Capacitor in an AC circuit

Please send corrections (or suggestions) to youngwlim@hotmail.com.

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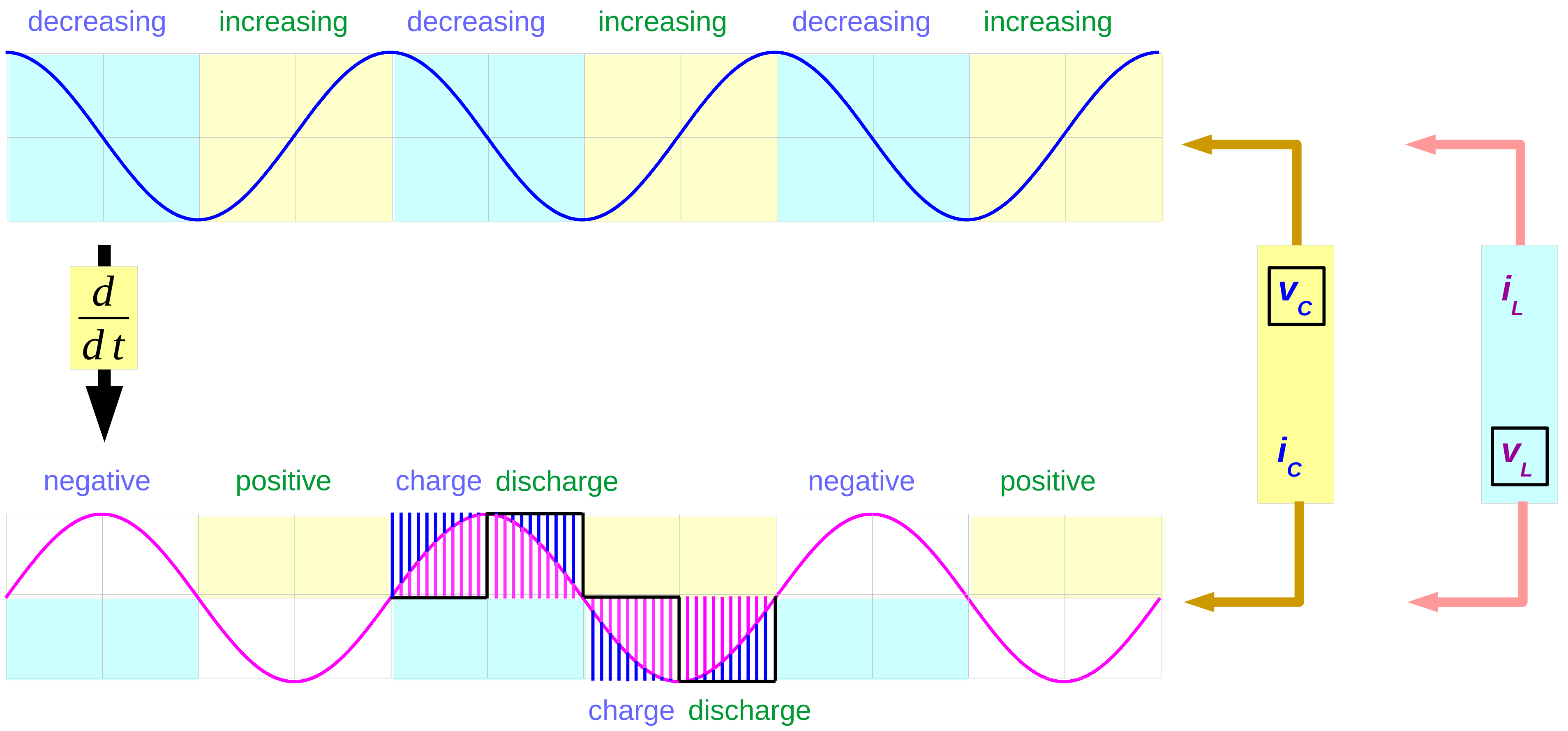
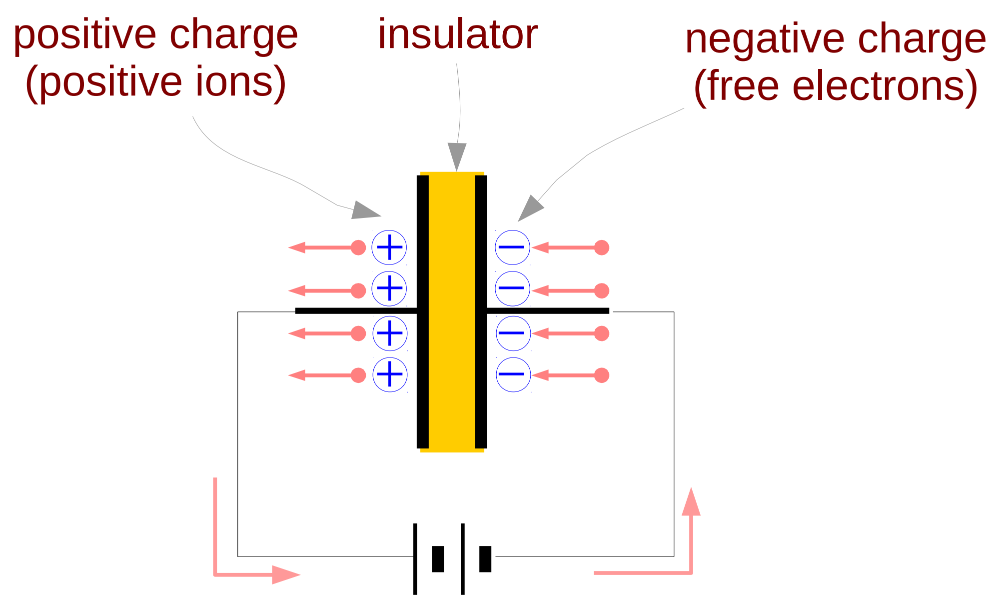
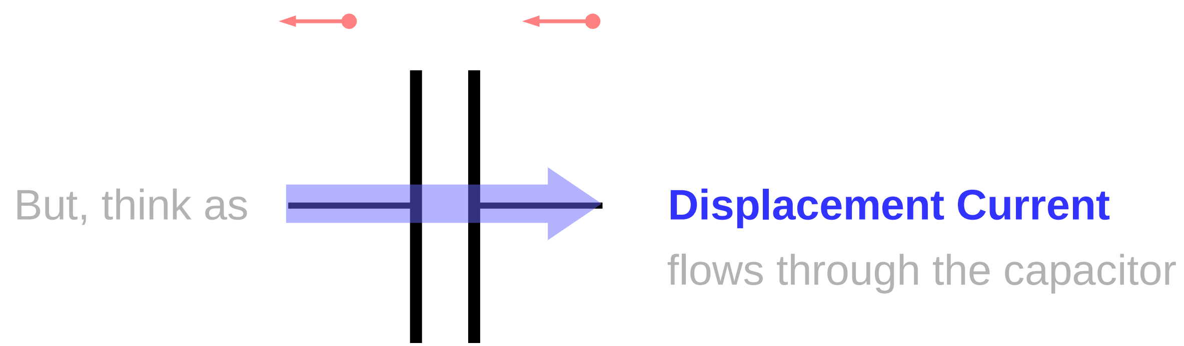
Everchanging signal pairs



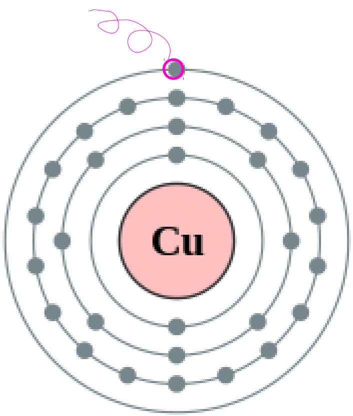
Capacitor Current

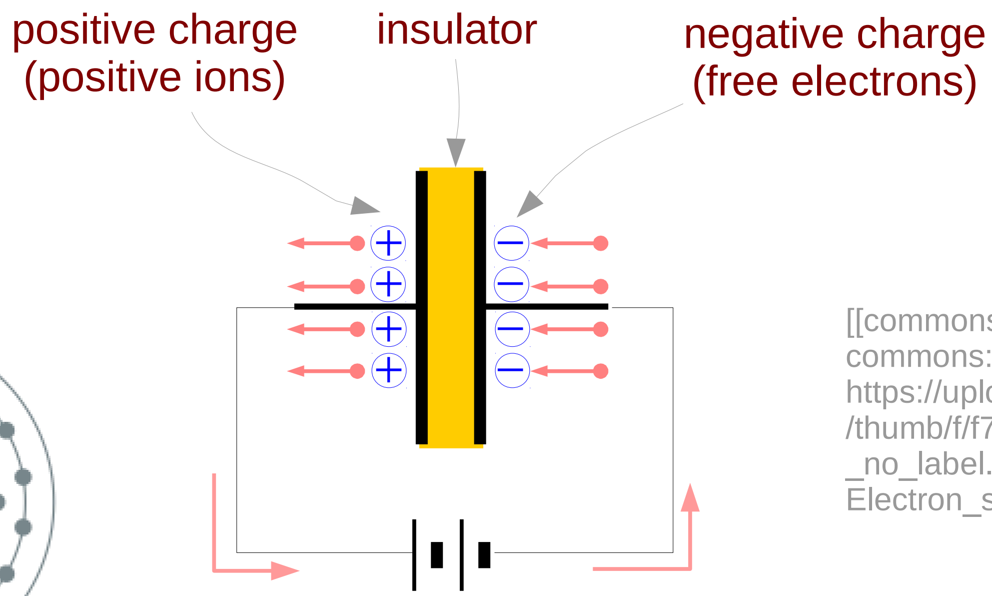


No actual electrons movement
across insulator materials

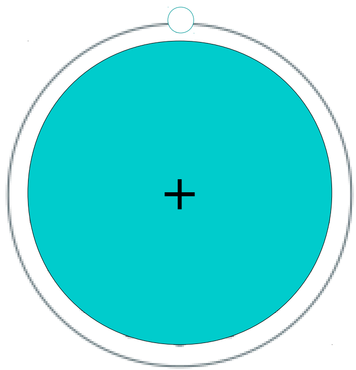


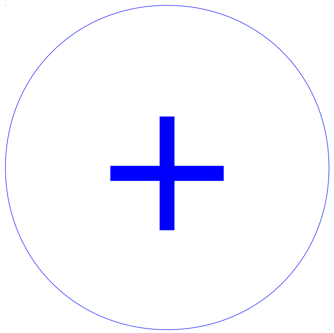
Positive ions and free electrons

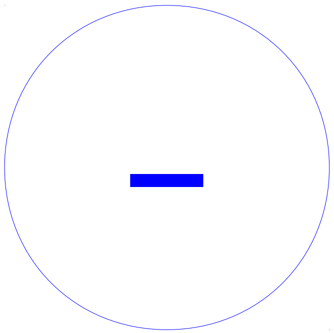




[[commons:User crap]] (original work by commons:User:Greg Robson)
https://upload.wikimedia.org/wikipedia/commons/thumb/f/f7/Electron_shell_029_Copper_-_no_label.svg/200px-Electron_shell_029_Copper_-_no_label.svg.png





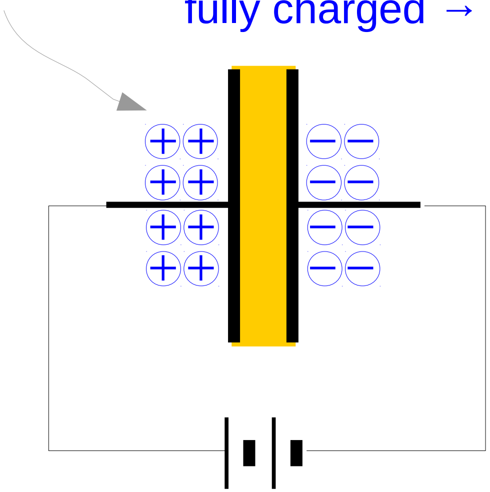


Three States

positive charge
(positive ions)

Positive Charged State

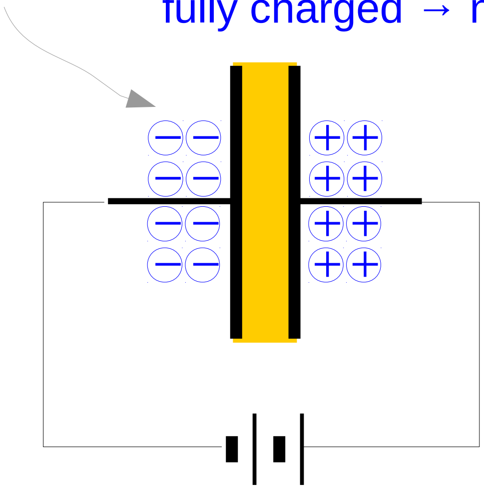
fully charged → no current

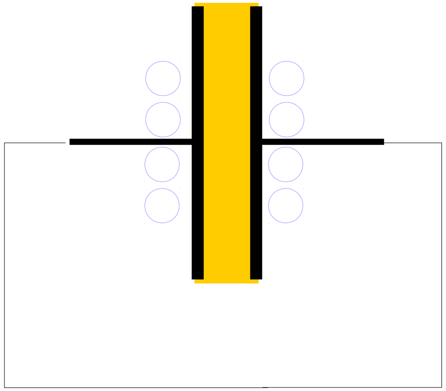


negative charge
(free electrons)

Negative Charged State

fully charged → no current

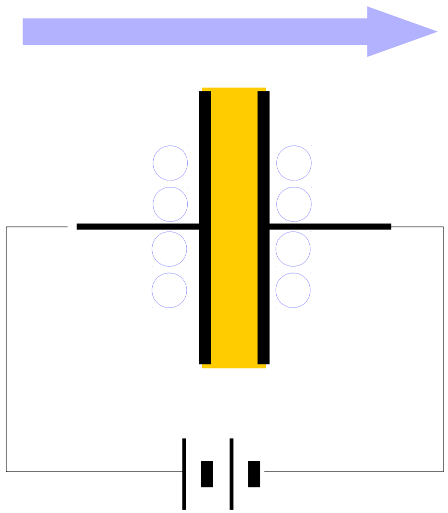




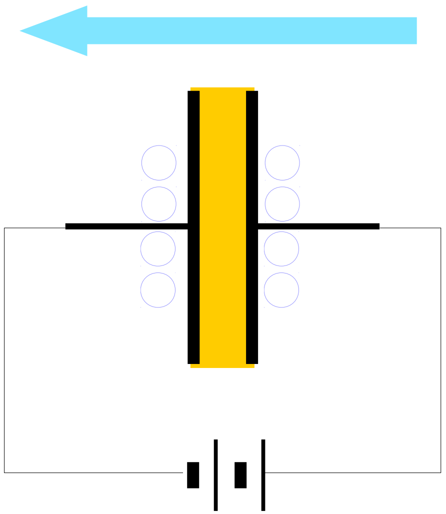
Fully Discharged State

possible large current

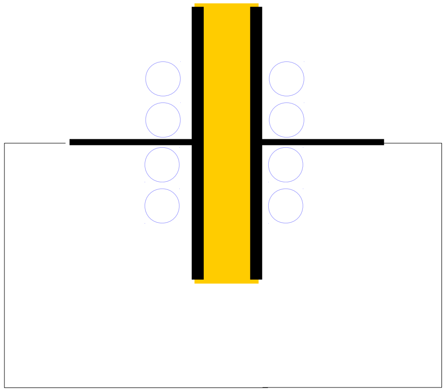
Three States



Fully Discharged State



Fully Discharged State

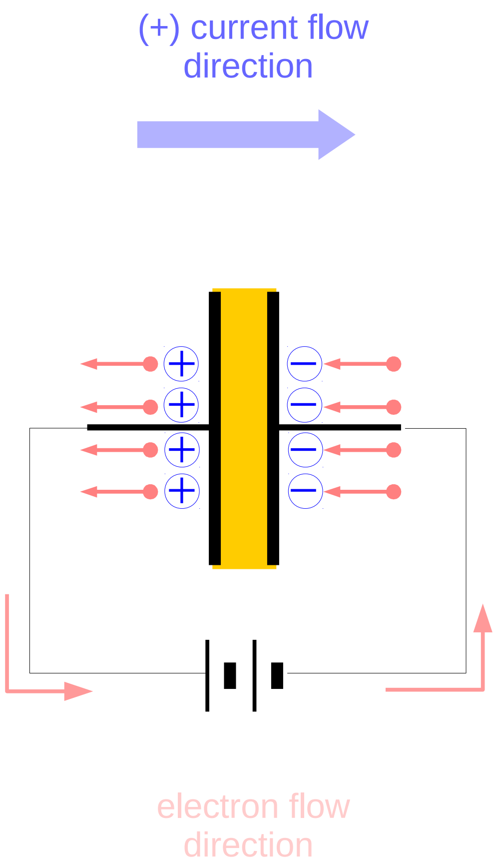


Fully Discharged State

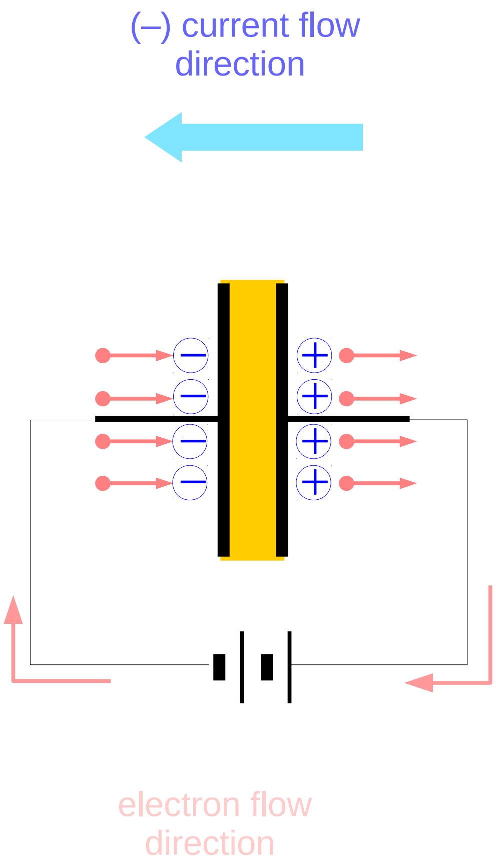
possible large current

Inter-State Current Flowing

Under Positive Charging



Under Negative Charging

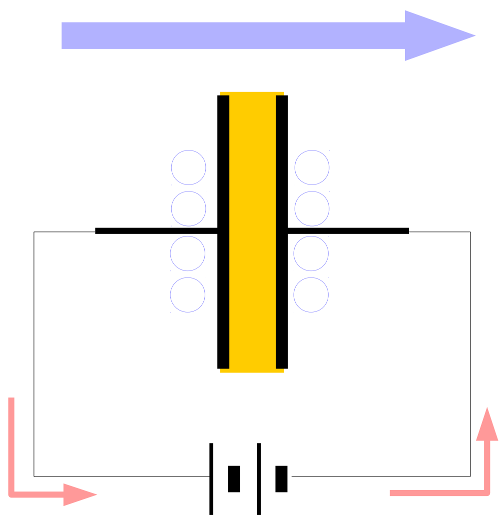


Inter-State Current Flowing

Fully Discharged State

Initial large current

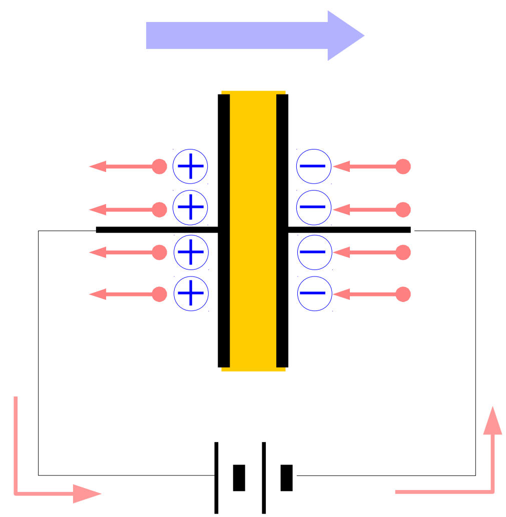
(+) current flow direction



electron flow direction

Under Positive Charging

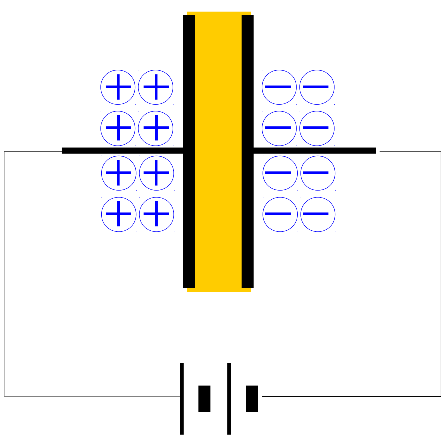
(+) current flow direction



electron flow direction

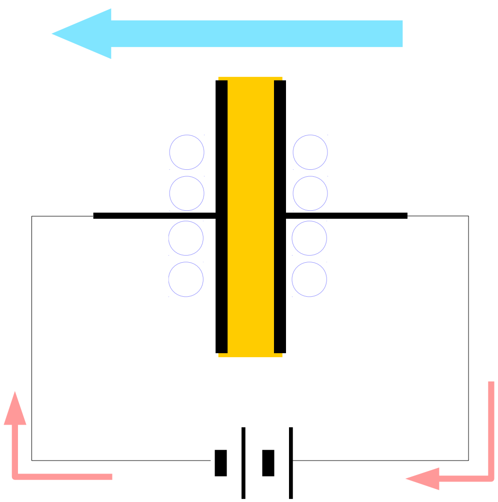
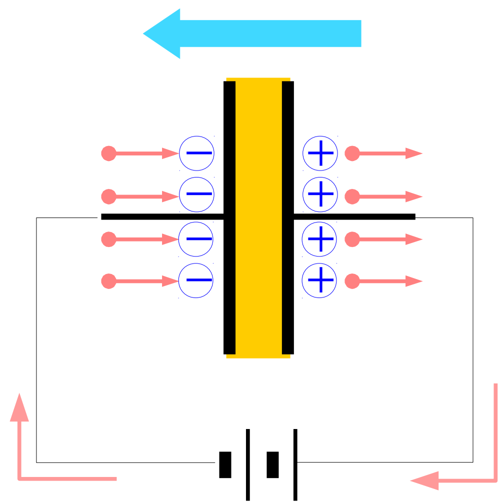
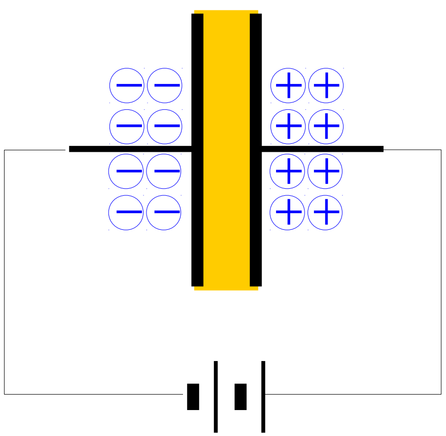
Positive Charged State

no current



Crowded →
No more space

Inter-State Current Flowing

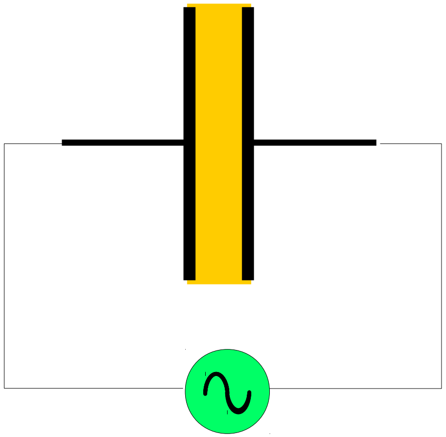
Fully Discharged State	Under Negative Charging	Negative Charged State
Initial large current		no current
(–) current flow direction	(–) current flow direction	
		
electron flow direction	electron flow direction	Crowded → No more space

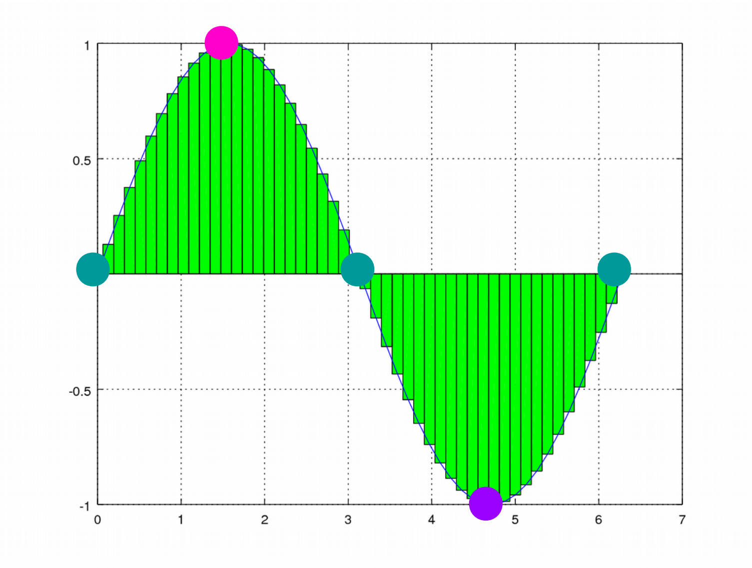
An AC Voltage Source

Under Positive Charging

Fully Discharged State

Positive Charged State





Fully Discharged State

Under Negative Charging

Negative Charged State

An AC Voltage Source

Fully Discharged State

Under Positive Charging

Positive Charged State

Under Negative Charging

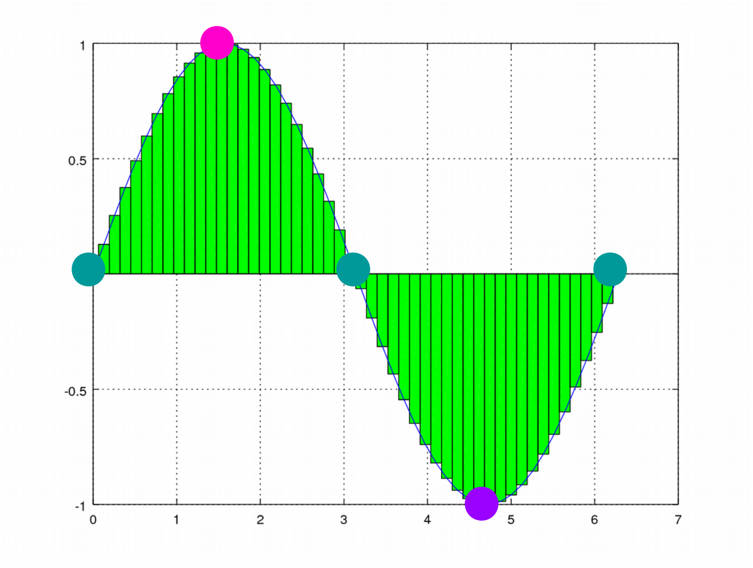
Fully Discharged State

Under Negative Charging

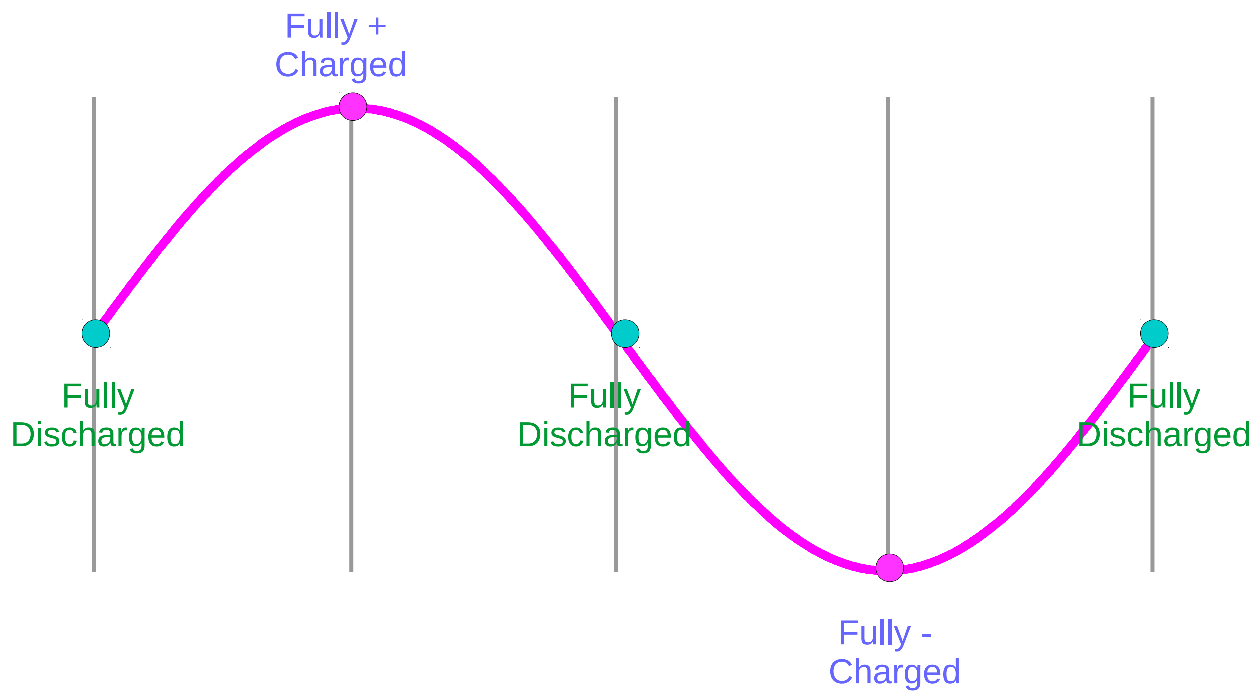
Negative Charged State

Under Positive Charging

Fully Discharged State

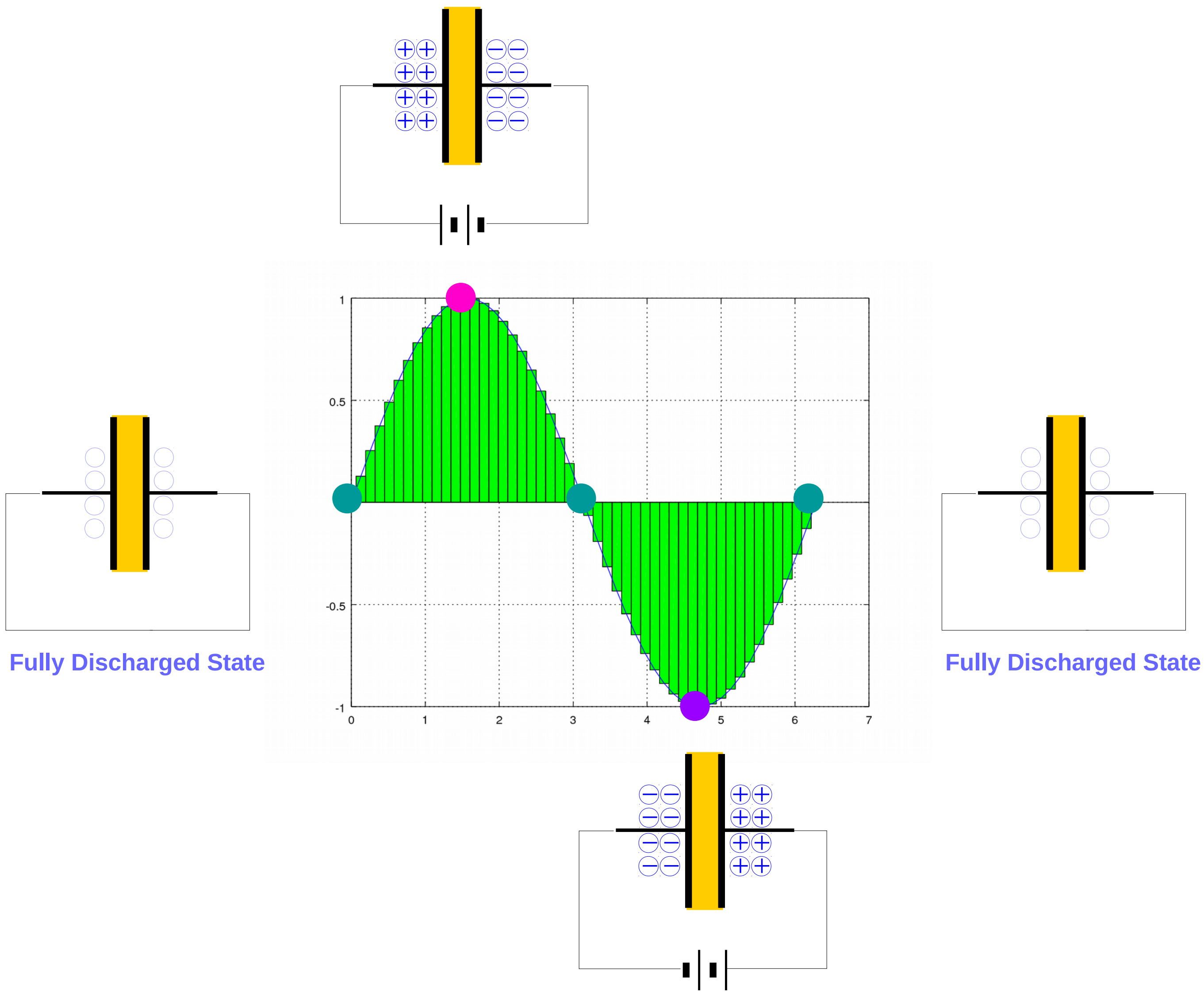


Fully Charged and Fully Discharged

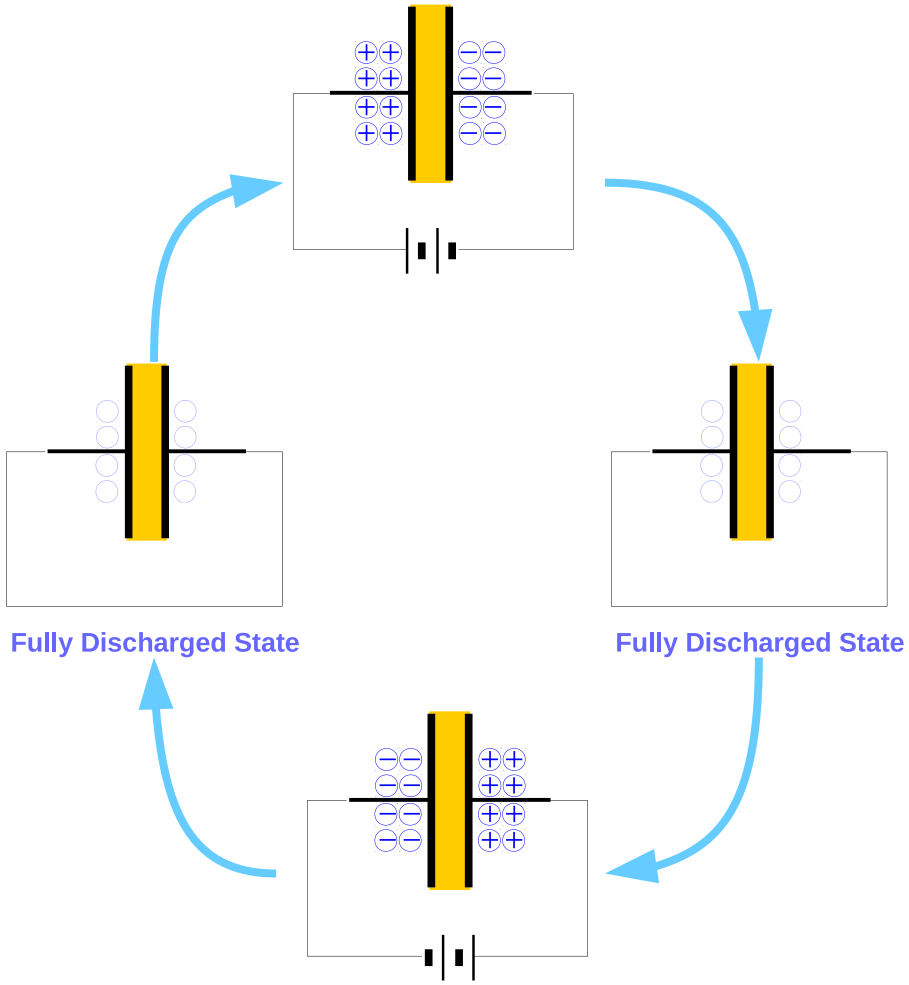


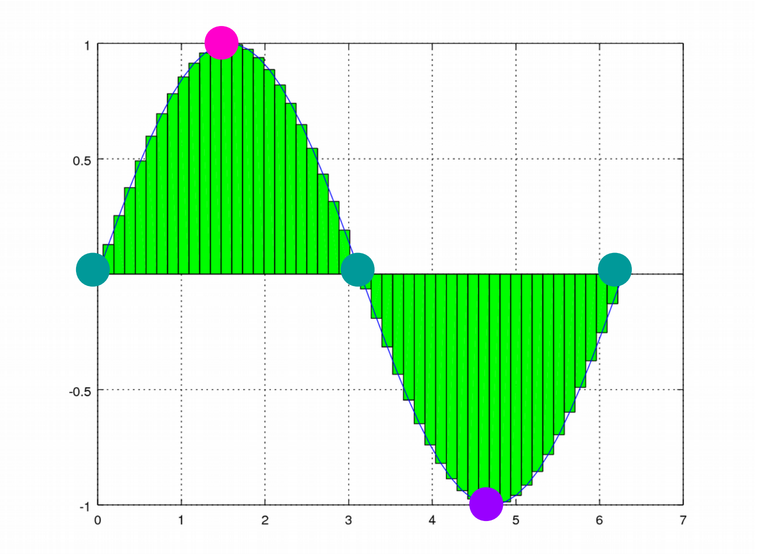
	(+) Charging	(–) Charging	(–) Charging	(+) Charging
(+) current	(+) current	(–) current	(–) current	(+) current
	(+) Charging	(+) **Dis**charging	(–) Charging	(–) **Dis**charging

A Cycle

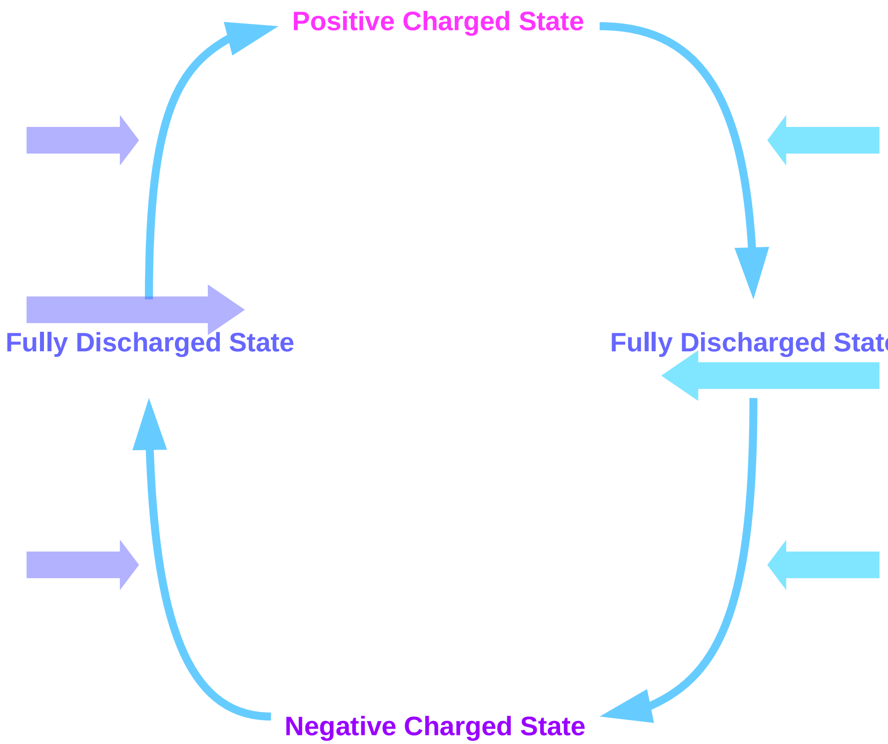

Fully Discharged State
Fully Discharged State
1
0.5
-0.5
-1
0
1
2
3
4
5
6
7

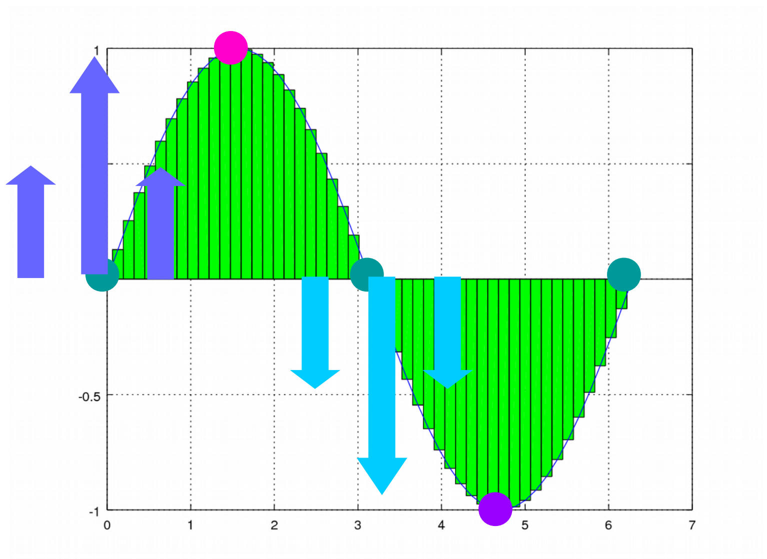
State Transition Diagram



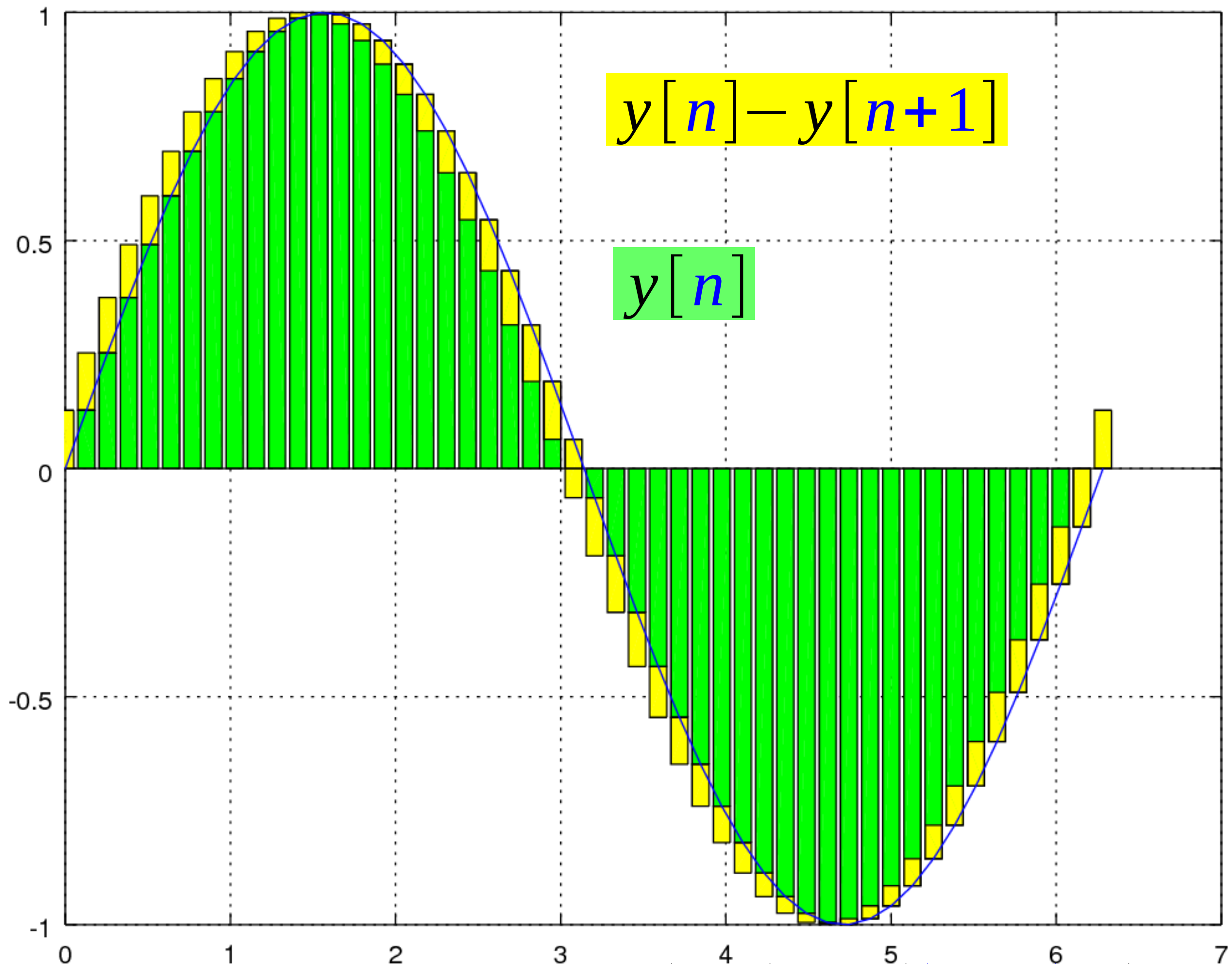


Current Flow





Fully Charged and Fully Discharged



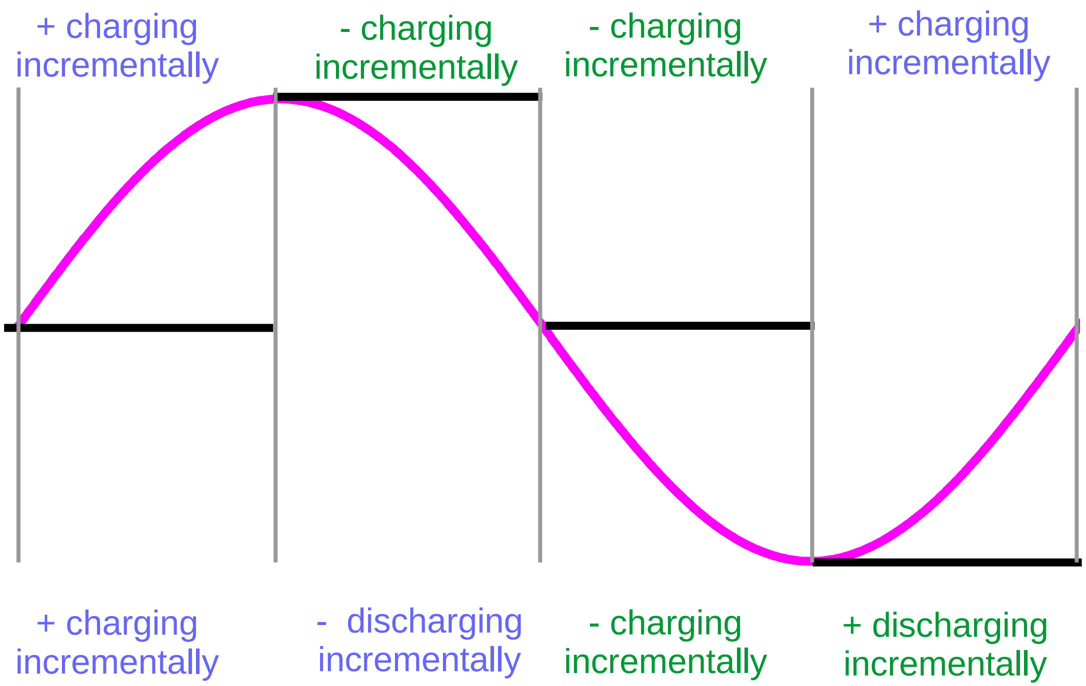

```
h = bar(t1, [y1' y2'], "stacked")
set(h(1), "facecolor", "g");
set(h(2), "facecolor", "y");
hold on
plot(t1, y1)
axis([0 7 -1 1]);
```

$$y[n]-y[n+1] = y(nT)-y((n+1)T)=\sin(nT)-\sin((n+1)T)$$

Continuous Charing and Discharging Operations

Incremental Voltage Increment ➡ **+ Charging incrementally**

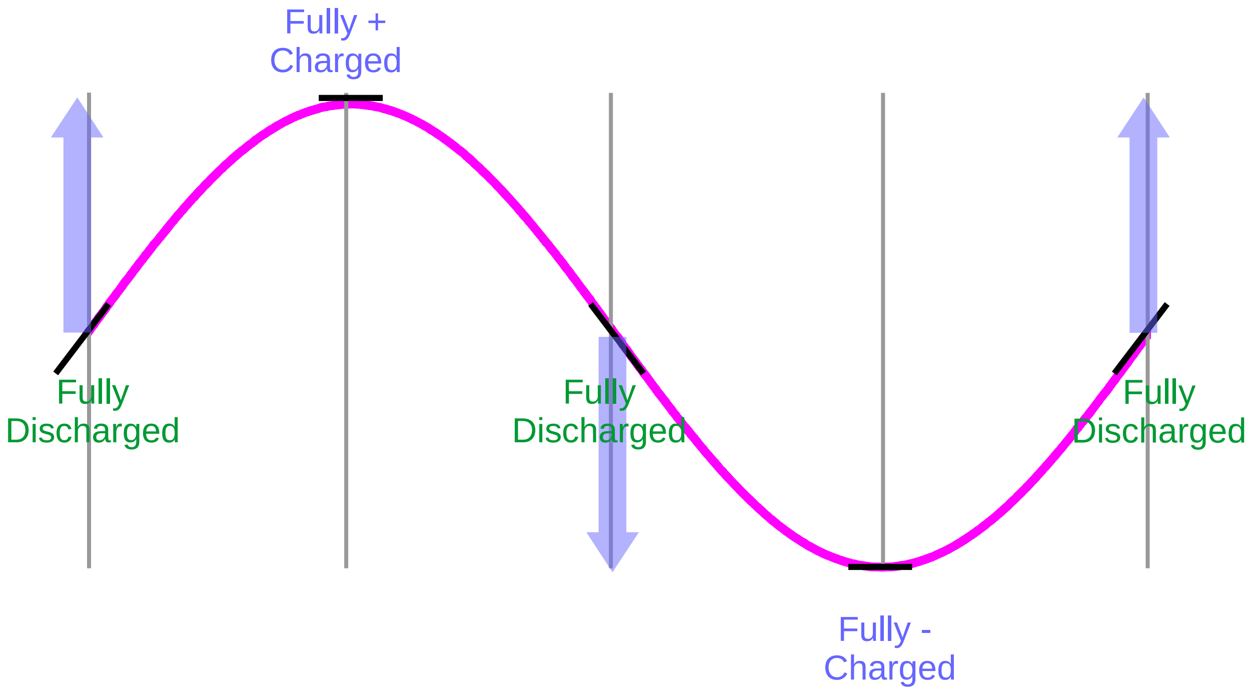
Incremental Voltage Decrement ➡ **– Charging incrementally**



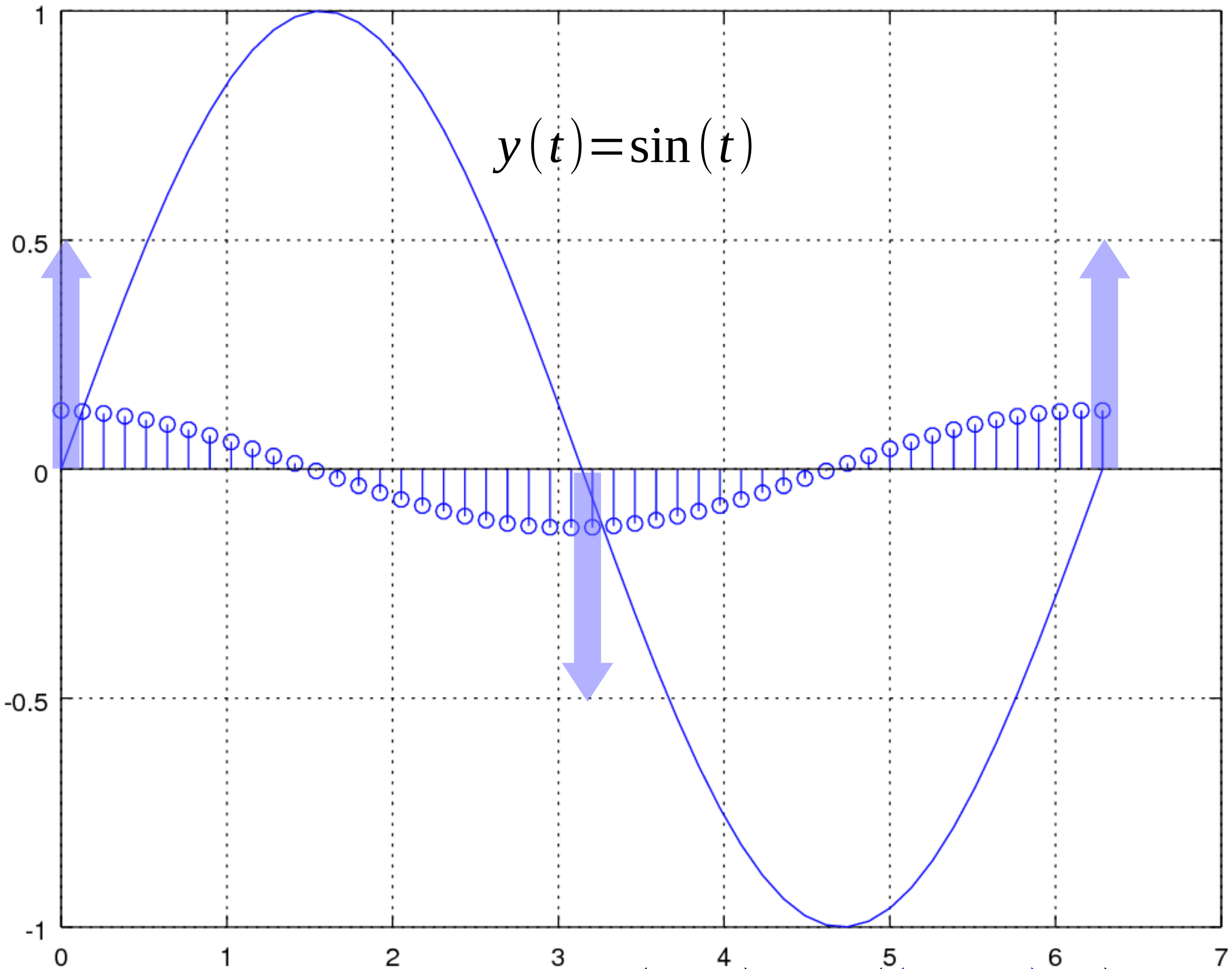
Fully Discharged : Large Current

Incremental Voltage Increment ➡ **Continuous Charging**

Incremental Voltage Decrement ➡ **Continuous Discharging**



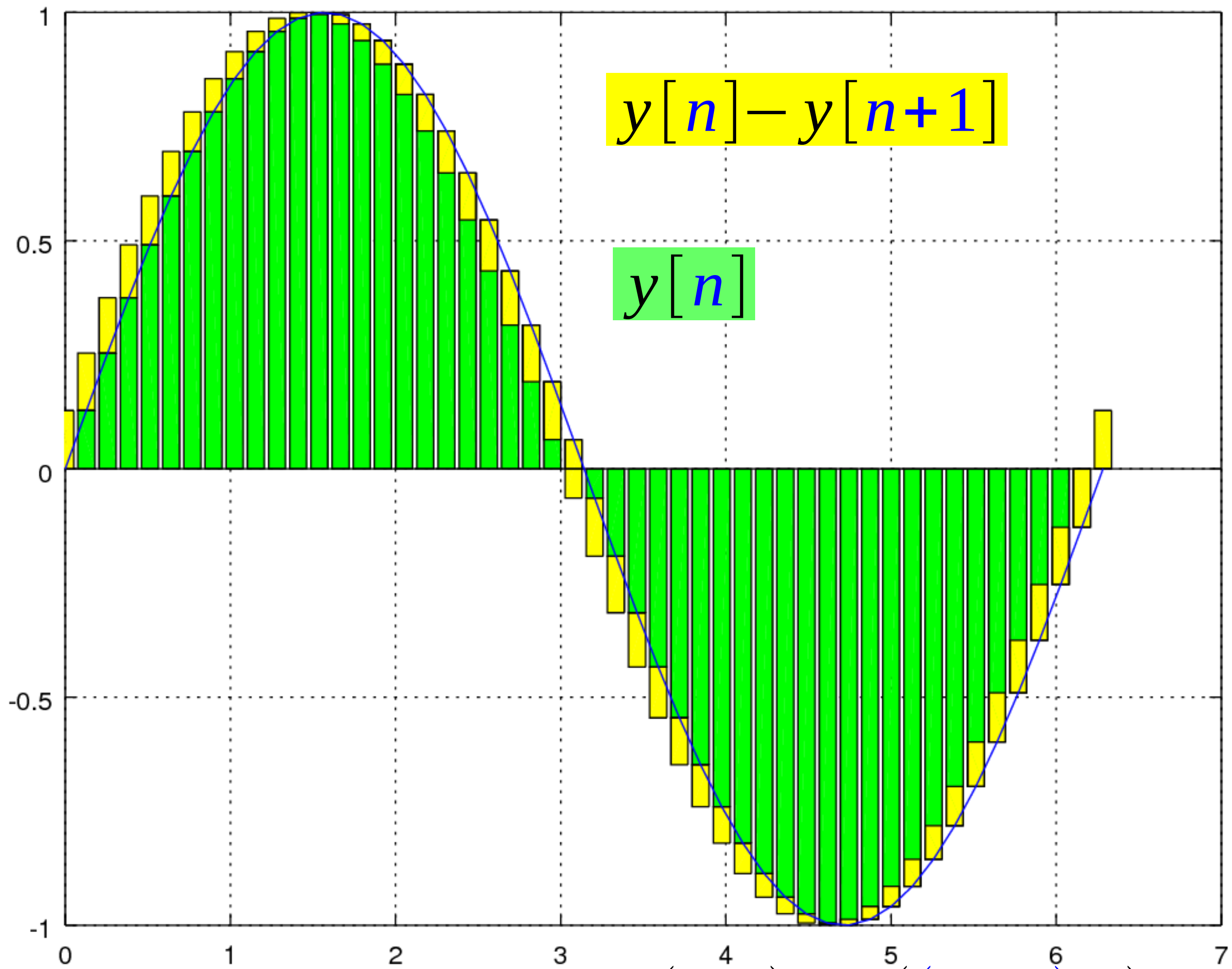
y[n+1] – y[n]




```
t = linspace(0, pi*2, 50);
t1 = t;
t2 = t + t(2);
y1 = sin(t1);
y2 = sin(t2) - sin(t1);
stem(t1, y2)
hold on
plot(t1, y1)
```

$$y[n] - y[n+1] = y(nT) - y((n+1)T) = \sin(nT) - \sin((n+1)T)$$

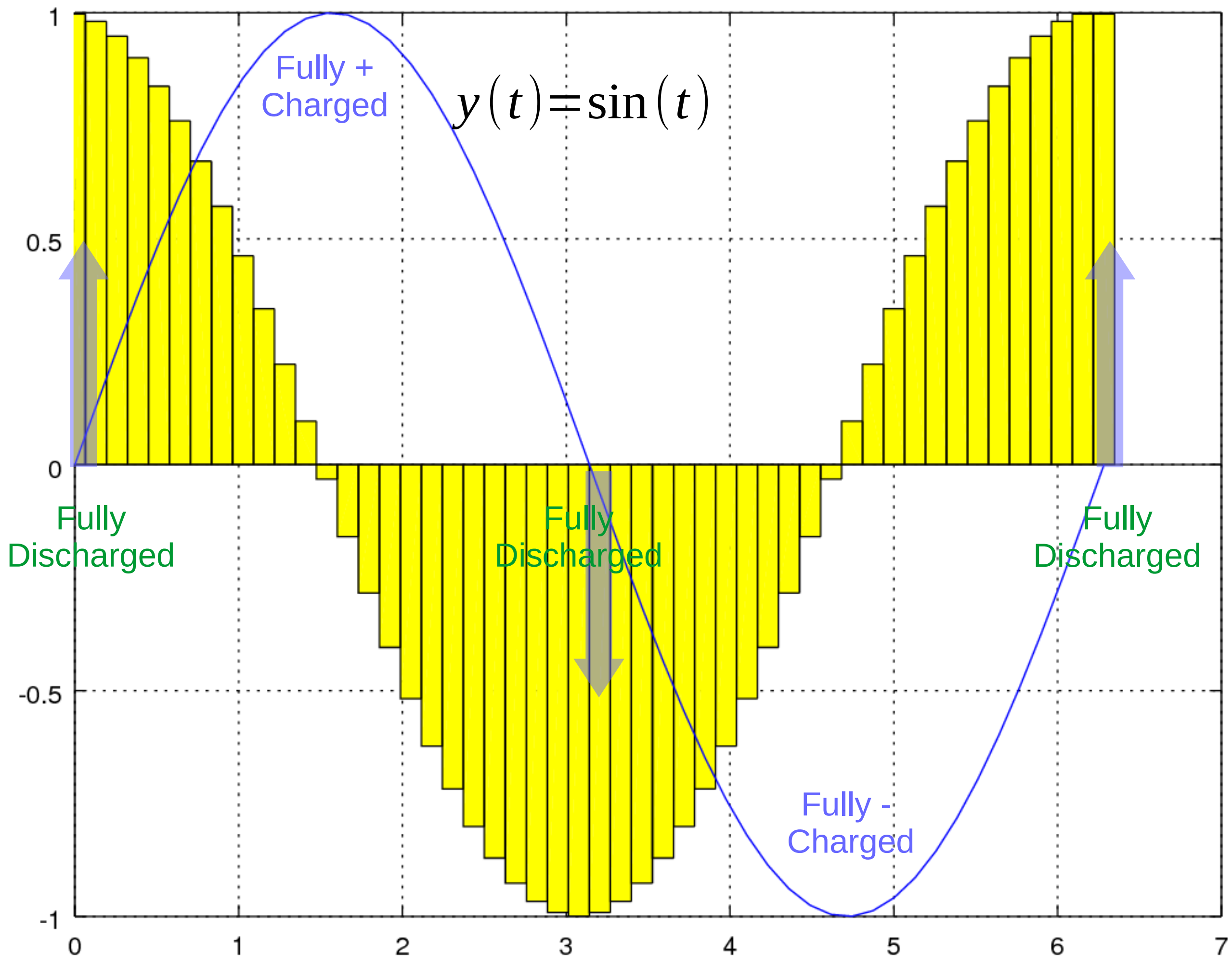
Fully Charged and Fully Discharged




```
h = bar(t1, [y1' y2'], "stacked")
set(h(1), "facecolor", "g");
set(h(2), "facecolor", "y");
hold on
plot(t1, y1)
axis([0 7 -1 1]);
```

$$y[n] - y[n+1] = y(nT) - y((n+1)T) = \sin(nT) - \sin((n+1)T)$$

Fully Charged and Fully Discharged

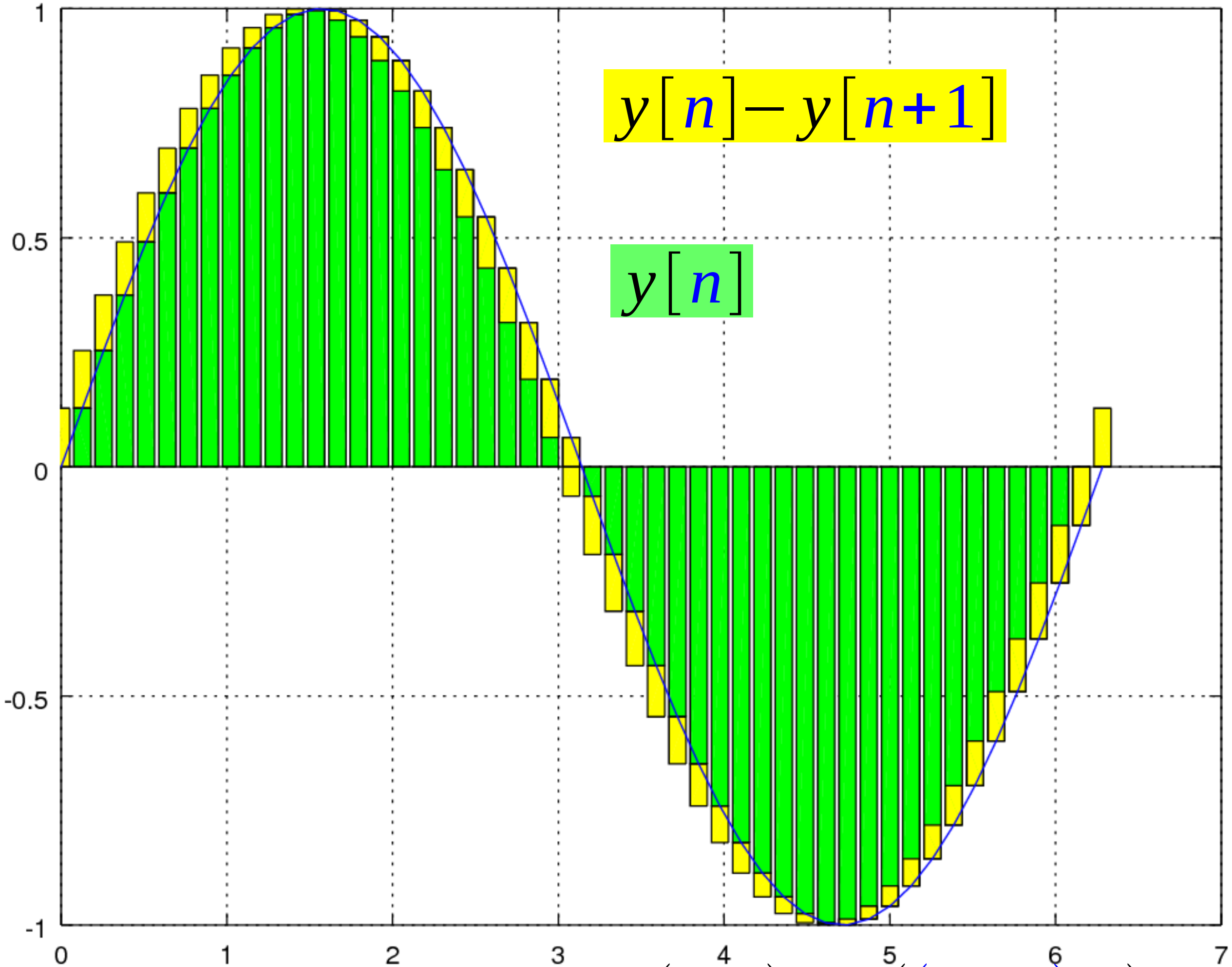



```
h = bar(t1, y2/t(2), "hist")
set(h(1), "facecolor", "y");
hold on
plot(t1, y1)
axis([0 7 -1 1]);
```

$$\frac{y[n] - y[n+1]}{T}$$

$$\propto \frac{dy}{dt}$$

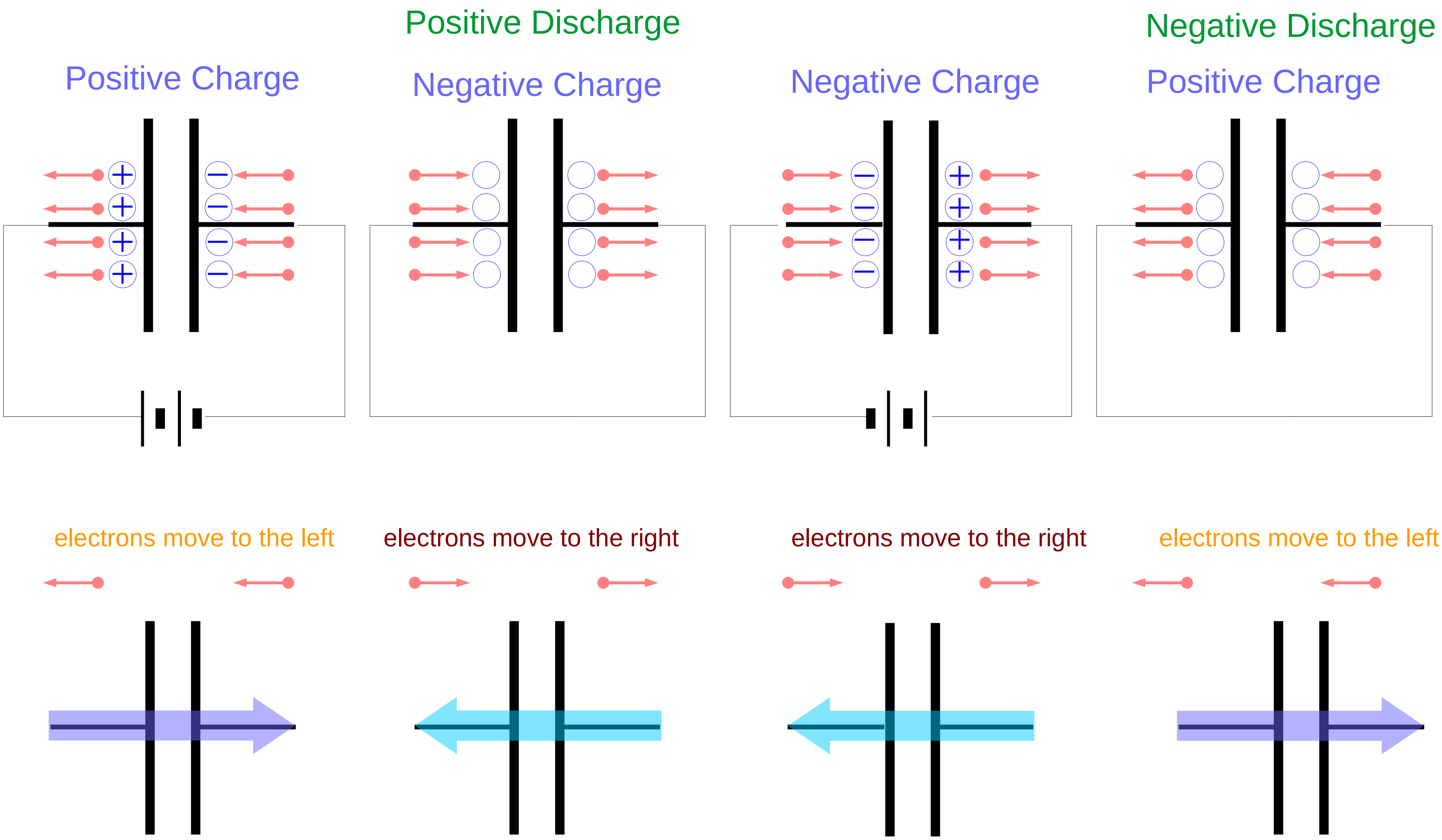
Fully Charged and Fully Discharged



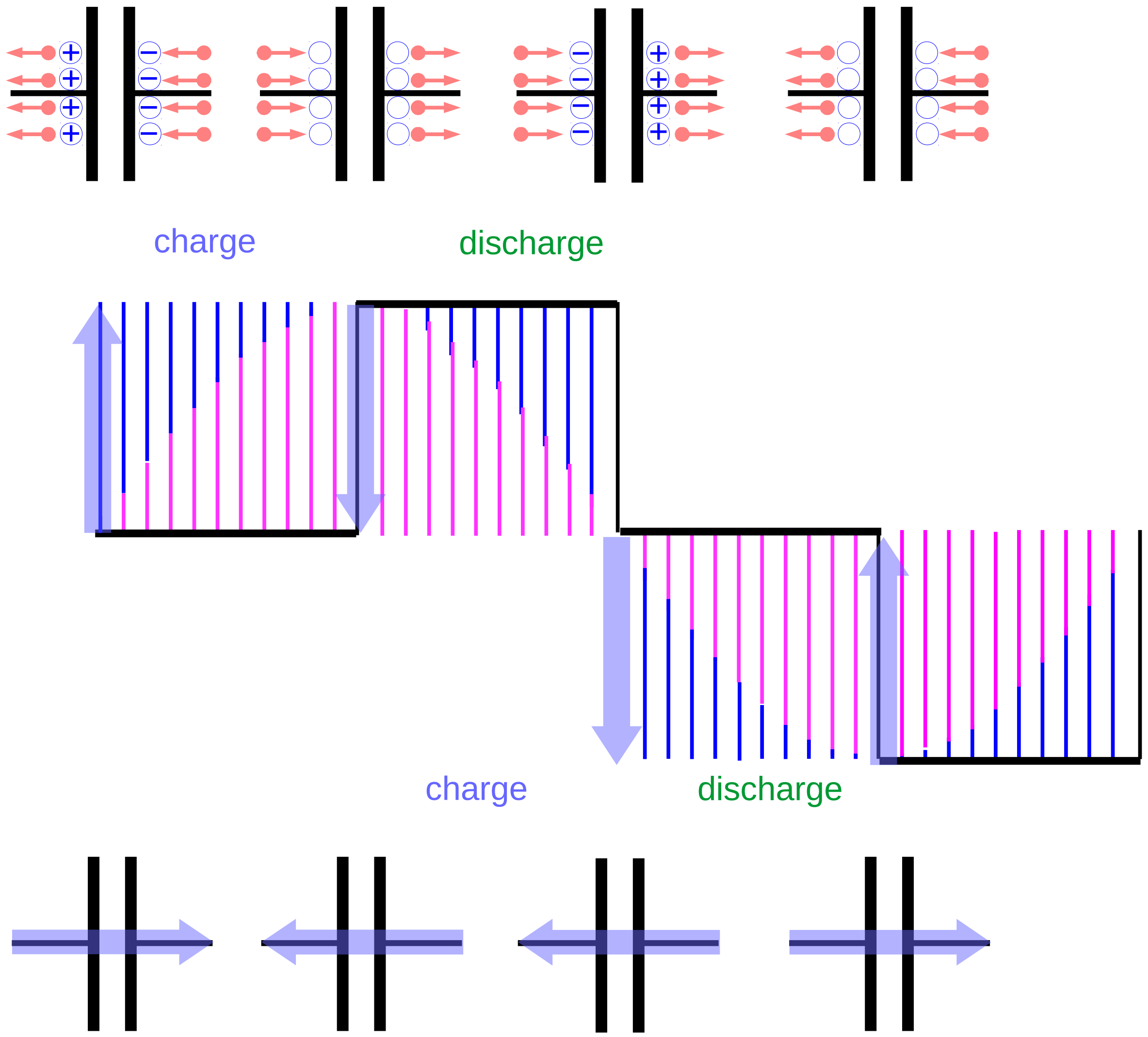

```
 h = bar(t1, [y1' y2'],
"stacked")
set(h(1), "facecolor", "g");
set(h(2), "facecolor", "y");
hold on
plot(t1, y1)
axis([0 pi]);
```

$$y[n]-y[n+1] = y(nT)-y((n+1)T)=\sin(nT)-\sin((n+1)T)$$

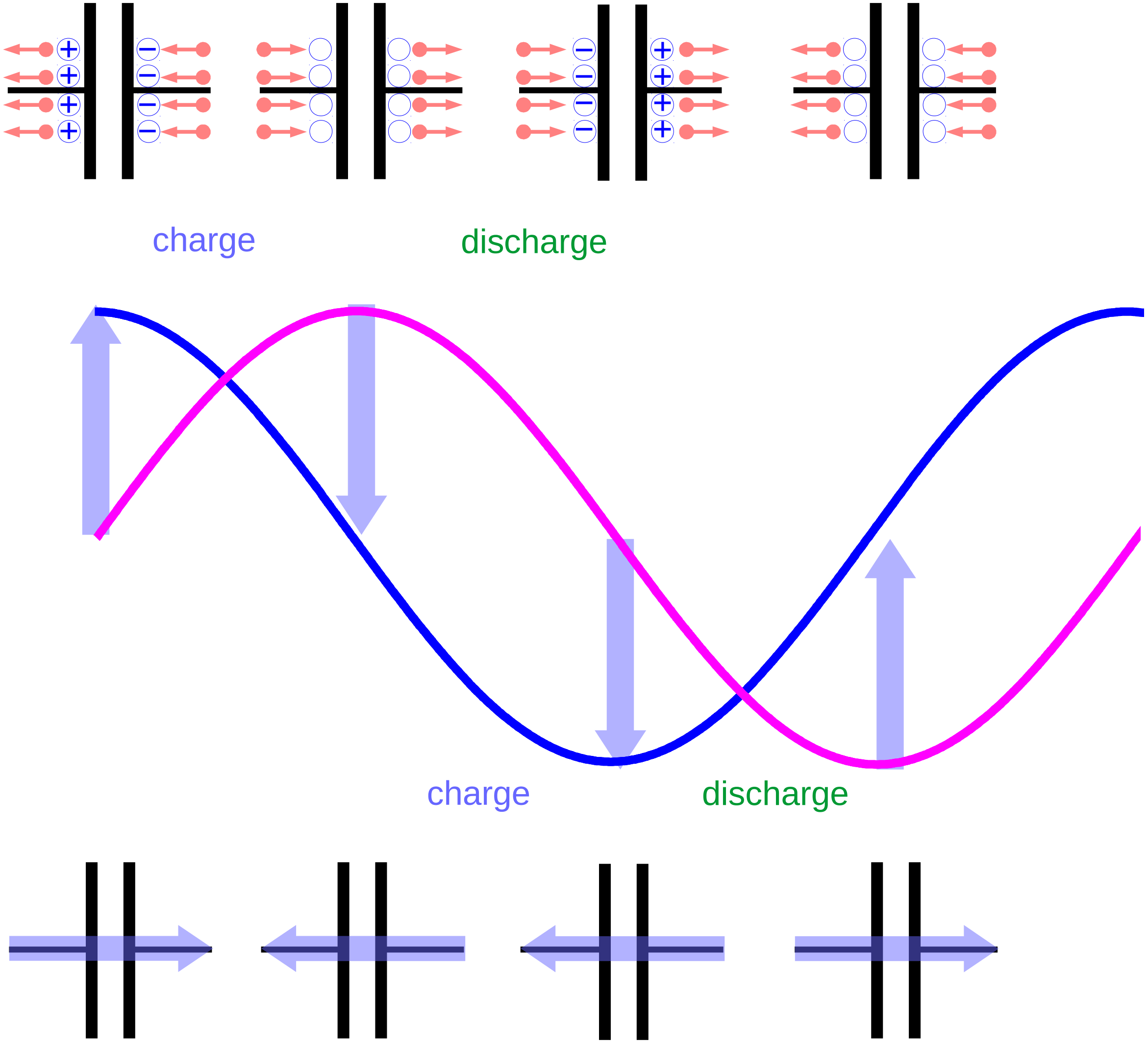
Everchanging signal pairs



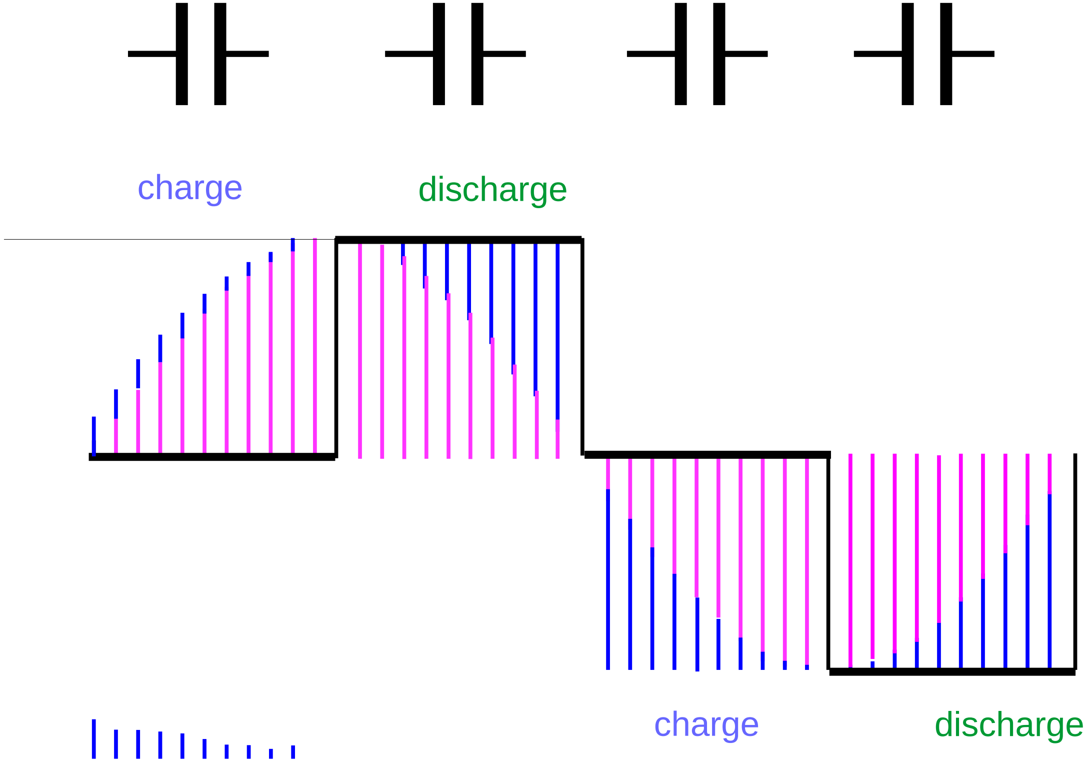
Everchanging signal pairs



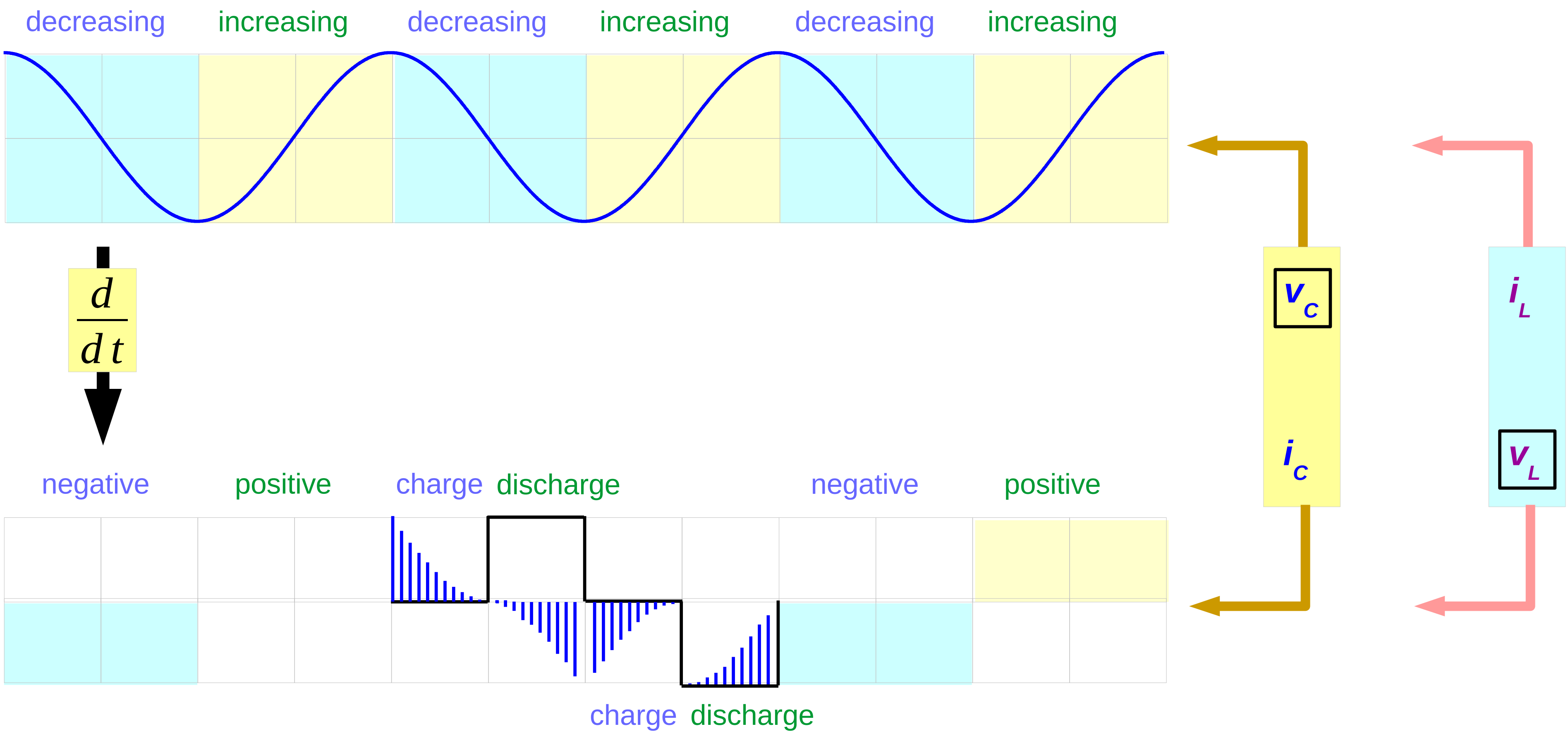
Everchanging signal pairs



Everchanging signal pairs

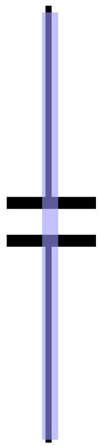


Everchanging signal pairs



I leads V by 90°

Initial charge

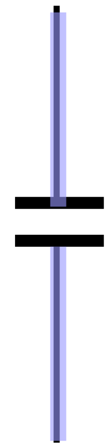


SHORT

V = 0

I : peak

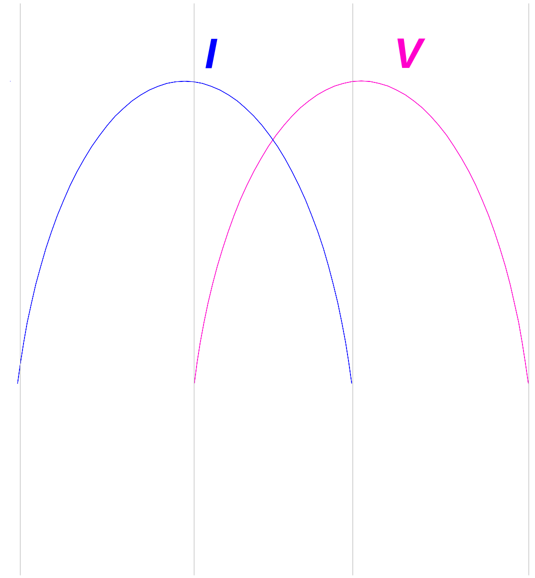
Full charge



OPEN

I = 0

V : peak



References

[1] http://en.wikipedia.org/
[2] J.H. McClellan, et al., Signal Processing First, Pearson Prentice Hall, 2003