

Capacitor in an AC circuit

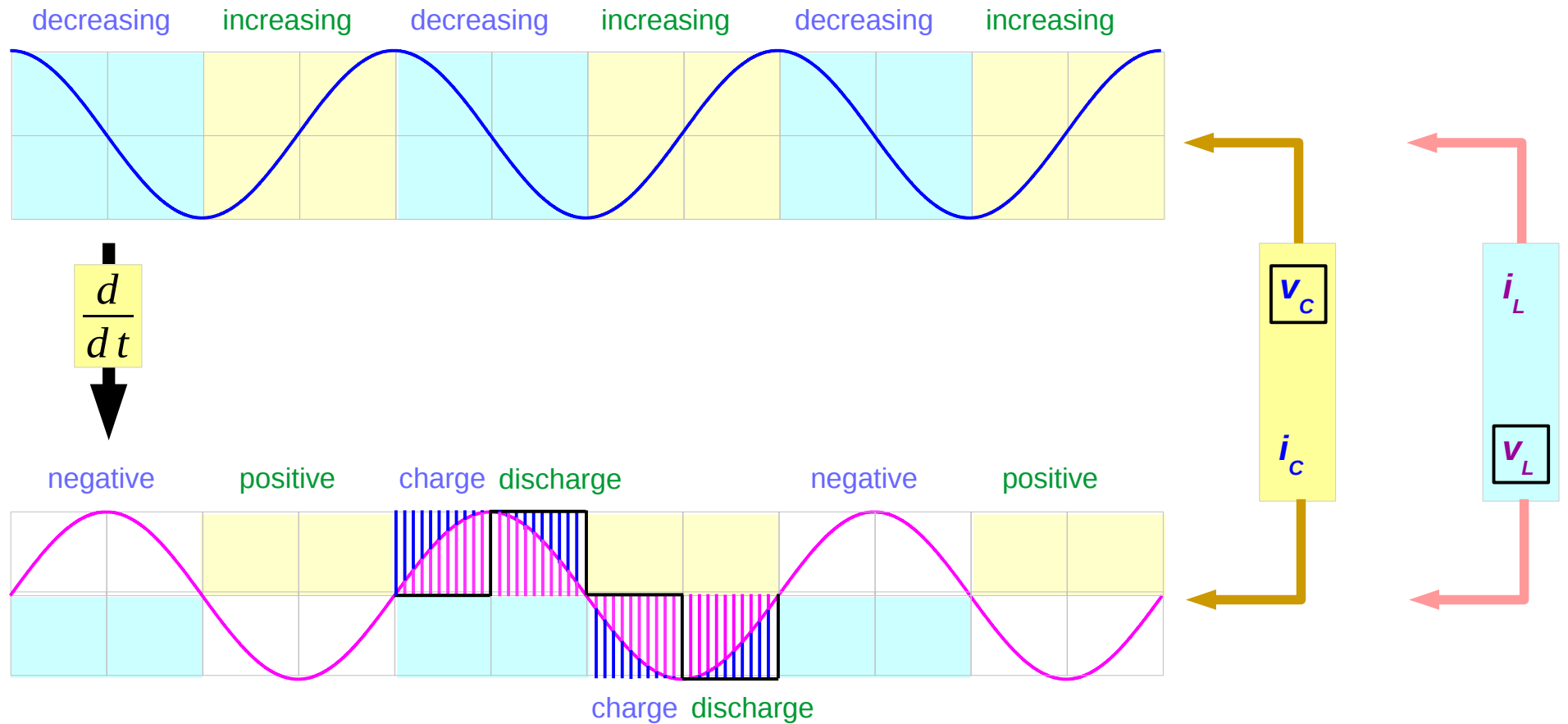
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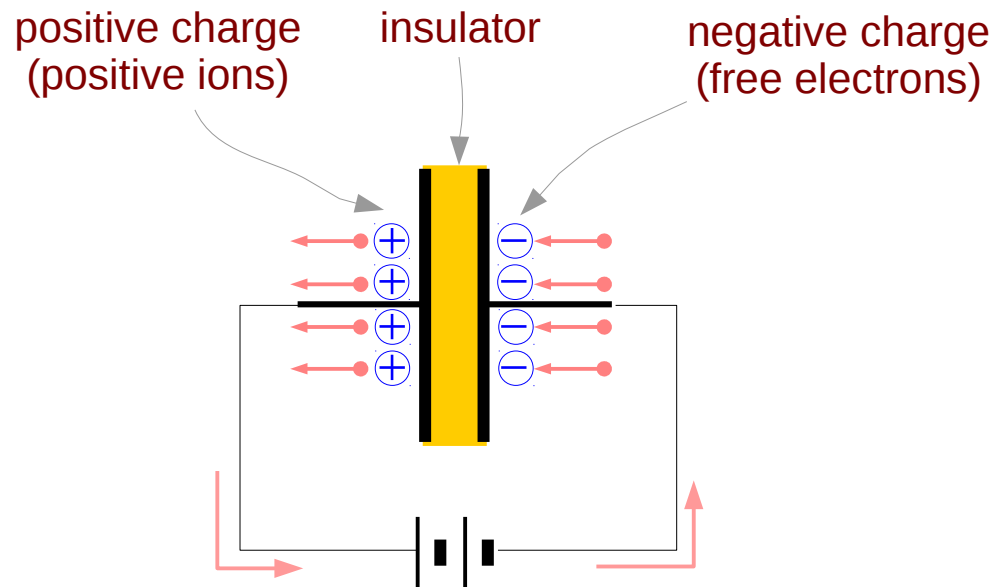
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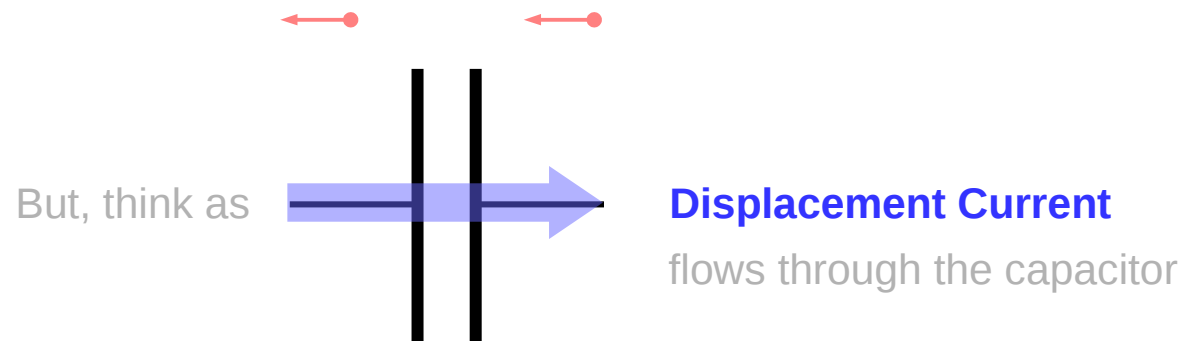
Everchanging signal pairs



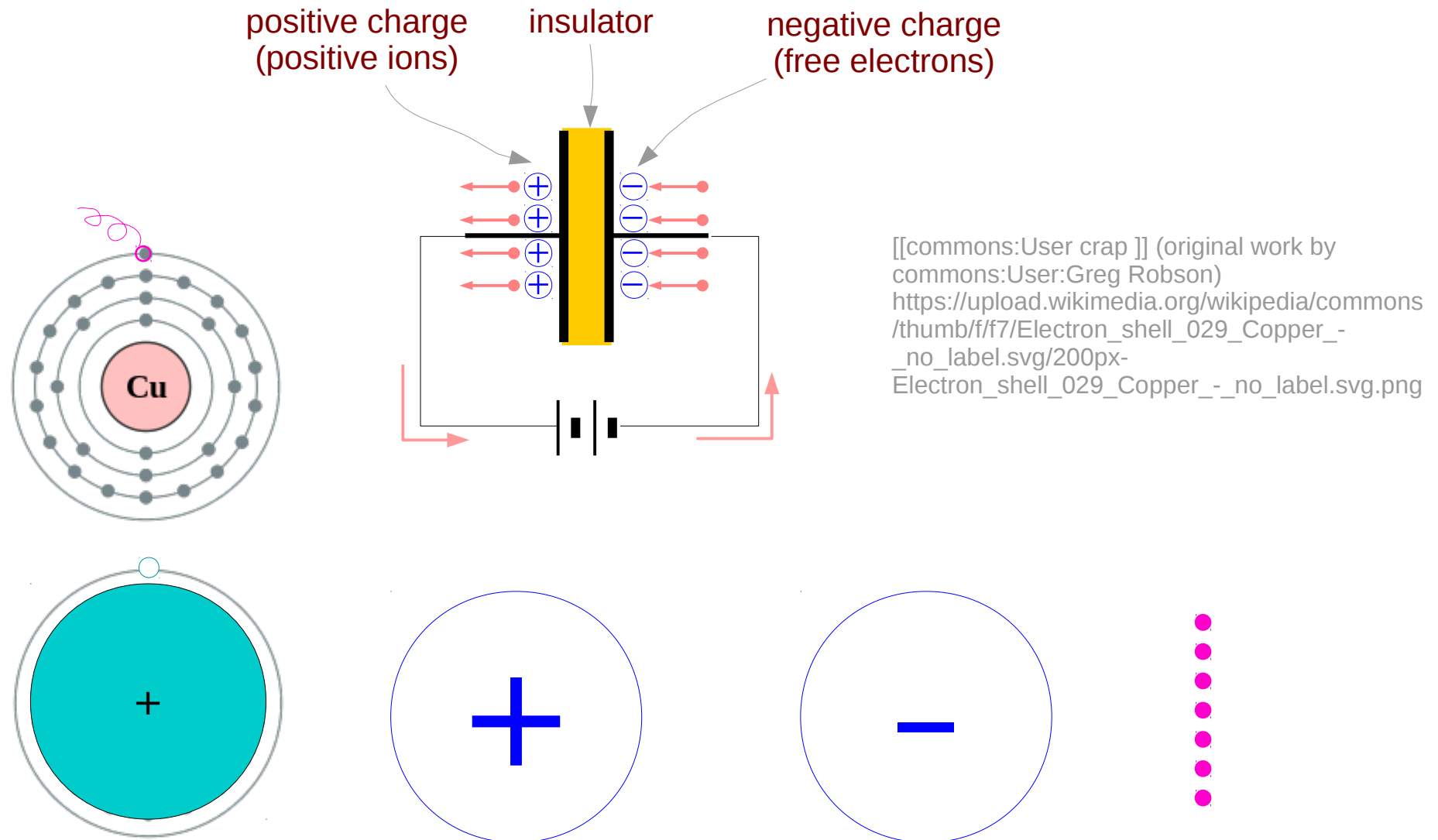
Capacitor Current



No actual electrons movement across insulator materials



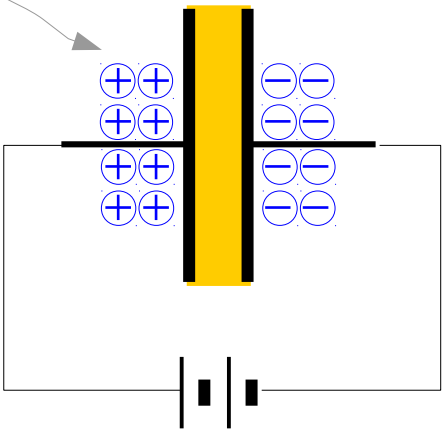
Positive ions and free electrons



Three States

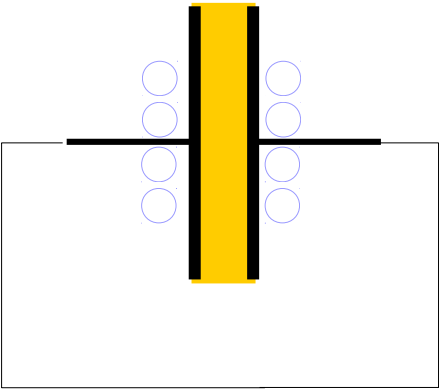
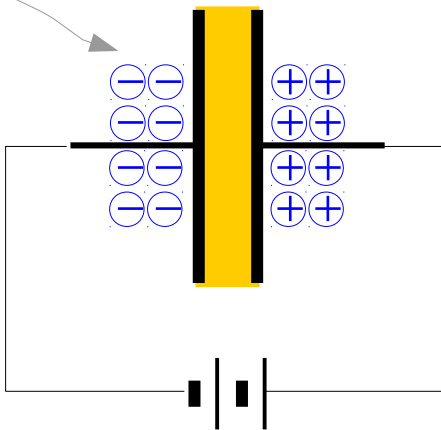
positive charge
(positive ions)

Positively Charged State
fully charged → no current



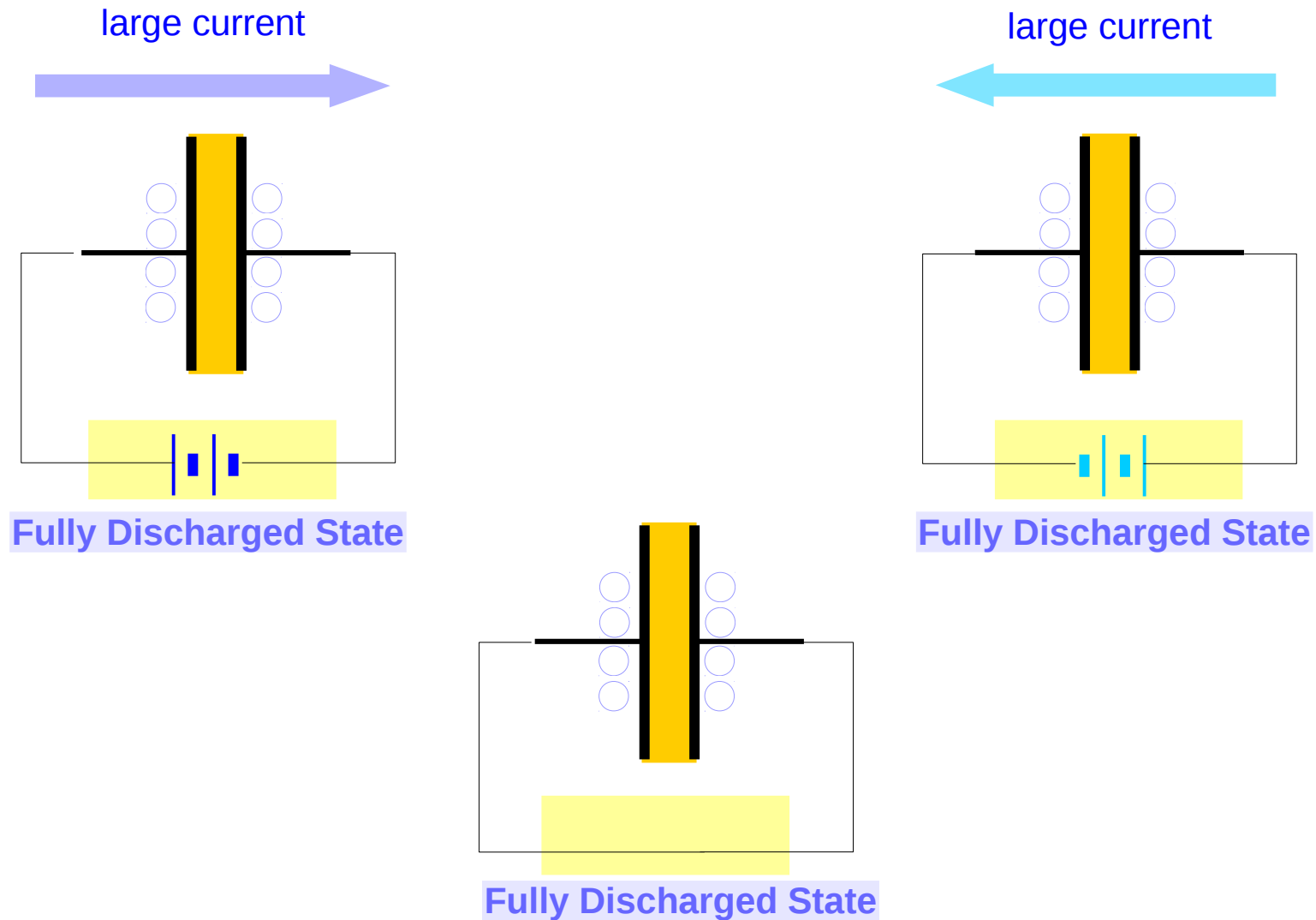
negative charge
(free electrons)

Negatively Charged State
fully charged → no current



Fully Discharged State
possible large current

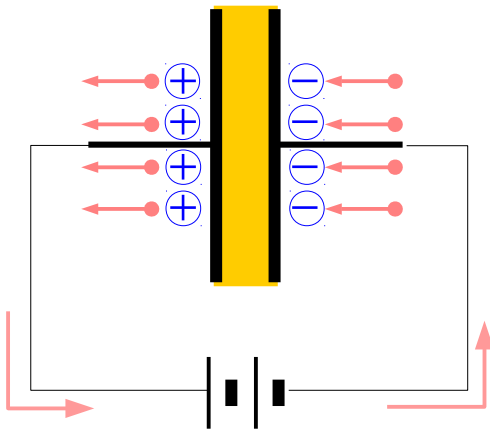
Currents in the Fully Discharged State



Inter-State Current Flowing

Under Positively Charging

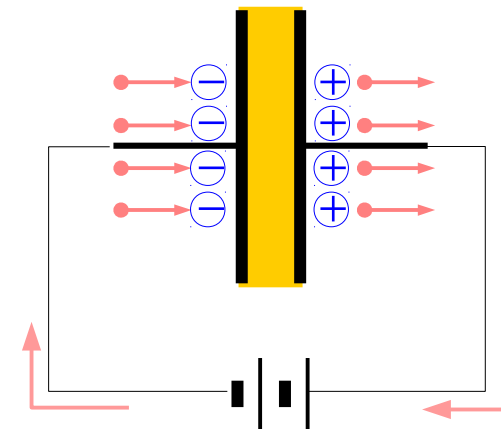
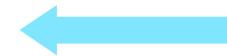
(+) current flow direction



electron flow direction

Under Negatively Charging

(-) current flow direction



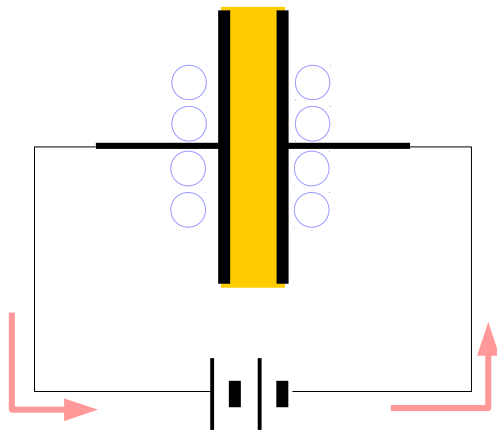
electron flow direction

Inter-State Current Flowing

Fully Discharged State

Initial large current

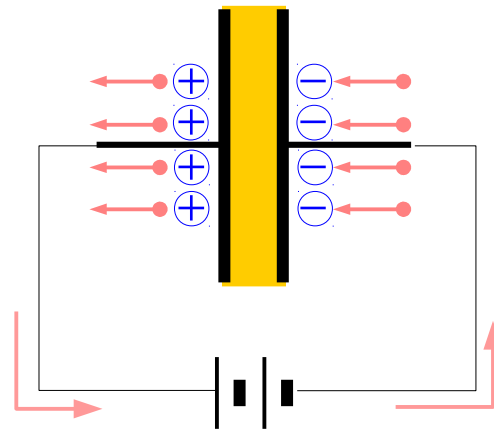
(+) current flow direction



electron flow direction

Under Positively Charging

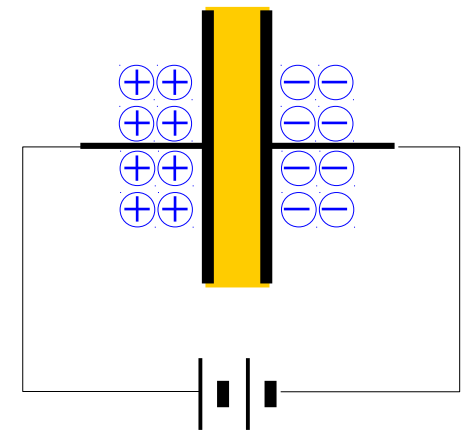
(+) current flow direction



electron flow direction

Positively Charged State

no current



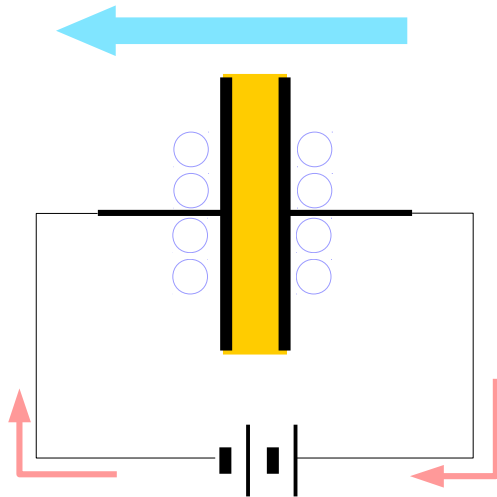
Crowded →
No more space

Inter-State Current Flowing

Fully Discharged State

Initial large current

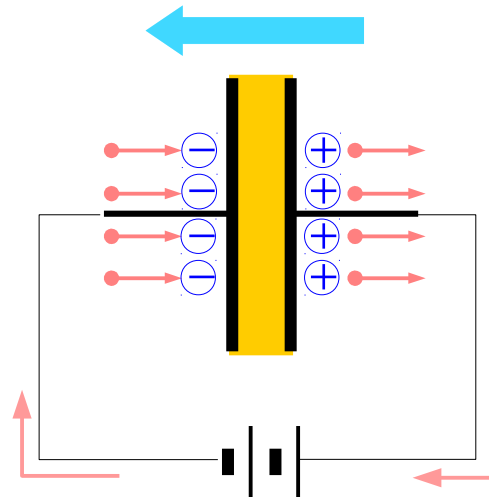
(-) current flow direction



electron flow direction

Under Negatively Charging

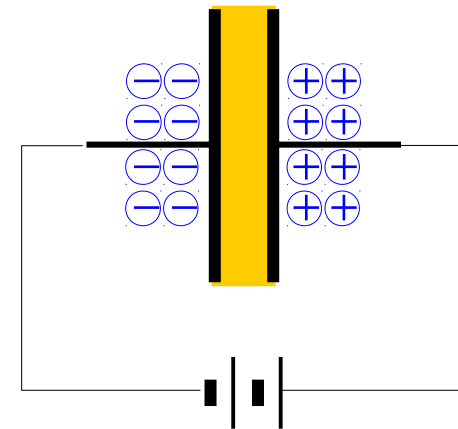
(-) current flow direction



electron flow direction

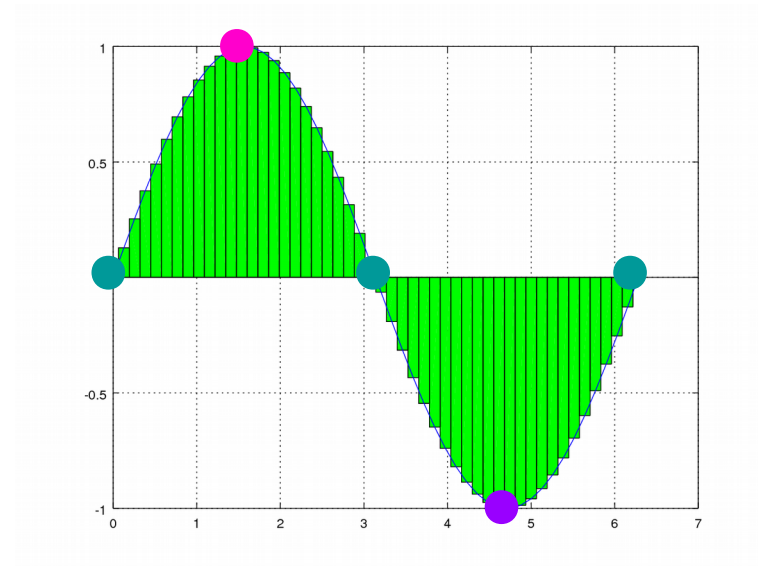
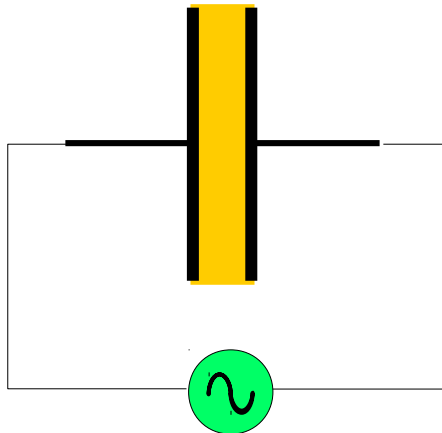
Negatively Charged State

no current

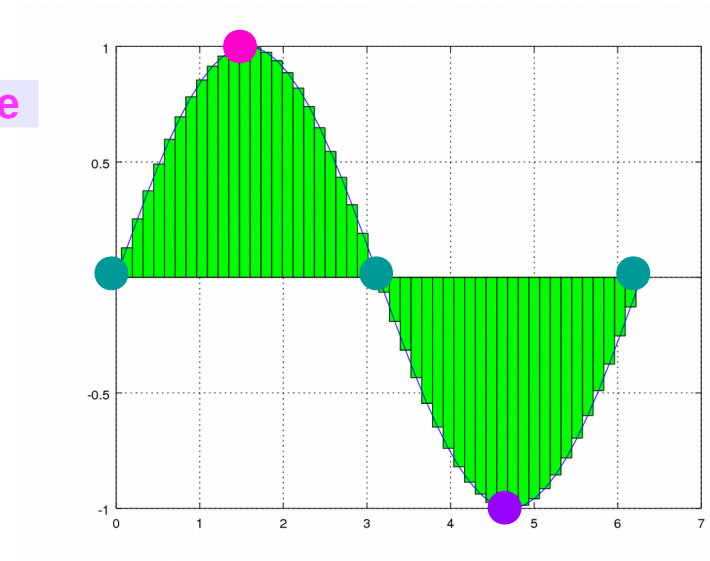
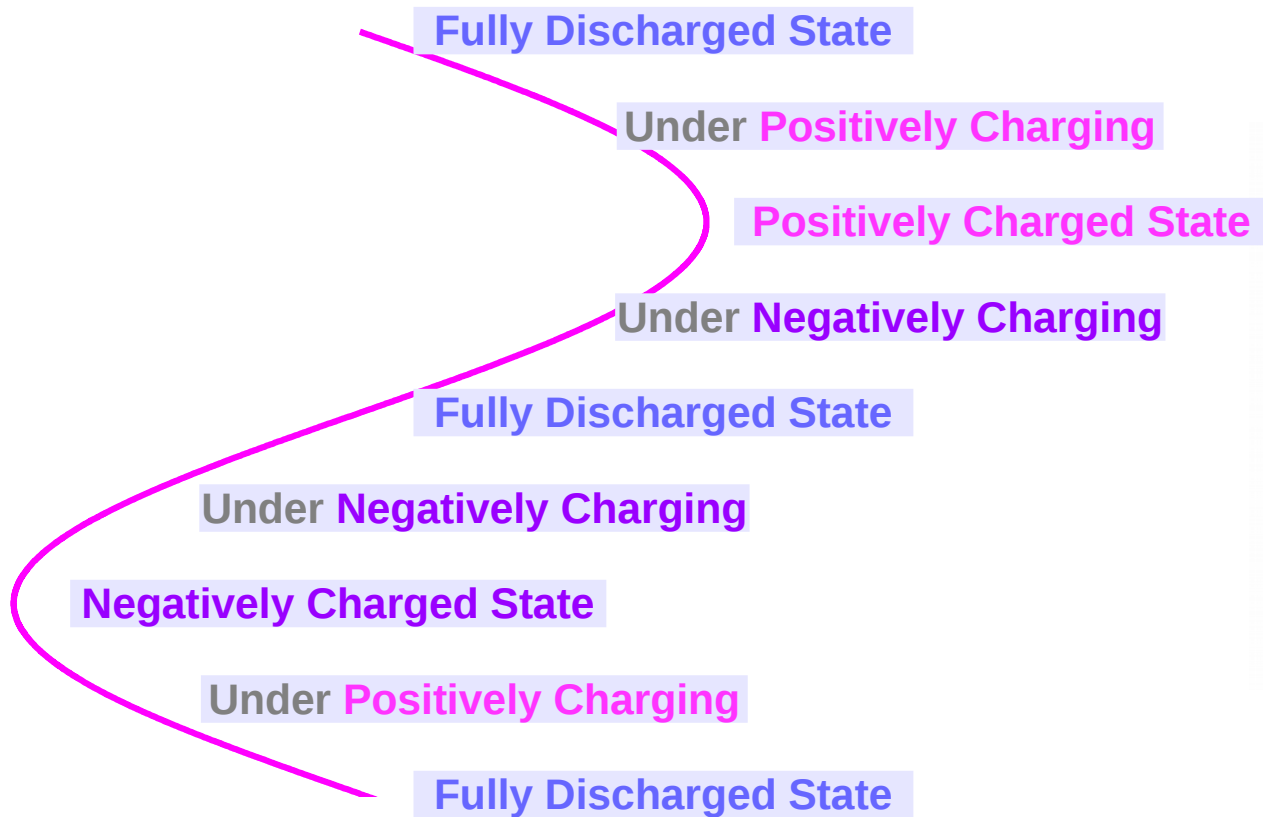


Crowded →
No more space

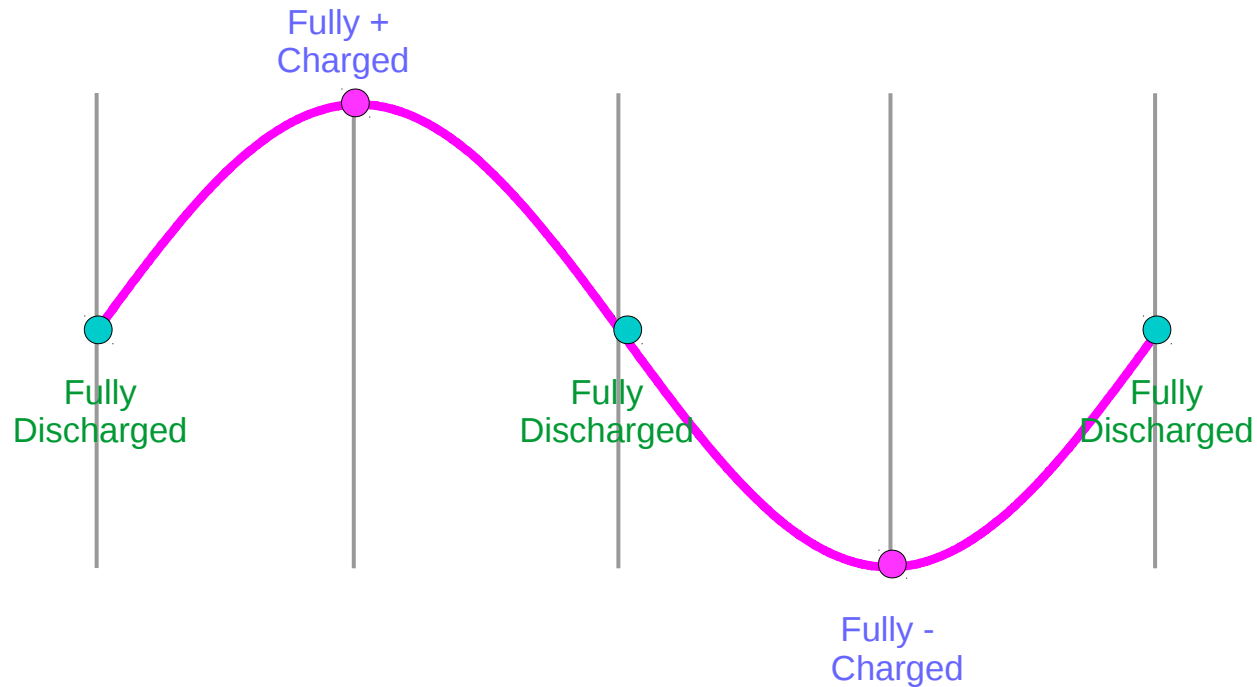
An AC Voltage Source



An AC Voltage Source

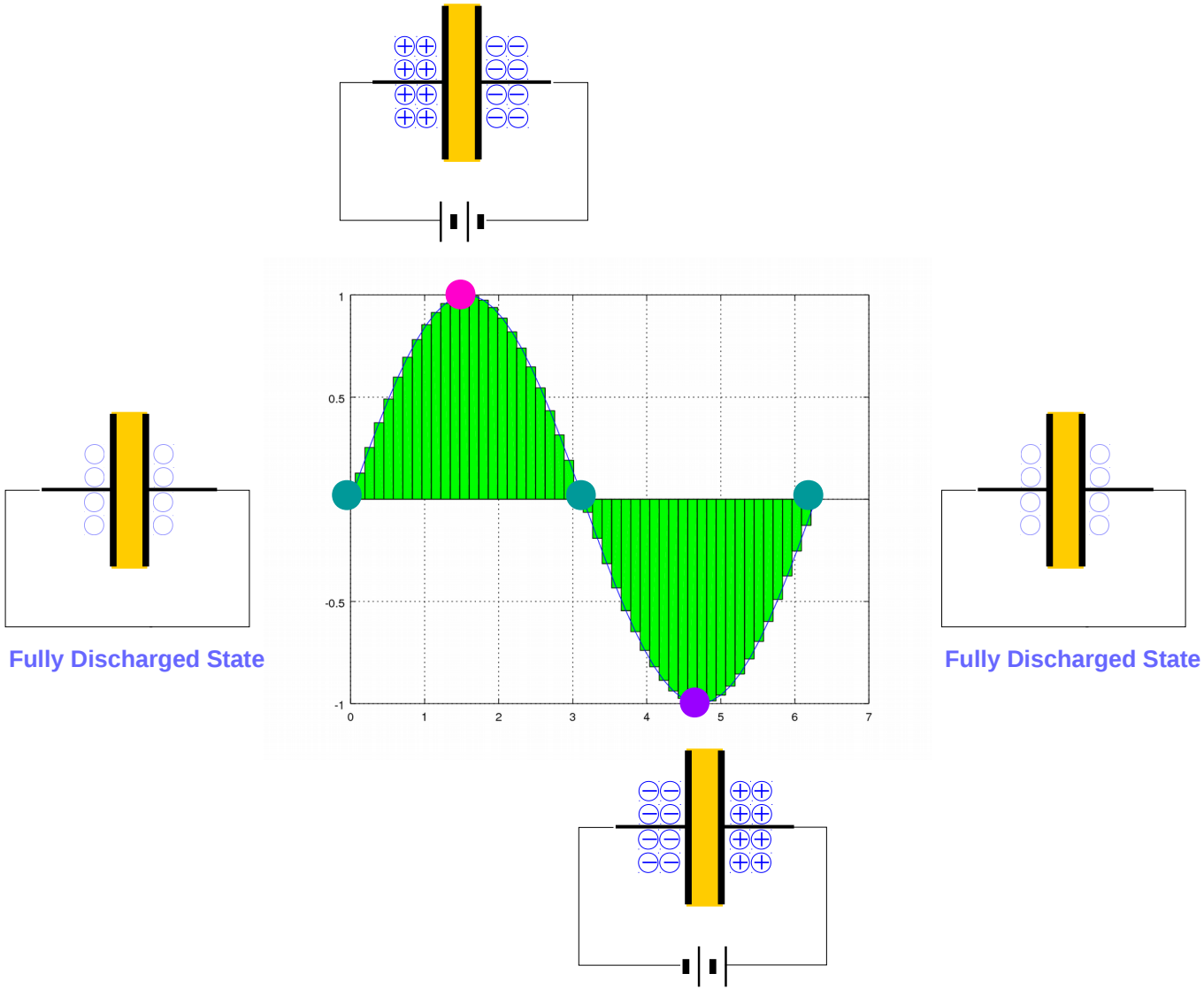


Fully Charged and Fully Discharged

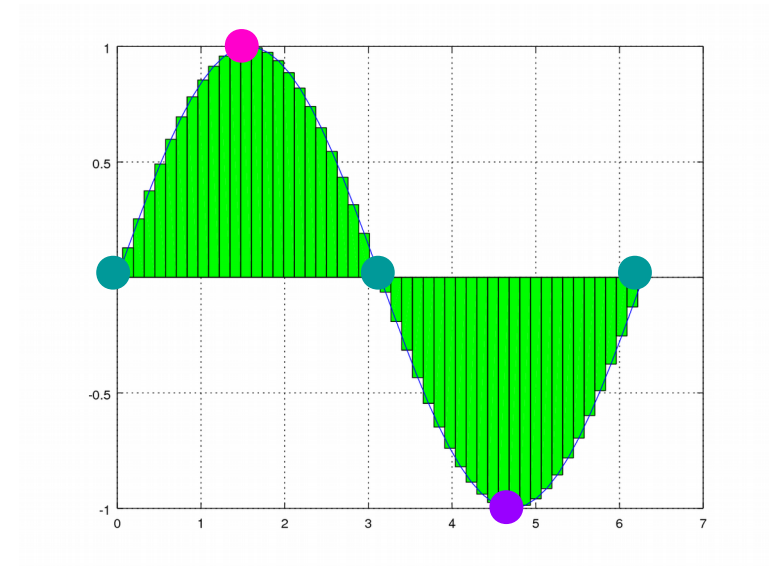
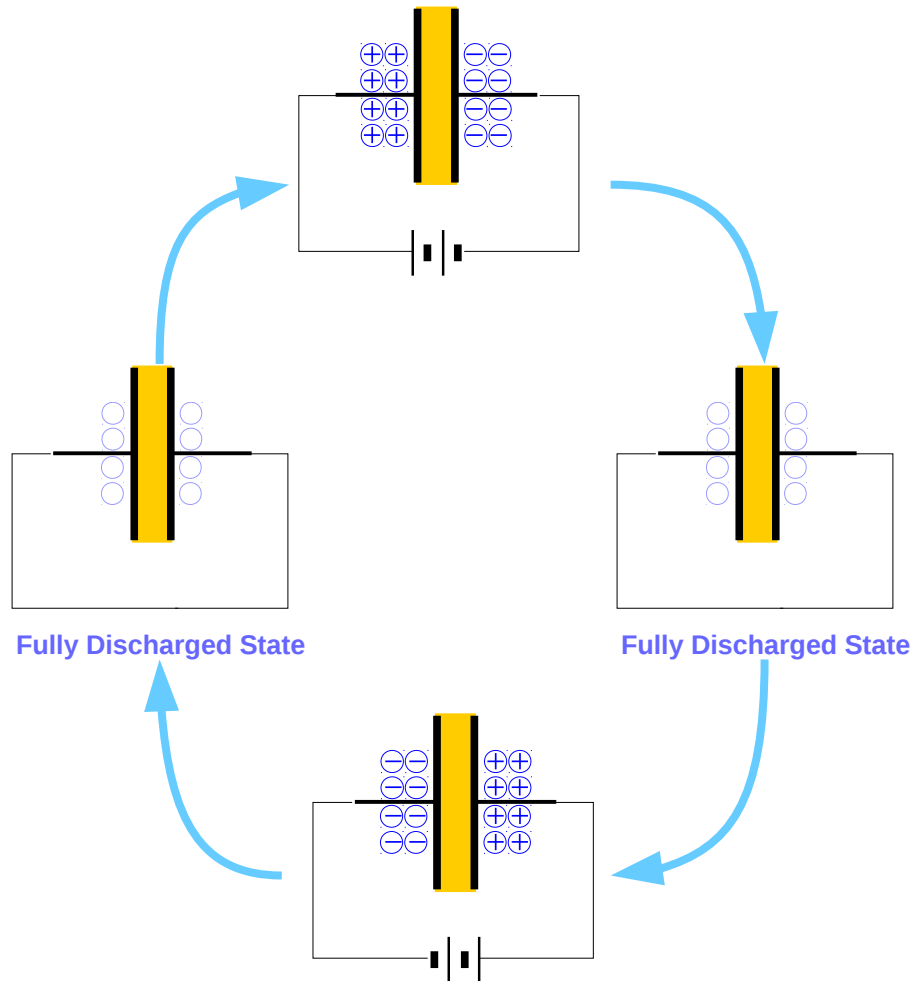


	(+) Charging	(-) Charging	(-) Charging	(+) Charging
(+) current	(+) current	(-) current	(-) current	(+) current
	(+) Charging	(+) Discharging	(-) Charging	(-) Discharging

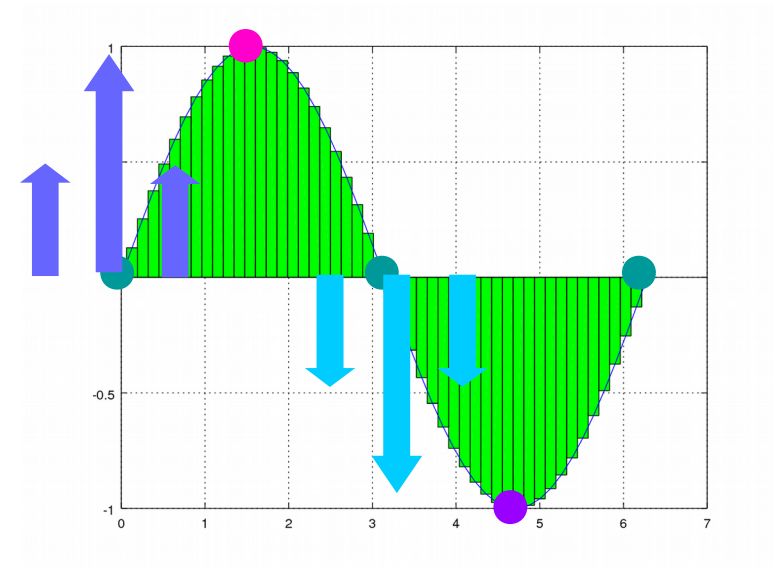
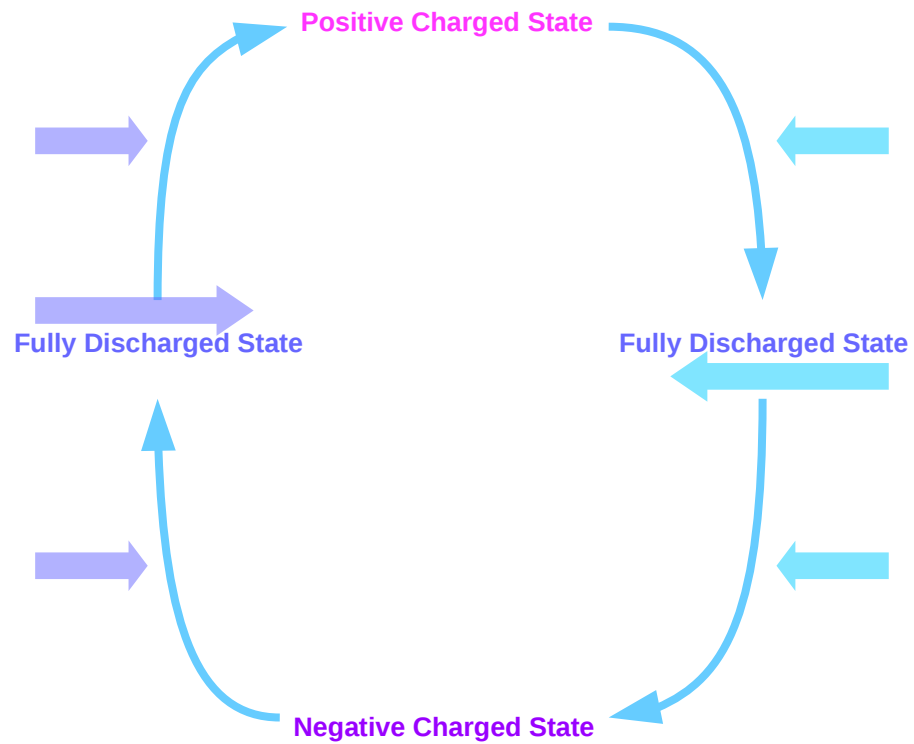
A Cycle



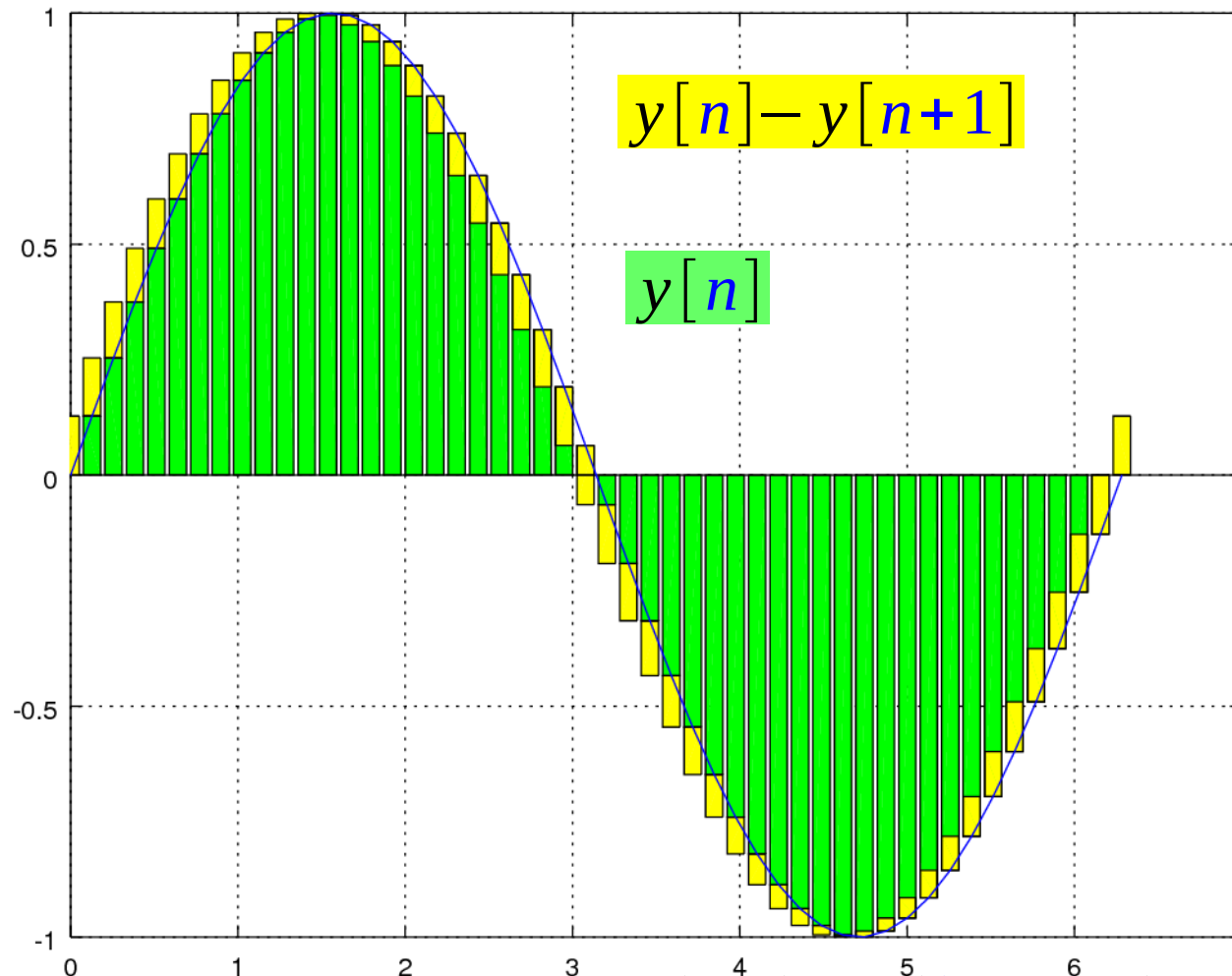
State Transition Diagram



Current Flow



Fully Charged and Fully Discharged



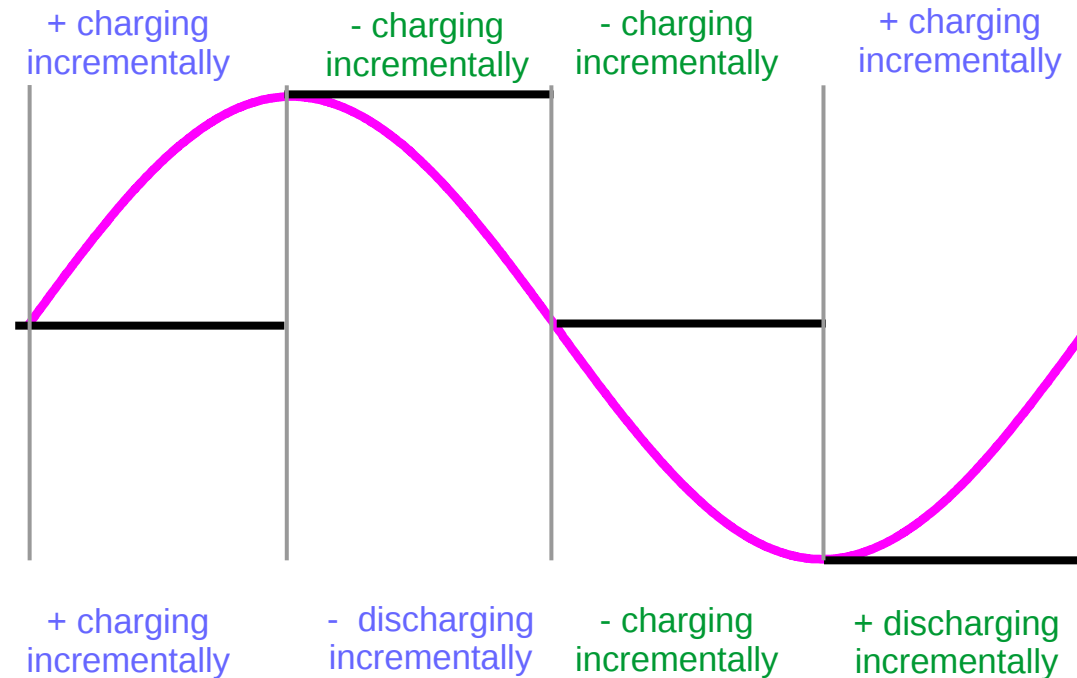
```
h = bar(t1, [y1' y2'],  
"stacked")  
set(h(1), "facecolor", "g");  
set(h(2), "facecolor", "y");  
hold on  
plot(t1, y1)  
axis([0 7 -1 1]);
```

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

Continuous Charging and Discharging Operations

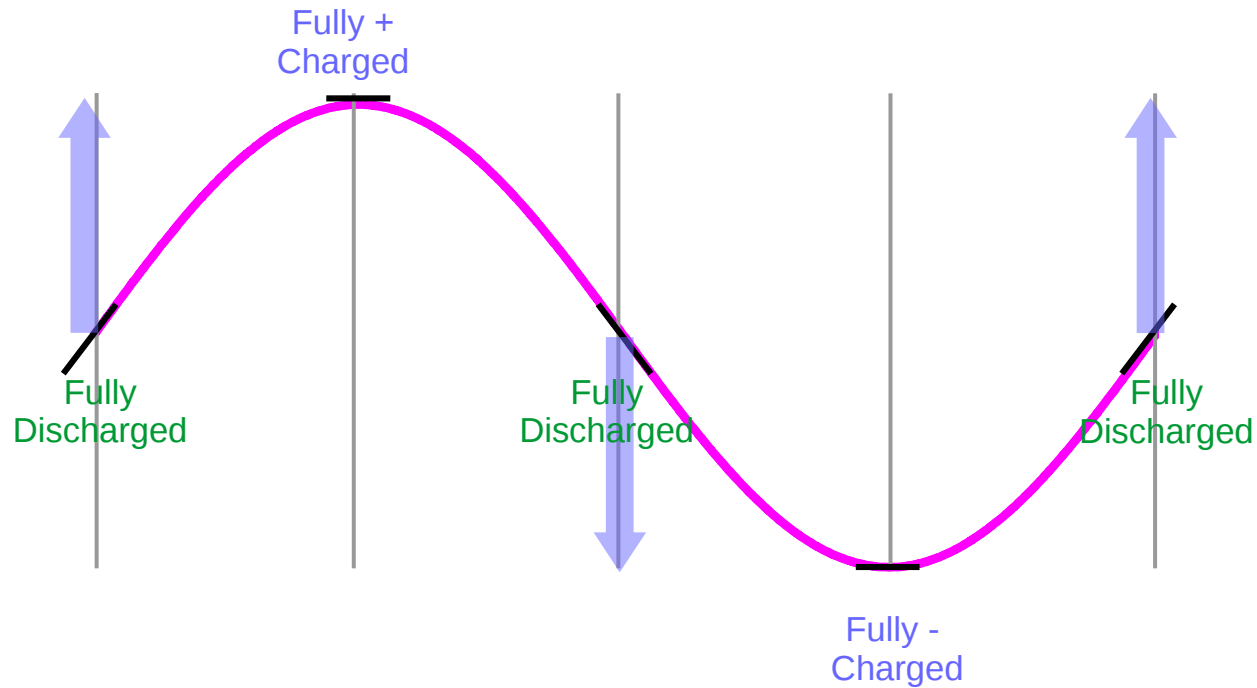
Incremental Voltage Increment \rightarrow + Charging incrementally

Incremental Voltage Decrement \rightarrow - Charging incrementally

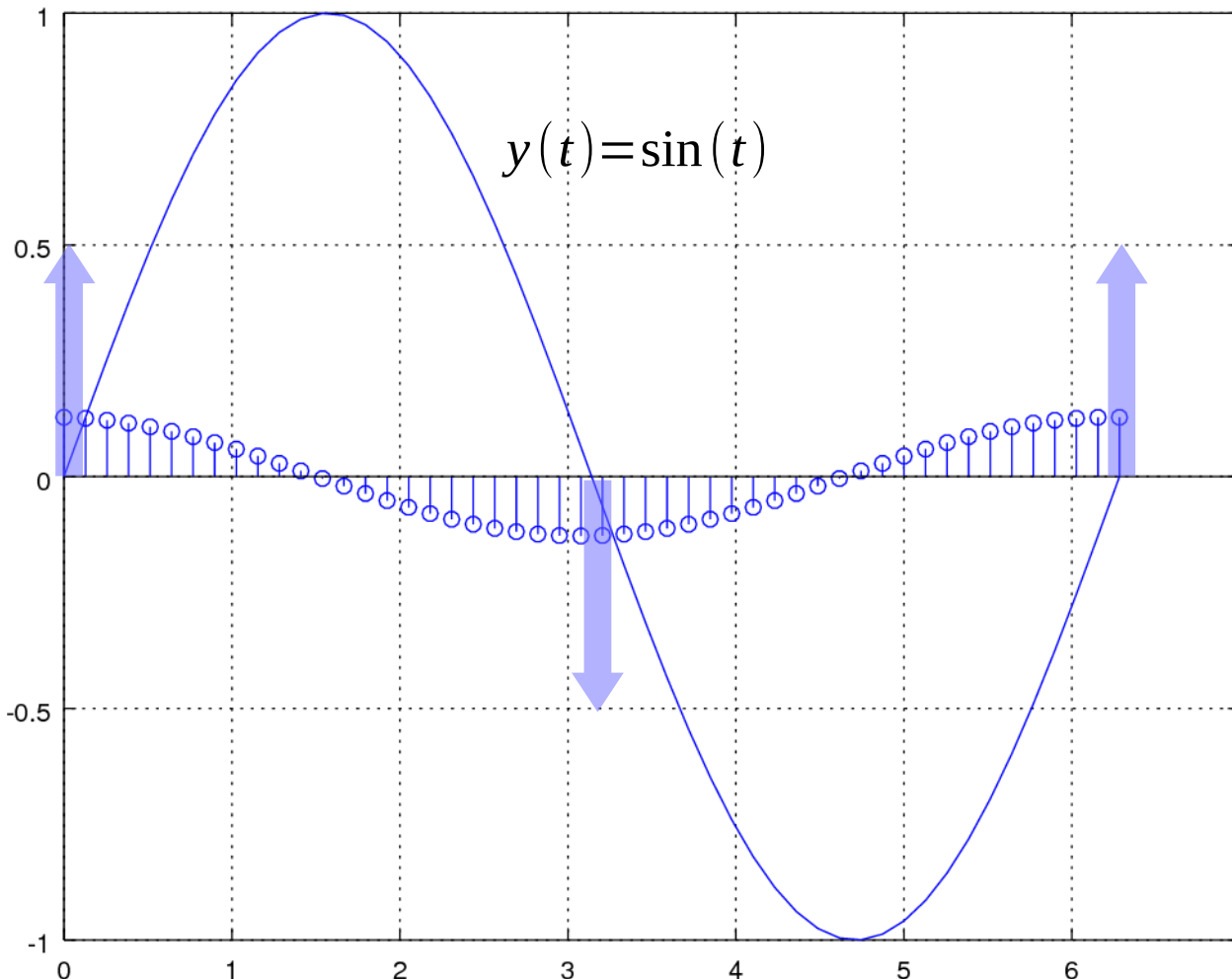


Fully Discharged : Large Current

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



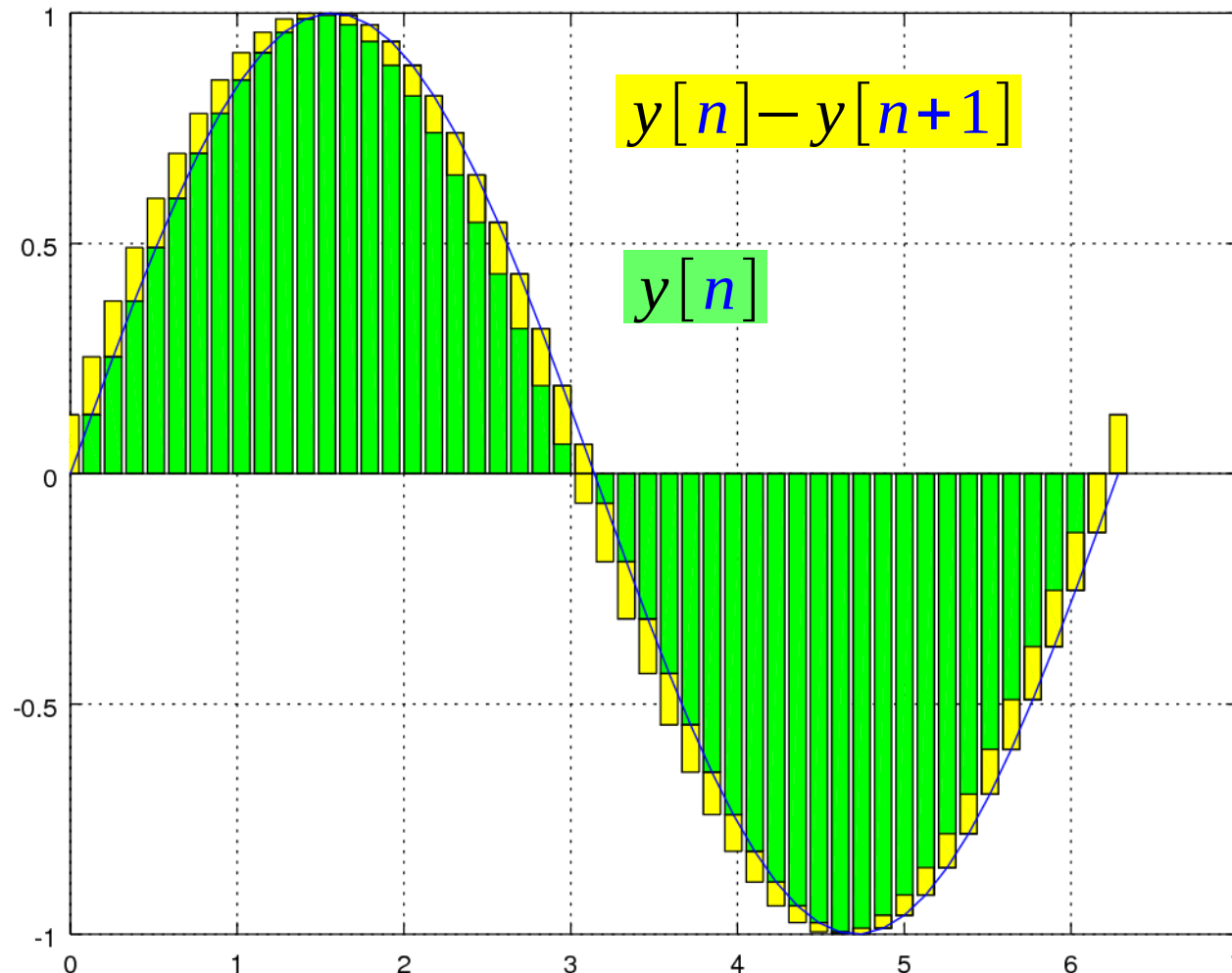
$y[n+1] - y[n]$



```
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)
```

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

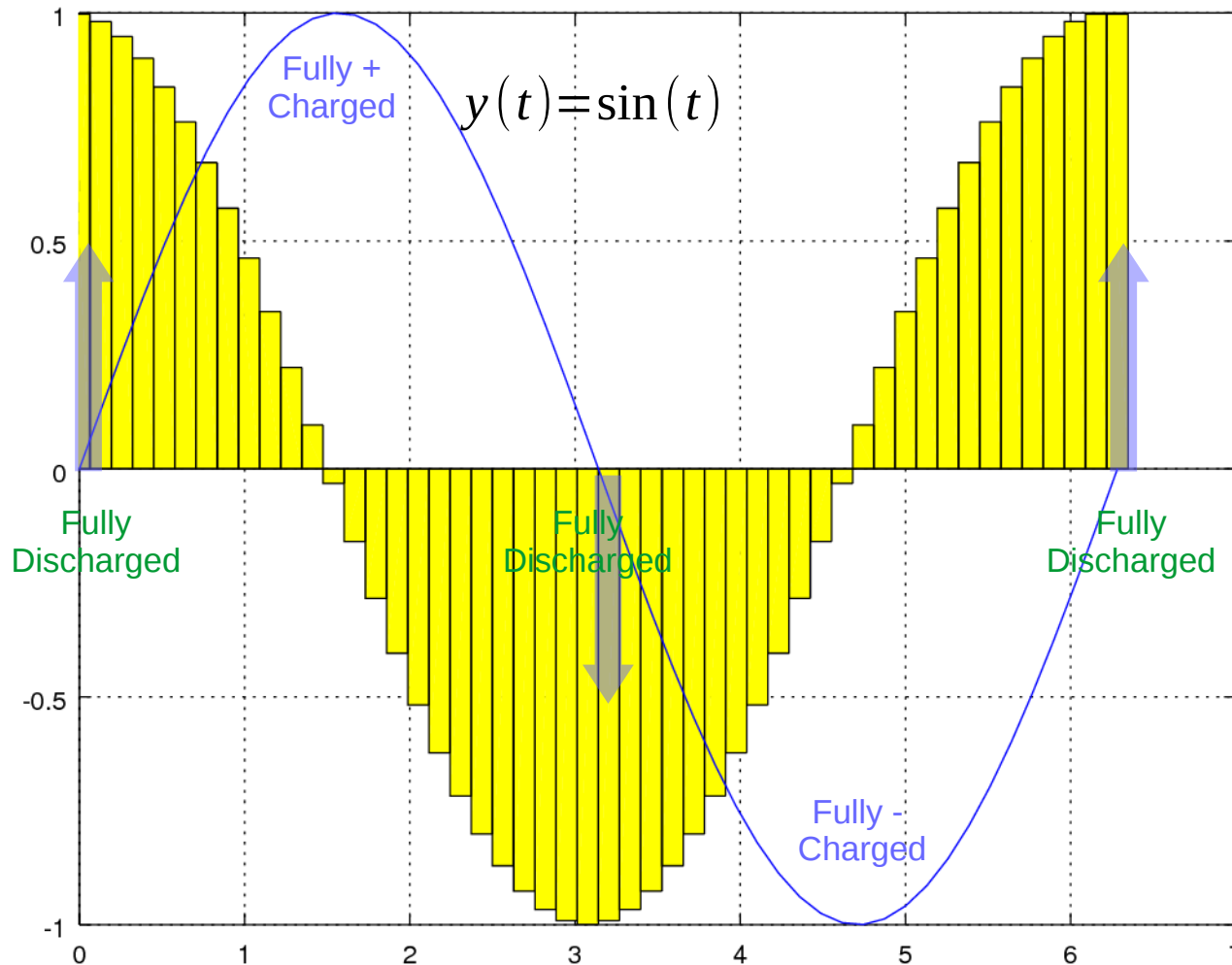
Fully Charged and Fully Discharged



```
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

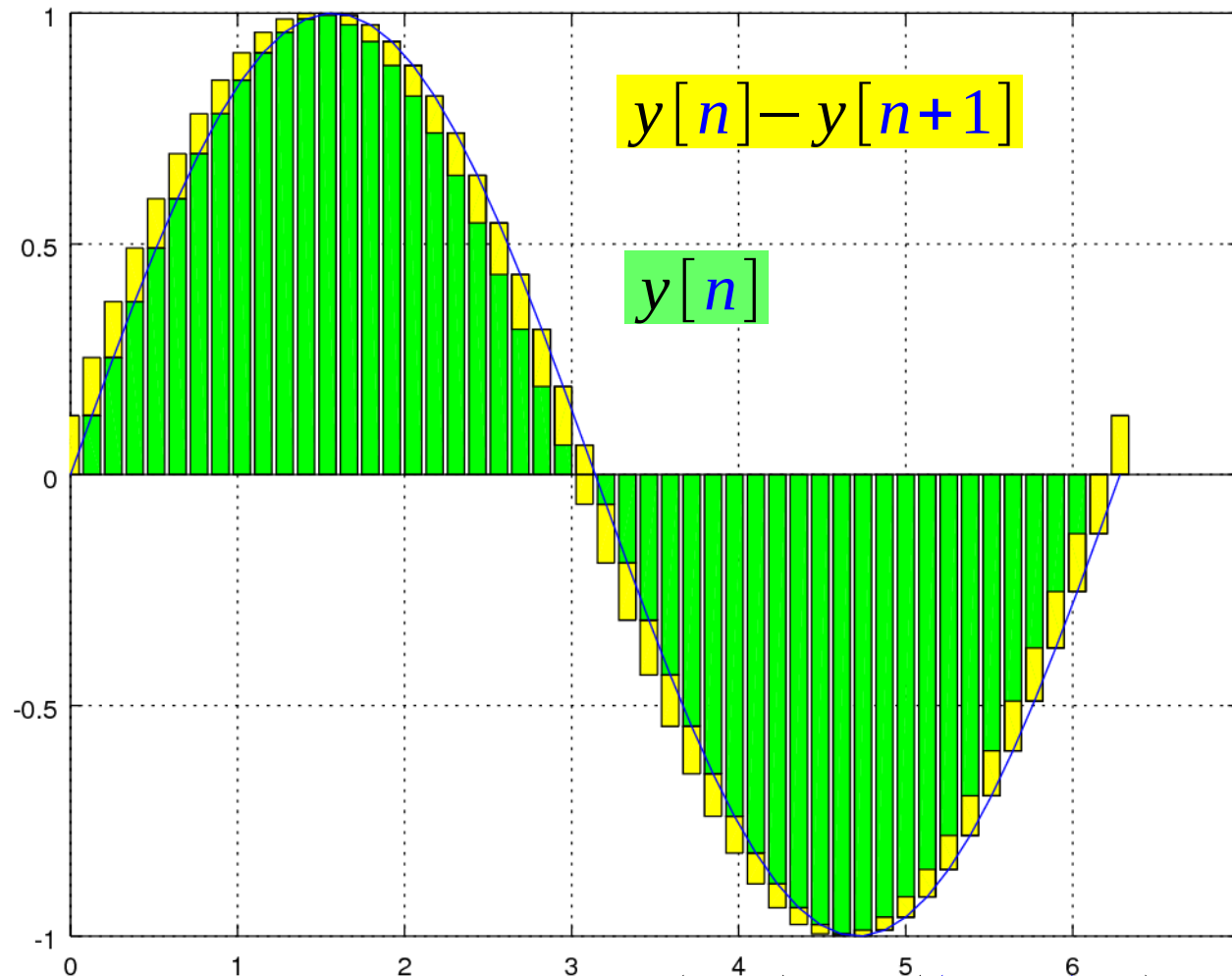


```
h = bar(t1, y2/t(2), "hist")
set(h(1), "facecolor", "y");
hold on
plot(t1, y1)
axis([0 7 -1 1]);
```

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

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

Fully Charged and Fully Discharged

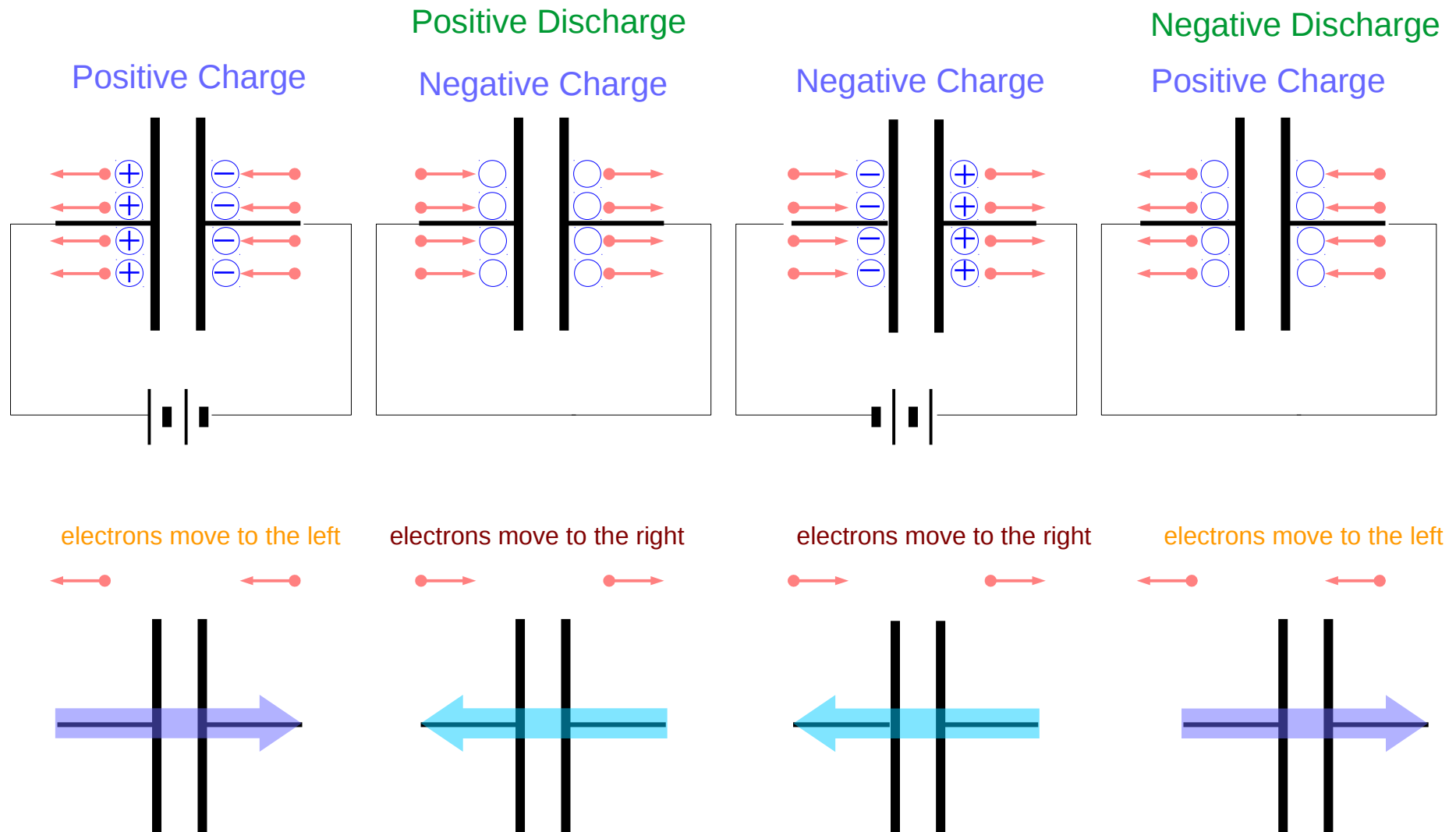


```

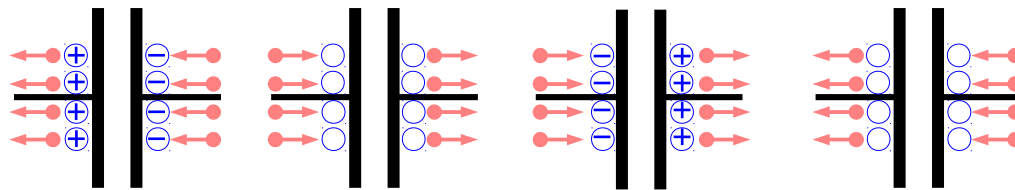
h = bar(t1, [y1' y2'],
"stacked")
set(h(1), "facecolor", "g");
set(h(2), "facecolor", "y");
hold on
plot(t1, y1)
axis([0 pi]);
    
```

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

Everchanging signal pairs

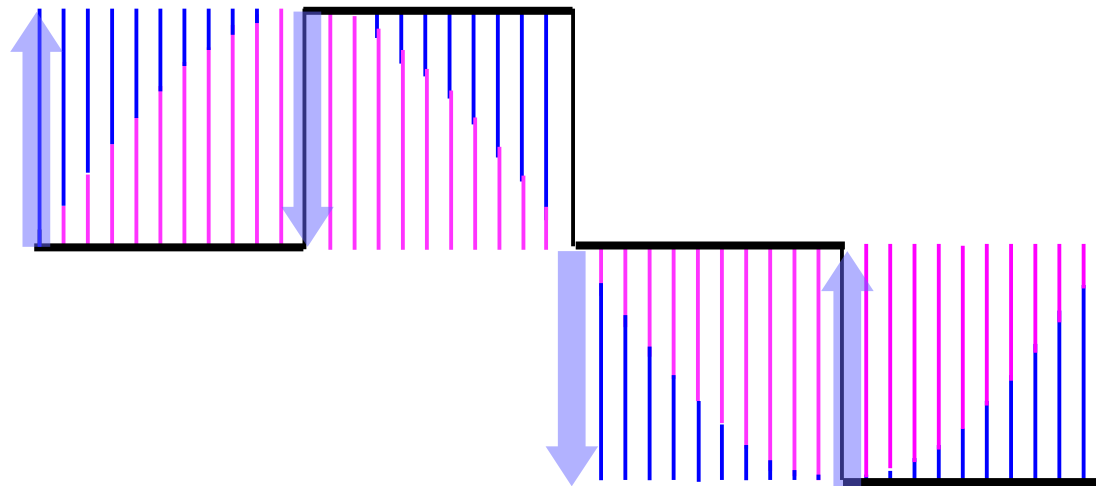


Everchanging signal pairs



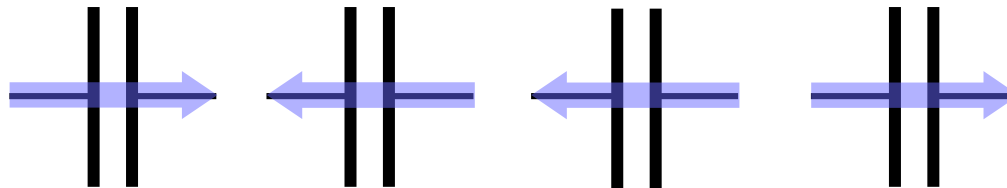
charge

discharge

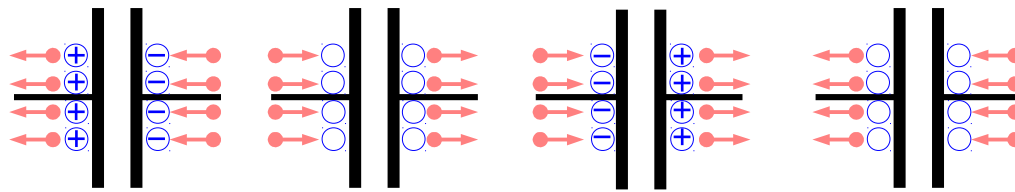


charge

discharge

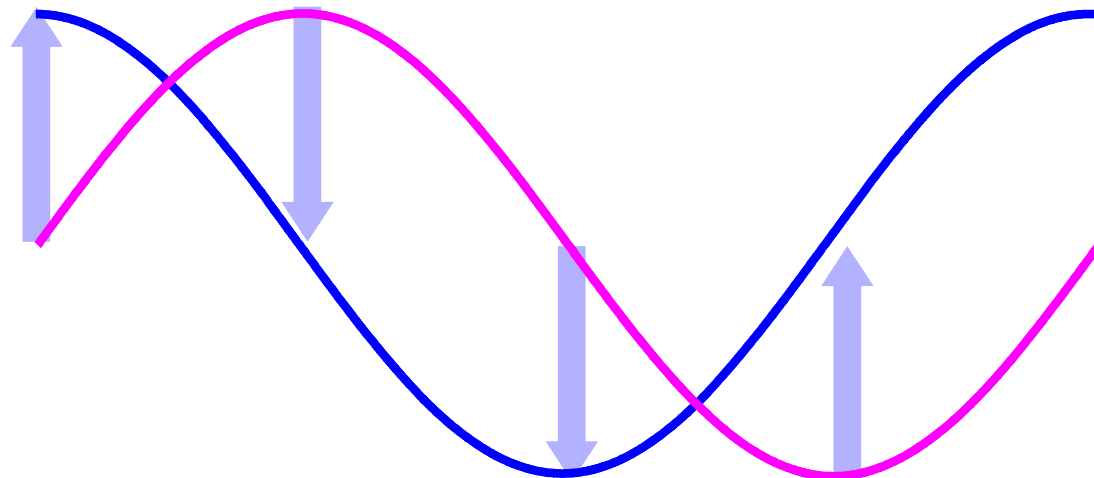


Everchanging signal pairs



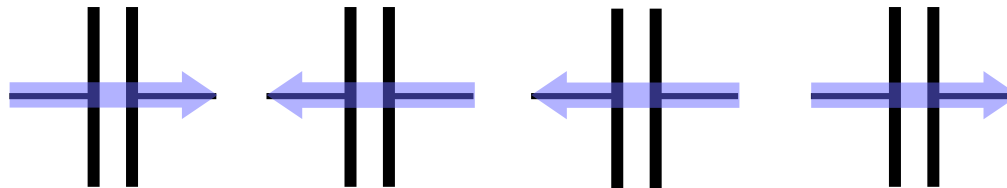
charge

discharge

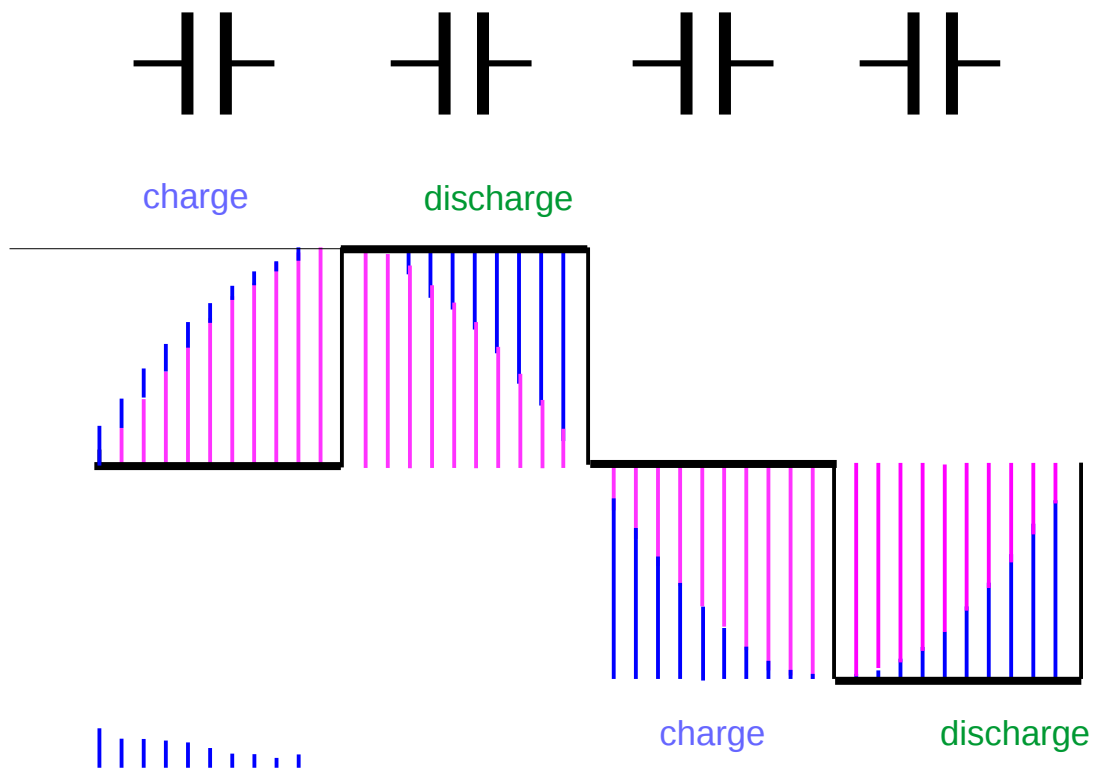


charge

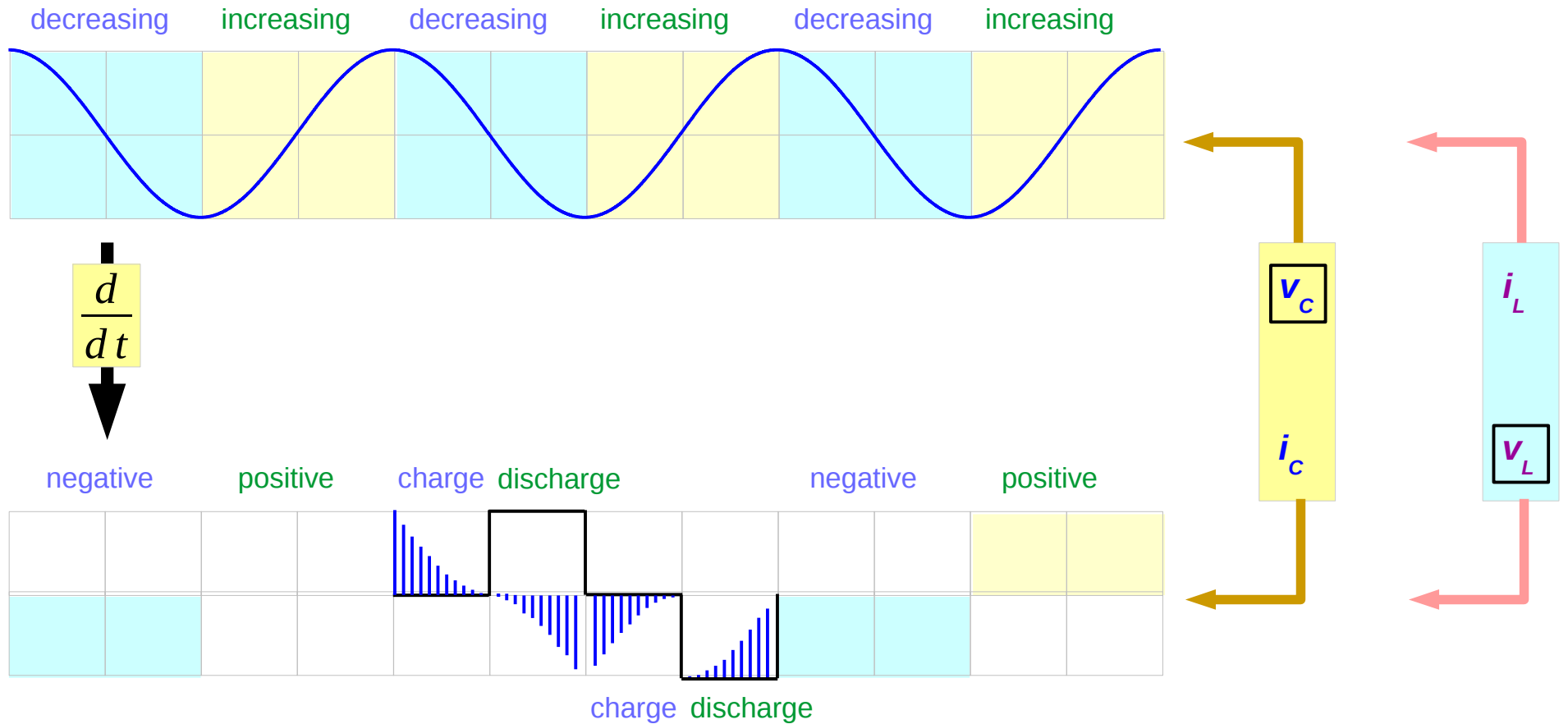
discharge



Everchanging signal pairs

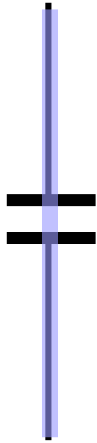


Everchanging signal pairs



I leads V by 90°

Initial charge

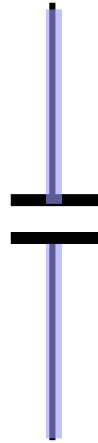


SHORT

V = 0

I : peak

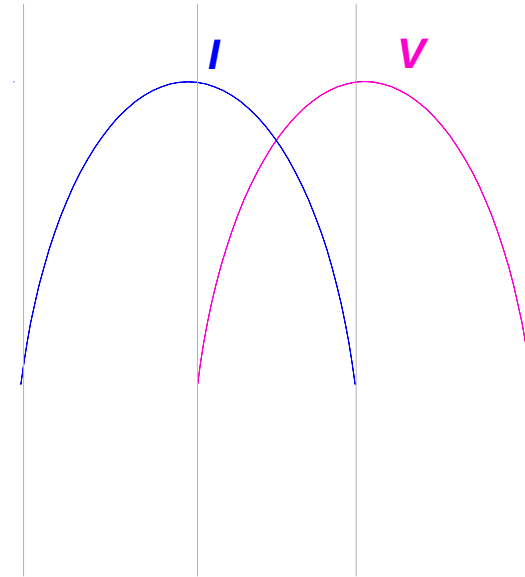
Full charge



OPEN

I = 0

V : peak



References

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

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