

# Capacitor in an AC circuit

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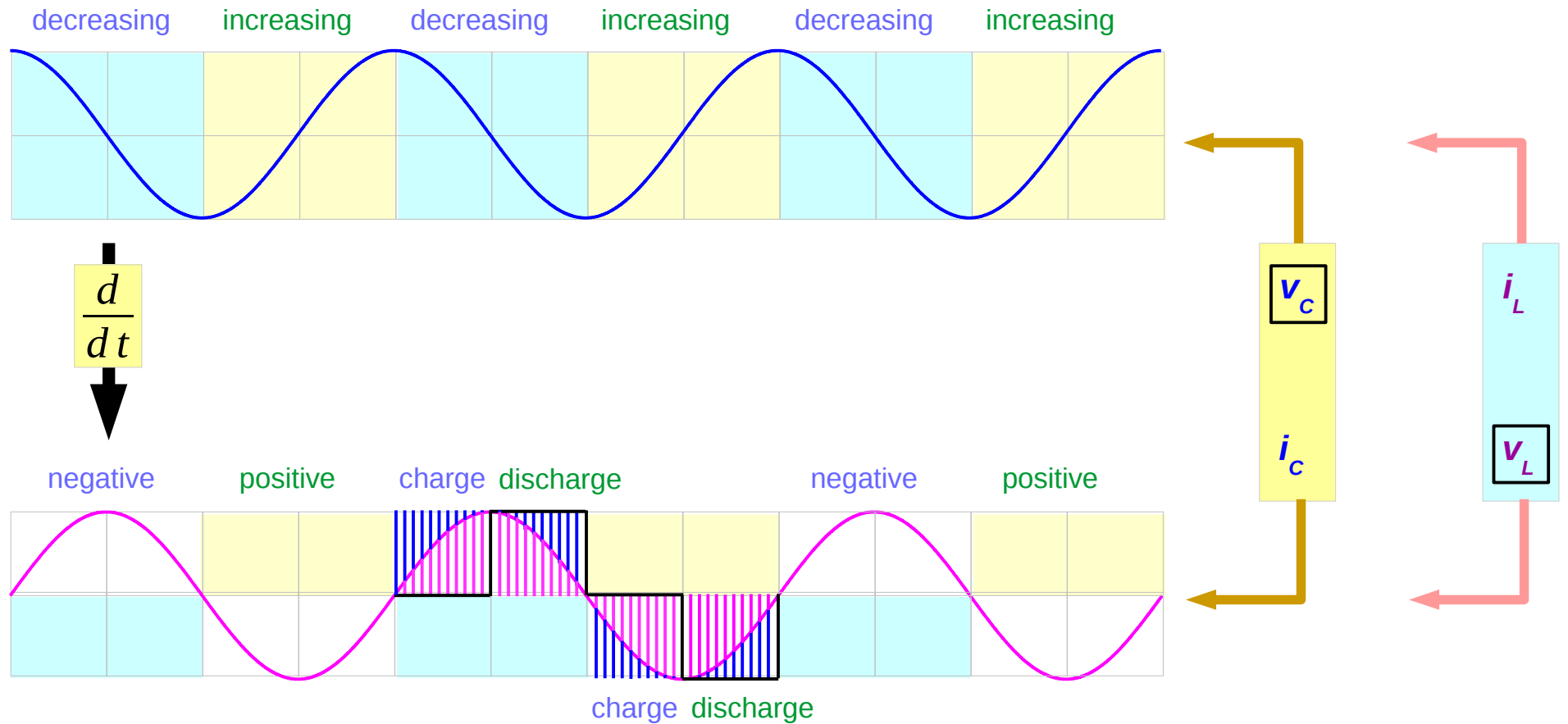
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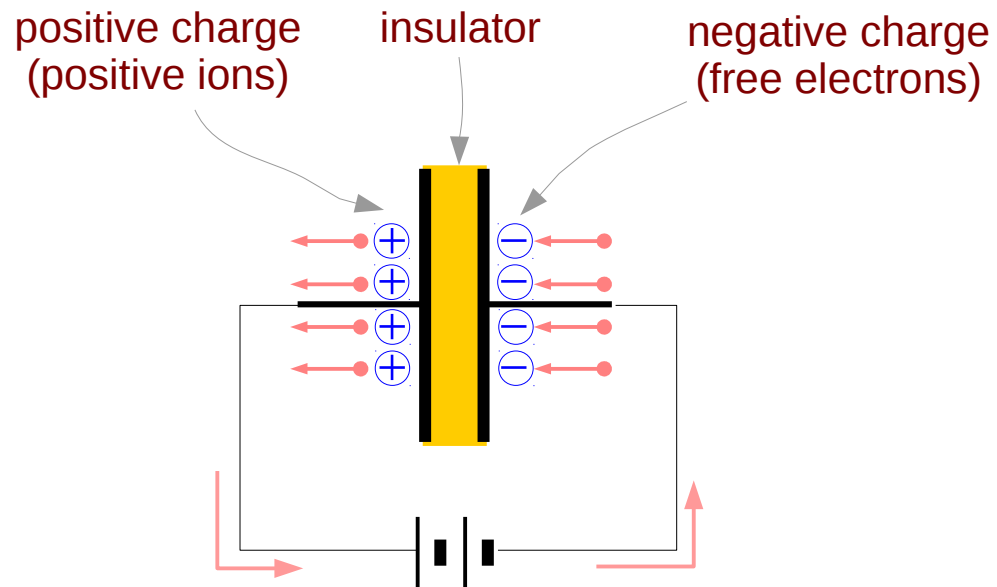
Please send corrections (or suggestions) to [youngwlim@hotmail.com](mailto:youngwlim@hotmail.com).

This document was produced by using OpenOffice and Octave.

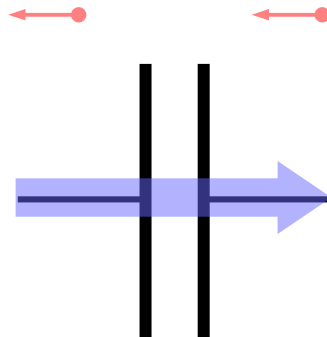
# Everchanging signal pairs



# Capacitor Current

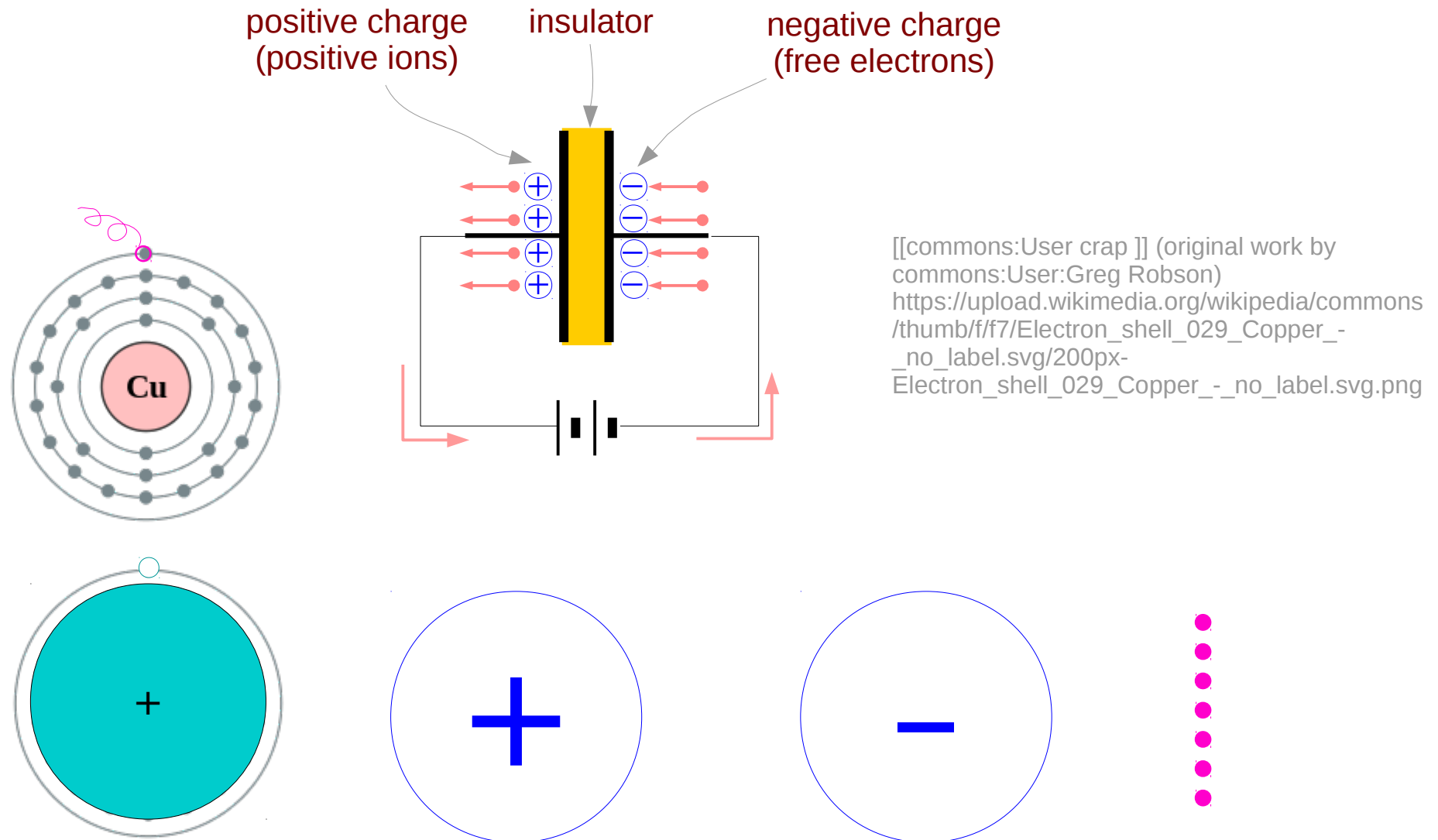


Think as electrons move to the left



Displacement Current

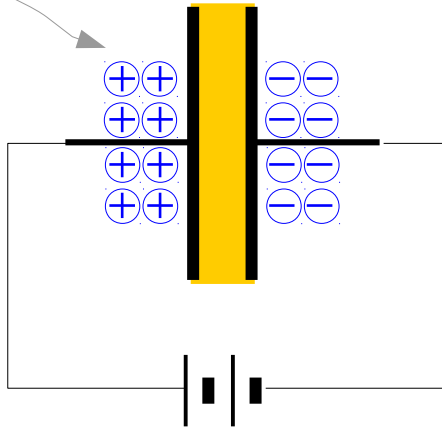
# Positive ions and free electrons



# Three States

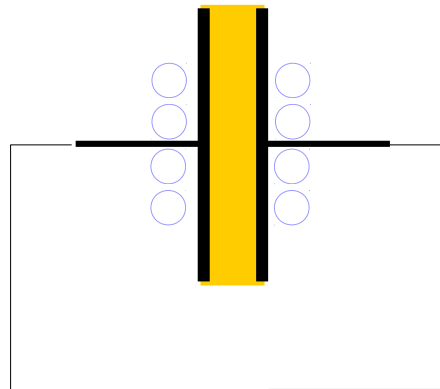
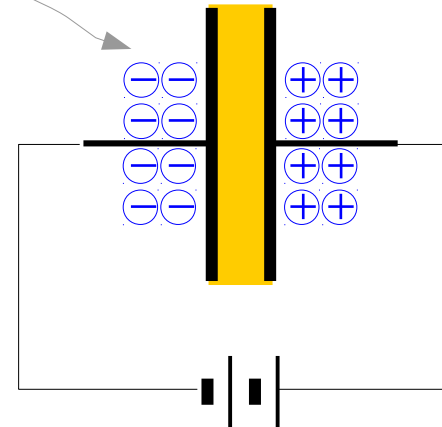
positive charge  
(positive ions)

**Positive Charged State**  
fully charged → no current



negative charge  
(free electrons)

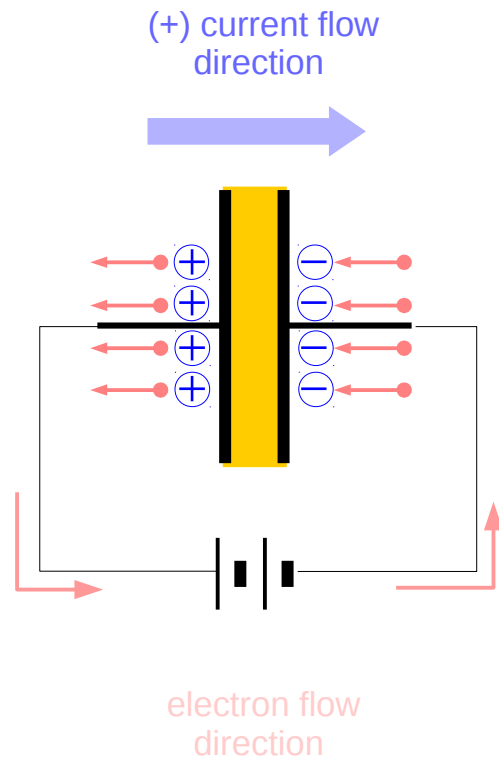
**Negative Charged State**  
fully charged → no current



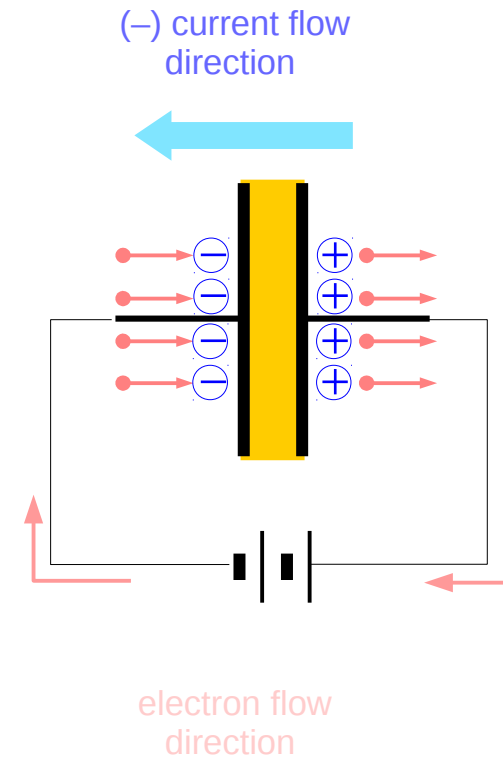
**Fully Discharged State**  
large current

# Inter-State Current Flowing

## Under Positive Charging



## Under Negative Charging

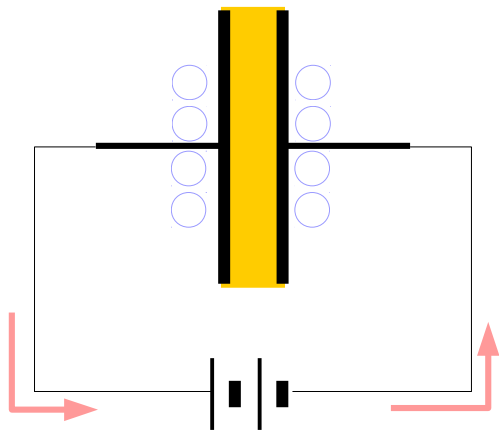


# Inter-State Current Flowing

## Fully Discharged State

Initial large current

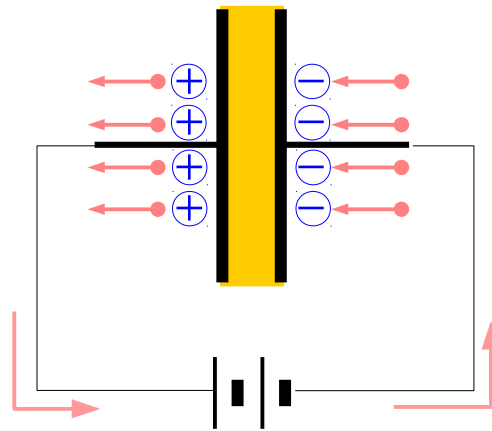
(+) current flow direction



electron flow direction

## Under Positive Charging

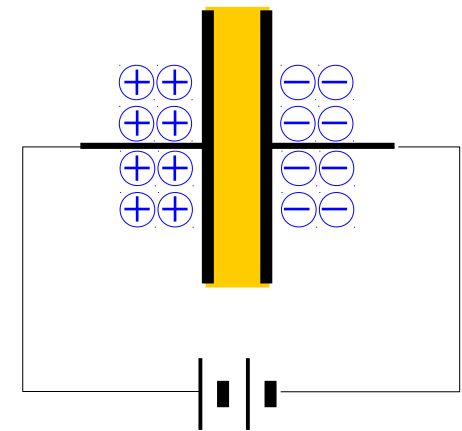
(+) current flow direction



electron flow direction

## Positive Charged State

no current



Crowded  
No more space

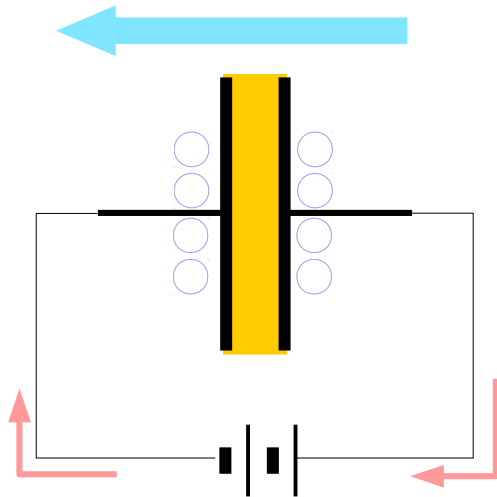


# Inter-State Current Flowing

## Fully Discharged State

Initial large current

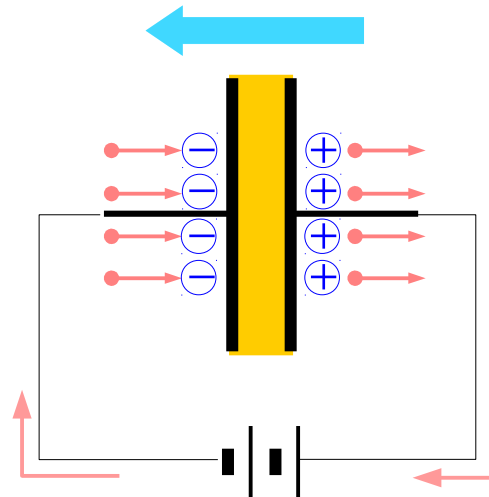
(-) current flow direction



electron flow direction

## Under Negative Charging

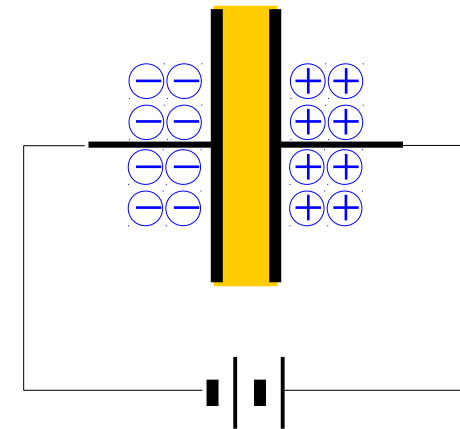
(-) current flow direction



electron flow direction

## Negative Charged State

no current



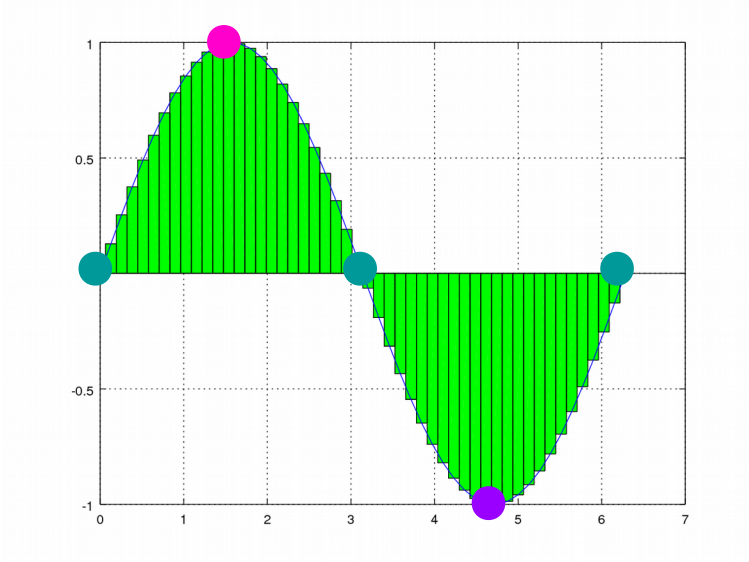
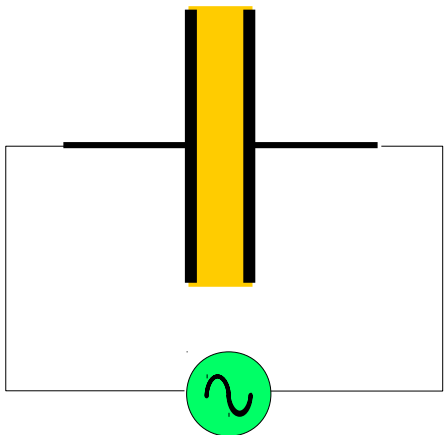
Crowded  
No more space

# 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

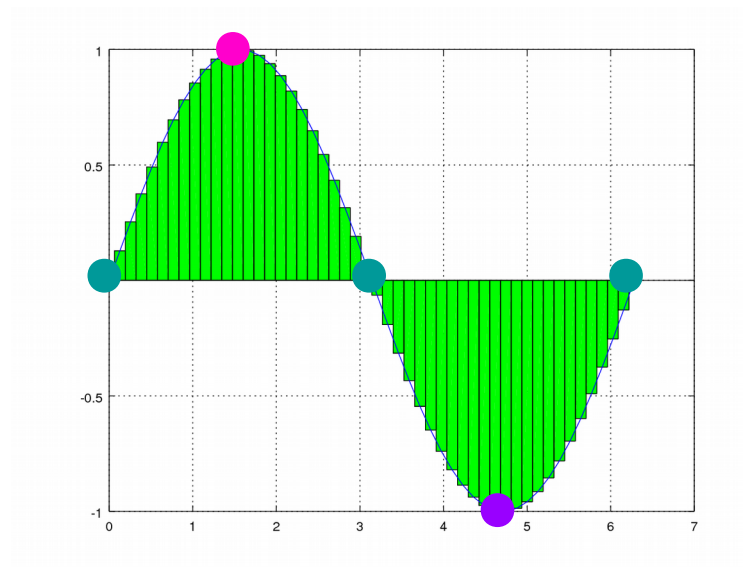
Fully Discharged State

Under Negative Charging

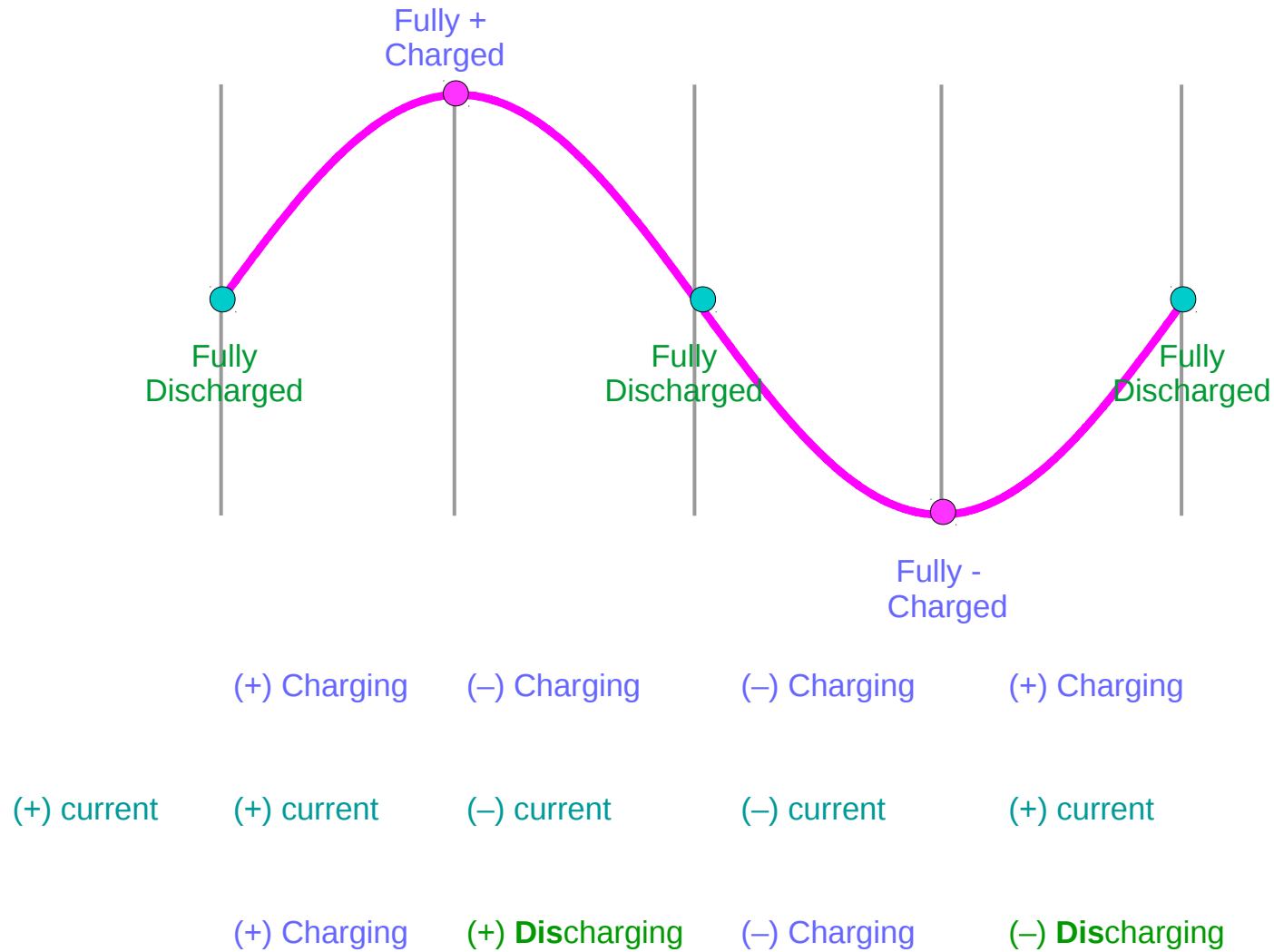
Negative Charged State

Under Positive Charging

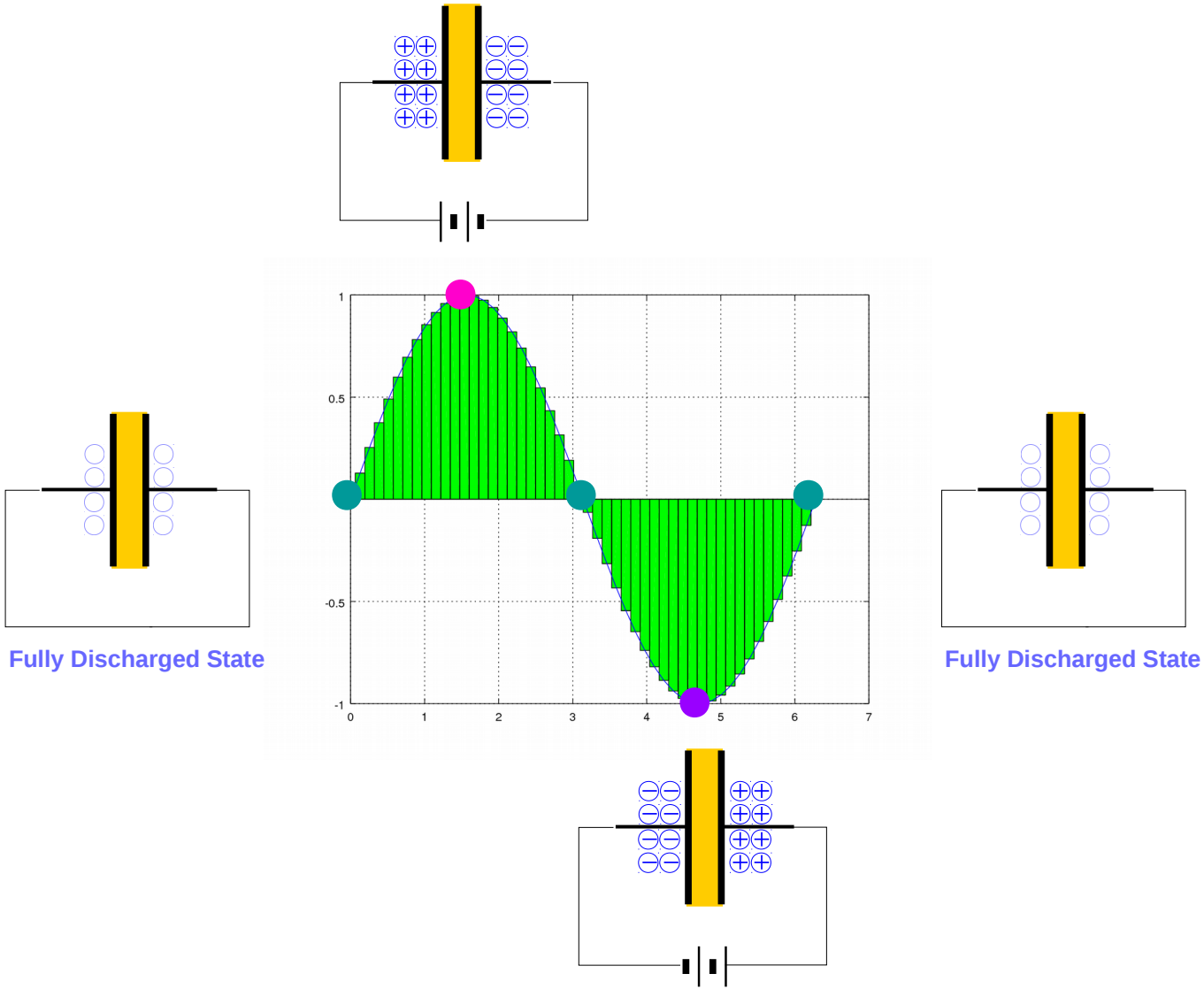
Fully Discharged State



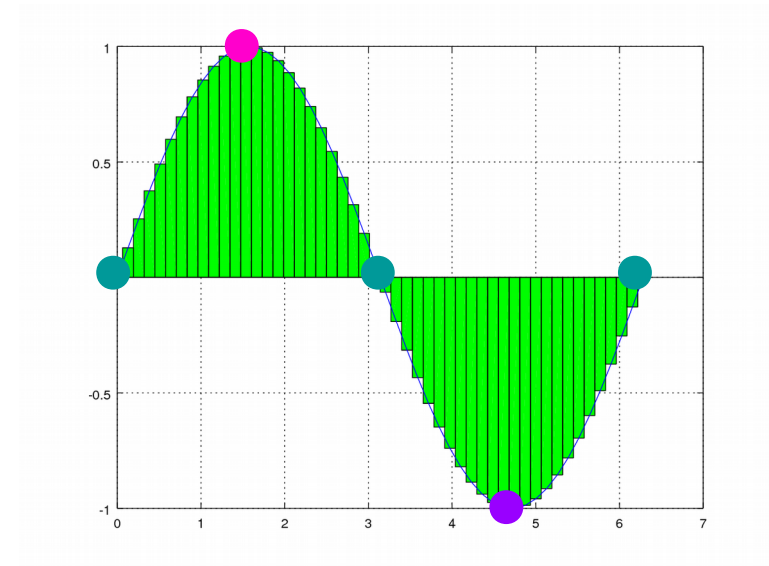
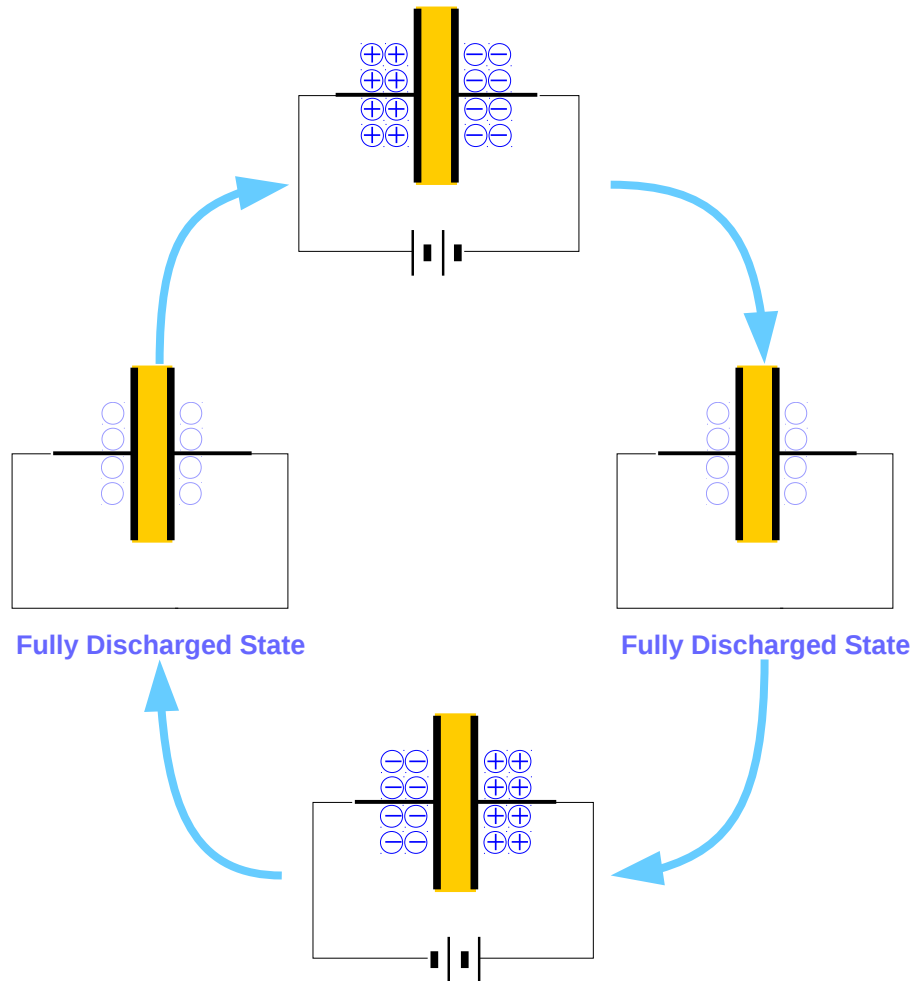
# Fully Charged and Fully Discharged



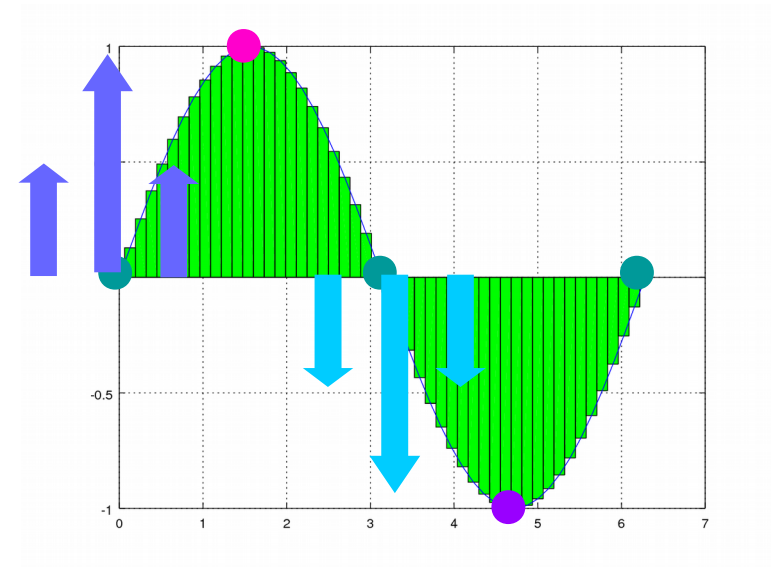
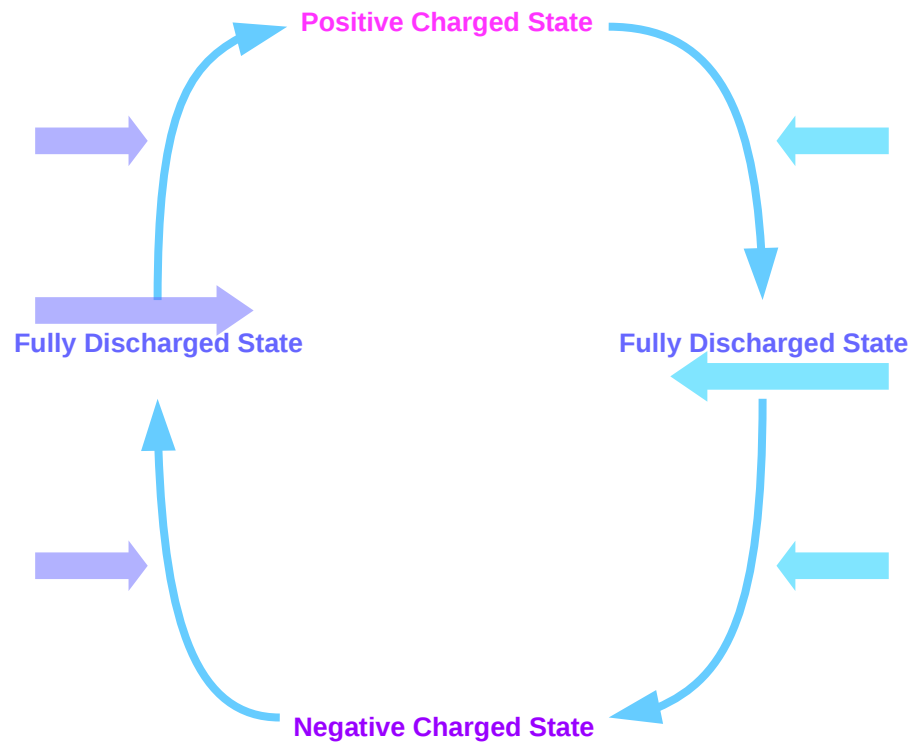
# A Cycle



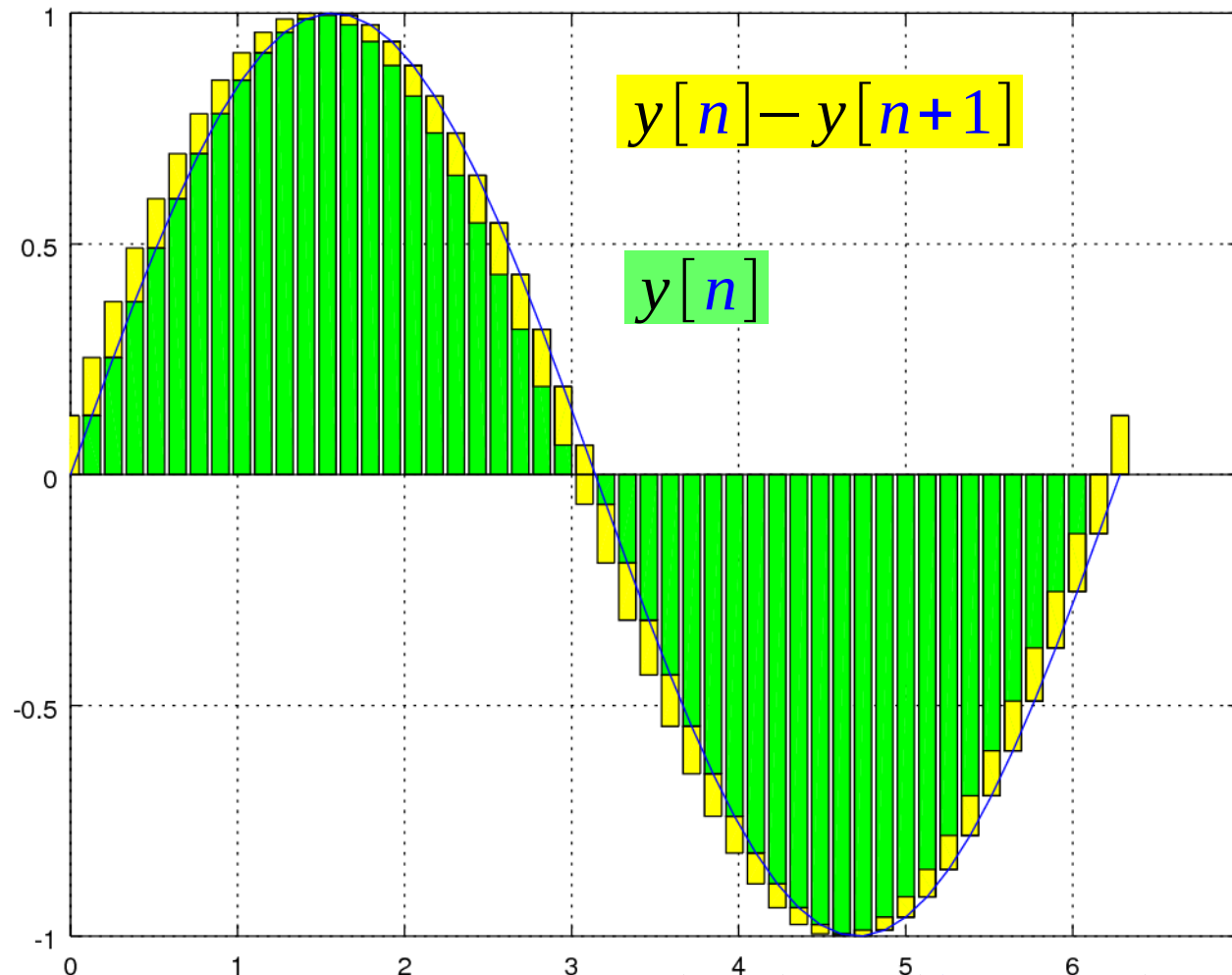
# State Transition Diagram



# 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]);
    
```

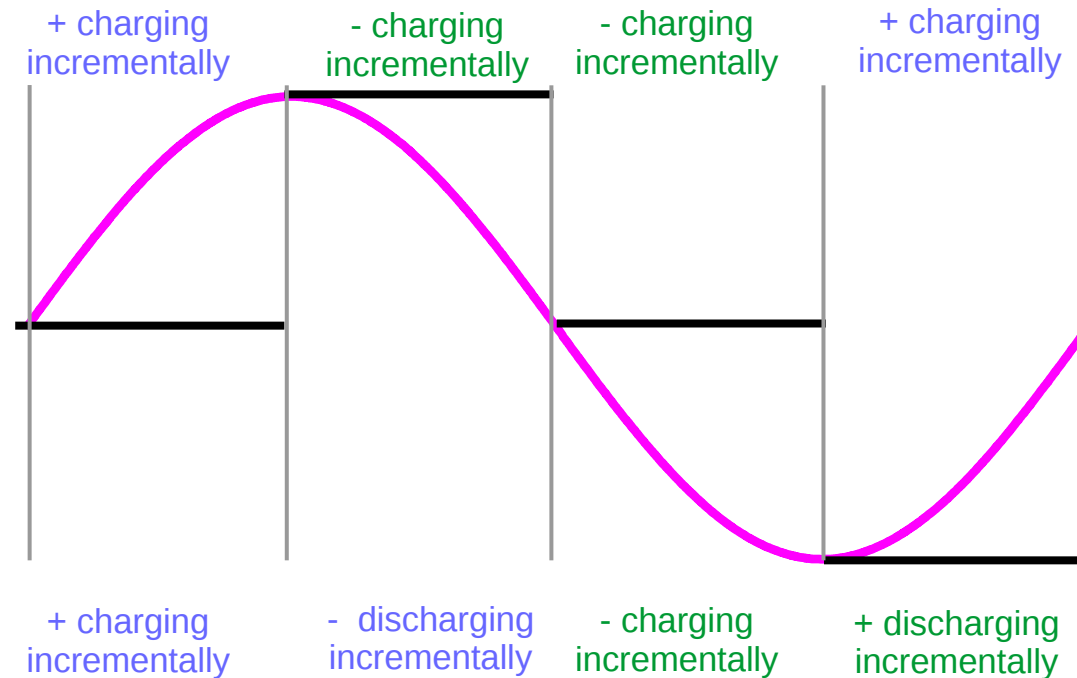
$$y[n] - y[n+1] = y(nT) - y((n+1)T) = \sin(nT) - \sin((n+1)T)$$



# Continuous Charging and Discharging Operations

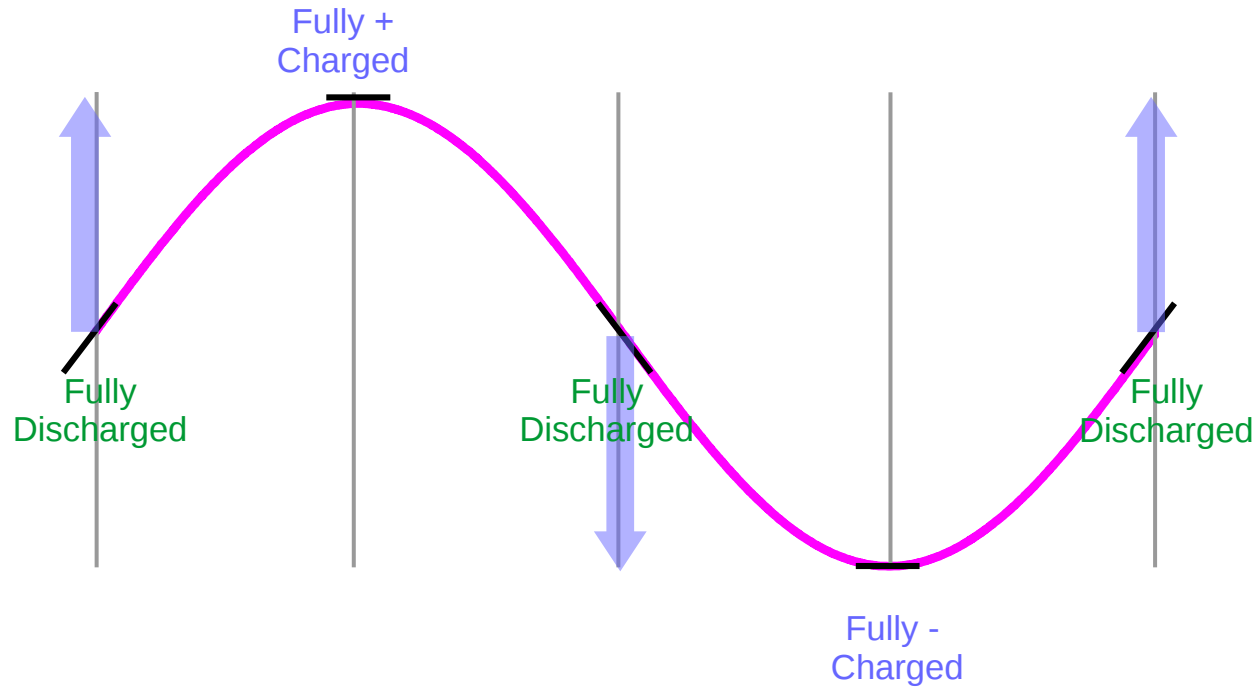
Incremental Voltage Increment  $\rightarrow$  + Charging incrementally

Incremental Voltage Decrement  $\rightarrow$  - Charging incrementally

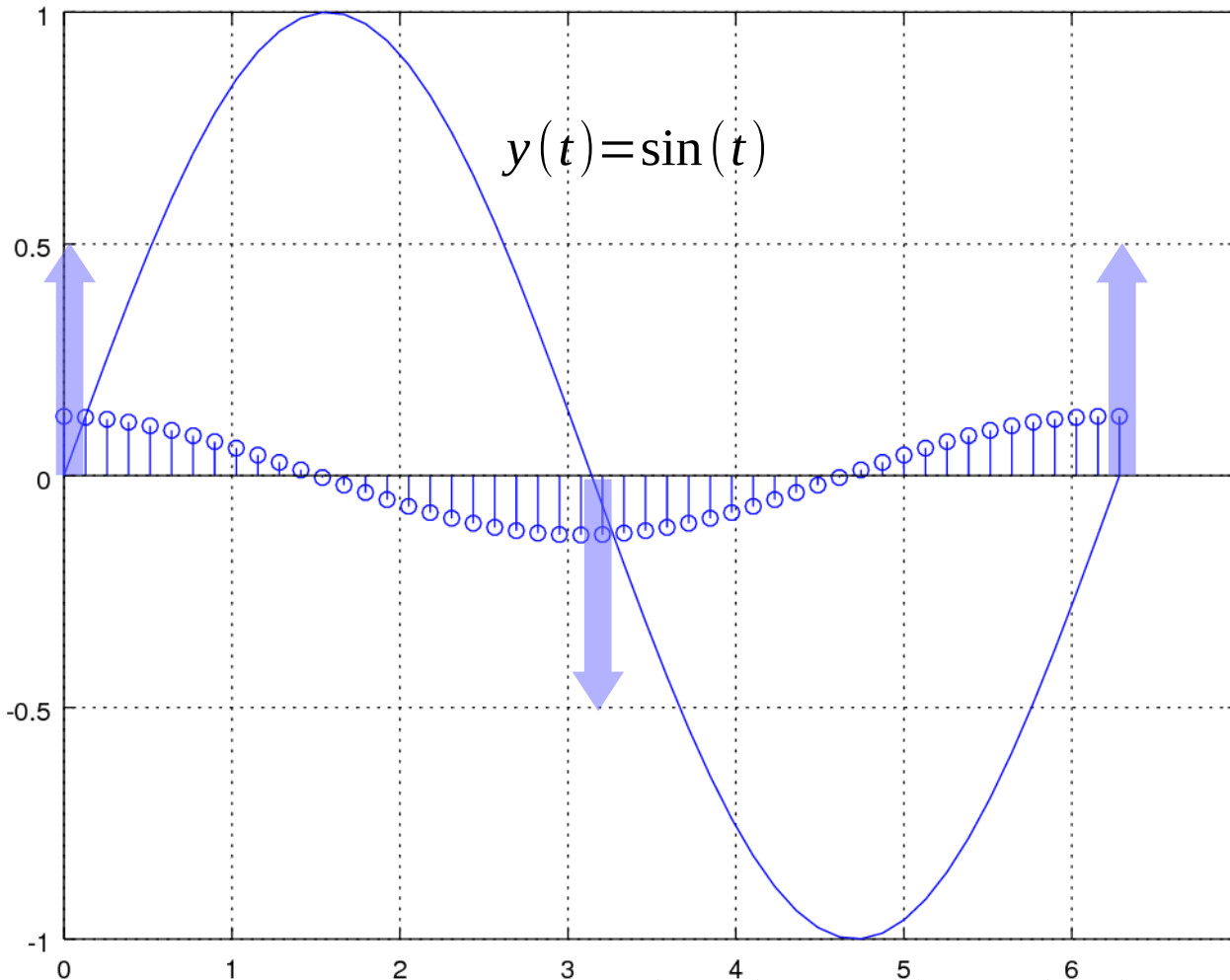


# Fully Discharged : Large Current

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



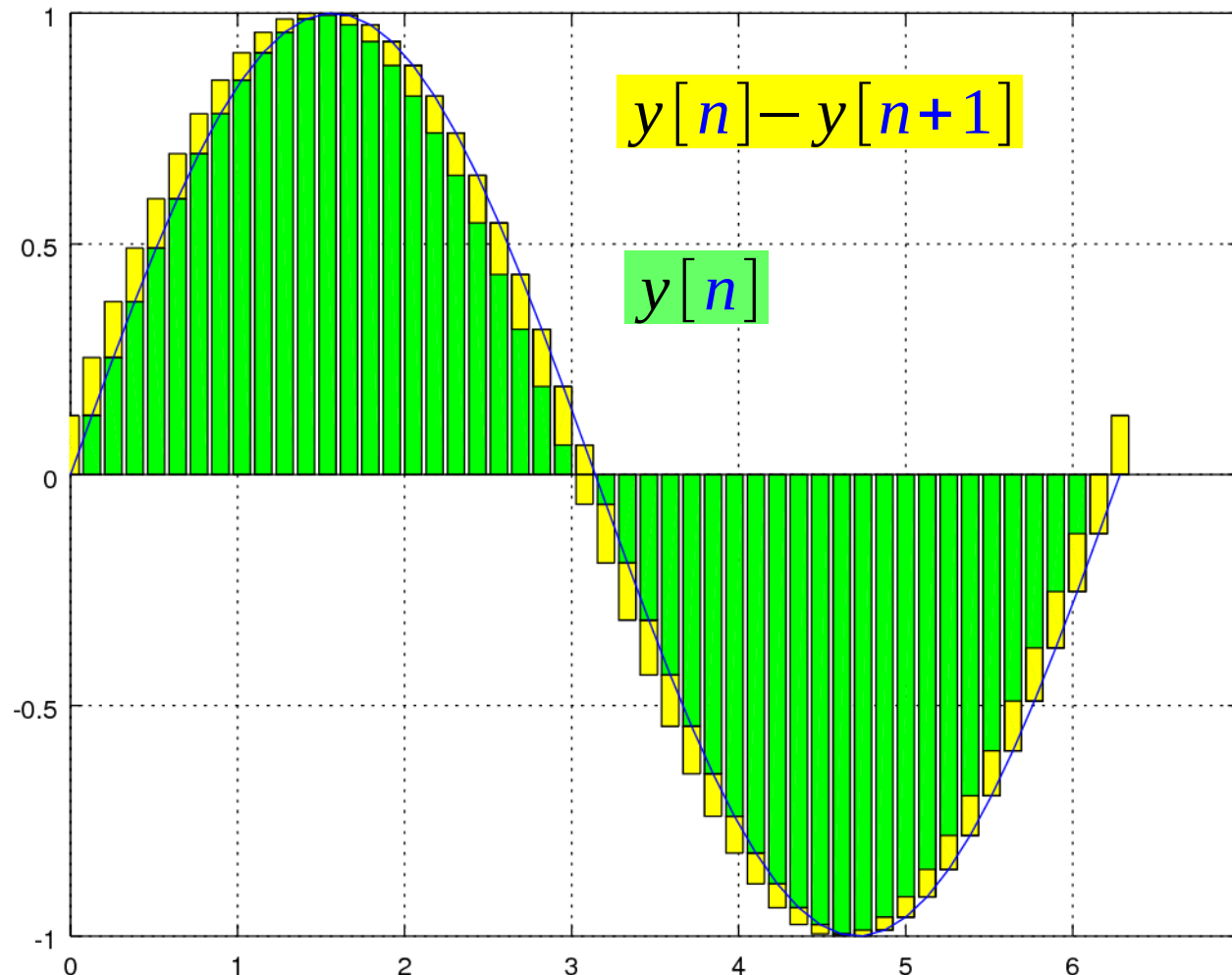
# $y[n+1] - y[n]$



```
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)
```

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

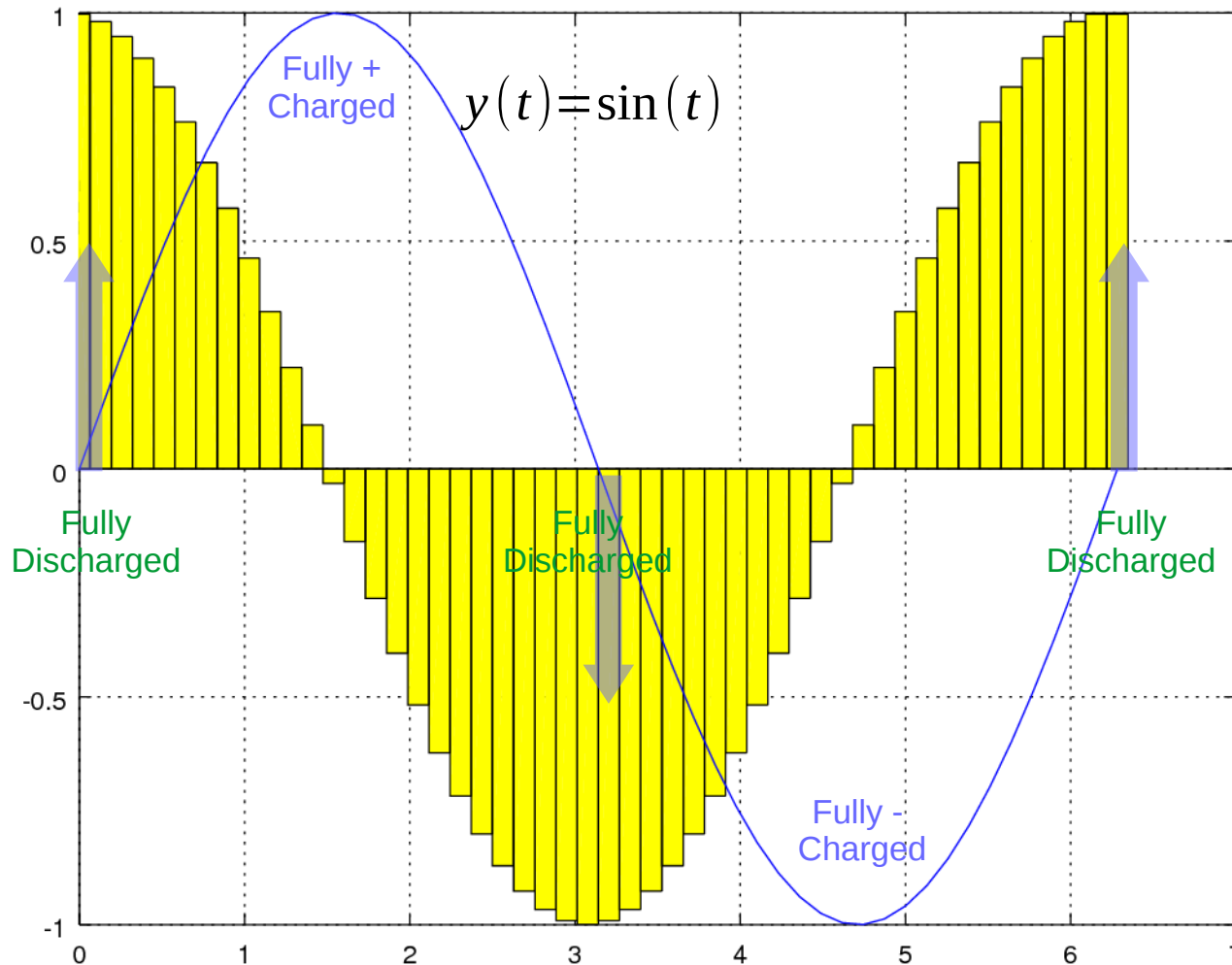
# Fully Charged and Fully Discharged



```
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

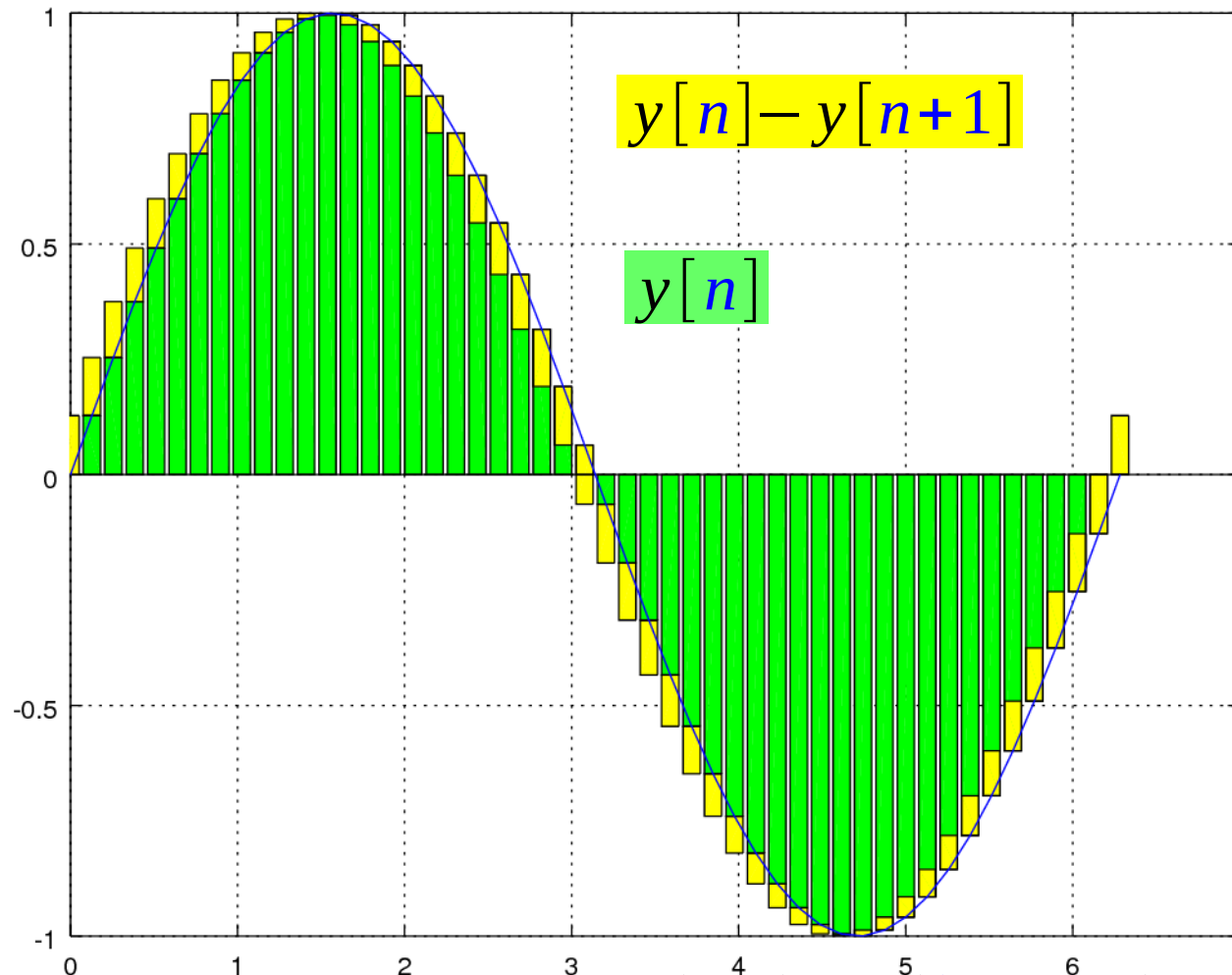


```
h = bar(t1, y2/t(2), "hist")
set(h(1), "facecolor", "y");
hold on
plot(t1, y1)
axis([0 7 -1 1]);
```

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

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

# Fully Charged and Fully Discharged

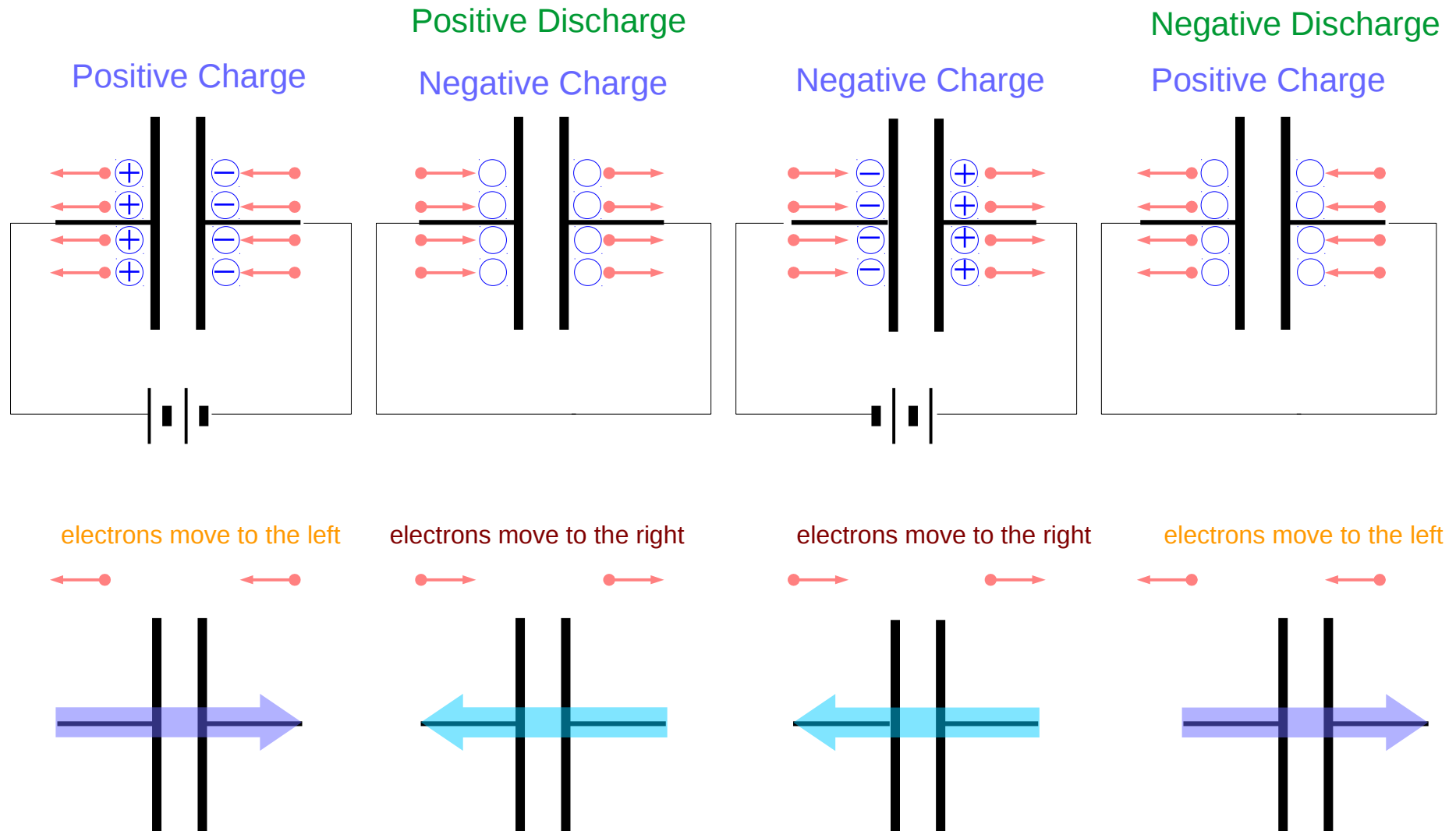


```

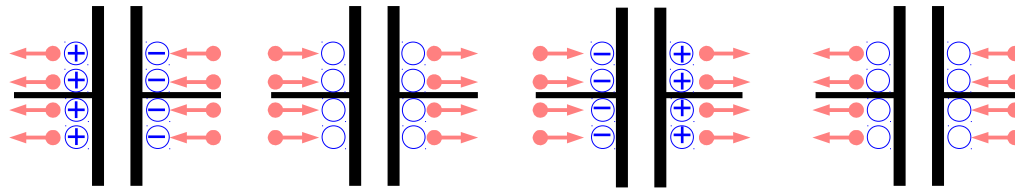
h = bar(t1, [y1' y2'],
"stacked")
set(h(1), "facecolor", "g");
set(h(2), "facecolor", "y");
hold on
plot(t1, y1)
axis([0 pi]);
    
```

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

# Everchanging signal pairs

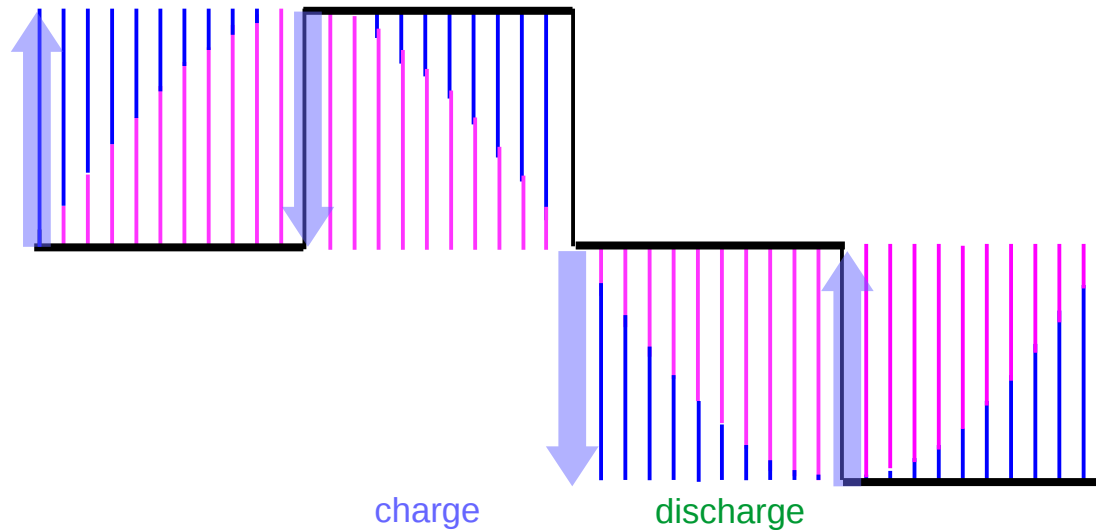


# Everchanging signal pairs



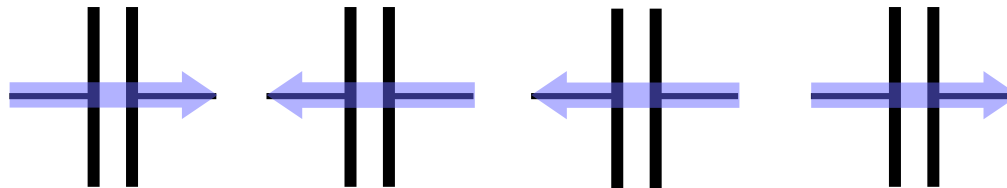
charge

discharge



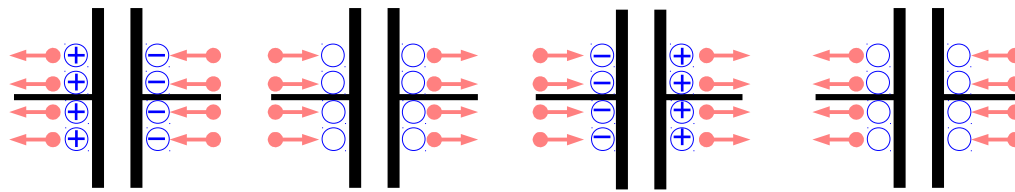
charge

discharge



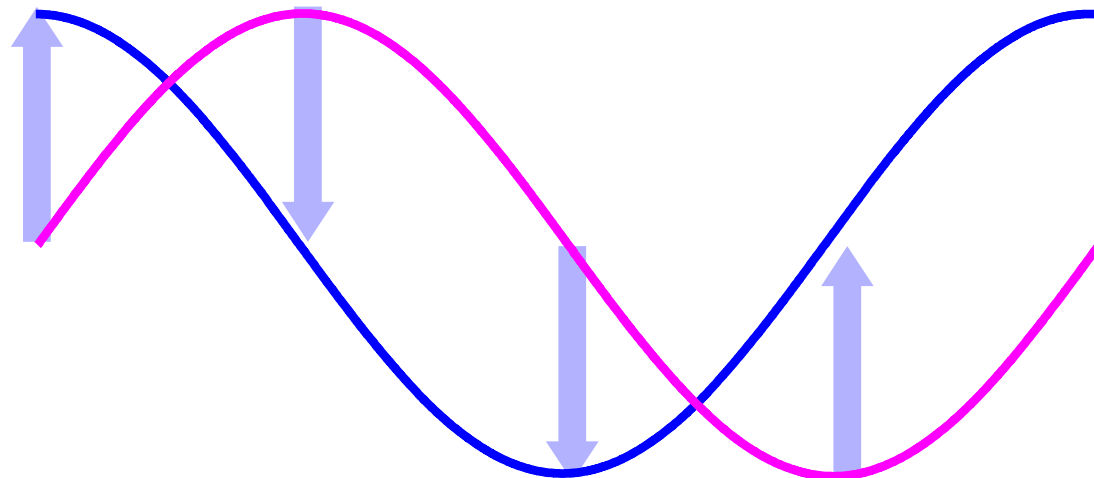


# Everchanging signal pairs



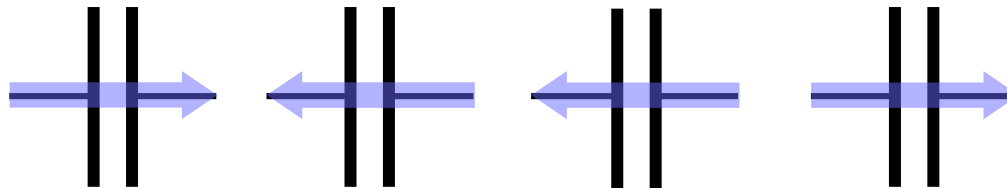
charge

discharge

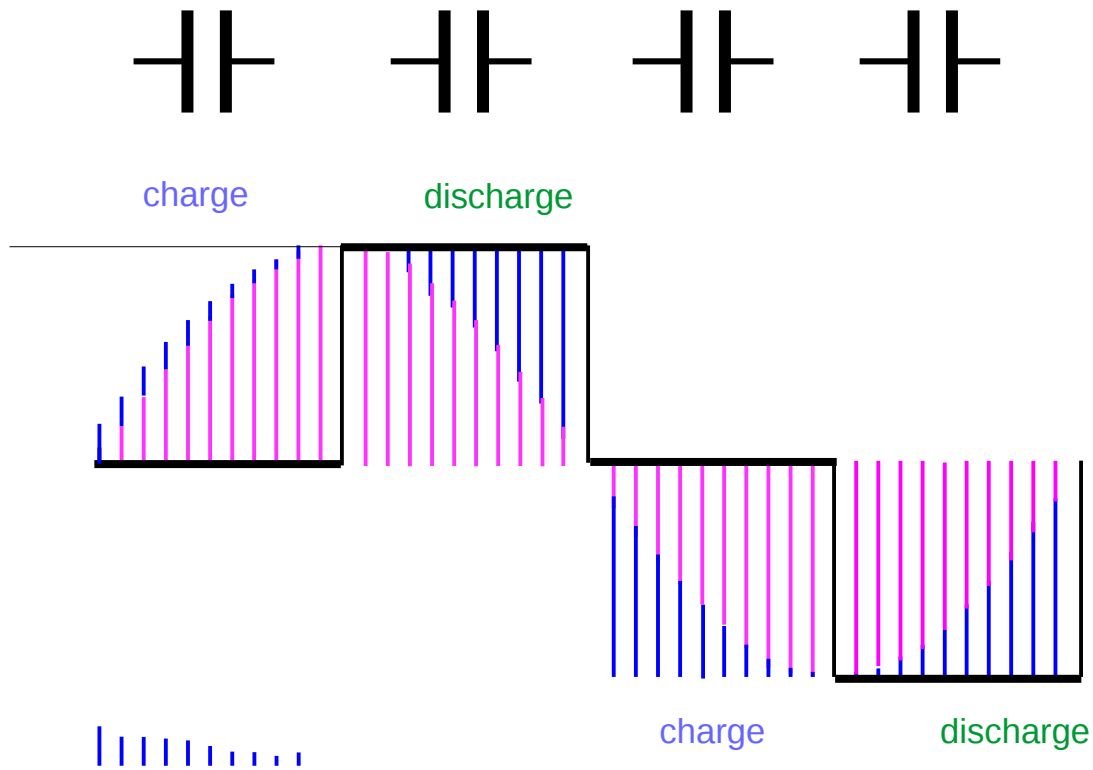


charge

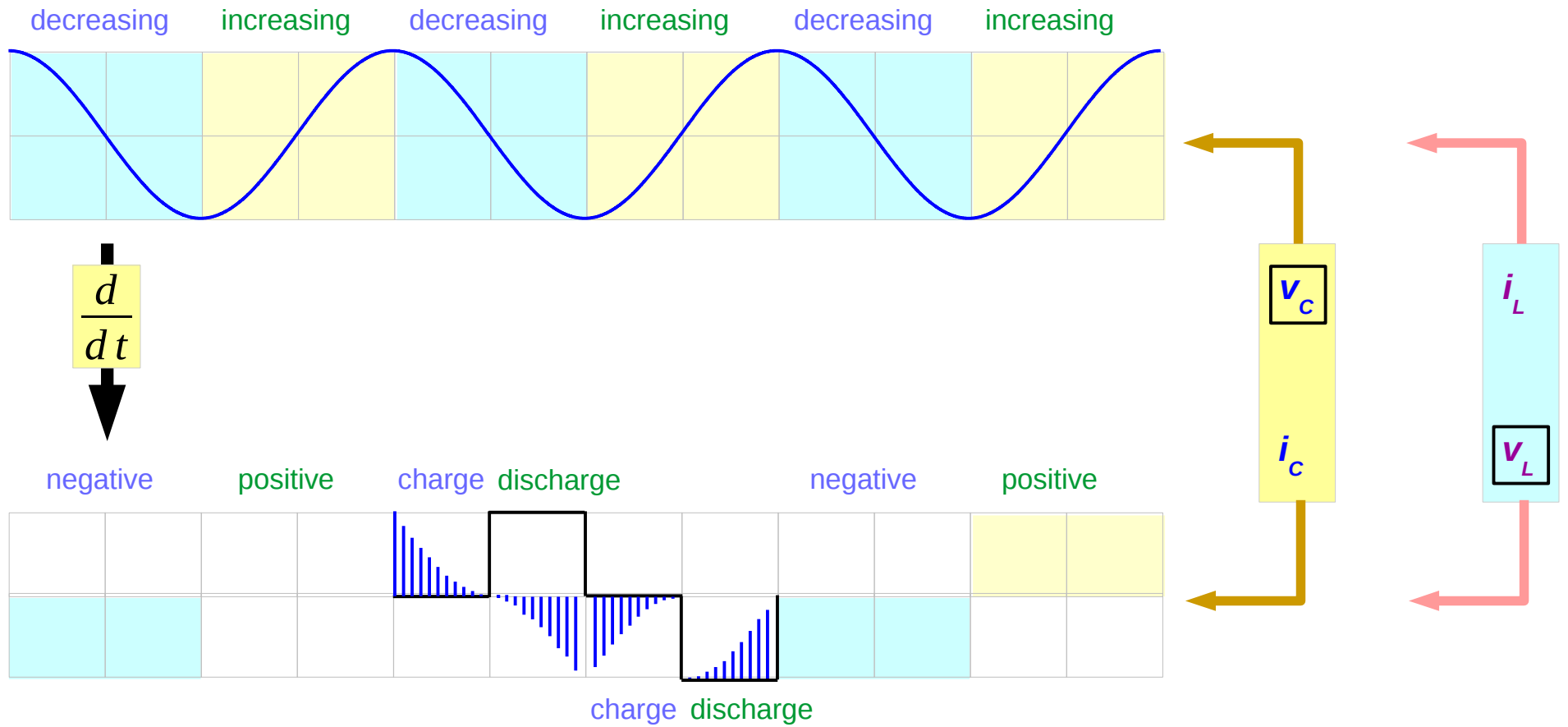
discharge



# Everchanging signal pairs

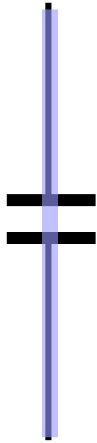


# Everchanging signal pairs



# I leads V by 90°

*Initial  
charge*

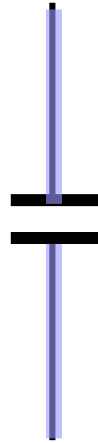


*SHORT*

*V = 0*

*I : peak*

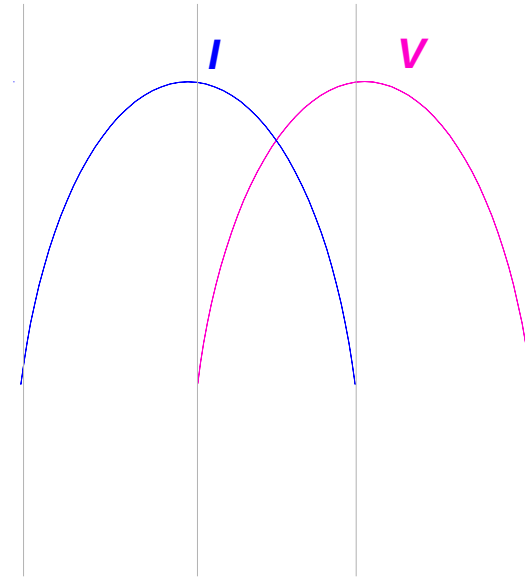
*Full  
charge*



*OPEN*

*I = 0*

*V : peak*



## References

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

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