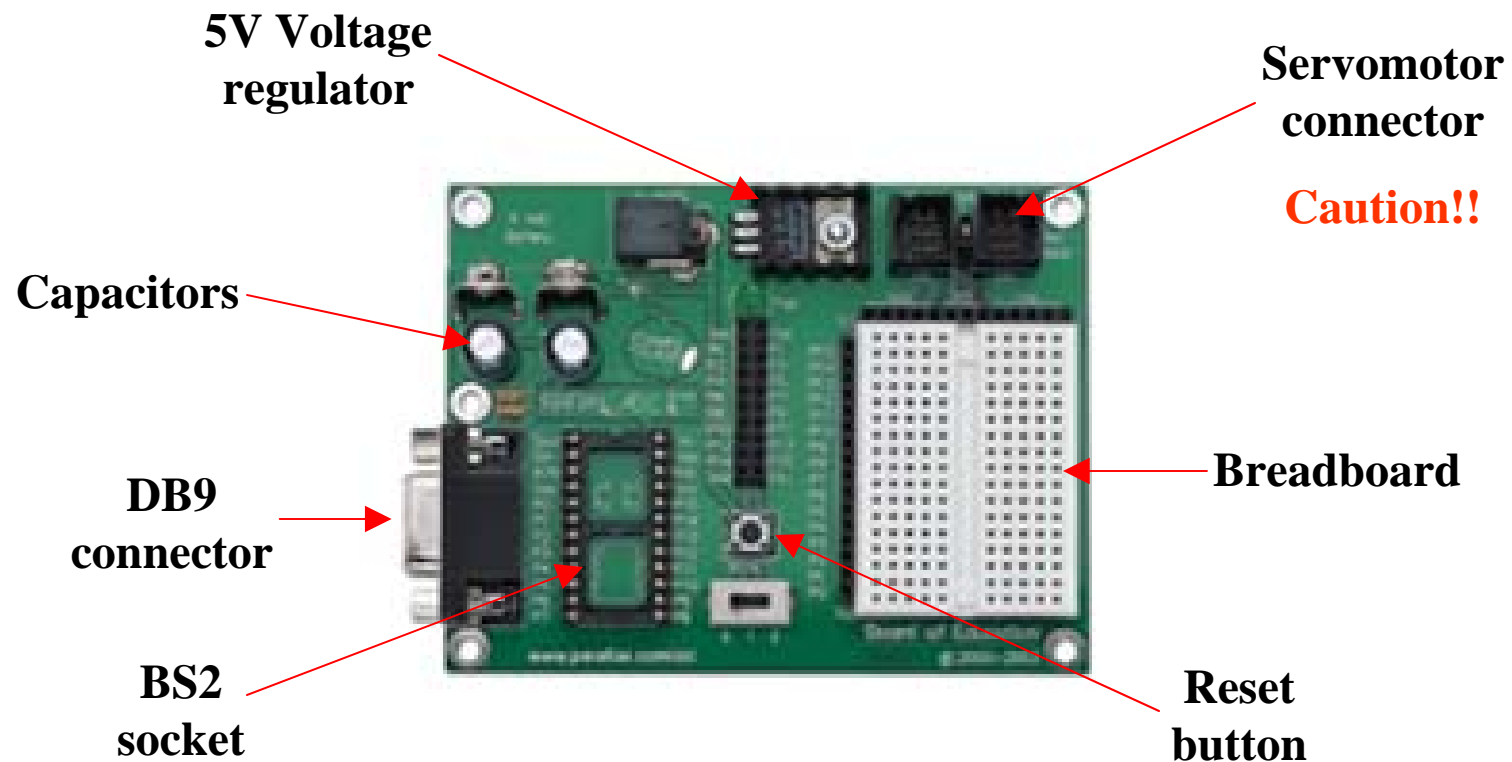
Basic Stamp 2



- Simple and easy to use
- PIC-based PBASIC interpreter on ROM
- 16 digital I/O

<http://www.parallax.com/Downloads/Documentation/bs/mod/BASIC Stamp 2 Schematic Rev F.pdf>

Stamp Development Board

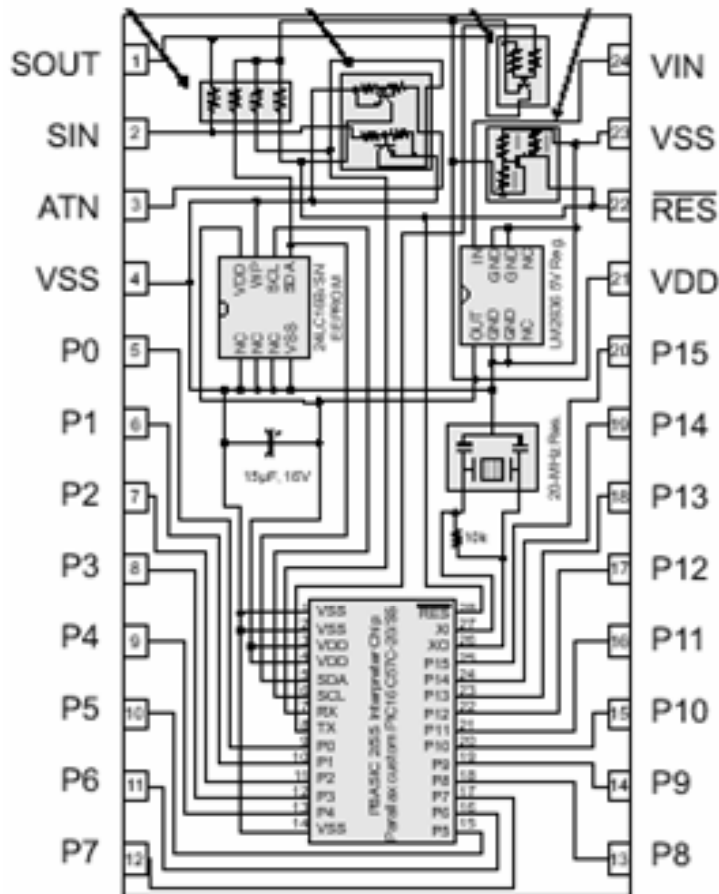


Board of education

Hardware Considerations

- Power requirements
 - BS2 requires regulated 5DCV and draws about 8mA
- Each I/O pin of BS2 can
 - Source up to **20mA**
 - Sink up to **25 mA**
- When the voltage regulator on BOE is being used, all I/O pin as a group can
 - Source up to **40mA**
 - Sink up to **50mA**

BS2 Pin Descriptions



Pin	Name	Description
1	SOUT	Serial out
2	SIN	Serial in
3	ATN	Attention
4	VSS	System ground
5-20	P0-P15	Input/Output pins
21	VDD	5DC V
22	RES	Reset
23	VSS	System ground
24	VIN	Unregulated power in

BS2 Variable Types

Var type	Size	Range of value
bit	1 bit	0, 1
nib	4 bits	0-15
byte	8 bits	0-255
word	16 bits	0-65535

OnOff var bit

InOutPins var nib

ADCin var byte

Count var word

Binary, Decimal, and Hexadecimal Numbers

Binary	Decimal	Hexadecimal
0000	0	0
0001	1	1
0010	2	2
0011	3	3
0100	4	4
0101	5	5
0110	6	6
0111	7	7

Binary	Decimal	Hexadecimal
1000	8	8
1001	9	9
1010	10	A
1011	11	B
1100	12	C
1101	13	D
1110	14	E
1111	15	F

Variable Command

b0=10

b0= %00001010

b0=\$0A

(375)₂ is 00000001

01110111

b3 var byte

$$01110111 = 2^7(0) + 2^6(1) + 2^5(1) + 2^4(1)$$

b3=375

$$+ 2^3(0) + 2^2(1) + 2^1(1) + 2^0(1)$$

Debug DEC b3

$$= 119$$

Result is 119

Assigning Pins for I/O

DIRS: 1 for output, 0 for input

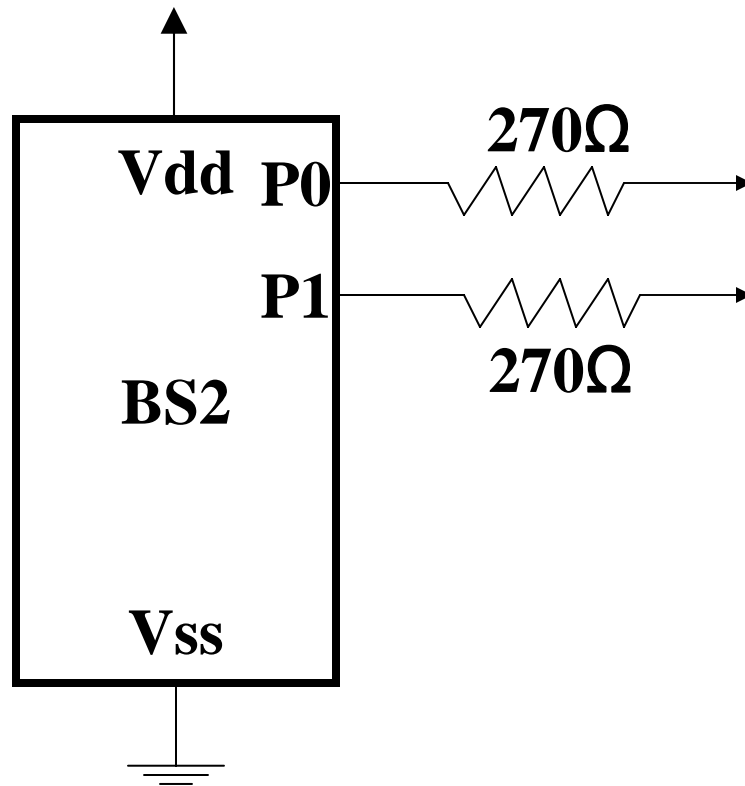
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
DIR D				DIR C				DIR B				DIR A			
DIR H								DIR L							

OUTS

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
OUT D				OUT C				OUT B				OUT A			
OUT H								OUT L							

Same as for INS

How to Protect the I/O Pins



$$I = \frac{5}{270} \approx 19mA$$

Variables Experiments

Experiments	Chapters
What's micro controller	
Basic A and D	
Earth measurements	
Robotics	
StampWorks	
Others	On coming slides

Experiment Details 1

myCon CON 10

myVar1 VAR Byte

myVar2 VAR Byte

myVar3 VAR word

myVar4 VAR word

myVar1=5

myVar2=25

myVar3=375

myVar4=400

Experiment Details 2

```
debug "myCon= ", DEC myCon, cr
debug "myVar1= ", DEC myVar1, cr
debug "myVar2= ", DEC myVar2, cr
debug "myVar3= ", DEC myVar3, cr
debug "myVar4= ", DEC myVar4, cr
debug "myVar3 in BIN= ", BIN myVar3, cr
debug "Low byte of 375=", BIN myVar3.byte0, cr
debug "High byte of 375=", BIN myVar3.byte1, cr
```

Experiment Details 3

b0=10

debug "b0 input in DEC.", cr

debug "b0 in DEC= ", DEC b0, cr

debug "b0 in BIN= ", BIN b0, cr

debug "b0 in HEX= ", HEX b0, cr

Experiment Details 4

b0=%00001010

debug "b0 input in BIN.", cr

debug "b0 in DEC= ", DEC b0, cr

debug "b0 in BIN= ", BIN b0, cr

debug "b0 in HEX= ", HEX b0, cr

Experiment Details 5

b0=\$0A

debug "b0 input in HEX.", cr

debug "b0 in DEC= ", DEC b0, cr

debug "b0 in BIN= ", BIN b0, cr

debug "b0 in HEX= ", HEX b0, cr

Experiment Details 6

b0=10

b1=20

b2=b0+b1

b3=375

debug "b0 in DEC= ", DEC b0, cr

debug "b1 in DEC= ", DEC b1, cr

debug "b2 in DEC= ", DEC b2, cr

debug "b3 in DEC= ", DEC b3, cr

Experiment Details 7

debug "b0 in BIN= ", BIN b0, cr

debug "b1 in BIN= ", BIN b1, cr

debug "b2 in BIN= ", BIN b2, cr

debug "b3 in BIN= ", BIN b3, cr

Experiment Details 8

w2=375

debug "w2 in DEC= ", DEC w2, cr

debug "w2 in BIN= ", BIN w2, cr

debug "b4 in BIN= ", BIN b4, cr

debug "b5 in BIN= ", BIN b5, cr

Experiment Details 9

- Please read “**BASIC Stamp Frequently Asked Questions**”
- Please read and run all programs on “**BASIC Stamp User's Manual**” from page 1 to page 75
- And **DEBUG** on page 97