

# Power Electronics

## No.1: Preparation

Prof. Takeshi Furuhashi

Furuhashi\_at\_cse.nagoya-u.ac.jp

# What is Power Electronics?

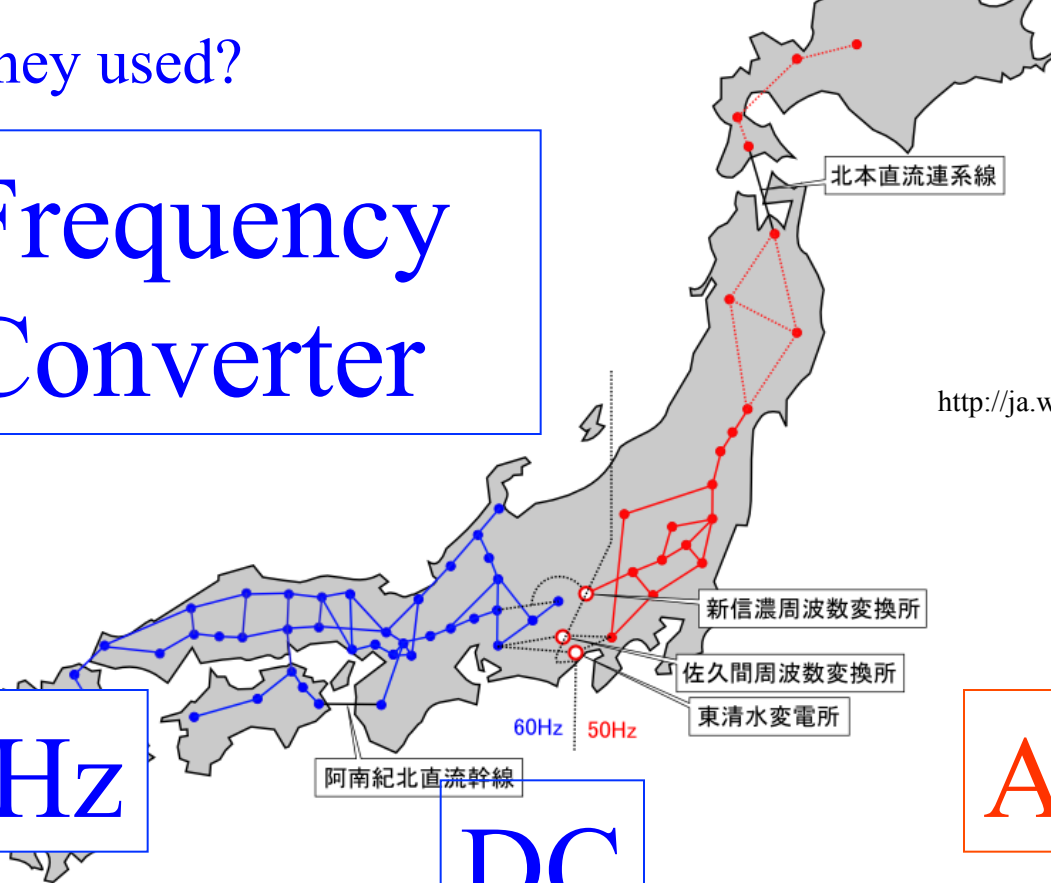


Power electronics circuits convert electric power from one form to another using electronic devices. They function by using semiconductor devices by switches, thereby controlling or modifying the voltage or current.

Where are they used?

# Frequency Converter

AC 60Hz



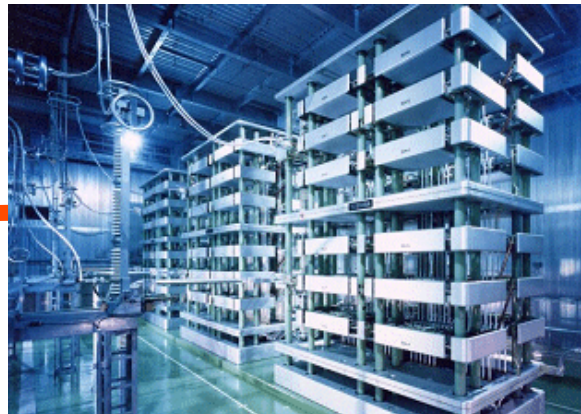
<http://ja.wikipedia.org/wiki/電力系統>

AC 50Hz

DC



<http://ja.wikipedia.org/wiki/佐久間周波数変換所>



<http://www.toshiba-smartcommunity.com/jp/smart-grid/hvdc>



# Where are they used?



Wind power generation  
(AC to AC)

<http://ja.wikipedia.org/wiki/風力発電-竜飛ウインドファーム1.jpg>



Solar power generation(DC to AC)

<http://ja.wikipedia.org/wiki/太陽光発電>



Hybrid car (DC to AC)

[http://ja.wikipedia.org/wiki/ファイル:TOYOTA\\_Prius.jpg](http://ja.wikipedia.org/wiki/ファイル:TOYOTA_Prius.jpg)



Fuel cell car (DC to AC)

[http://ja.wikipedia.org/wiki/ファイル:FCX\\_Clarity.jpg](http://ja.wikipedia.org/wiki/ファイル:FCX_Clarity.jpg)



Linear motor car  
(DC to AC)

[http://www.linimo.jp/sonota/syaryo/syaryo\\_050125\\_04\(1\)\\_photo.html](http://www.linimo.jp/sonota/syaryo/syaryo_050125_04(1)_photo.html)



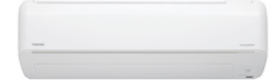
Bullet train (DC to AC)

[http://ja.wikipedia.org/wiki/のぞみ\\_\(列車\)](http://ja.wikipedia.org/wiki/のぞみ_(列車))

Home  
appliances  
(AC to AC)



<https://www.mitsubishielectric.co.jp/home/fan/>



[http://www.toshiba.co.jp/living/air\\_conditioners/](http://www.toshiba.co.jp/living/air_conditioners/)



<http://panasonic.jp/soji/>



<http://ja.wikipedia.org/wiki/ロボット>

Robot  
(DC to AC)



[http://ja.wikipedia.org/wiki/ファイル:Honda ASIMO \(ver. 2011\) 2013 Tokyo Motor Show.jpg](http://ja.wikipedia.org/wiki/ファイル:Honda_ASIMO_(ver.2011)_2013_Tokyo_Motor_Show.jpg)



# Where are they used?



Audio amplifier (AC to AC)

[http://www.jp.onkyo.com/audiovisual/purecomponents/amplifier/a7vl/img//a7vl\\_11.jpg](http://www.jp.onkyo.com/audiovisual/purecomponents/amplifier/a7vl/img//a7vl_11.jpg)



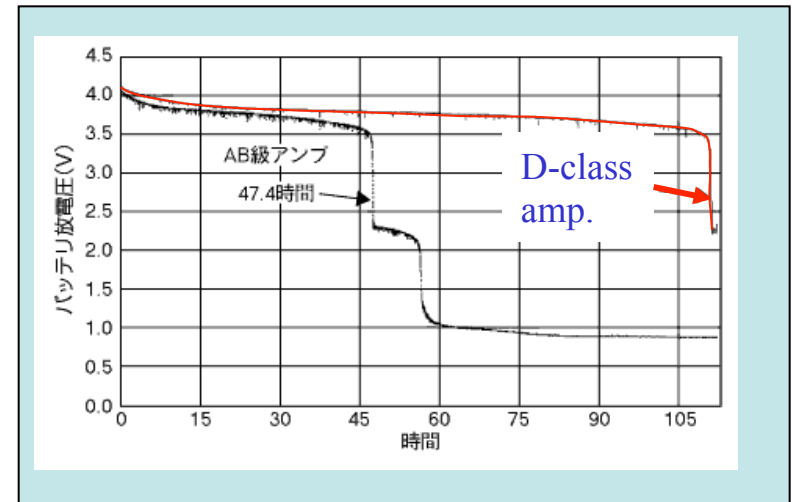
Mobile music player (AC to AC)

[http://upload.wikimedia.org/wikipedia/commons/archive/1/11/20090323073303%21IPod\\_family.png](http://upload.wikimedia.org/wikipedia/commons/archive/1/11/20090323073303%21IPod_family.png)



Television (AC to AC)

<http://www.sharp.co.jp/aquos/lineup/index-series.html>



Battery lives of mobile phones

<http://www.cqpub.co.jp/dwm/contents/0068/dwm006801360.pdf>

## Regenerative energy

Solar energy

Sunlight

Solar heat

Wind energy

Geothermal energy

Hydro-energy

Ocean energy

Temperature difference

Tidal energy

Wave energy

Salinity difference

Biomass energy

Hydrogen energy

Fuel cell

Cogeneration

Electric power



Power electronics equipment



Different form of electric power

# Power Electronics

The key technology for

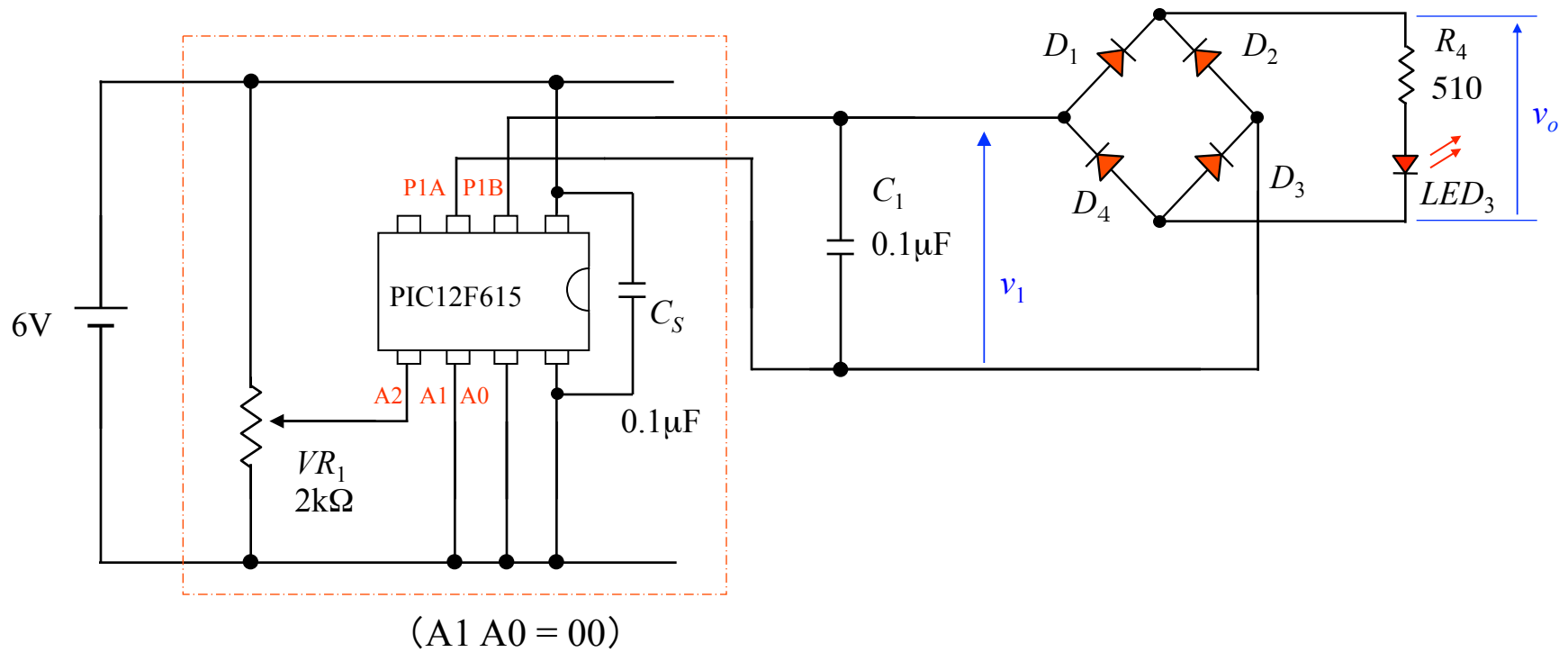
- Energy conservation
- Regeneration

# Lecture Program

1. Preparation
2. Rectifier circuit
3. Smoothing circuit
4. Step-down chopper
5. Step-down chopper with smoothing circuit
6. Step-up/down chopper
7. Operational amplifier
8. DC motor
9. Motor drive using chopper circuit
10. PI controller
11. Braking circuit
12. Half bridge inverter
13. Full bridge inverter
14. Three-phase PWM inverter
15. Three-phase PWM inverter II

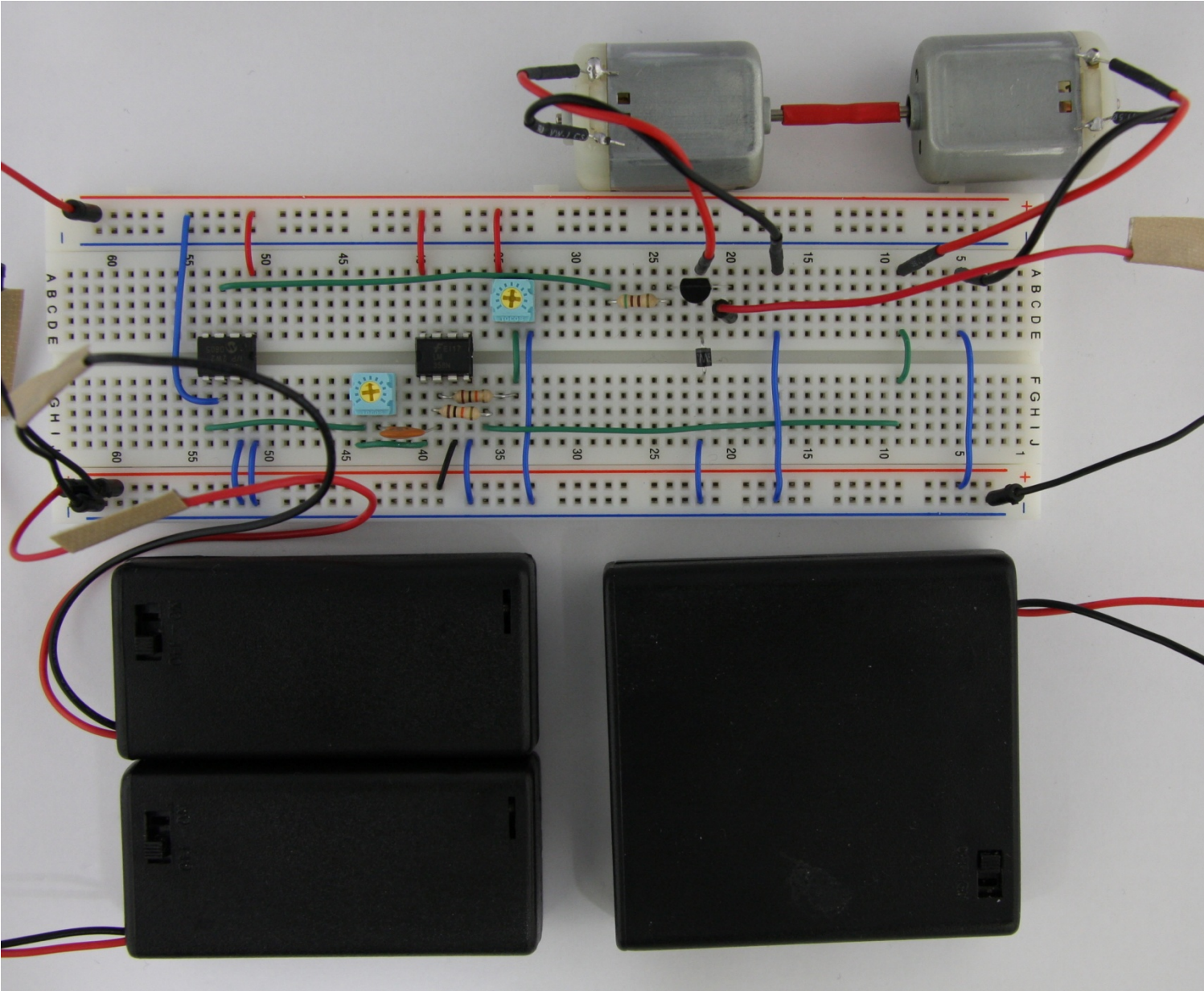


# Construction Practice STEP1 Rectifier



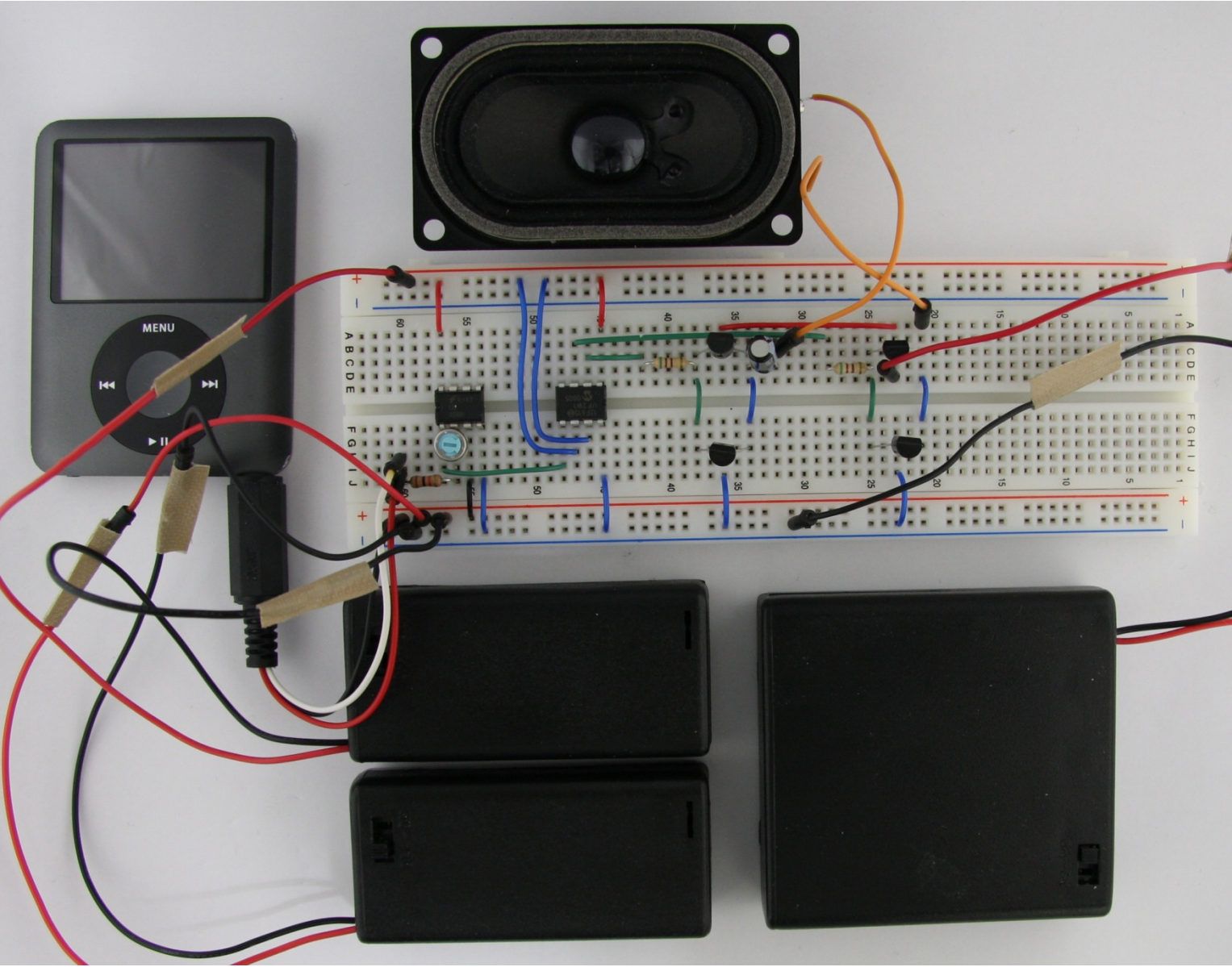


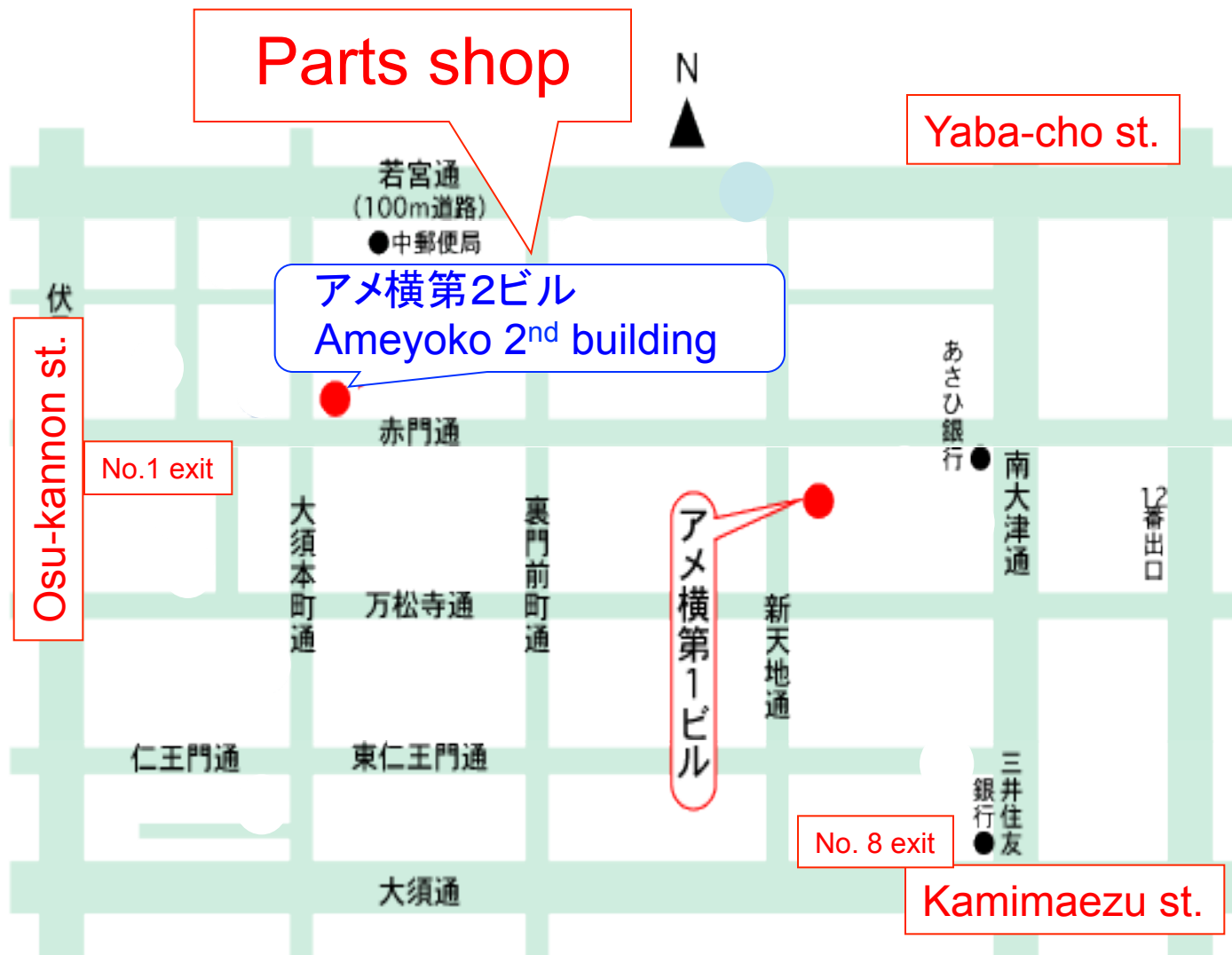
# Construction Practice STEP7 Speed control of DC motor using a step-down chopper





# Construction Practice STEP10 Audio amplifier using a full bridge inverter





### Web shops

<http://akizukidenshi.com/>

<http://www.marutsu.co.jp/user/index.php>

<http://www.rswww.co.jp/>

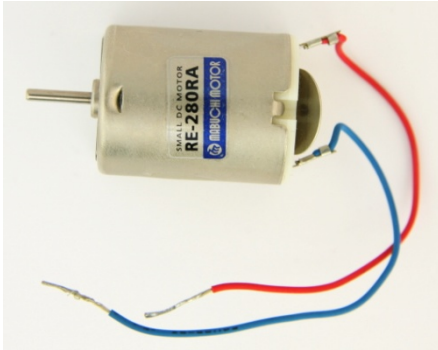
# Parts list

parts, ratings		quantity	un it cost	sum
DC motor	RE-280RA	2	200	400
LED	Red	7	5	35
Ear phone plug		1	60	60
Ope-amp	LM358N	1	20	20
Variable Resistor	2 k $\Omega$	1	40	40
	100 k $\Omega$	1	40	40
Capacitor	0.001 $\mu$ F	1	10	10
	0.0047 $\mu$ F	1	10	10
	0.01 $\mu$ F	1	10	10
	0.047 $\mu$ F	1	10	10
	0.1 $\mu$ F	1	10	10
	0.47 $\mu$ F	1	10	10
	1 $\mu$ F	2	10	20
	4.7 $\mu$ F	1	10	10
Jumper wire		1	150	150
Diode	30 V, 1 A	4	20	80
Speaker		1	150	150
Switch	toggle type	1	50	50
	push type	1	30	30
Reactor	1.5 mH	1	20	20
Resistor	50 $\Omega$	2	0.5	1
	100 $\Omega$	2	0.5	1
	510 $\Omega$	7	0.5	3.5
	1 k $\Omega$	2	0.5	1
	2.2 k $\Omega$	2	0.5	1
	5 k $\Omega$	2	0.5	1
	10 k $\Omega$	2	0.5	1
	20 k $\Omega$	2	0.5	1
	50 k $\Omega$	2	0.5	1
	100 k $\Omega$	2	0.5	1
	200 k $\Omega$	2	0.5	1

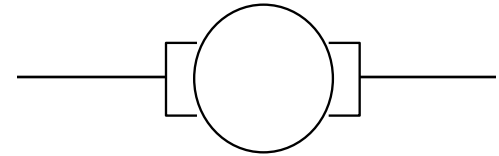
parts, ratings		quantity	un it cost	sum
Electrolytic capacitor	10 $\mu$ F	1	30	30
	47 $\mu$ F	1	30	30
	470 $\mu$ F	1	30	30
Battery box	(AA $\times$ 2)	2	60	120
	(AA $\times$ 4)	1	100	100
Transisor	2SA950	2	10	20
	2SC2120	2	10	20
Bread Board		1	300	300
Slotted screwdriver		1	40	40
Micro computer	PIC12F615-I/P	1	65	65
AA battery		8	25	200
Parts box		1	100	100
Carrying case		1	100	100
bag		1	20	20

Total sum 2353.5

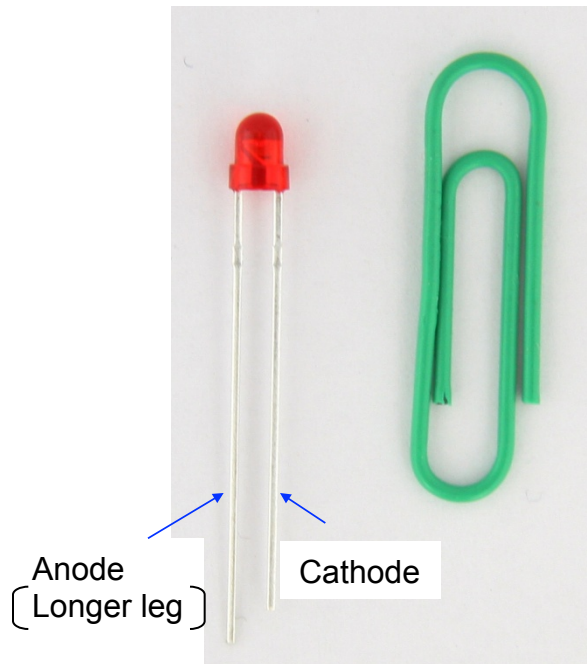




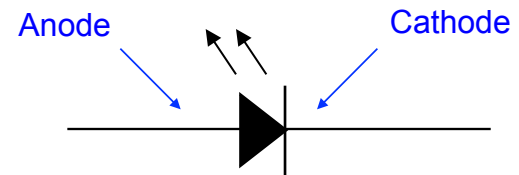
DC motor



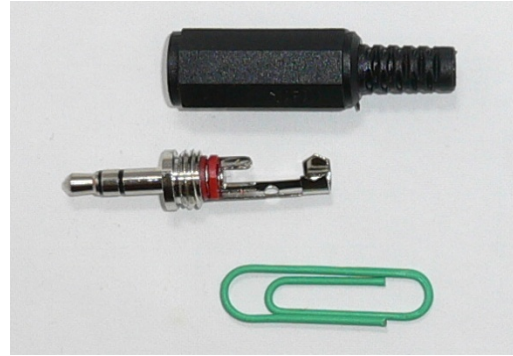
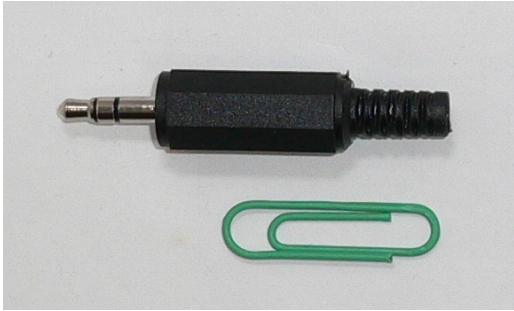
DC motor symbol



LED (Light Emitting Diode)

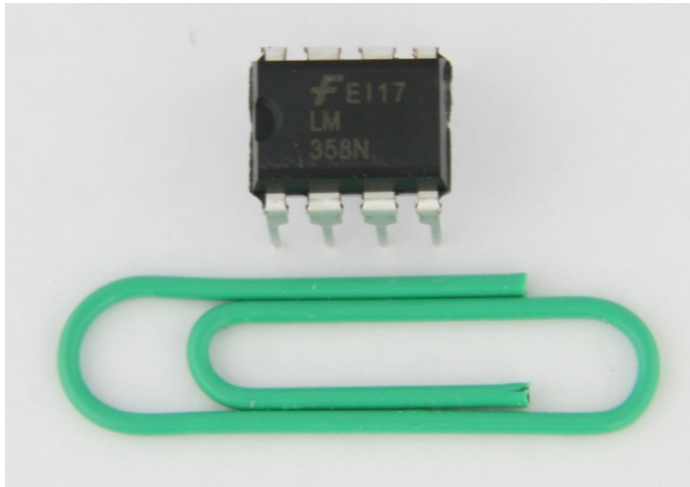


LED symbol

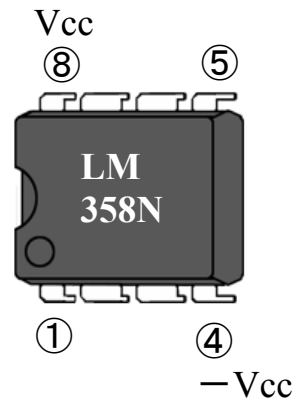


(decomposed)

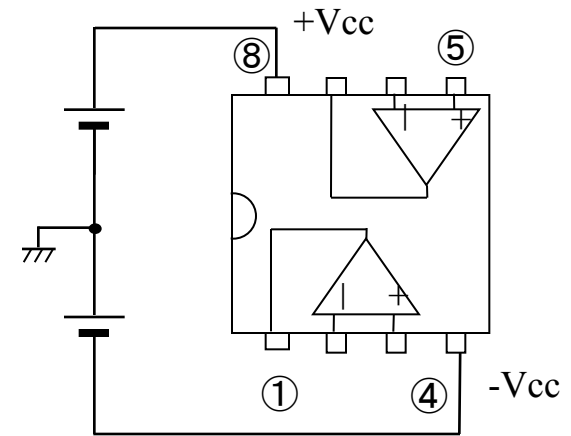
Earphone plug



Appearance



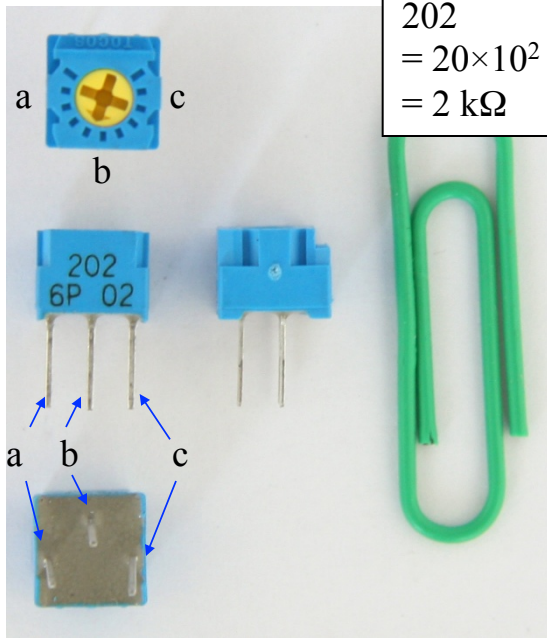
Solid figure



Pin Connections

Operational Amplifier (LM358N)

Upper surface

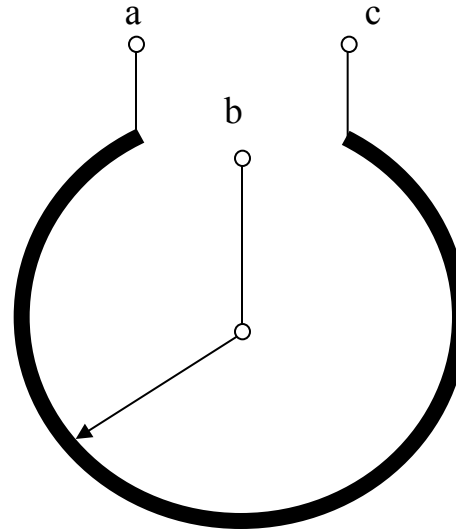


202  
 $= 20 \times 10^2 \Omega$   
 $= 2 \text{ k}\Omega$

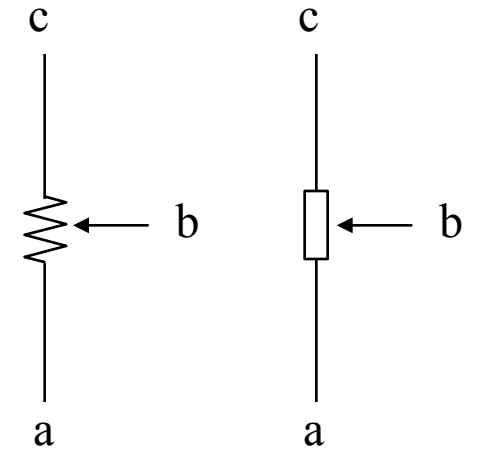
The front

Under surface

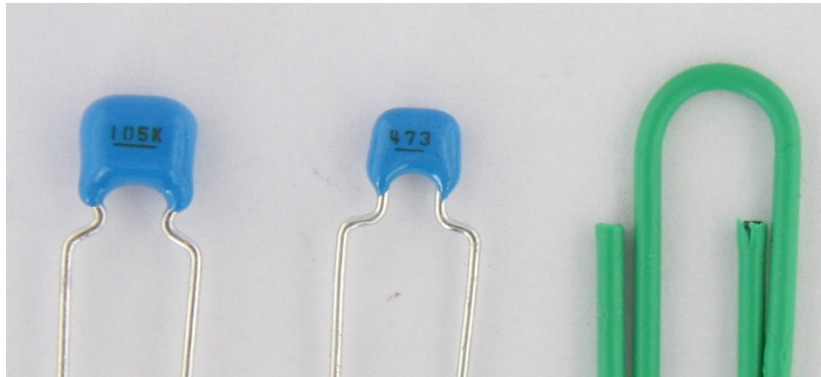
Variable resistor (2kΩ)



Pin connections



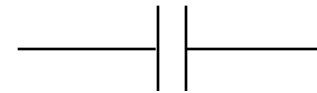
Variable resistor symbol



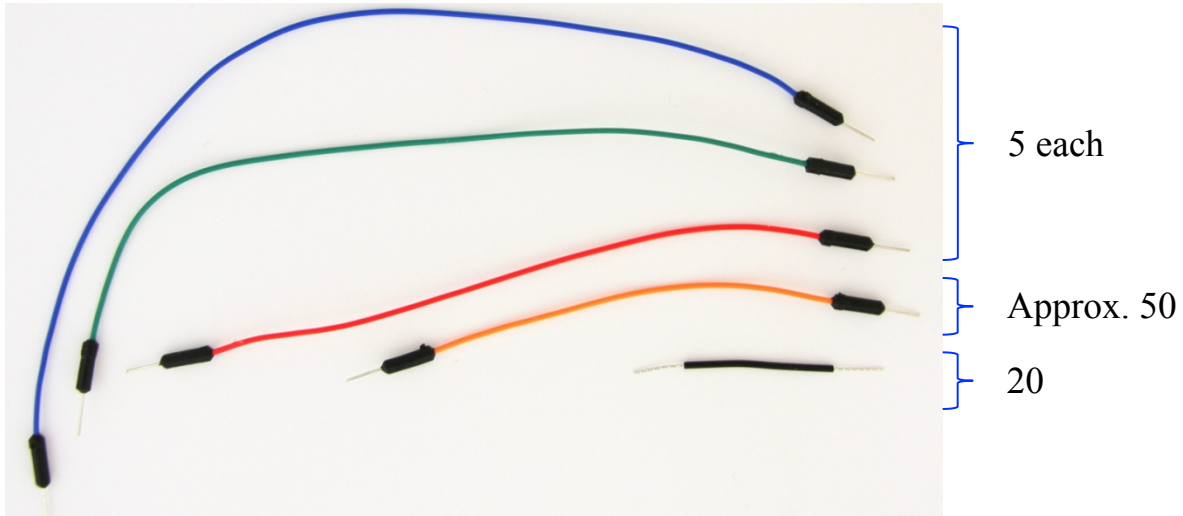
105  
 $= 10 \times 10^5 \text{ pF}$   
 $= 1000000 \text{ pF}$   
 $= 1 \text{ } [\mu\text{F}]$

473  
 $= 47 \times 10^3 \text{ pF}$   
 $= 47000 \text{ pF}$   
 $= 0.047 \text{ } \mu\text{F}$

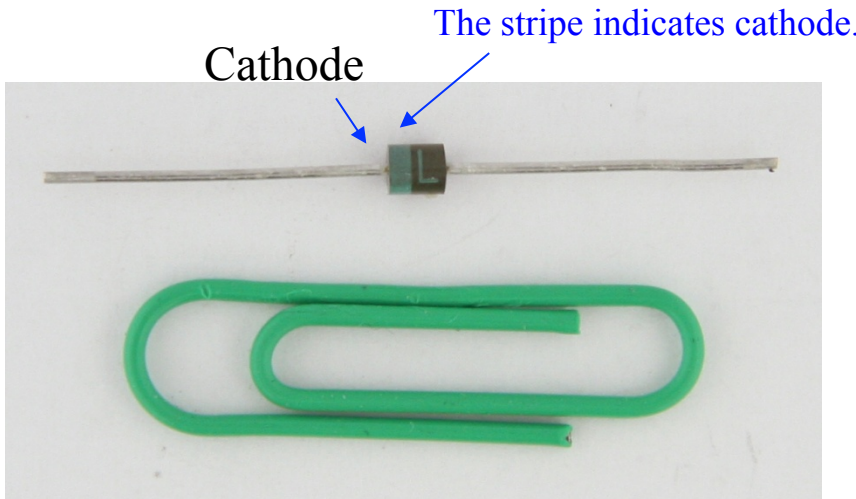
Capacitor



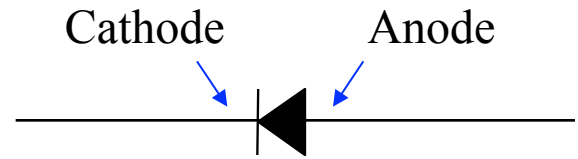
Capacitor symbol



Jumper Wires



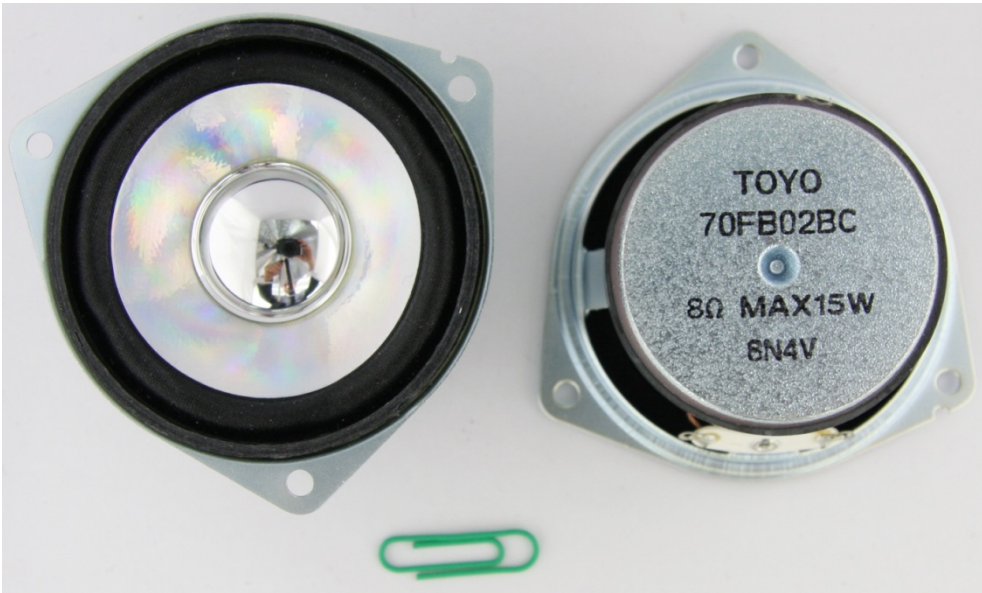
Diode (30V, 1A)



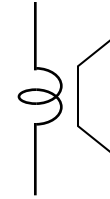
Diode symbol

front

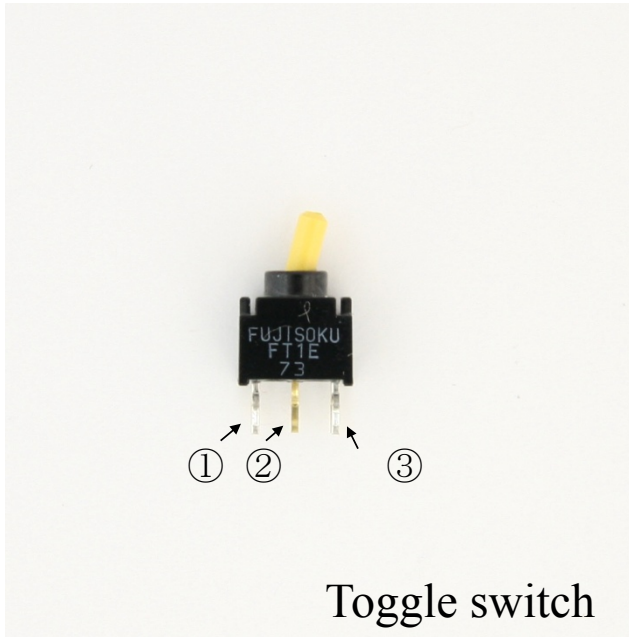
back



Speaker

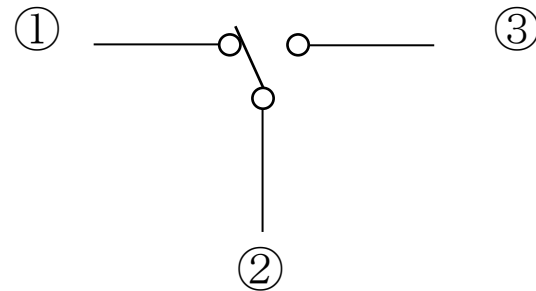


Speaker symbol



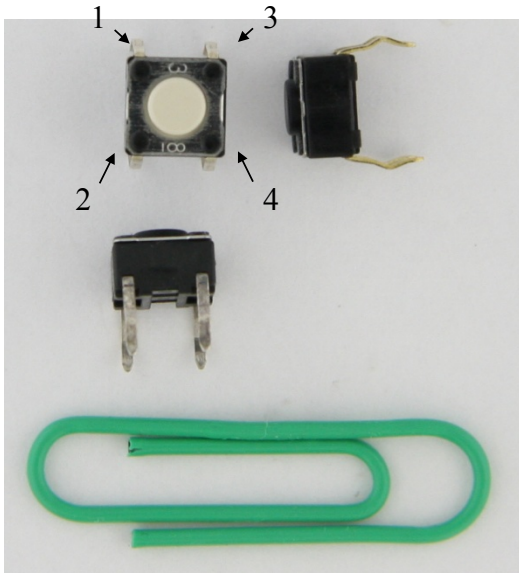
Toggle switch

Pins in this figure coincide with those in the photo.

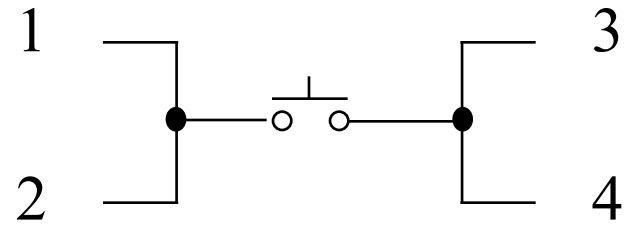


Toggle switch symbol

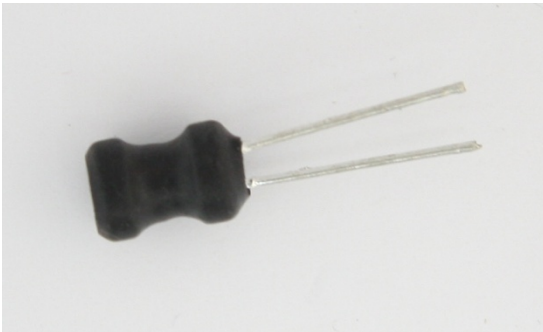




Push switch



Push switch symbol  
and pin connections

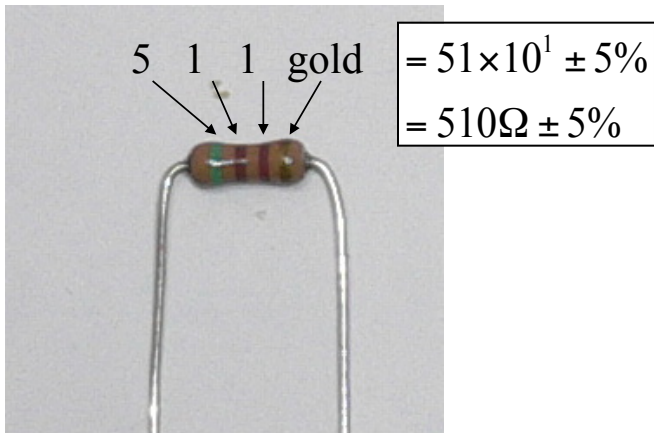


Reactor (1.5 mH)



Reactor symbol





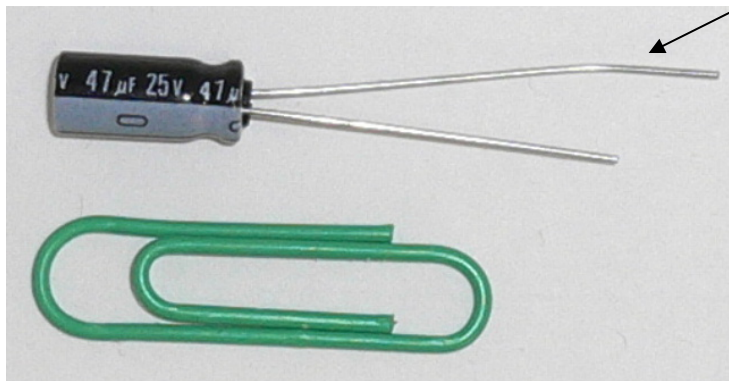
Resistor (510Ω)



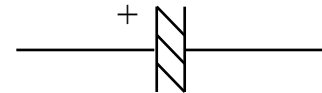
Resistor symbol

### Color code

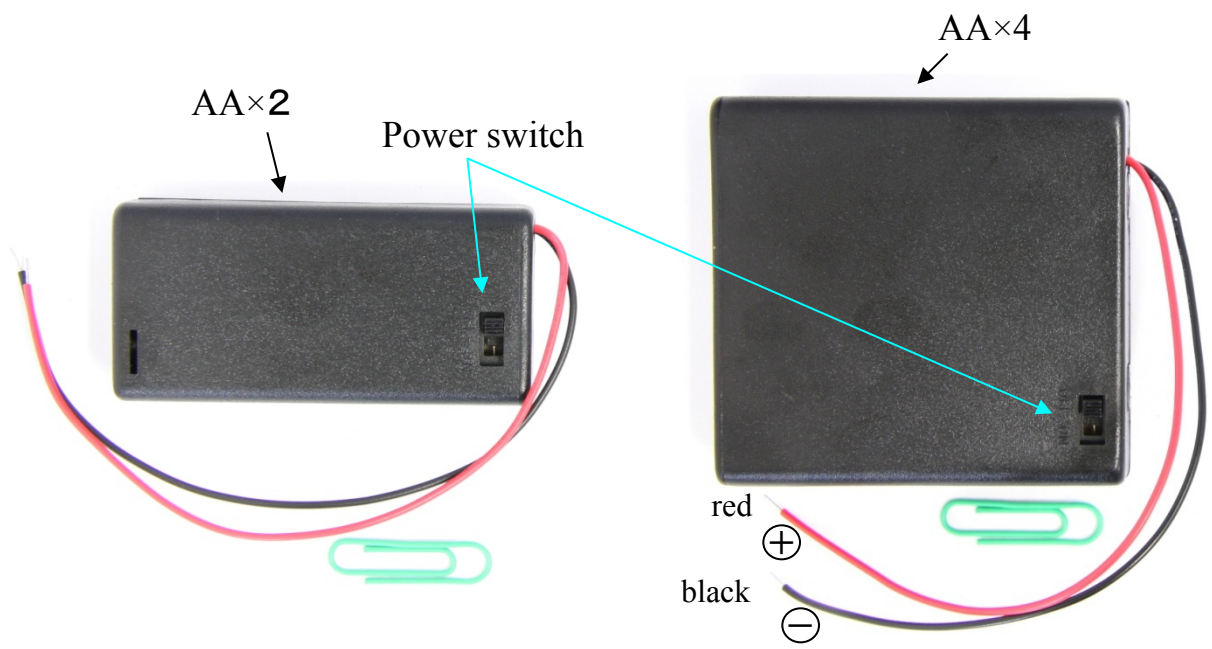
Black:	0	Gold:	±5%
Brown:	1	Silver:	±10%
Red:	2	No color:	±20%
Orange:	3		
Yellow:	4		
Green:	5		
Blue:	6		
Purple:	7		
Grey:	8		
White:	9		



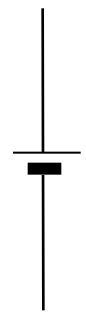
Electrolytic capacitor (47μF)



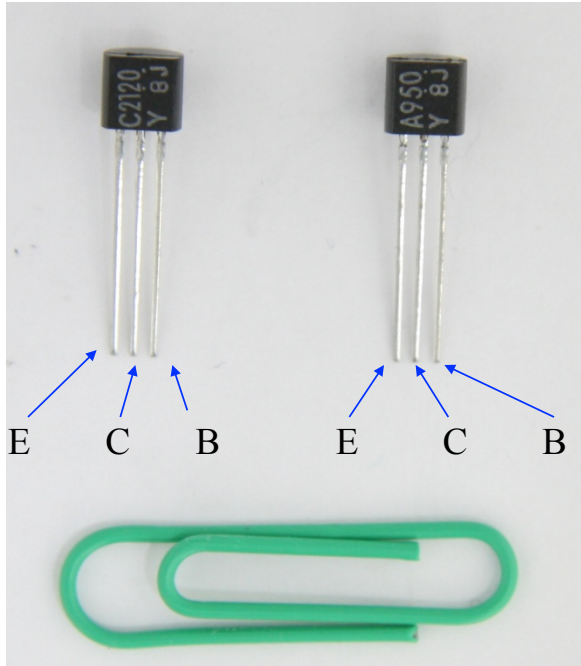
Electrolytic capacitor symbol



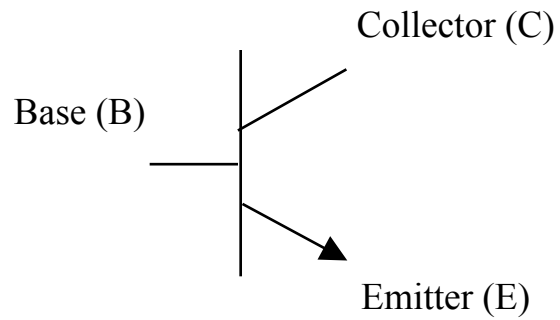
Battery box



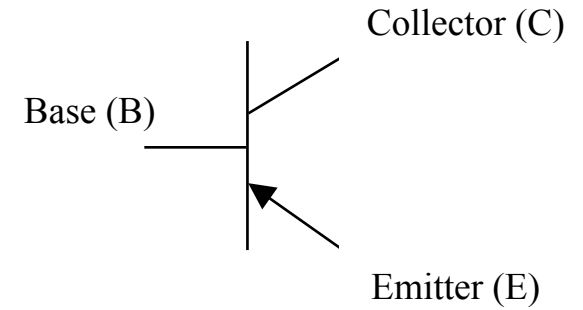
DC power supply symbol



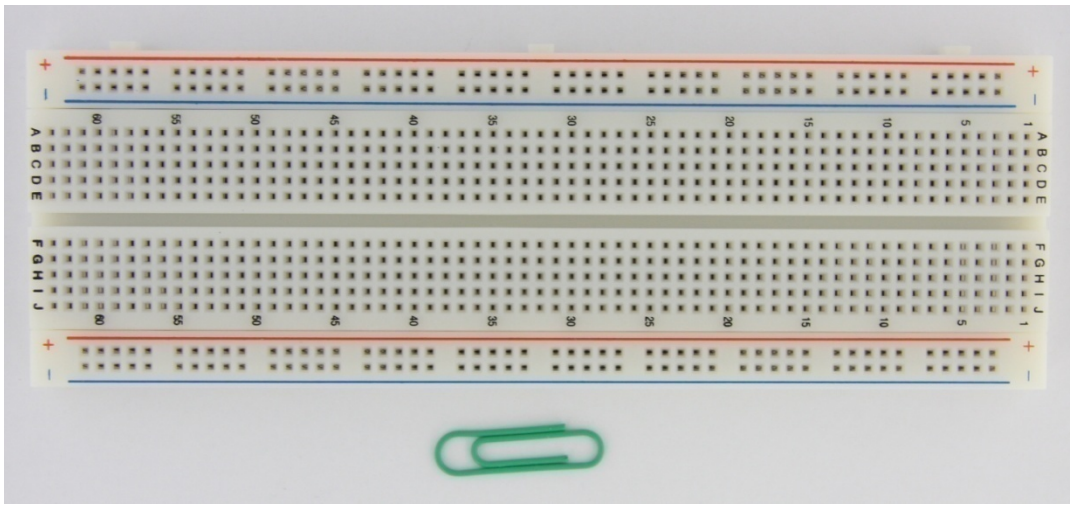
Transistor  
(left : 2SC2120(NPN-type)  
right : 2SA950(PNP-type))



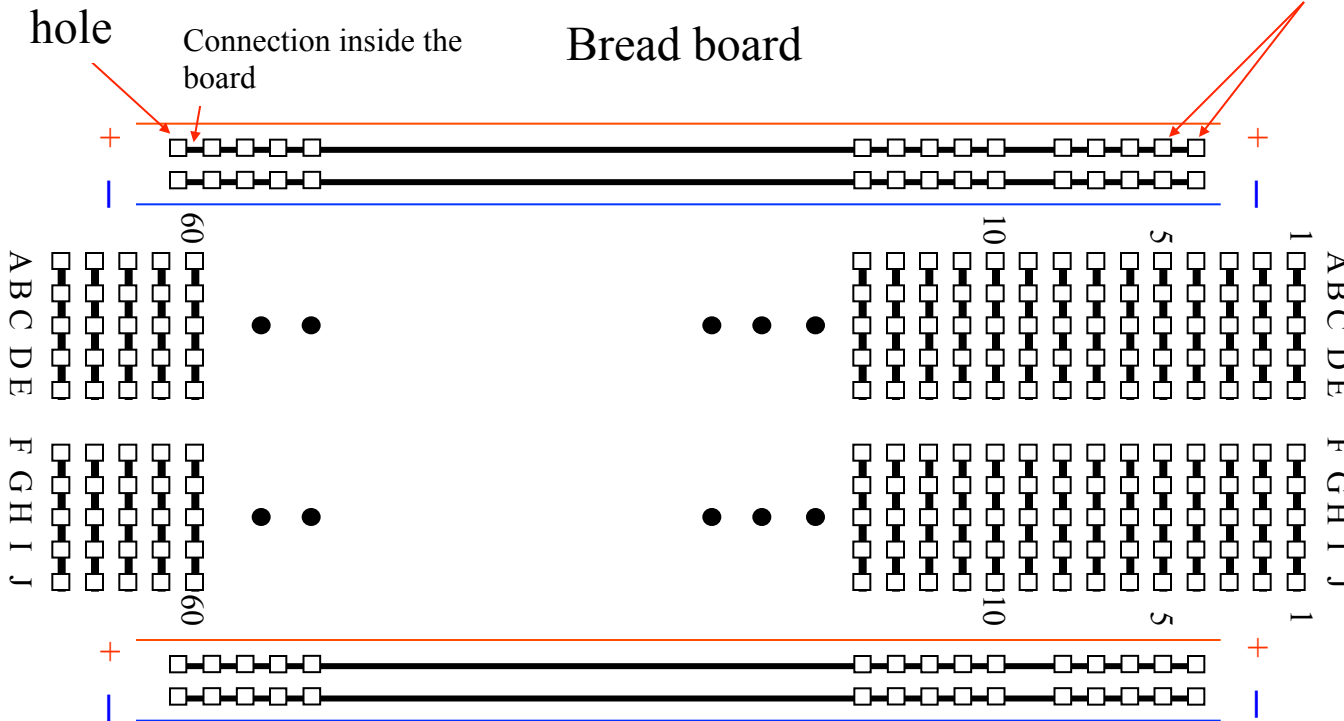
NPN-type transistor (2SC2120)



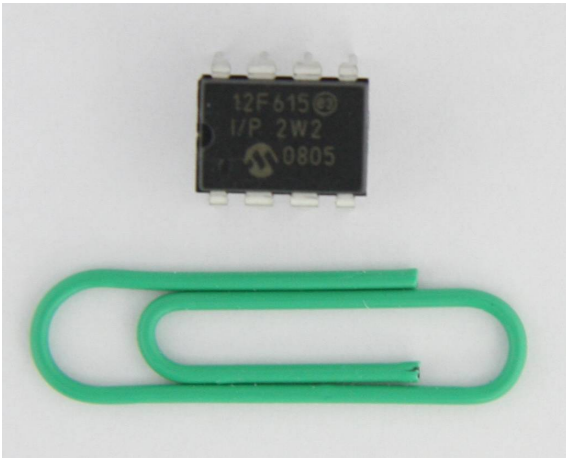
PNP-type transistor (2SA950)



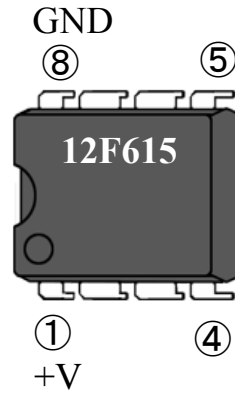
Holes connected by a black line are electrically connected.



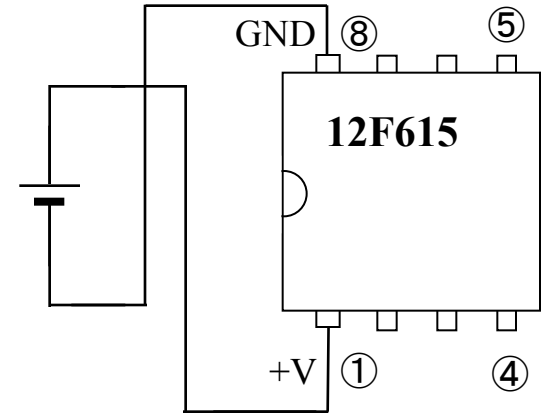
Hole connections



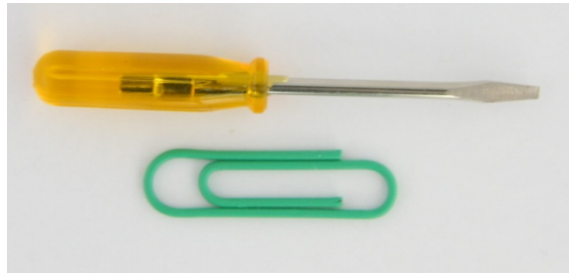
Micro computer PIC12F615



Solid figure

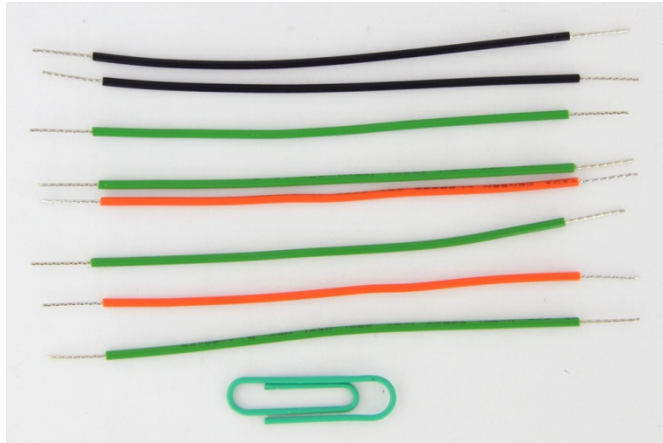


Connection of power lines



Slotted screwdriver

## How to solder



① select jumper wires with lengths of 100mm



② solder as shown in the video

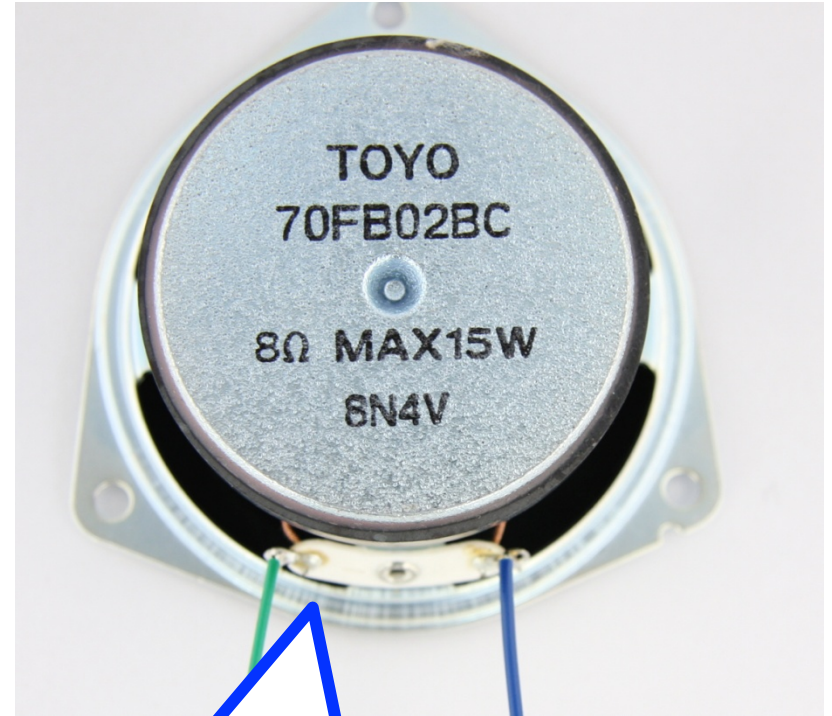
③ do not stain desk

④ be careful not to burn yourself.





DC motor



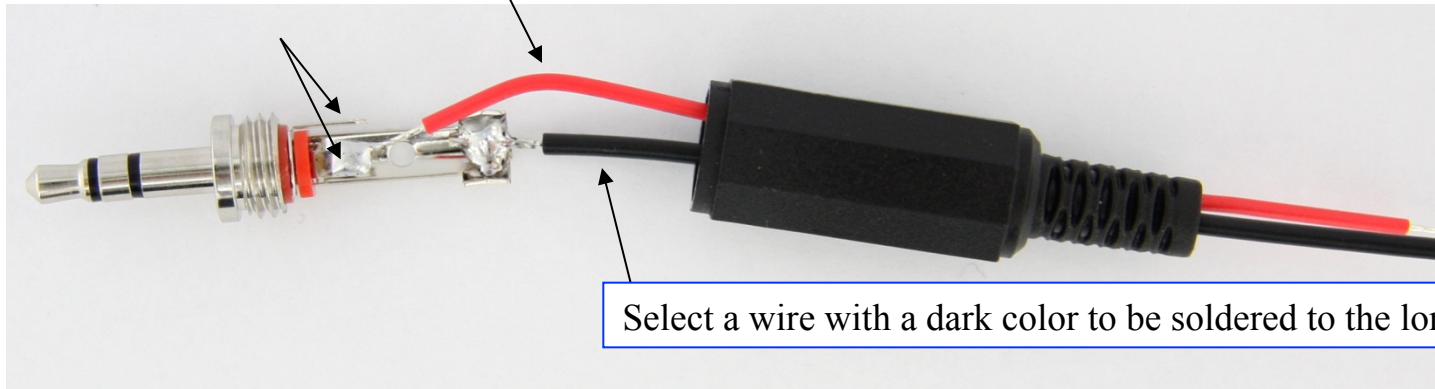
Speaker

# Earphone plug

There are three terminals.  
Two are short and one is long.

You can select either of the  
two shorter terminals

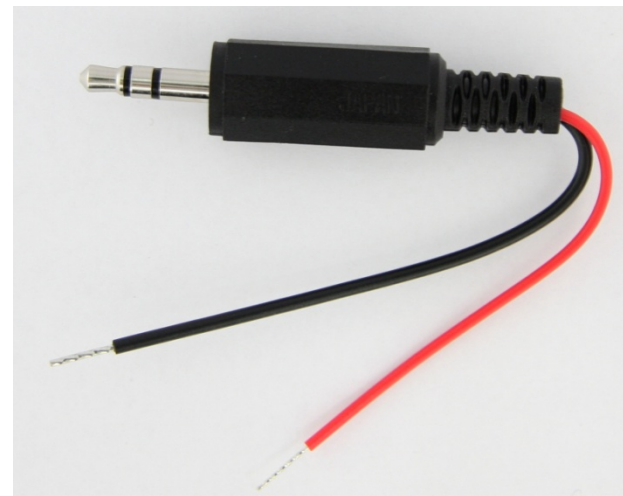
Select a wire with a bright color to be soldered to a shorter terminal.



Select a wire with a dark color to be soldered to the longer terminal.



Completed



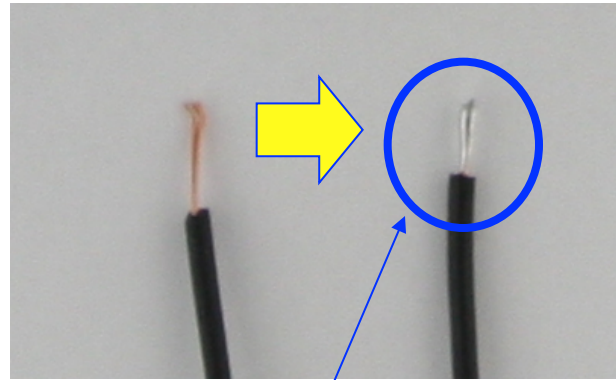
# Lesson in soldering

①



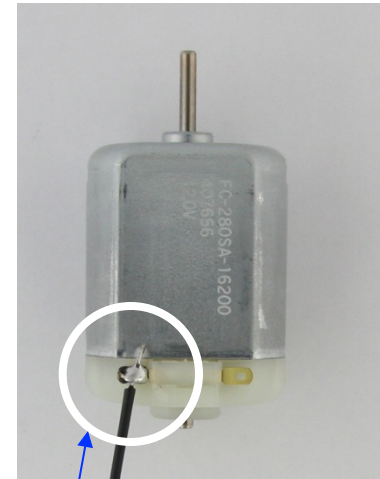
First, Put a solder on a terminal first.

②



Then, put solder on wire.

③



Finally, solder the wire on the terminal.

## One point lesson for battery box

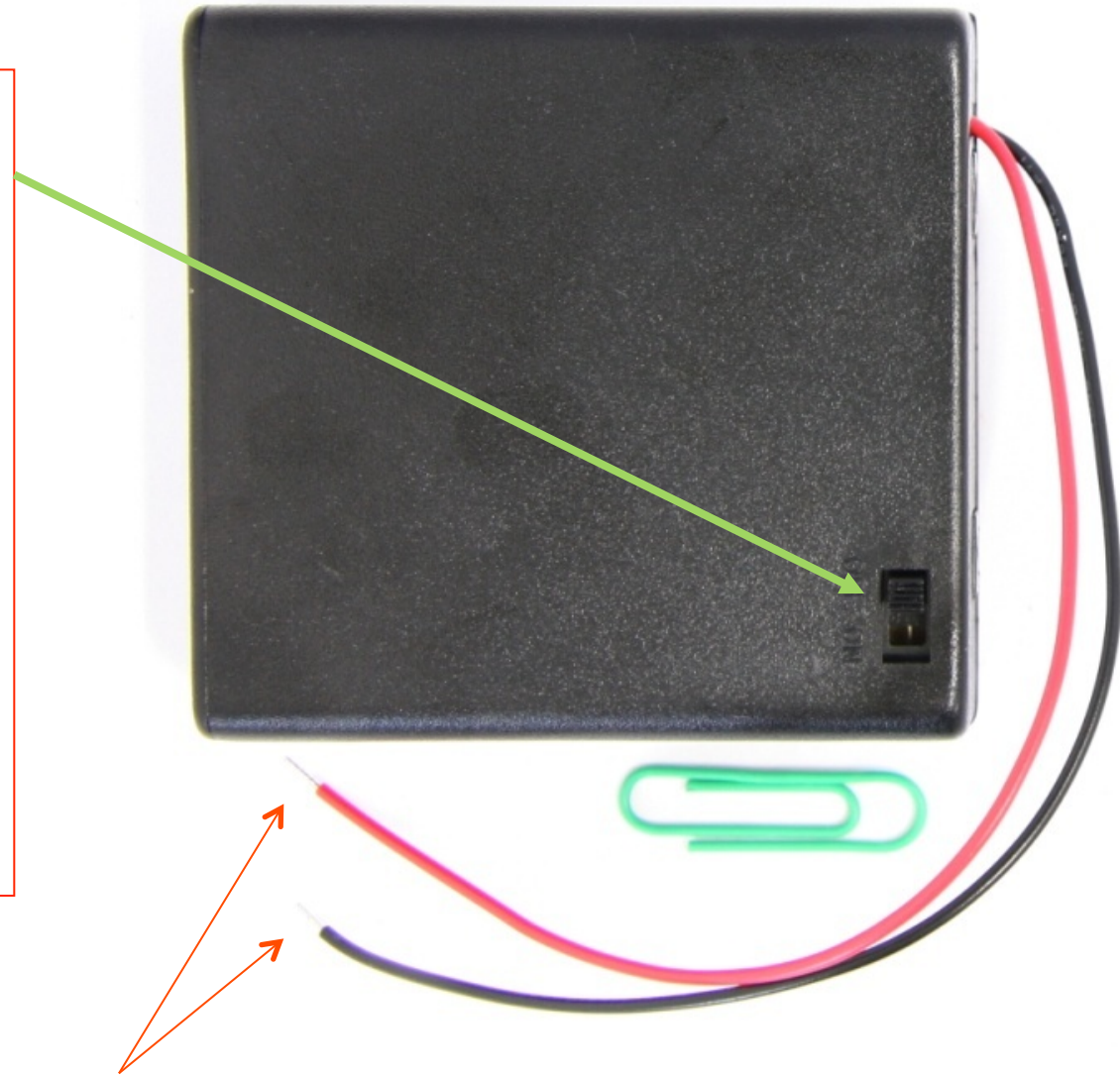
Do not forget to switch the box off when you are not using the battery.

The wires might happen to touch each other while you are carrying the box on the way to/from home.

→ Batteries will become too hot to touch. You can sustain a burn injury if you touch them.

→ Battery box will melt.

→ Batteries will shut off.



These terminals might touch each other.