

Capacitor in an AC circuit

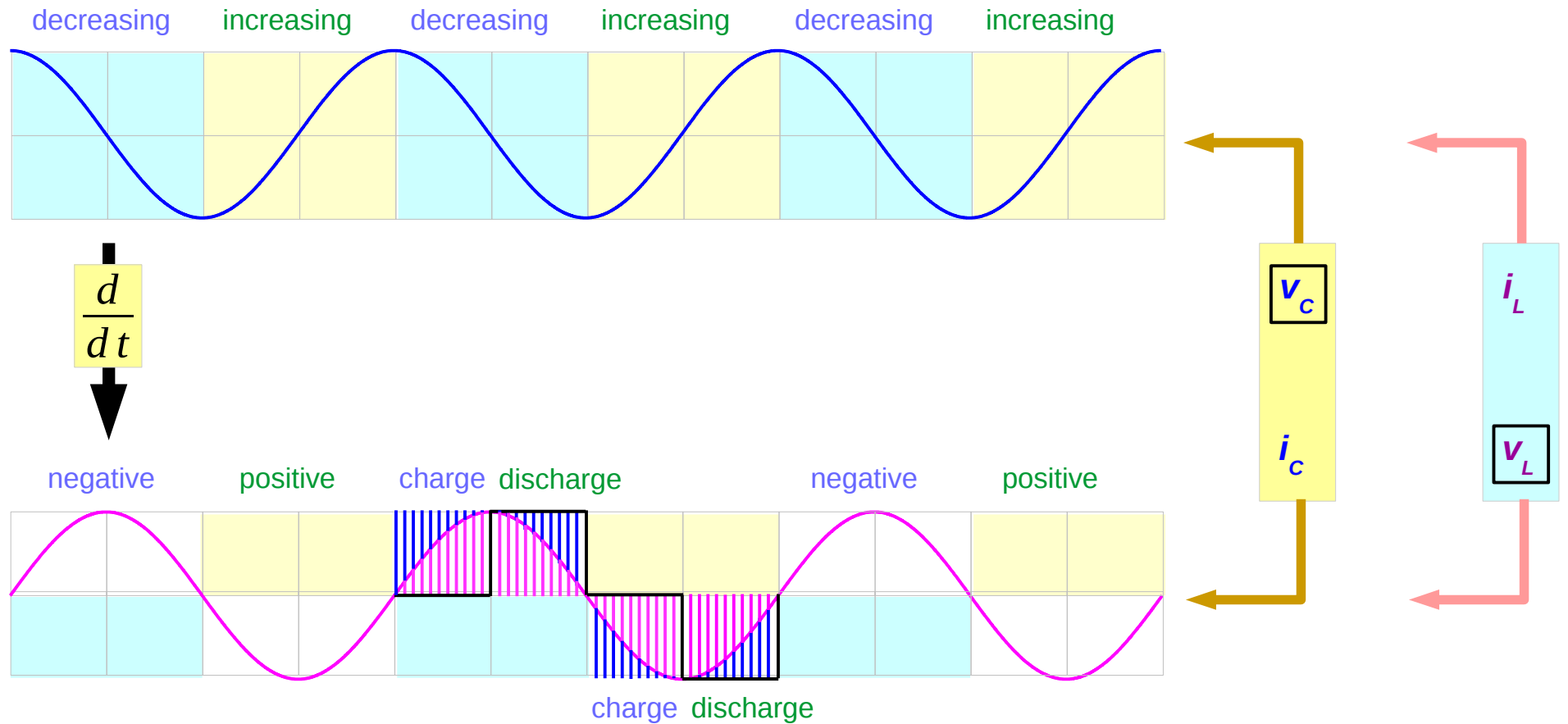
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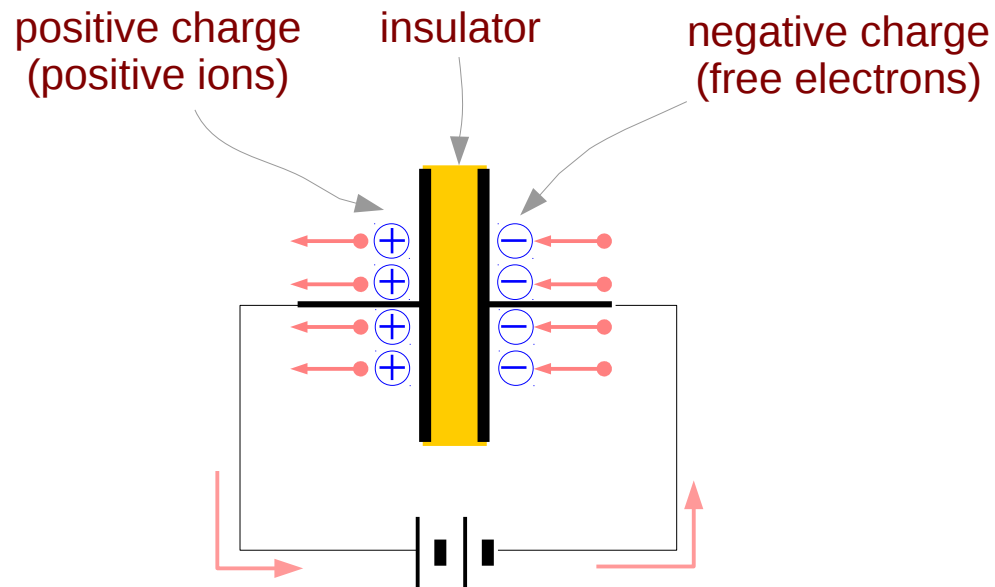
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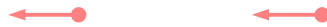
Everchanging signal pairs



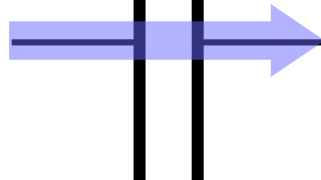
Capacitor Current



No actual electrons movement across insulator materials



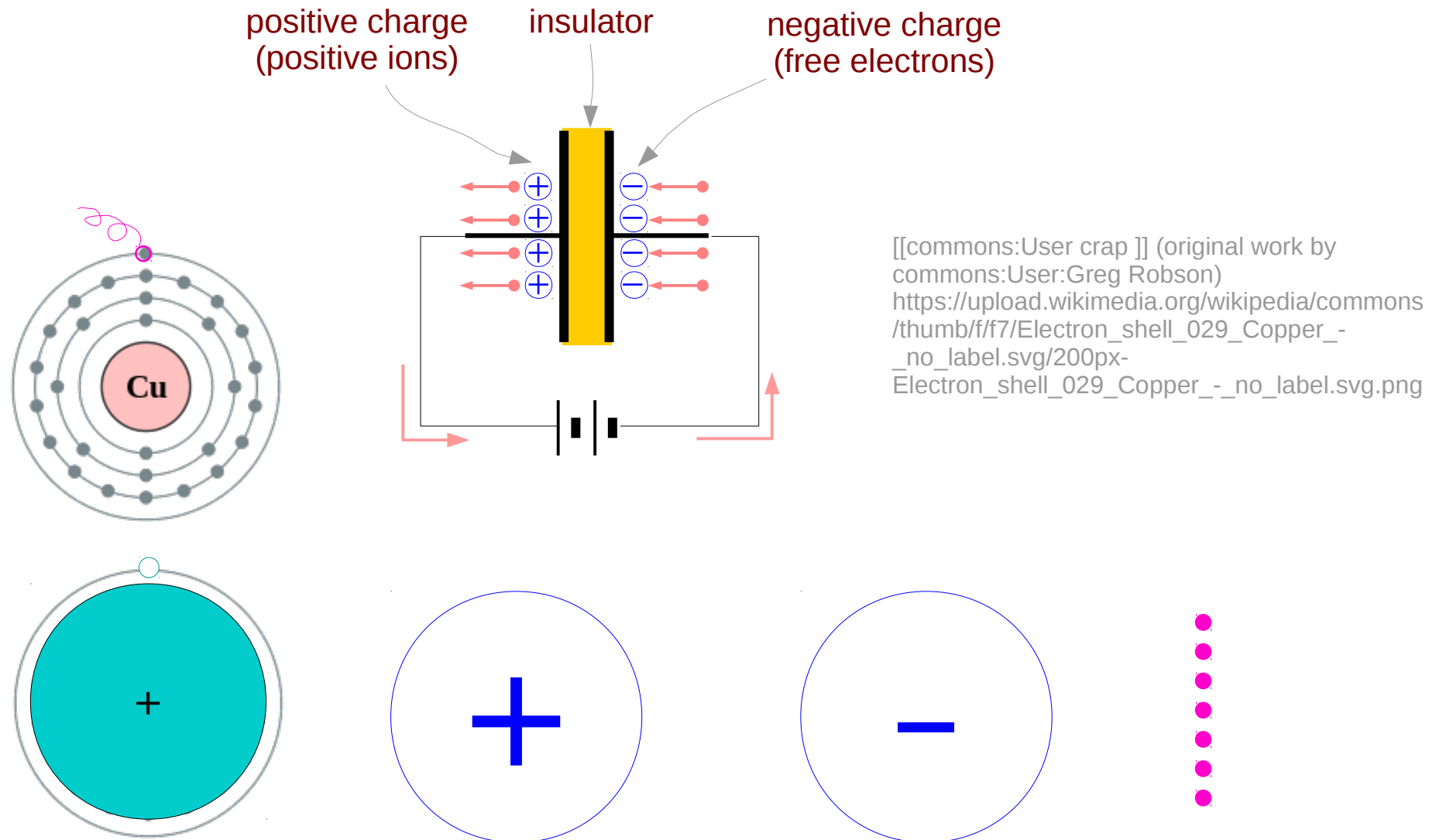
But, think as



Displacement Current

flows through the capacitor

Positive ions and free electrons

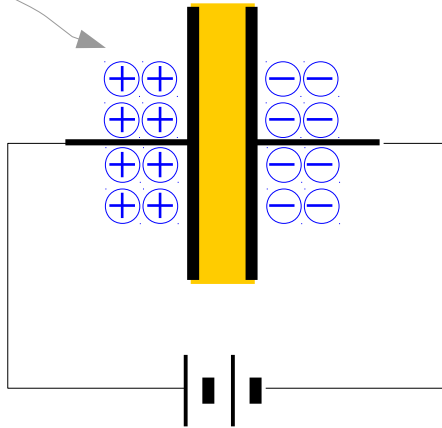


Three States

positive charge
(positive ions)

Positively Charged State

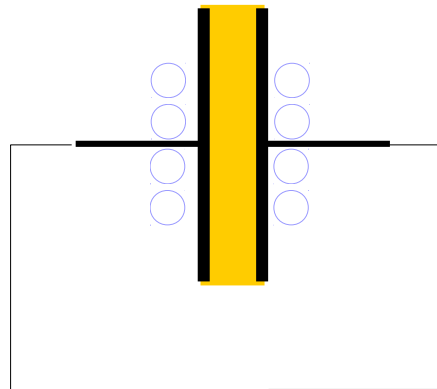
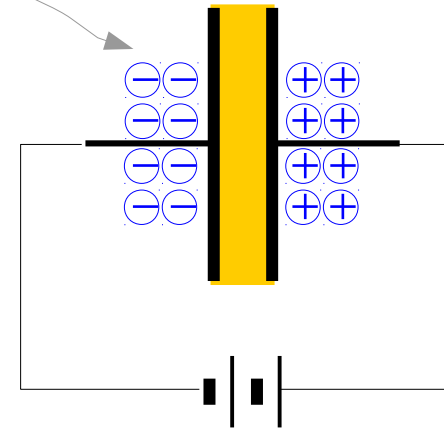
fully charged → no current



negative charge
(free electrons)

Negatively Charged State

fully charged → no current

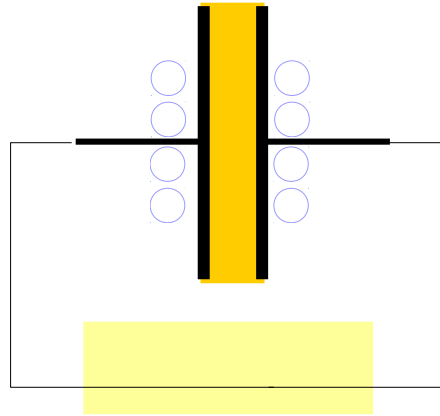


Fully Discharged State

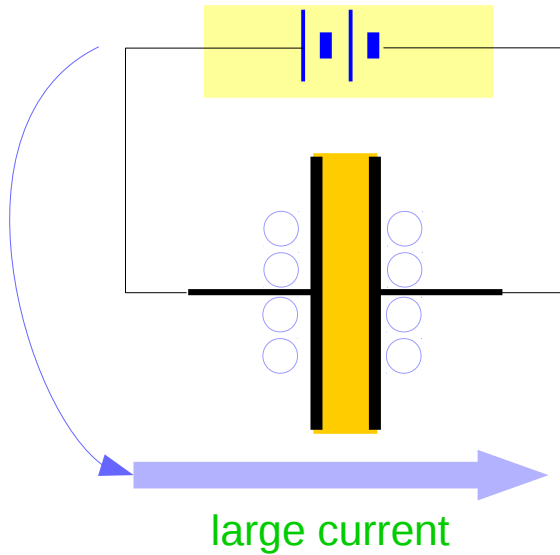
possible large current

Currents in the Fully Discharged State

Initially no current

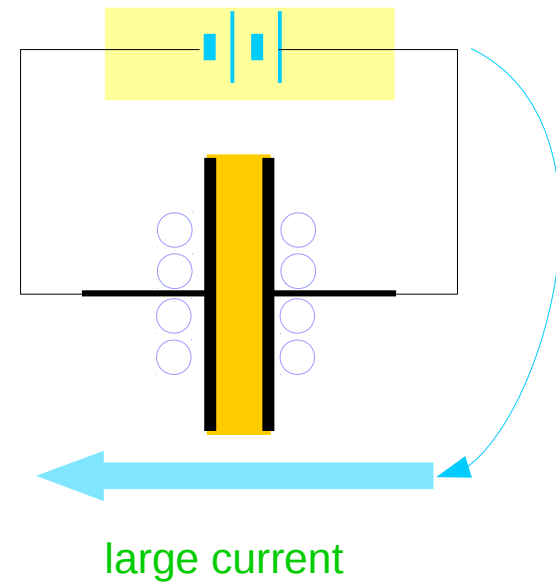


Fully Discharged State



Fully Discharged State

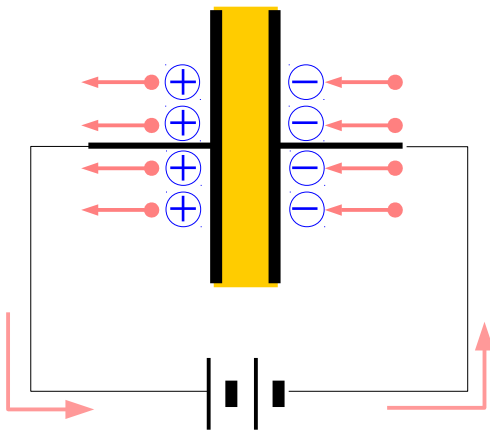
Fully Discharged State



Inter-State Current Flowing

Under Positively Charging

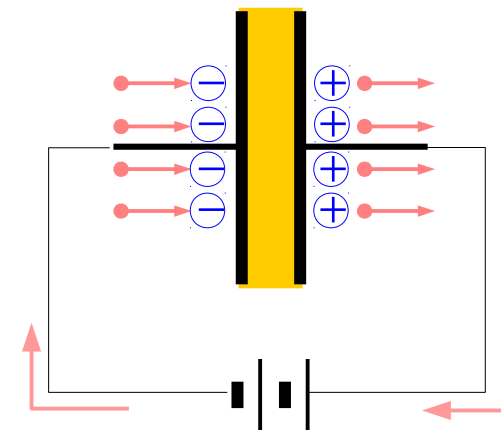
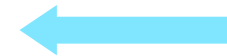
(+) current flow direction



electron flow direction

Under Negatively Charging

(-) current flow direction

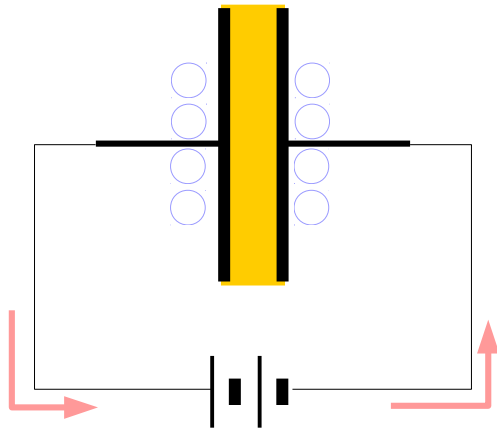


electron flow direction

Inter-State Current Flowing

Fully Discharged State

(+) current flow direction

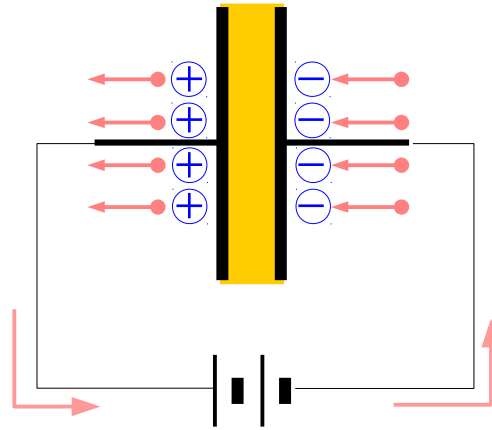


electron flow direction

Initial large current

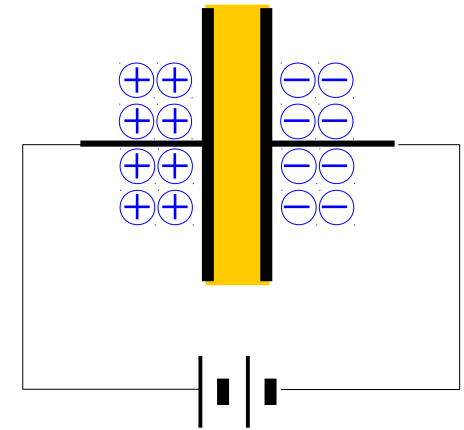
Under Positively Charging

(+) current flow direction



electron flow direction

Positively Charged State



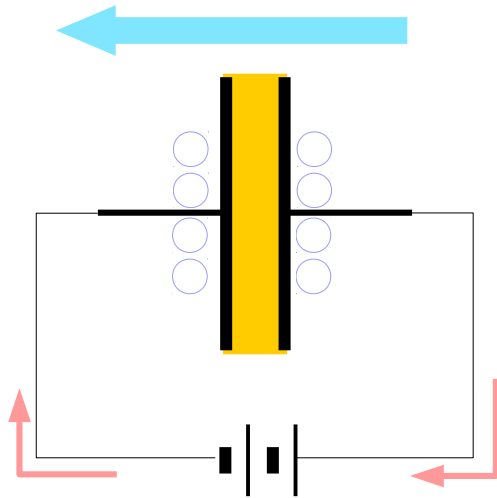
Crowded →
No more space

no current

Inter-State Current Flowing

Fully Discharged State

(-) current flow direction

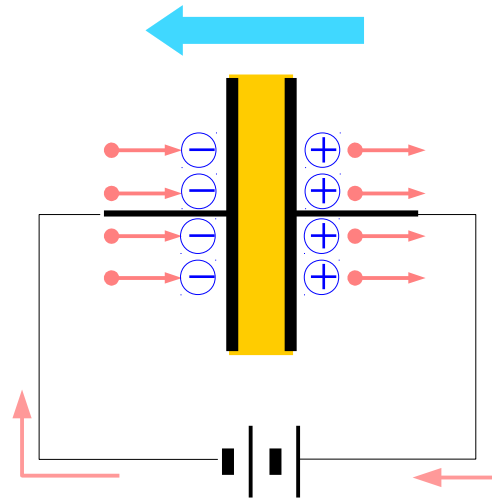


electron flow direction

Initial large current

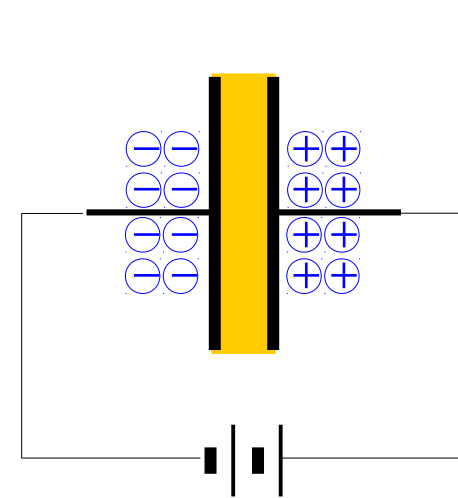
Under Negatively Charging

(-) current flow direction



electron flow direction

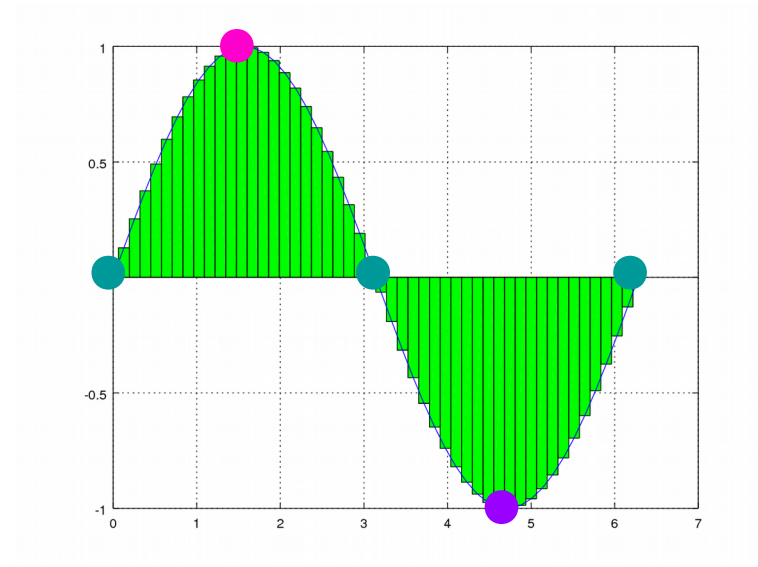
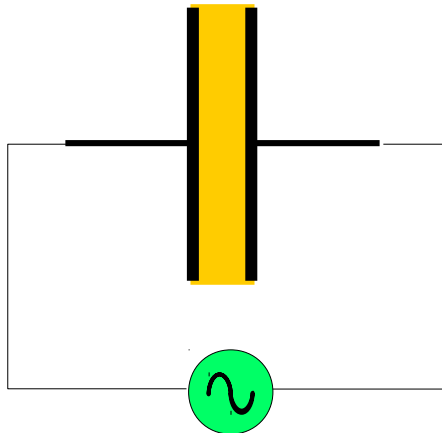
Negatively Charged State



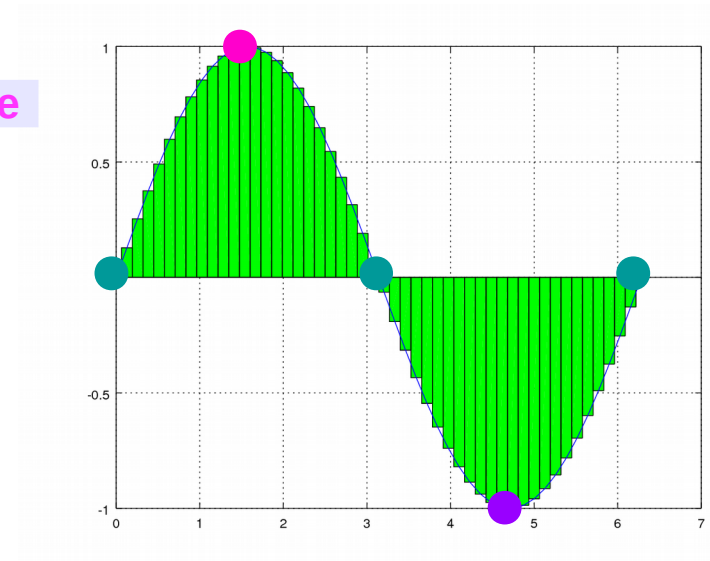
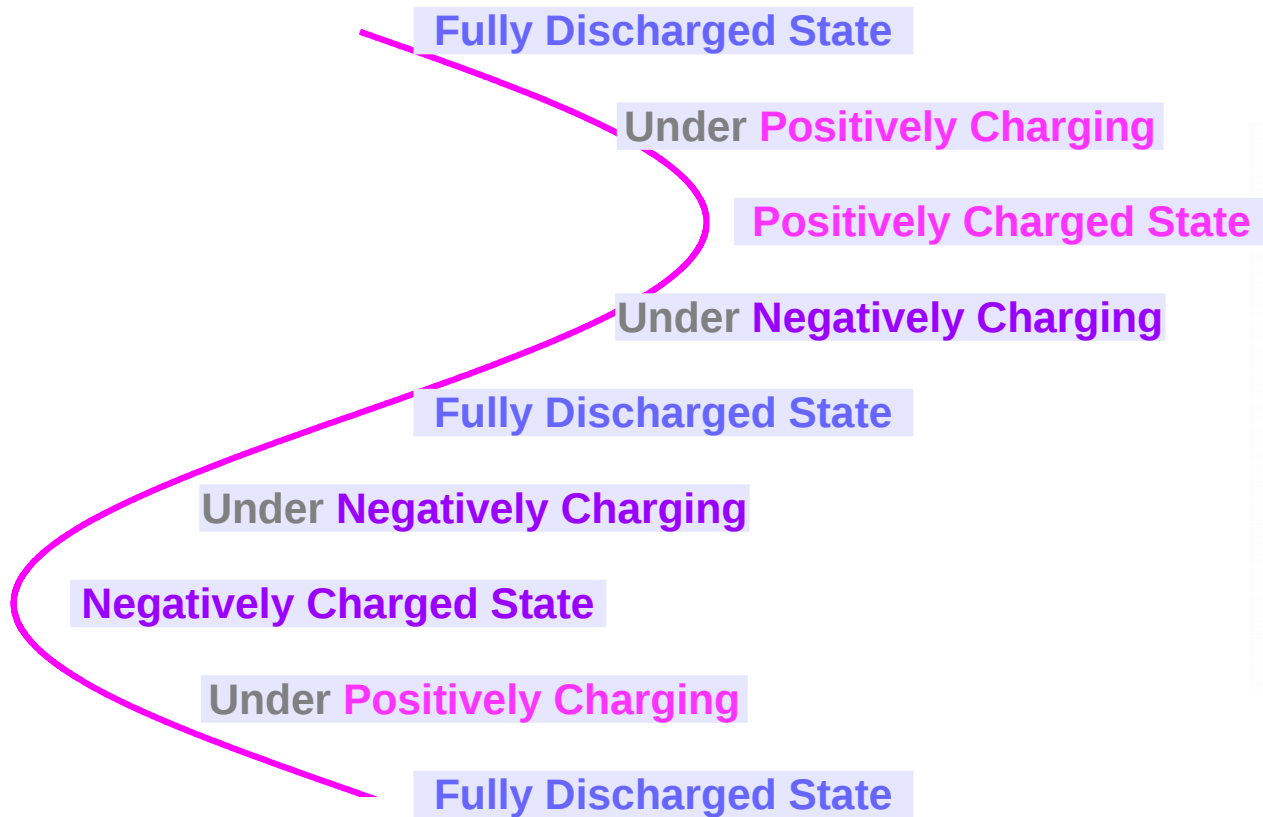
Crowded →
No more space

no current

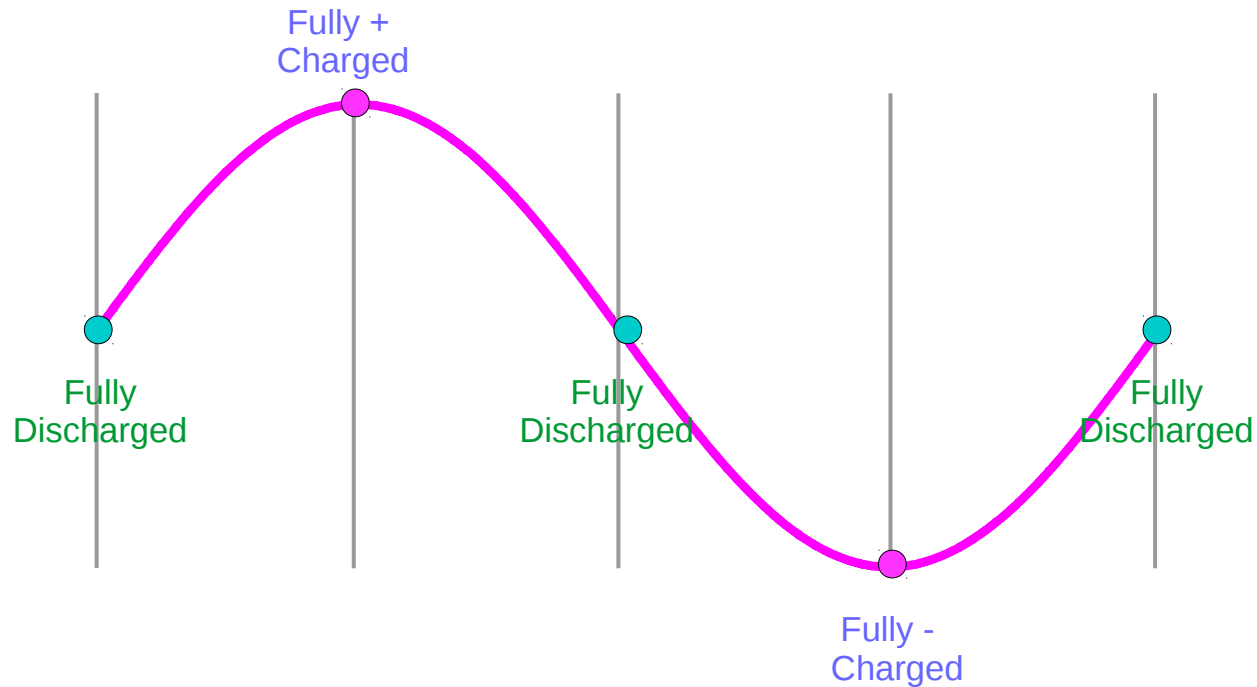
An AC Voltage Source



An AC Voltage Source

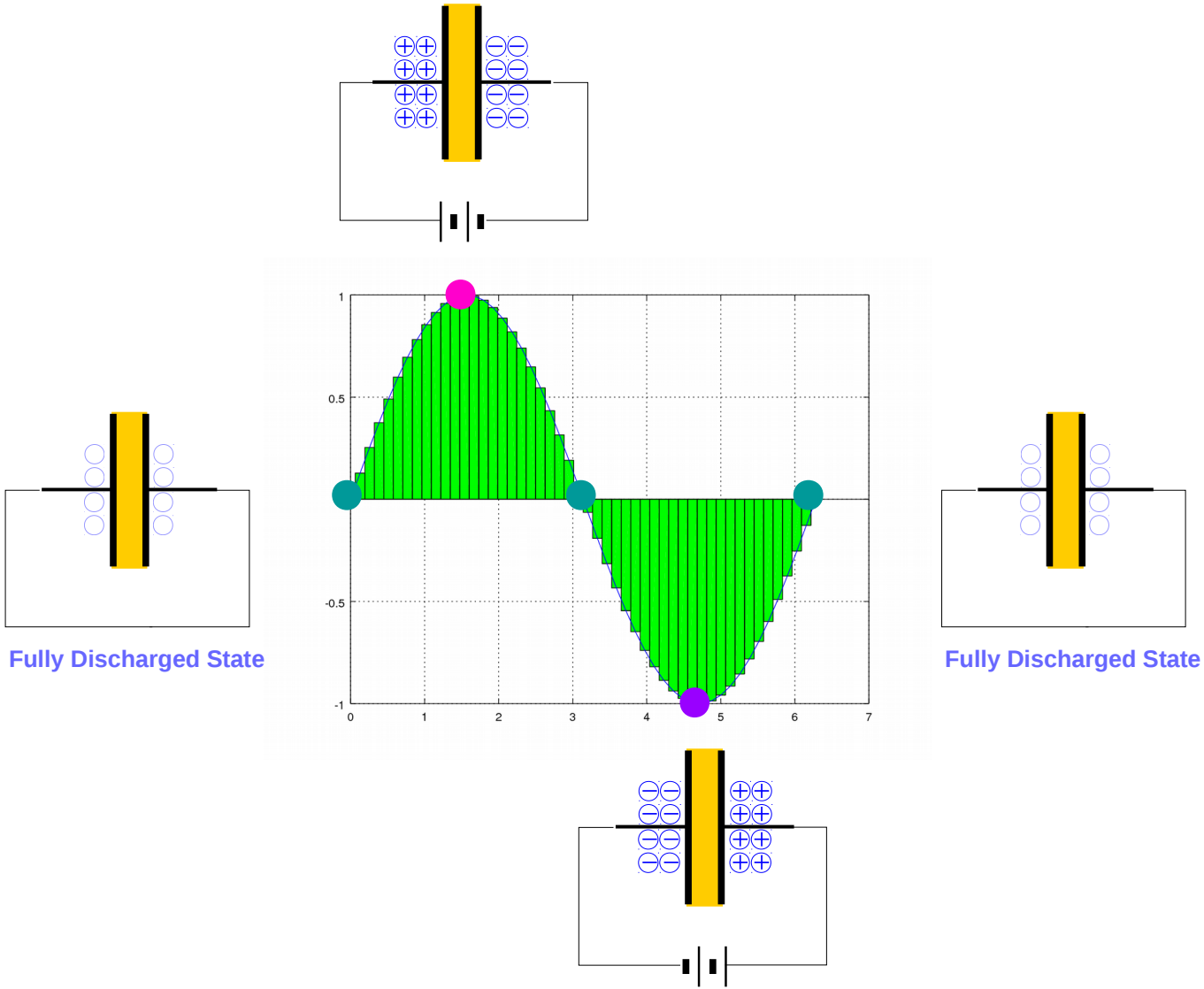


Fully Charged and Fully Discharged

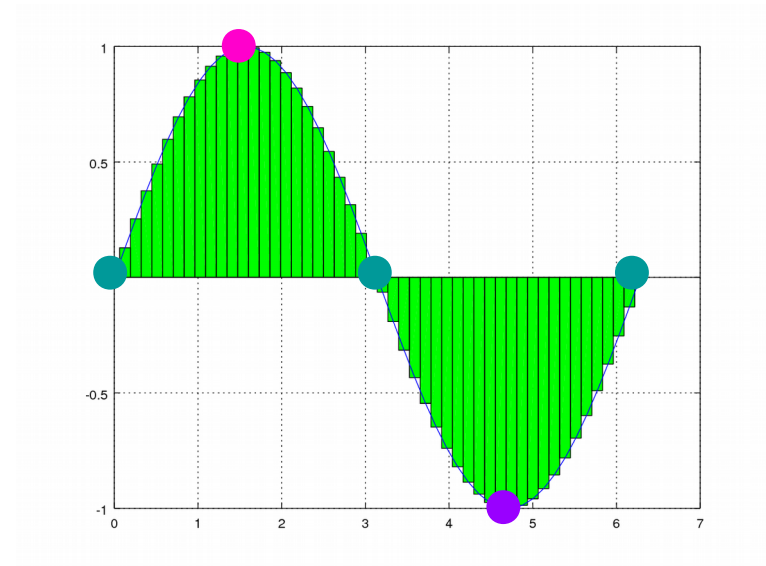
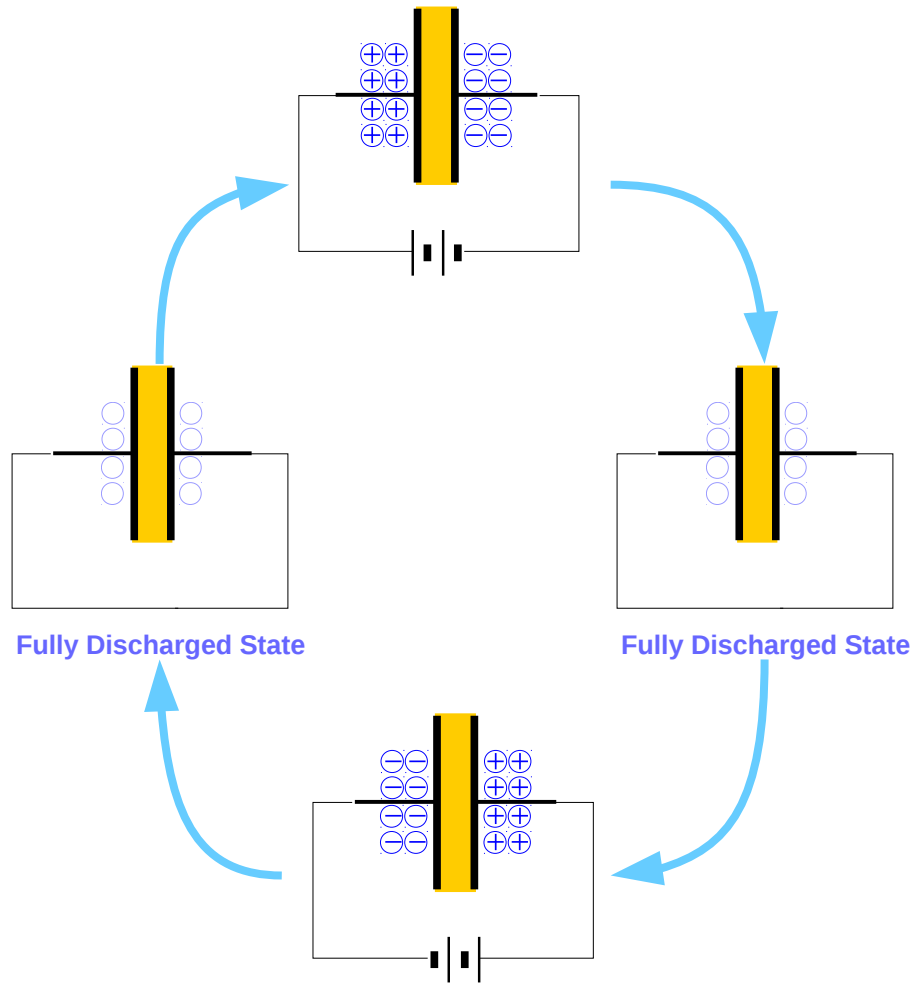


(+) Charging	(-) Charging	(-) Charging	(+) Charging
(+) current	(-) current	(-) current	(+) current
(+) Charging	(+) Discharging	(-) Charging	(-) Discharging

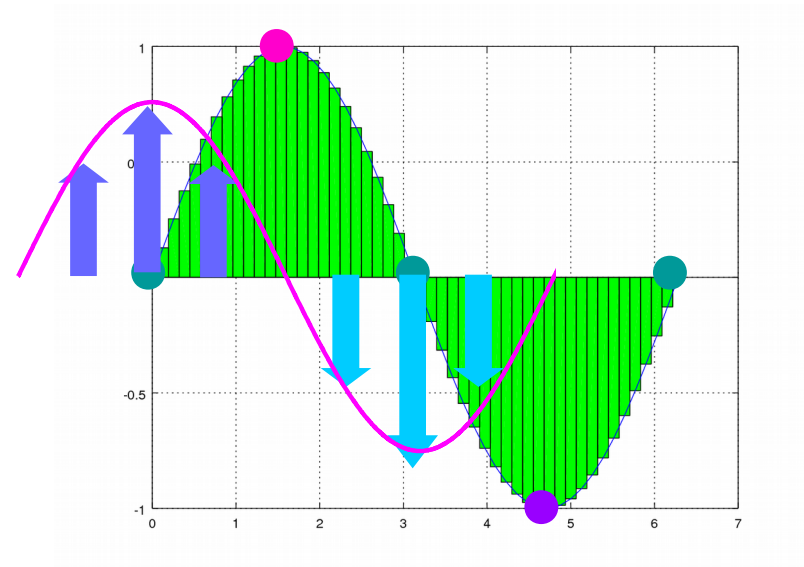
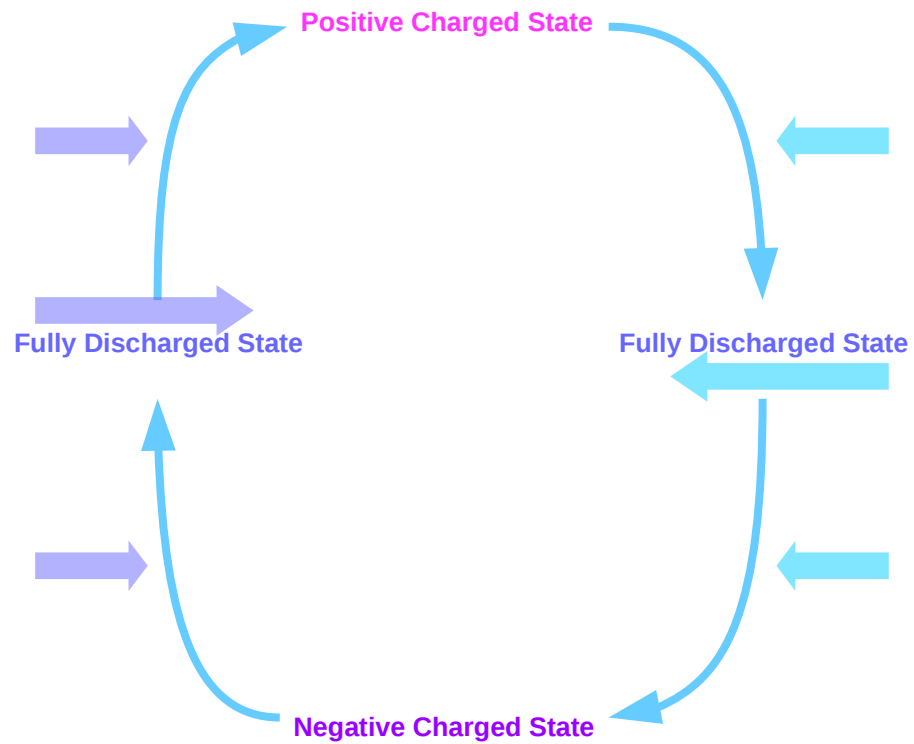
A Cycle



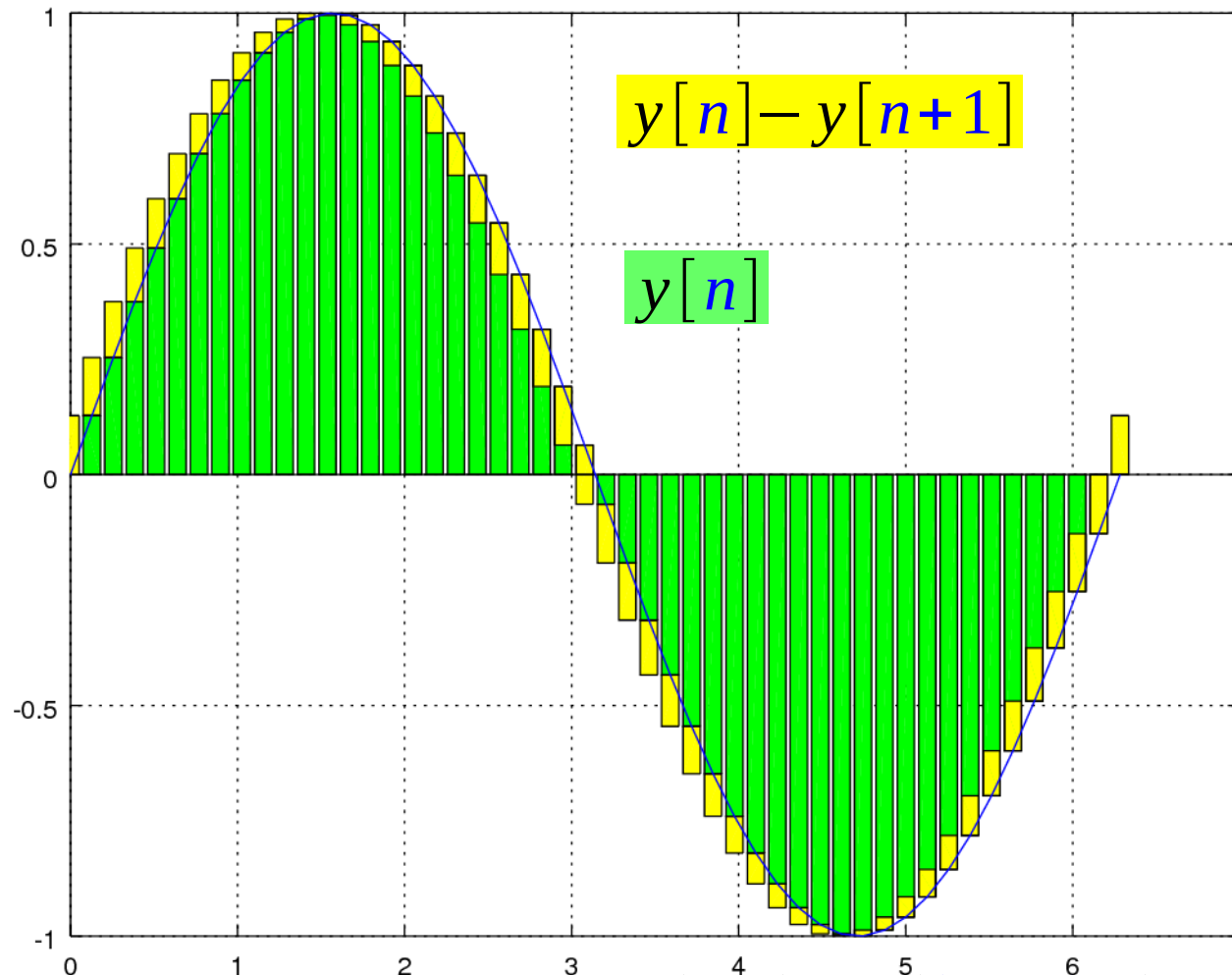
State Transition Diagram



Current Flow



Fully Charged and Fully Discharged



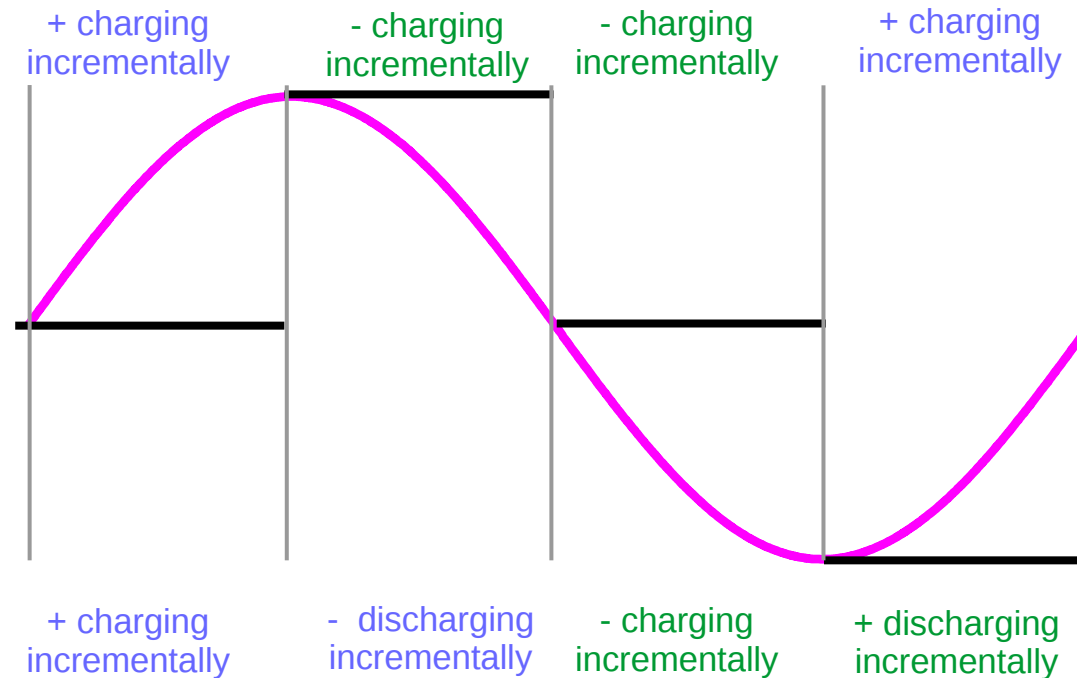
```
h = bar(t1, [y1' y2'],  
"stacked")  
set(h(1), "facecolor", "g");  
set(h(2), "facecolor", "y");  
hold on  
plot(t1, y1)  
axis([0 7 -1 1]);
```

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

Continuous Charging and Discharging Operations

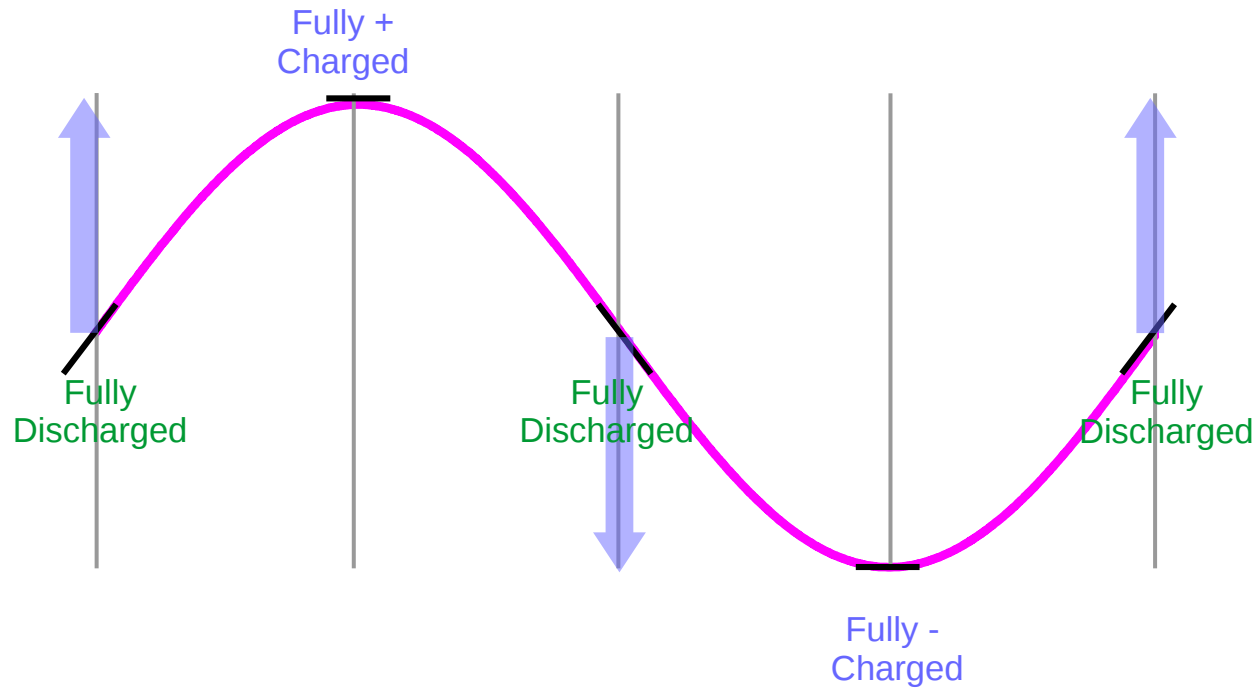
Incremental Voltage Increment \rightarrow + Charging incrementally

Incremental Voltage Decrement \rightarrow - Charging incrementally

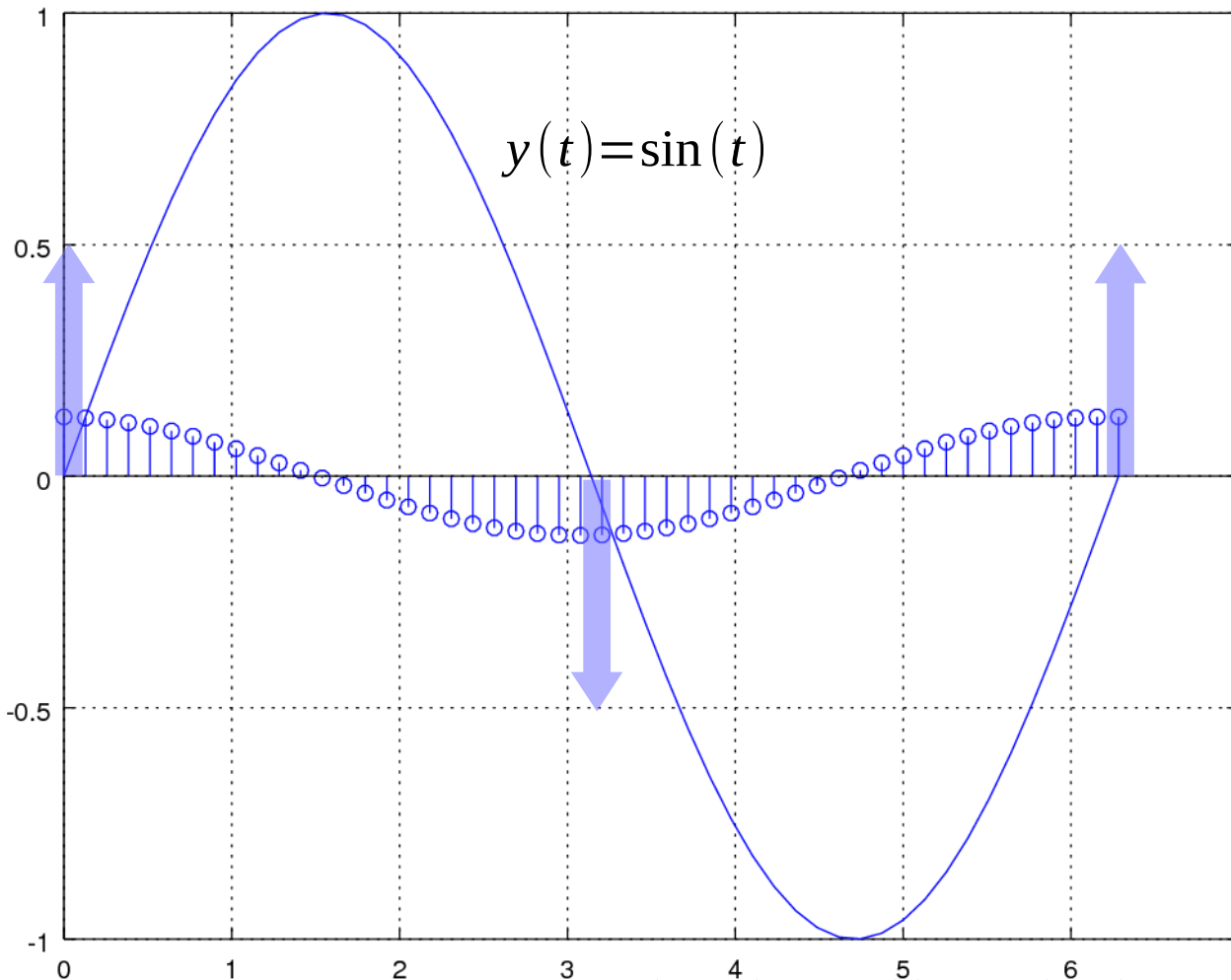


Fully Discharged : Large Current

Incremental Voltage Increment → Continuous Charging
Incremental Voltage Decrement → Continuous Discharging



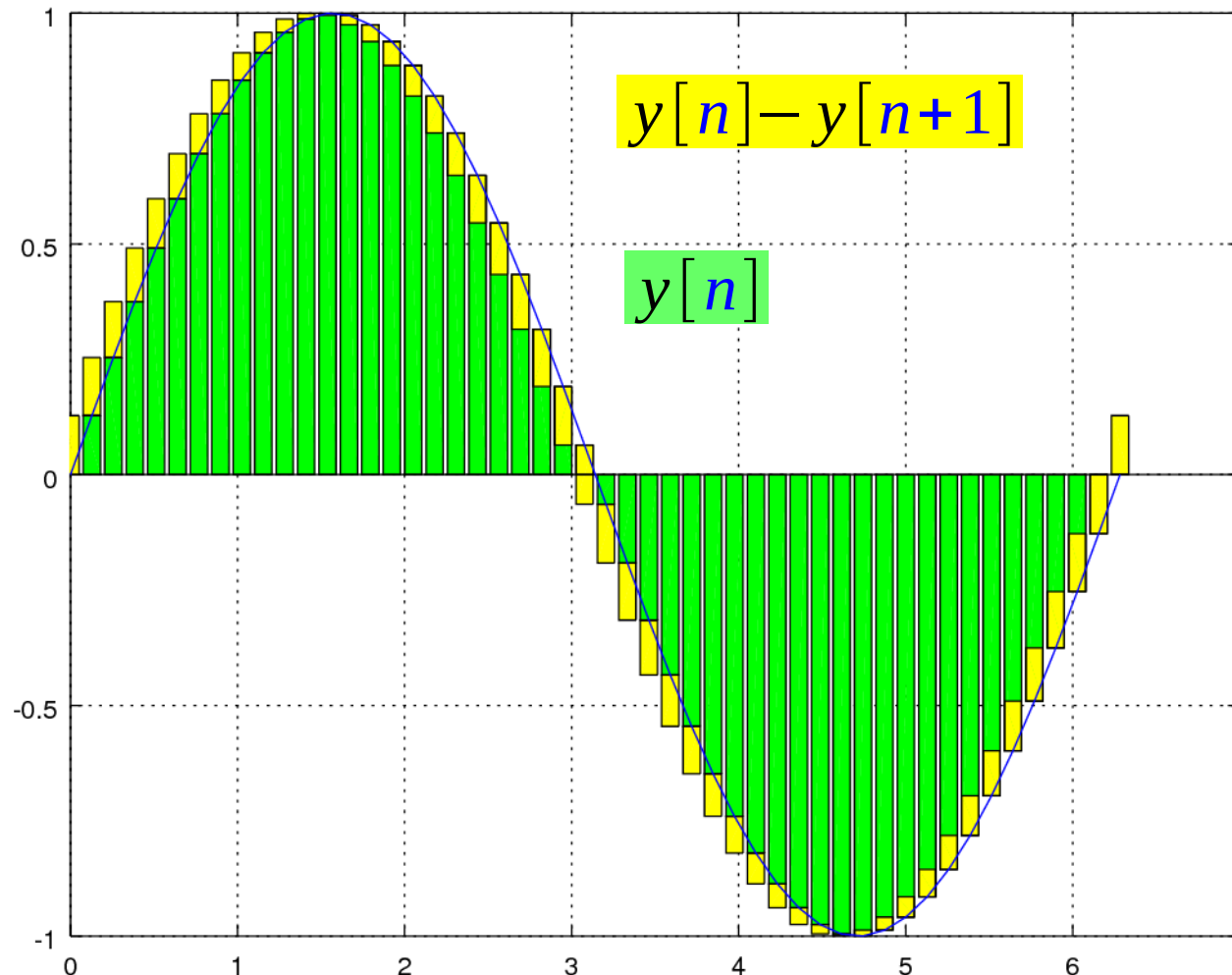
$y[n+1] - y[n]$



```
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)
```

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

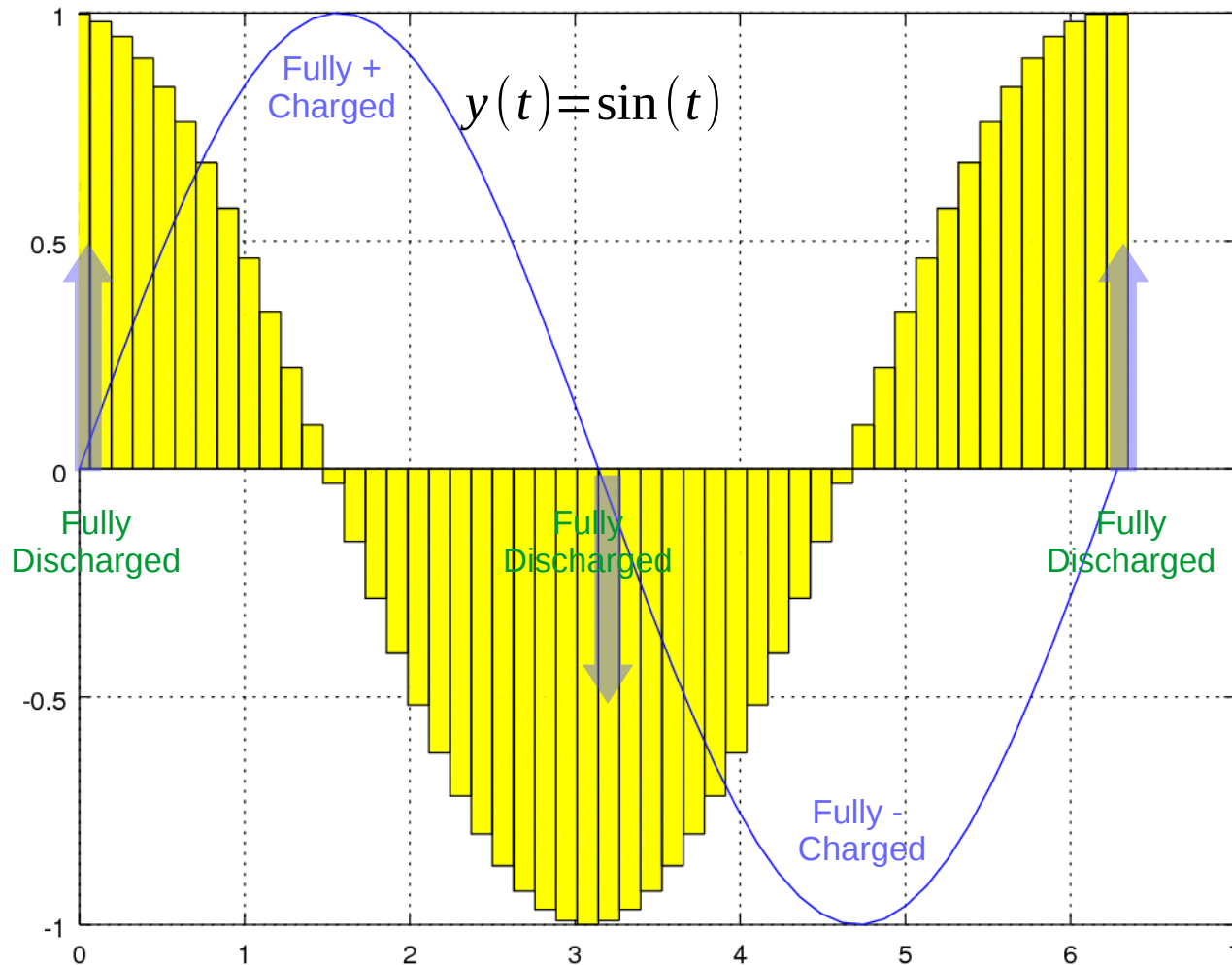
Fully Charged and Fully Discharged



```
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

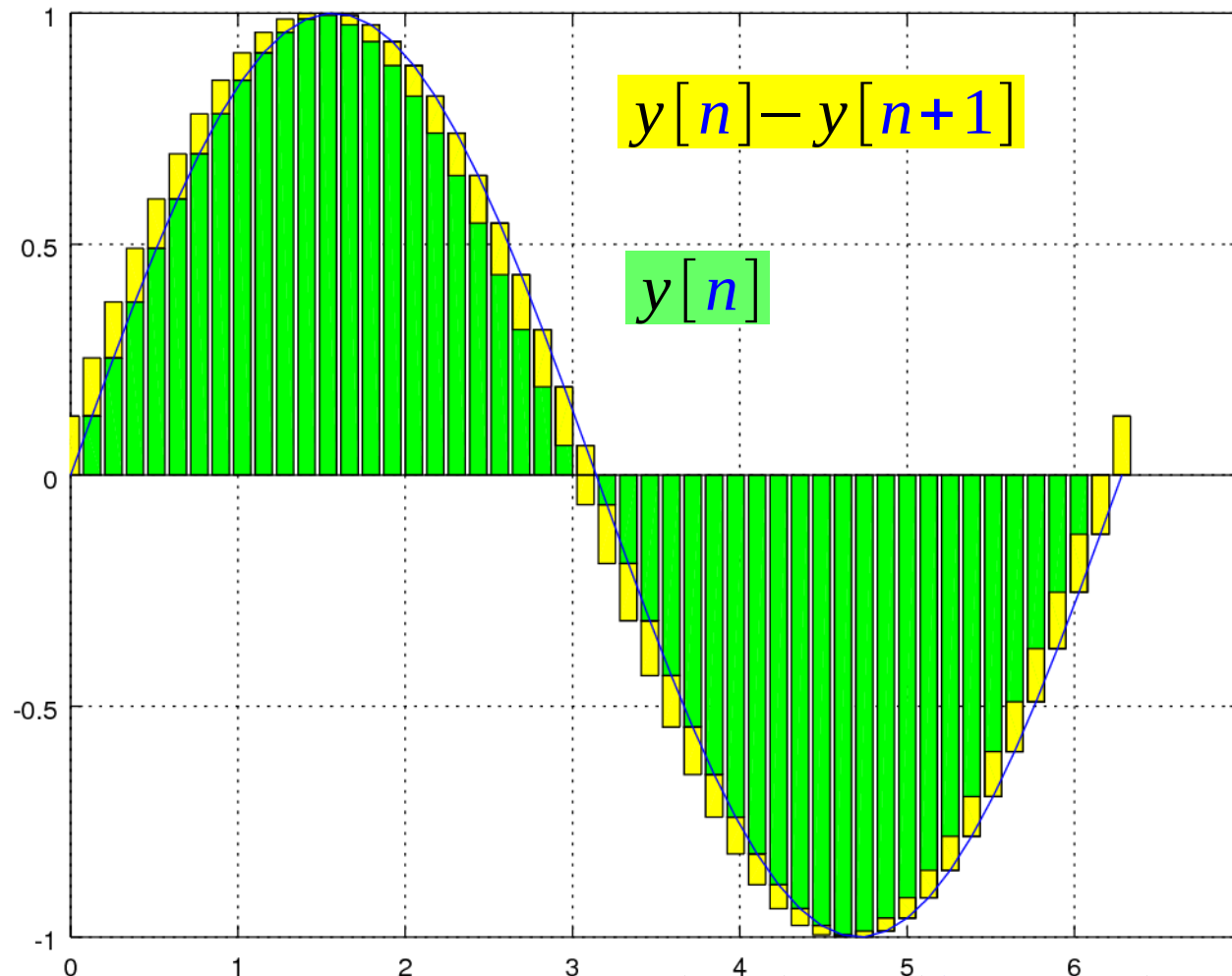


```
h = bar(t1, y2/t(2), "hist")
set(h(1), "facecolor", "y");
hold on
plot(t1, y1)
axis([0 7 -1 1]);
```

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

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

Fully Charged and Fully Discharged

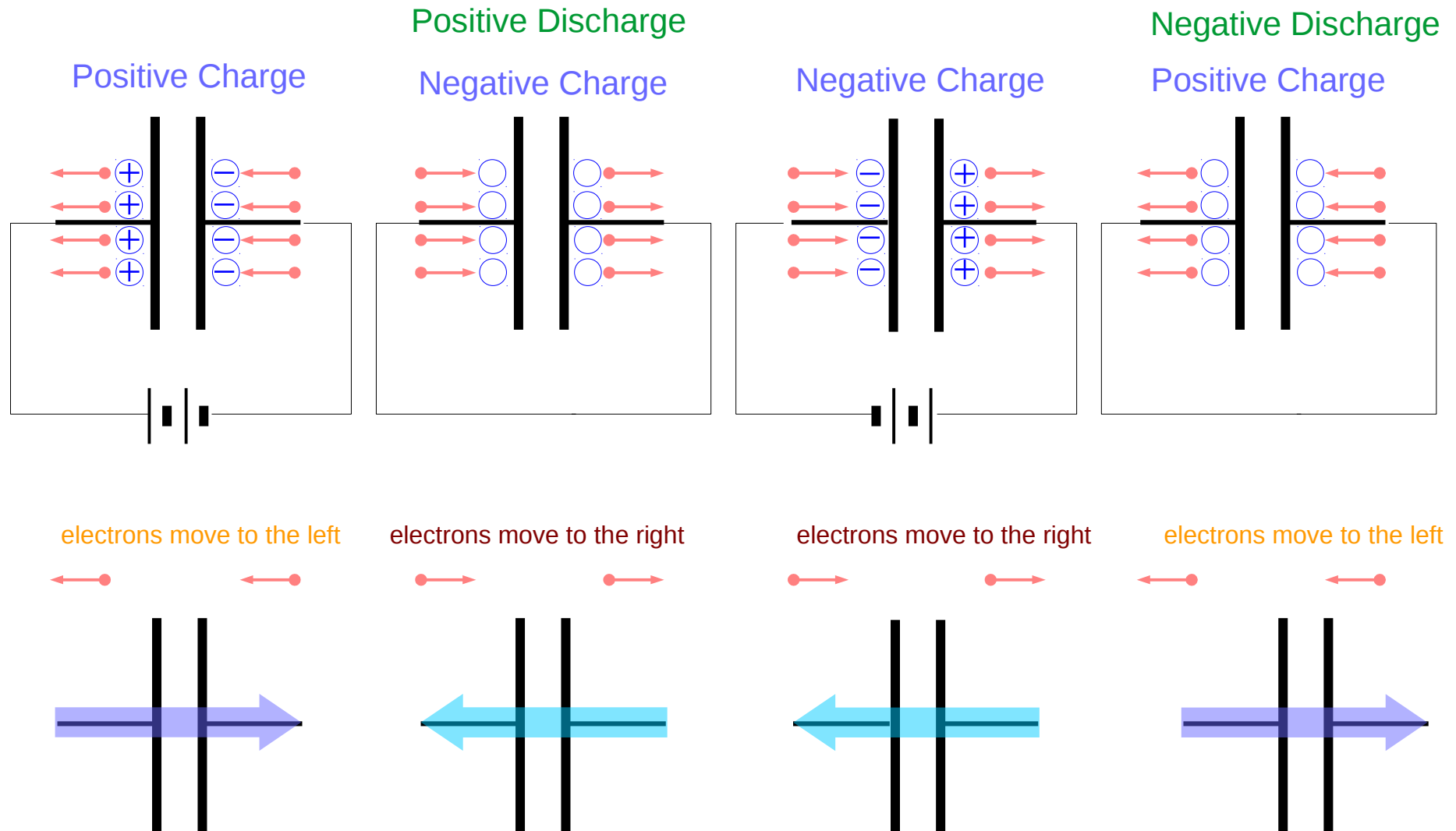


```

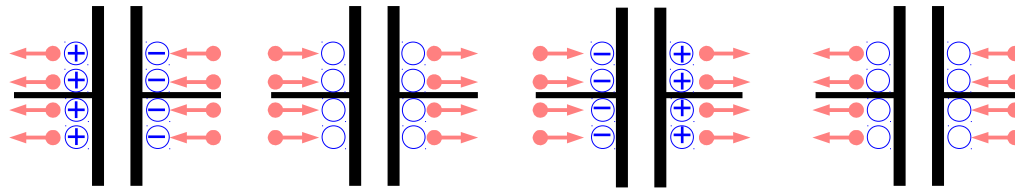
h = bar(t1, [y1' y2'],
"stacked")
set(h(1), "facecolor", "g");
set(h(2), "facecolor", "y");
hold on
plot(t1, y1)
axis([0 pi]);
    
```

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

Everchanging signal pairs

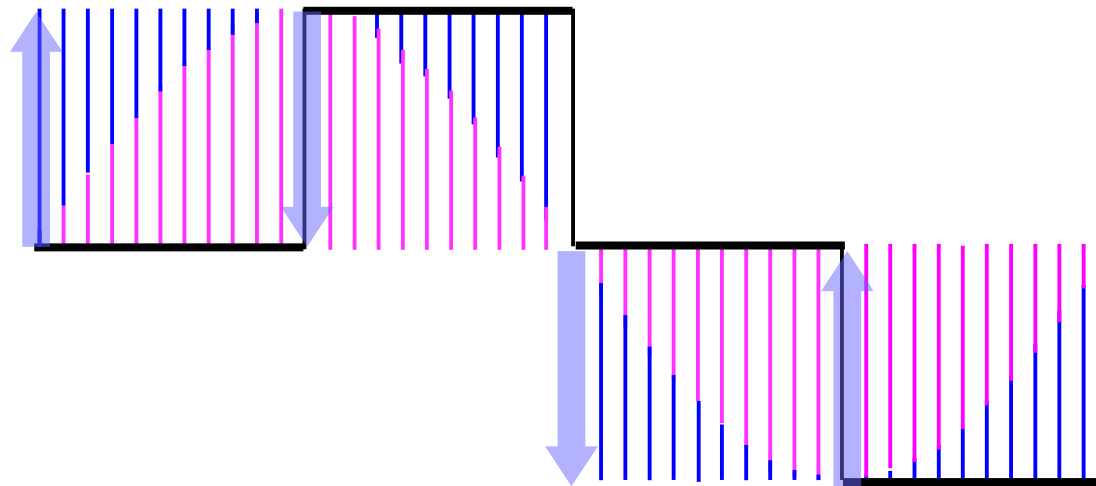


Everchanging signal pairs



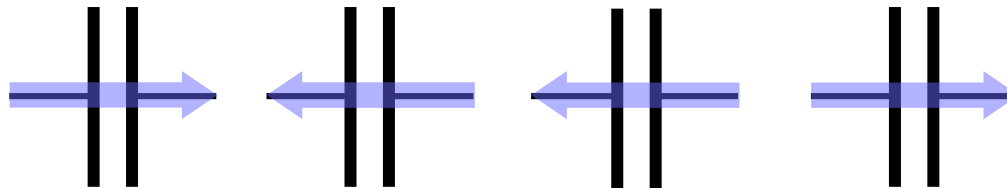
charge

discharge

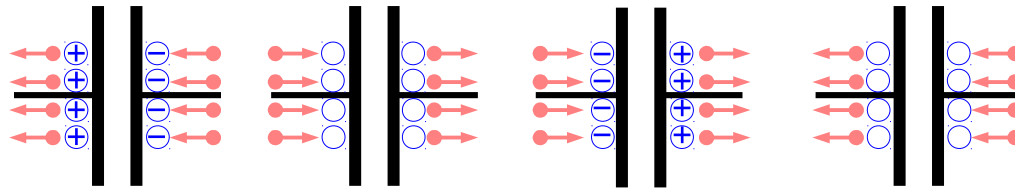


charge

discharge

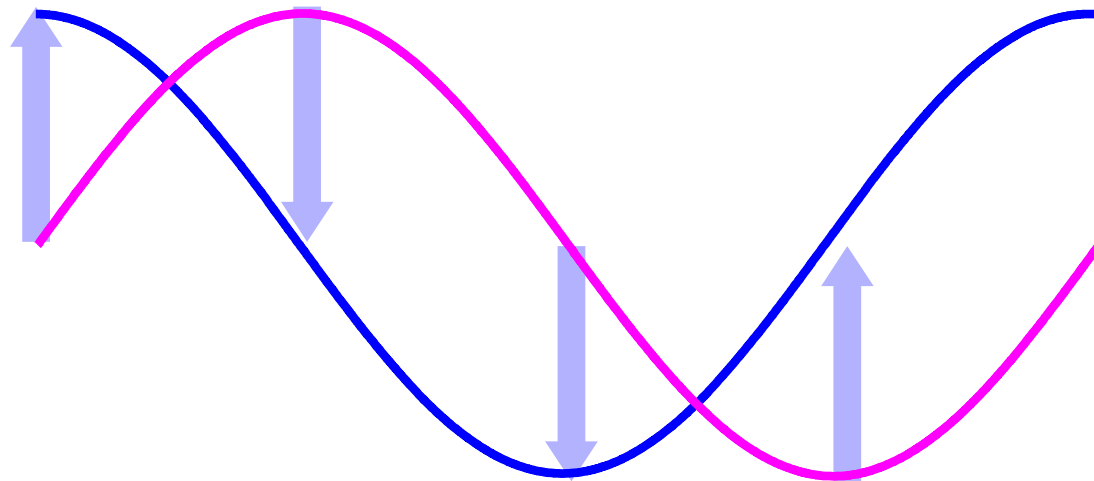


Everchanging signal pairs



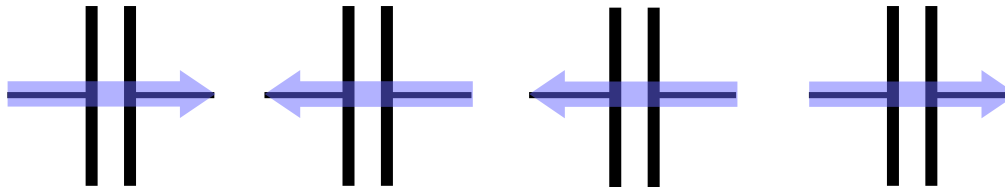
charge

discharge

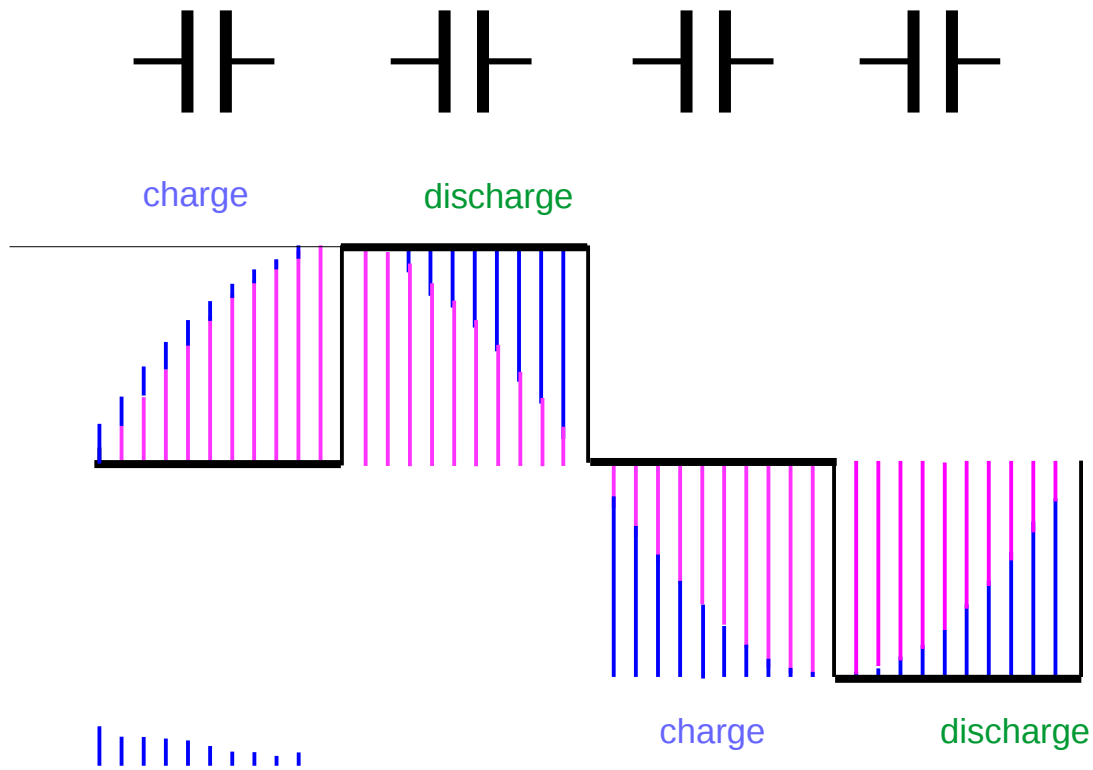


charge

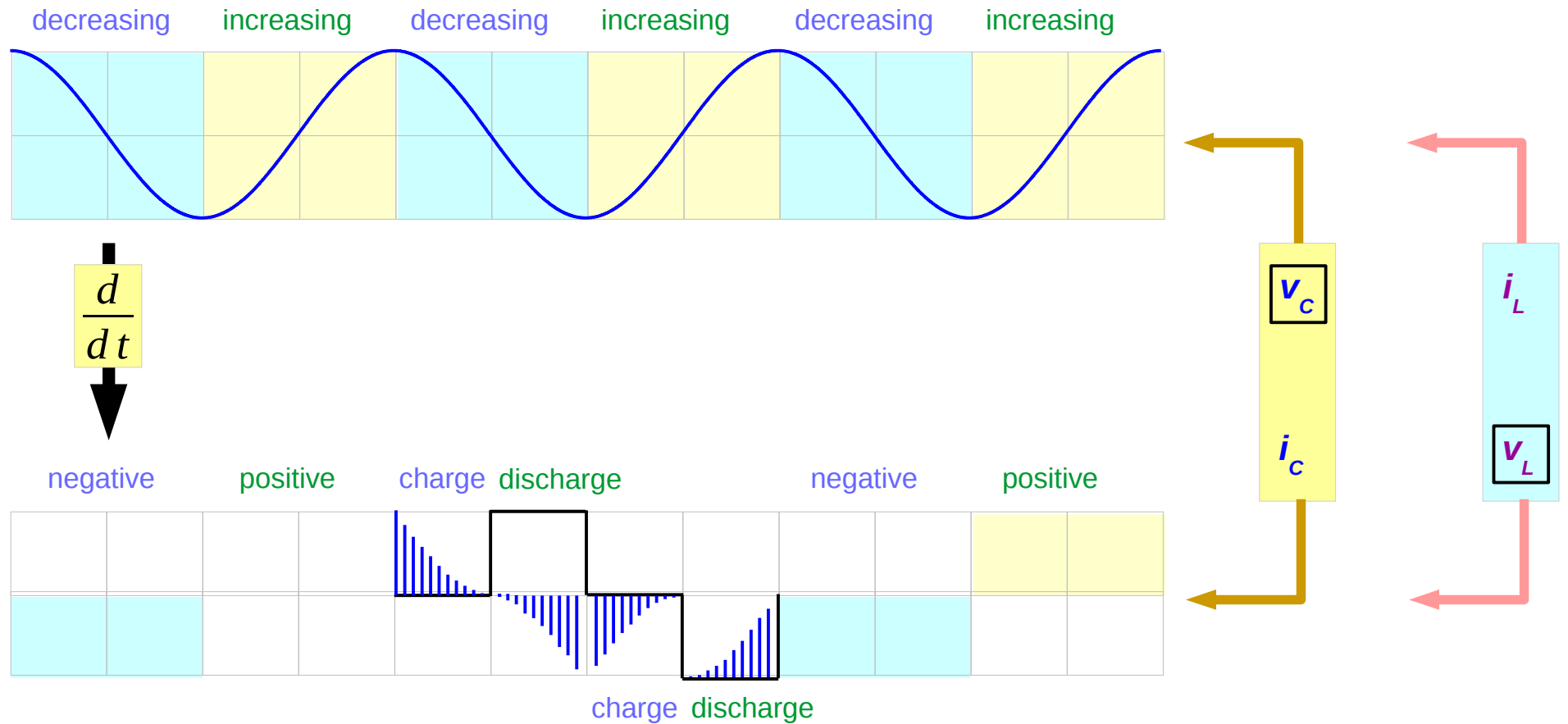
discharge



Everchanging signal pairs

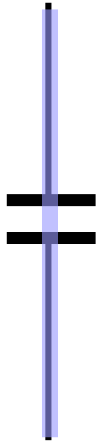


Everchanging signal pairs



I leads V by 90°

Initial charge

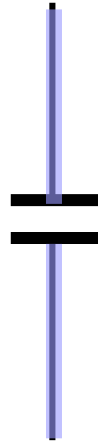


SHORT

V = 0

I : peak

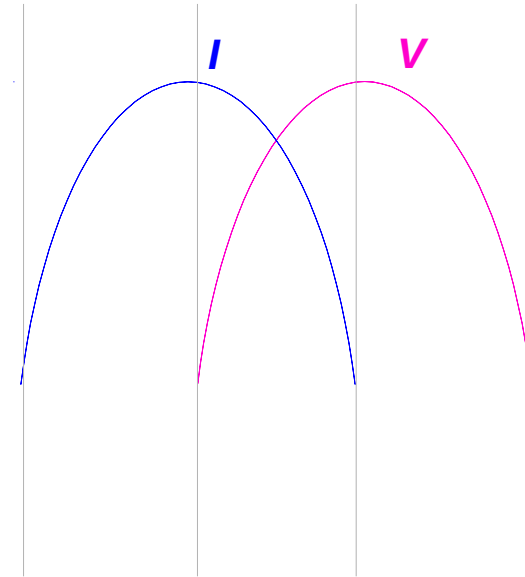
Full charge



OPEN

I = 0

V : peak



References

[1] <http://en.wikipedia.org/>

[2] J.H. McClellan, et al., Signal Processing First, Pearson Prentice Hall, 2003