

# Capacitor in an AC circuit

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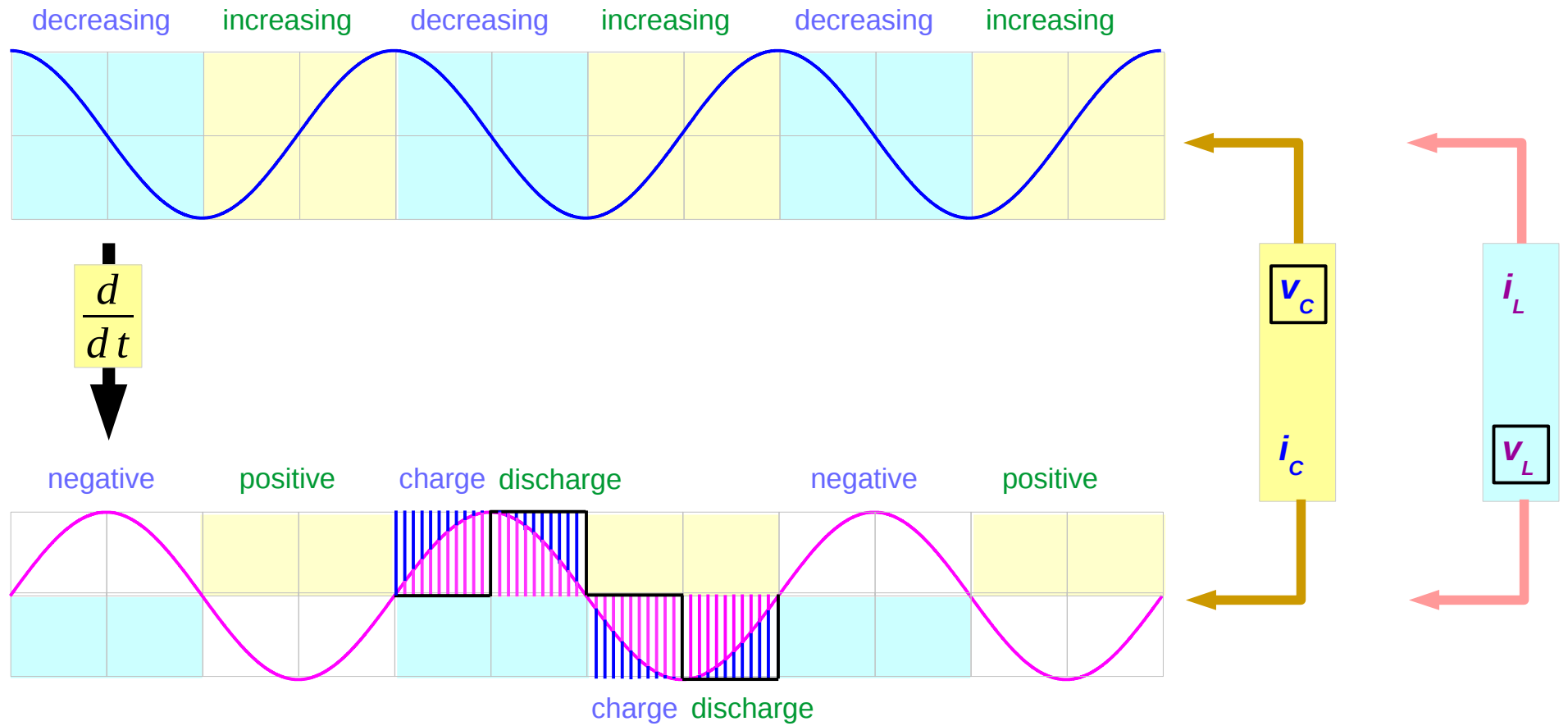
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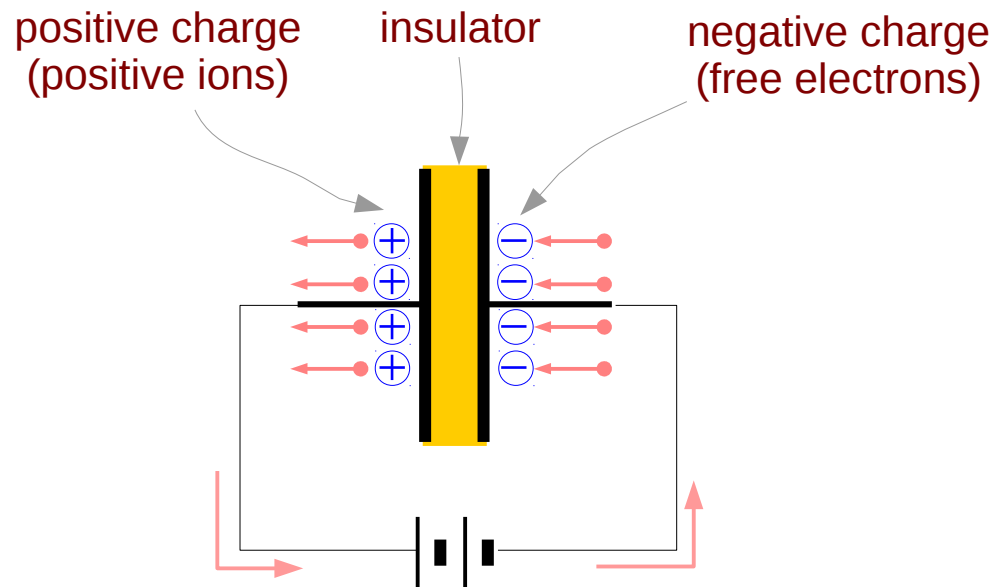
Please send corrections (or suggestions) to [youngwlim@hotmail.com](mailto:youngwlim@hotmail.com).

This document was produced by using OpenOffice and Octave.

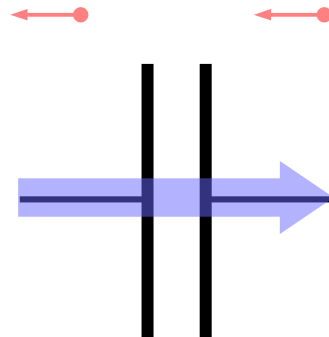
# Everchanging signal pairs



# Capacitor Current

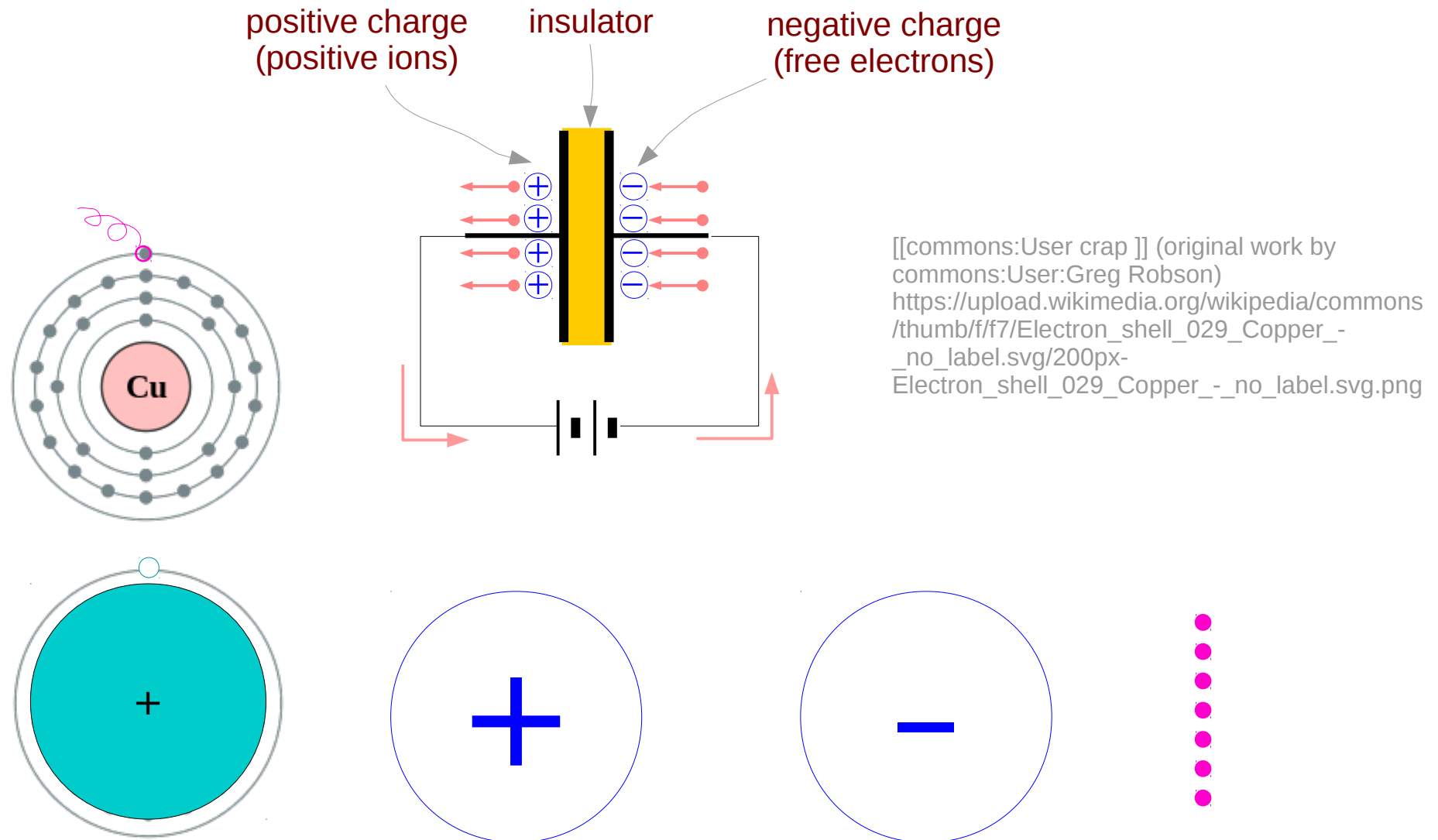


Think as electrons move to the left



Displacement Current

# Positive ions and free electrons

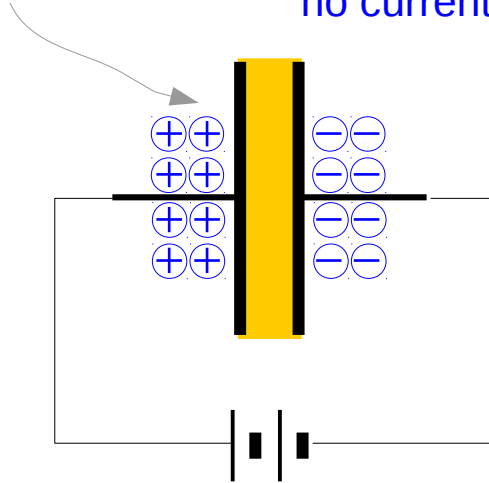


# Three States

positive charge  
(positive ions)

**Positive Charged State**

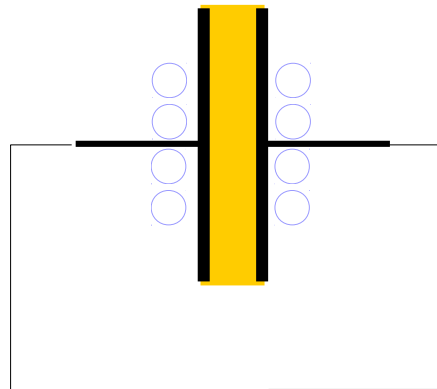
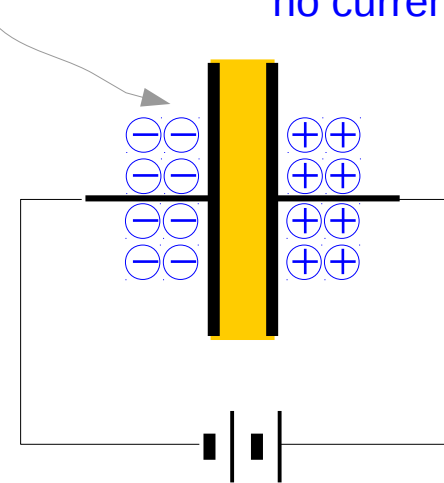
no current



negative charge  
(free electrons)

**Negative Charged State**

no current

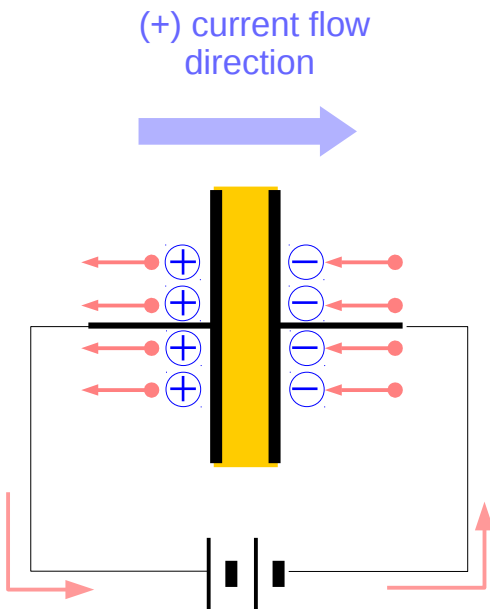


**Fully Discharged State**

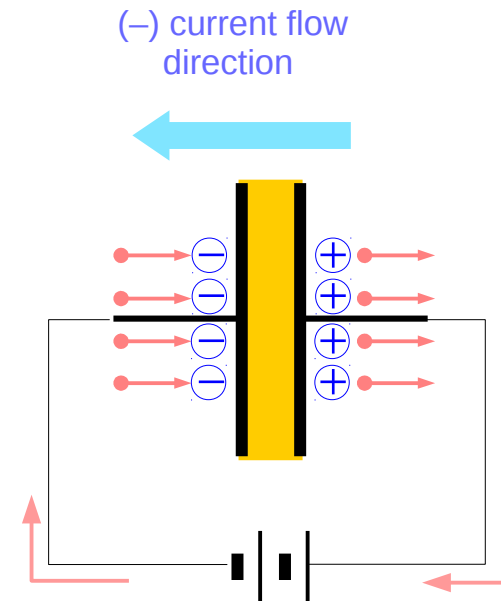
large current

# Inter-State Current Flowing

## Positive Charging



## Negative Charging

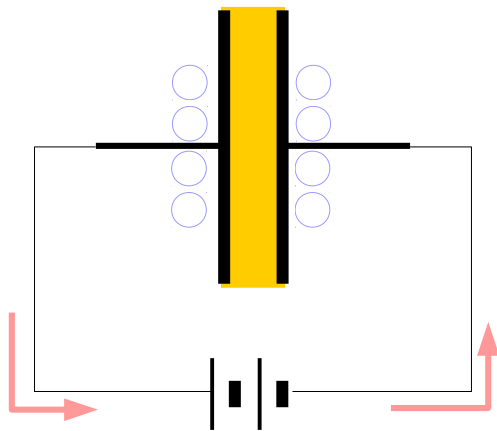


# Inter-State Current Flowing

Fully Discharged State

large current

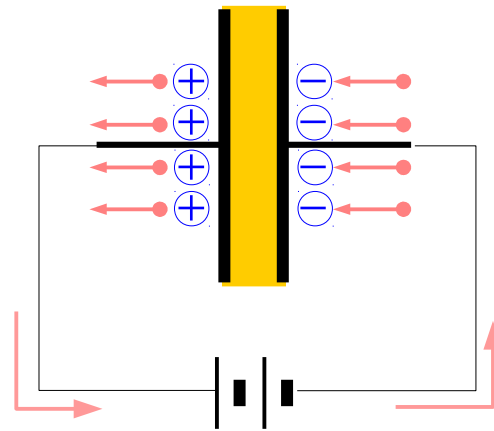
(+) current flow direction



electron flow direction

Positive Charging

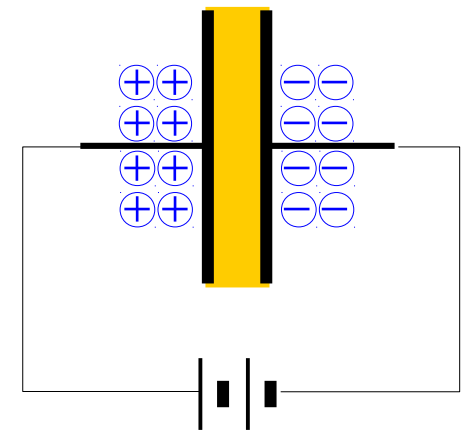
(+) current flow direction



electron flow direction

Positive Charged State

no current



Crowded  
No more space

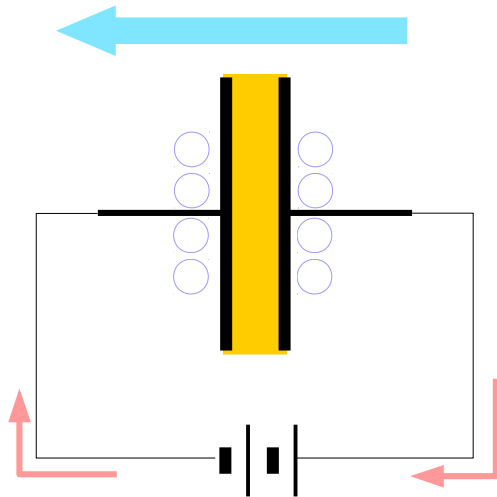


# Inter-State Current Flowing

Fully Discharged State

large current

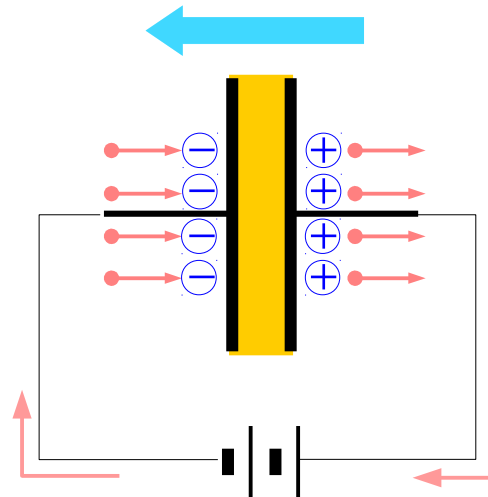
(-) current flow direction



electron flow direction

Positive Charging

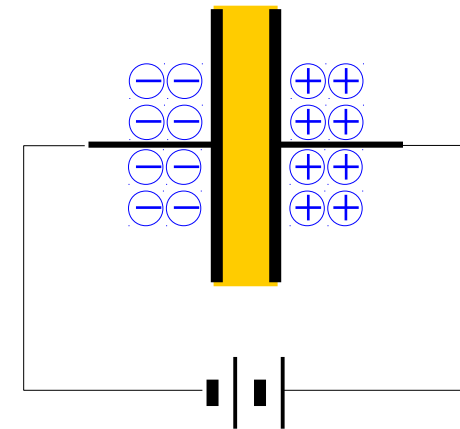
(-) current flow direction



electron flow direction

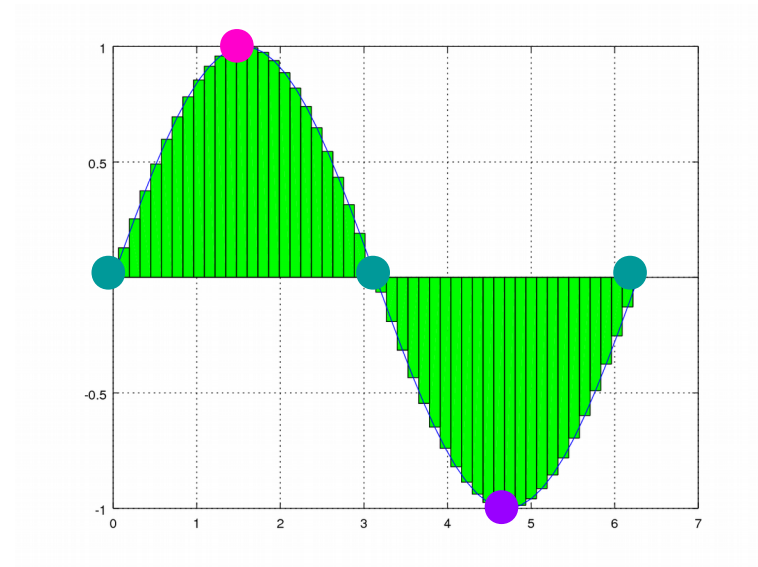
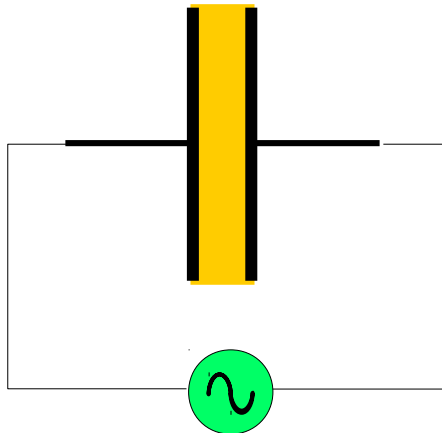
Positive Charged State

no current

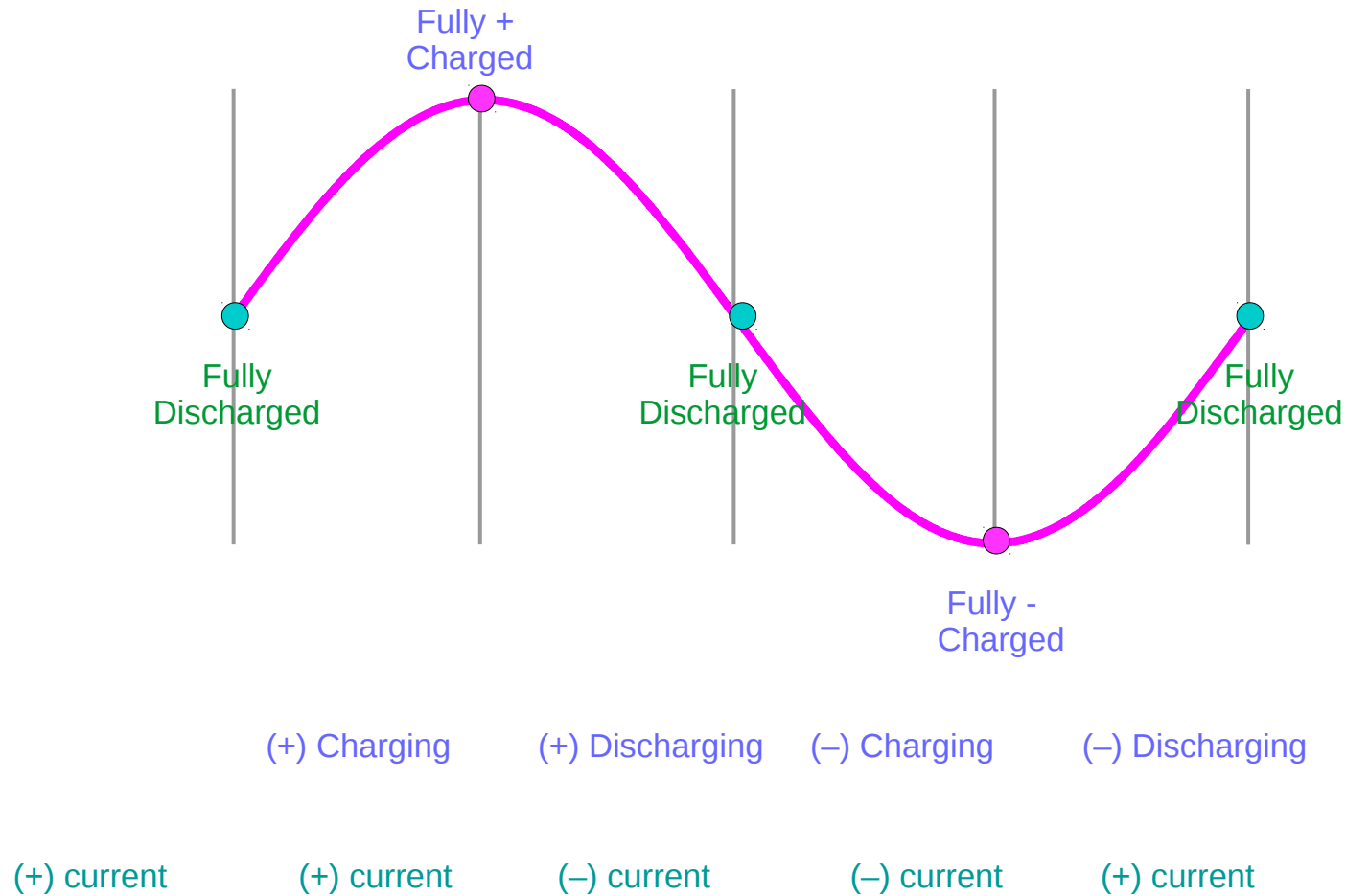


Crowded  
No more space

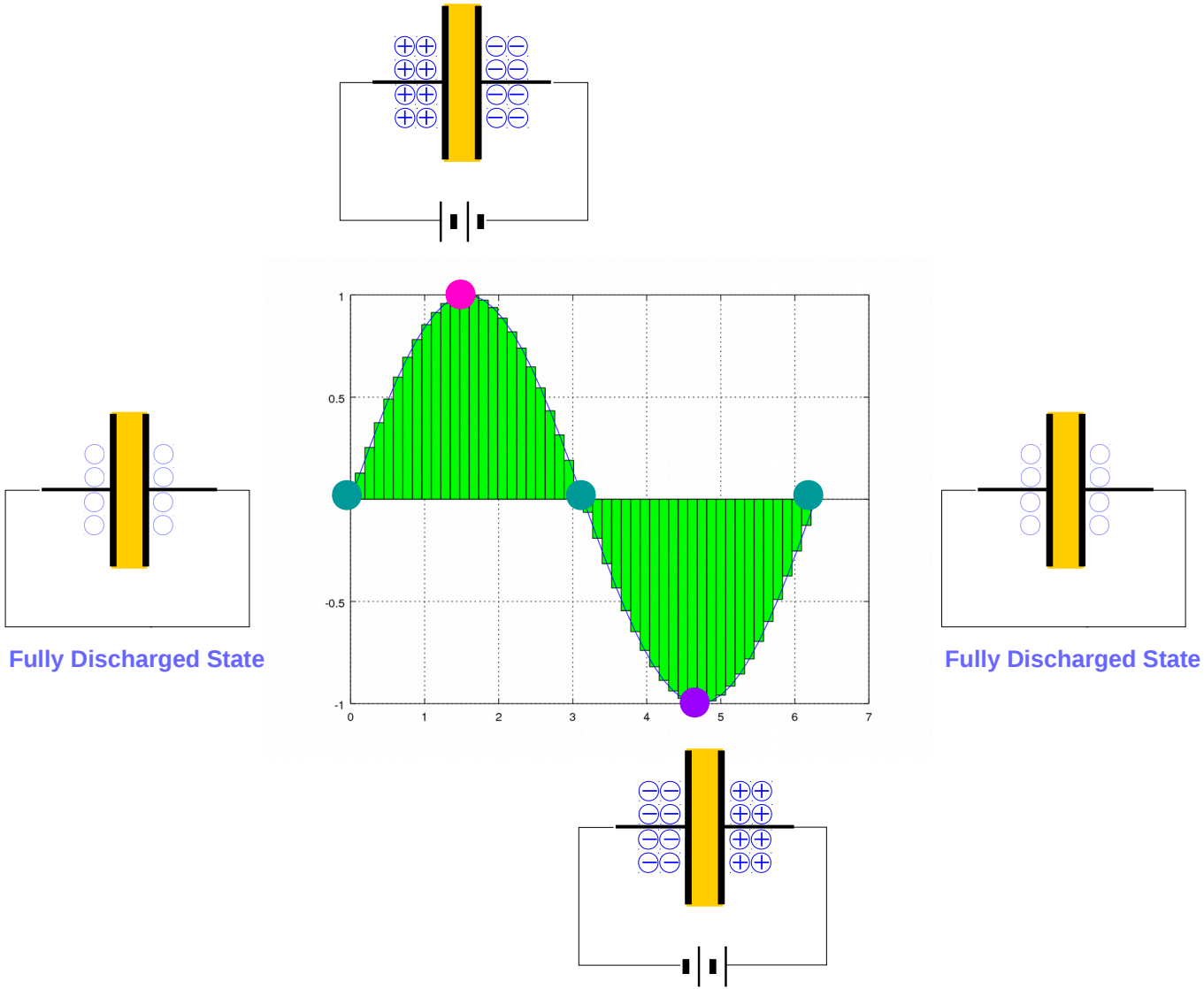
# An AC Voltage Source



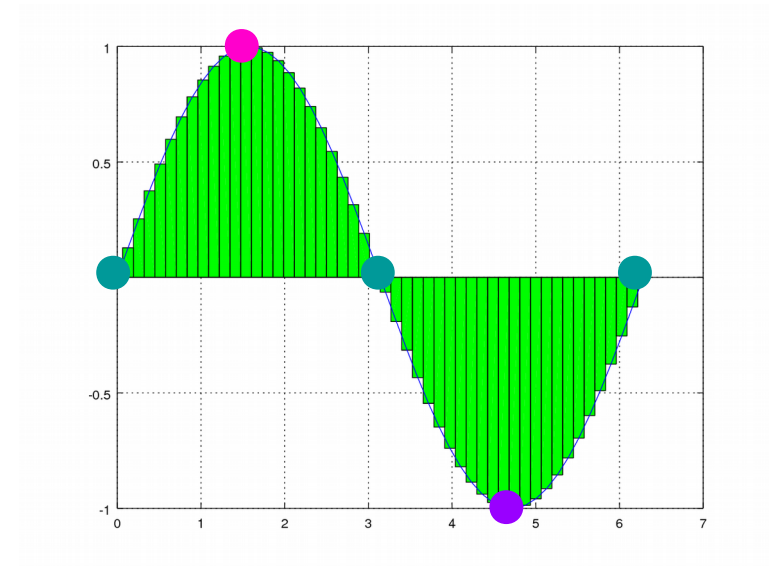
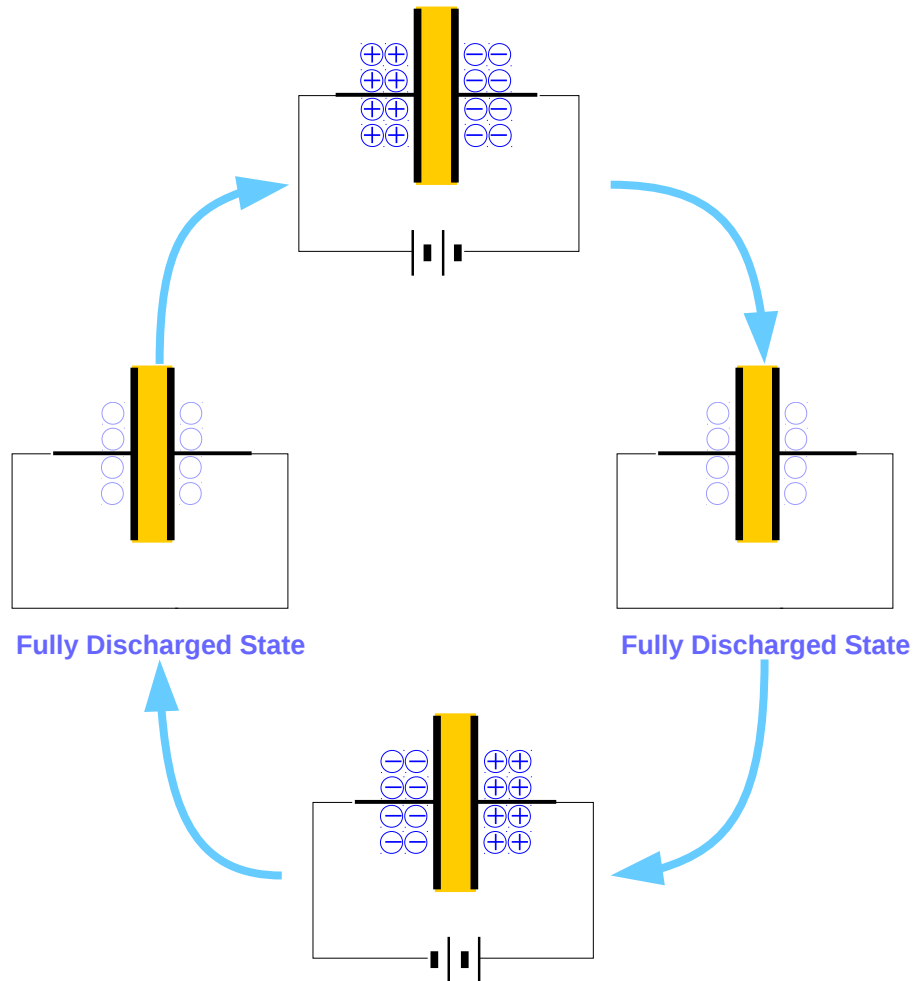
# Fully Charged and Fully Discharged



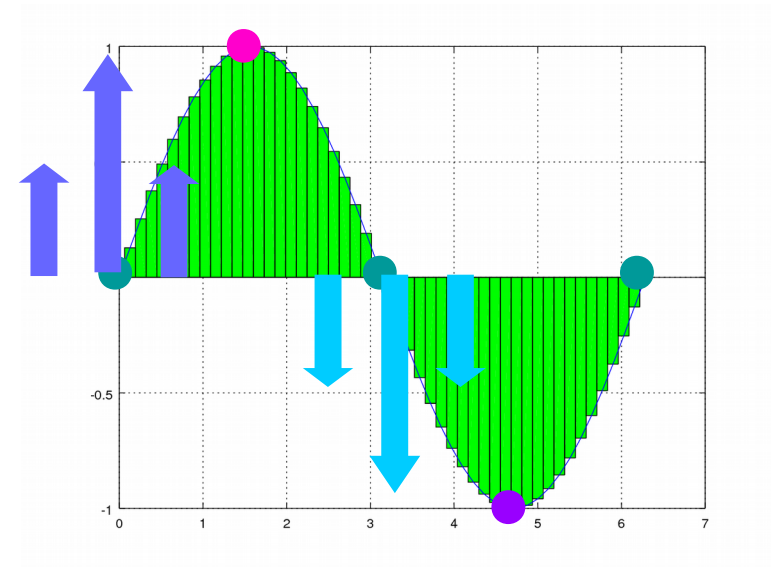
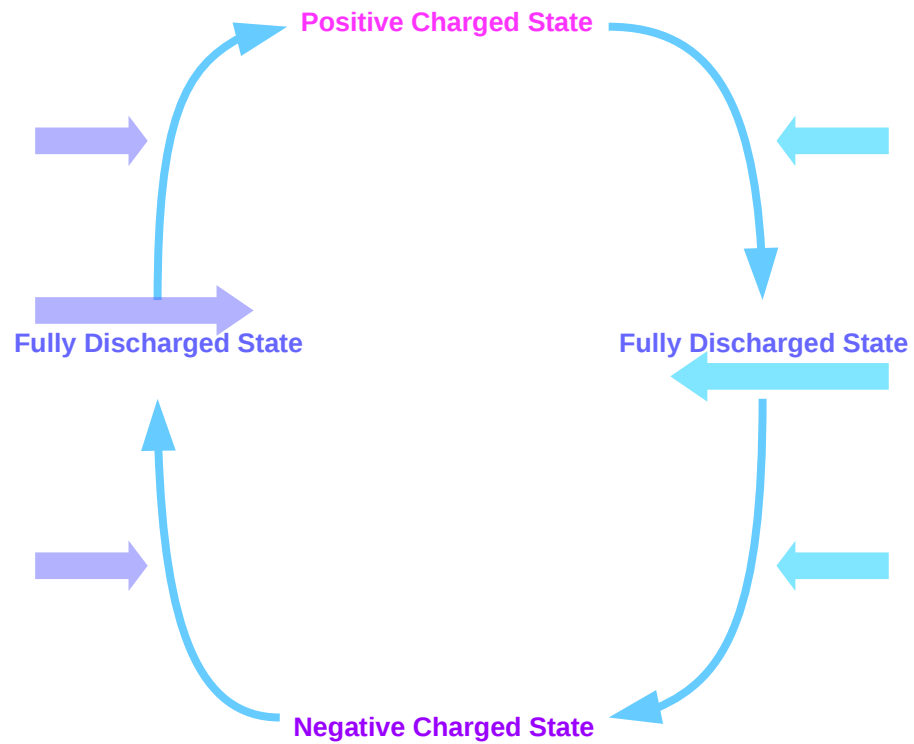
# A Cycle



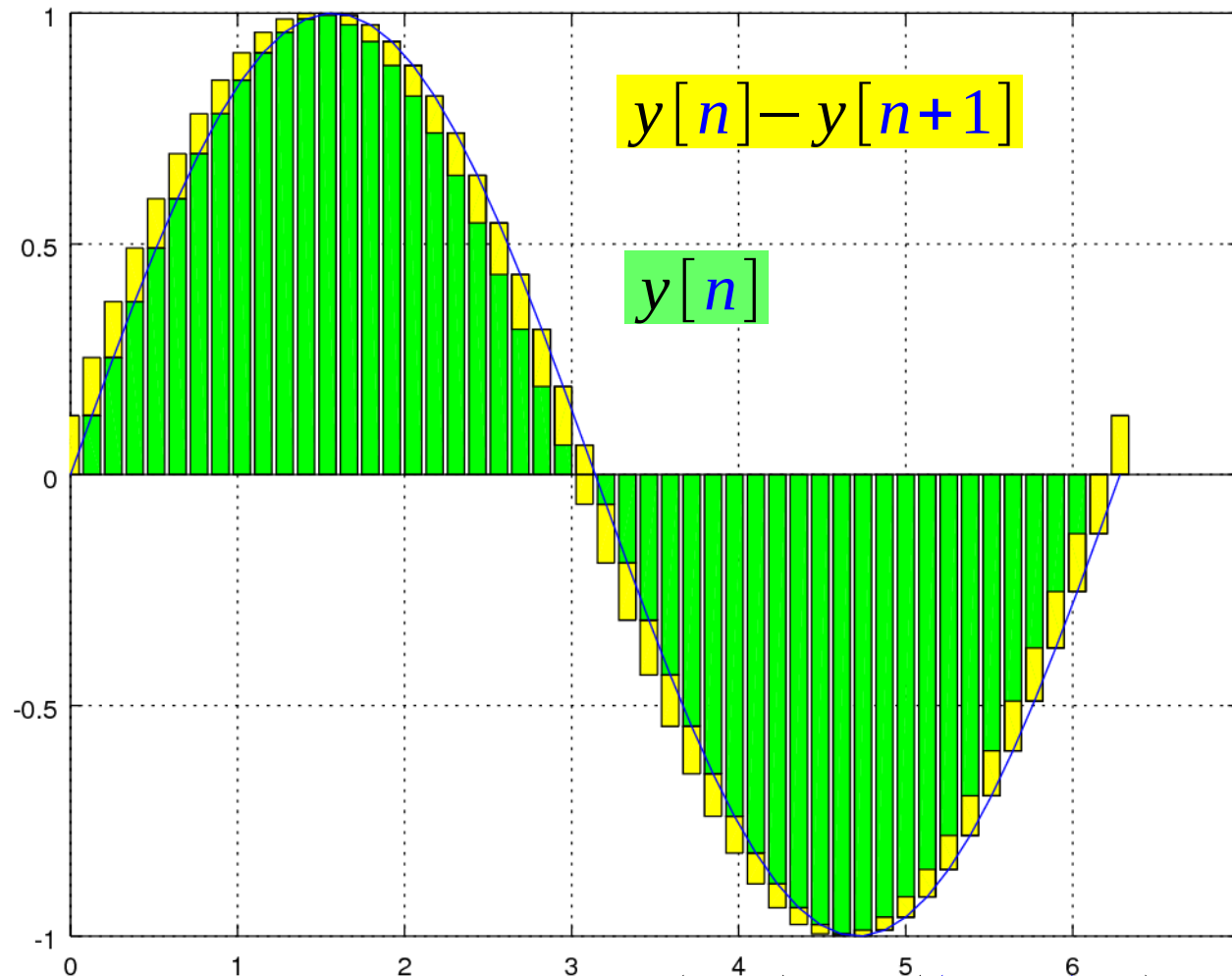
# State Transition Diagram



# Current Flow



# Fully Charged and Fully Discharged



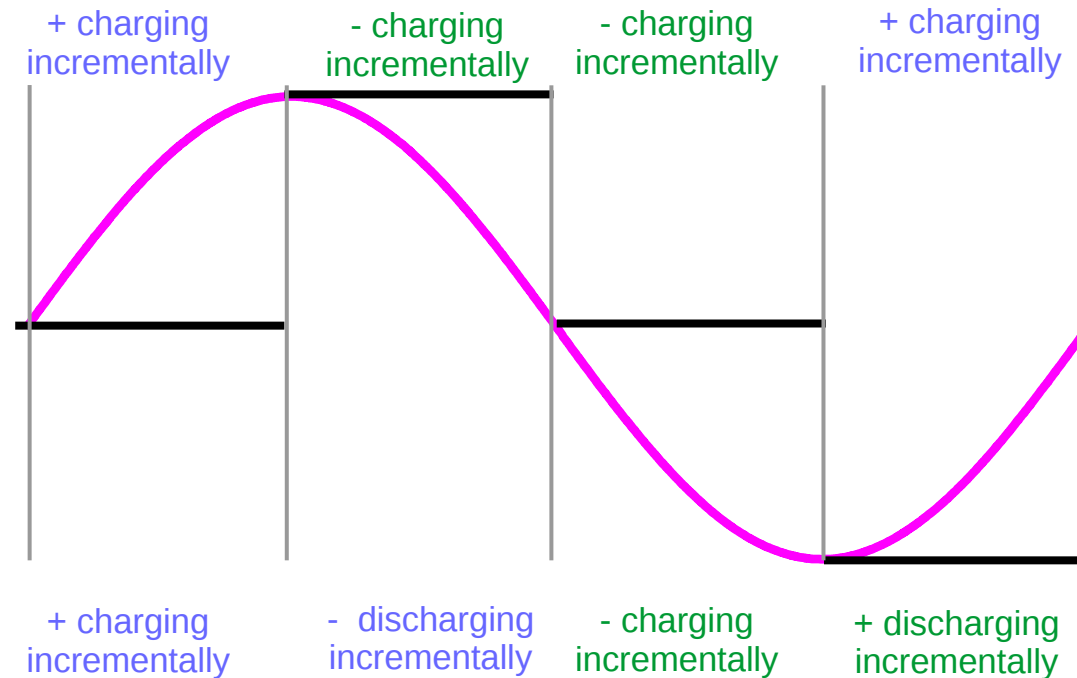
```
h = bar(t1, [y1' y2'],  
"stacked")  
set(h(1), "facecolor", "g");  
set(h(2), "facecolor", "y");  
hold on  
plot(t1, y1)  
axis([0 7 -1 1]);
```

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

# Continuous Charging and Discharging Operations

Incremental Voltage Increment  $\rightarrow$  + Charging incrementally

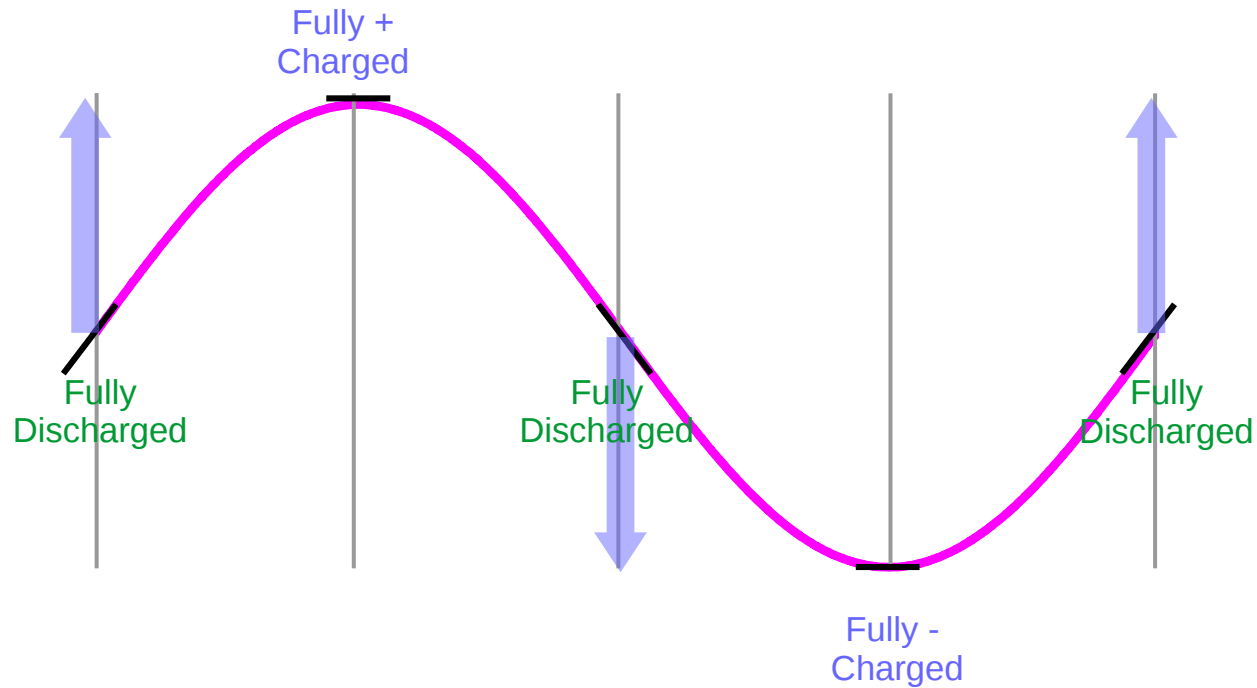
Incremental Voltage Decrement  $\rightarrow$  - Charging incrementally



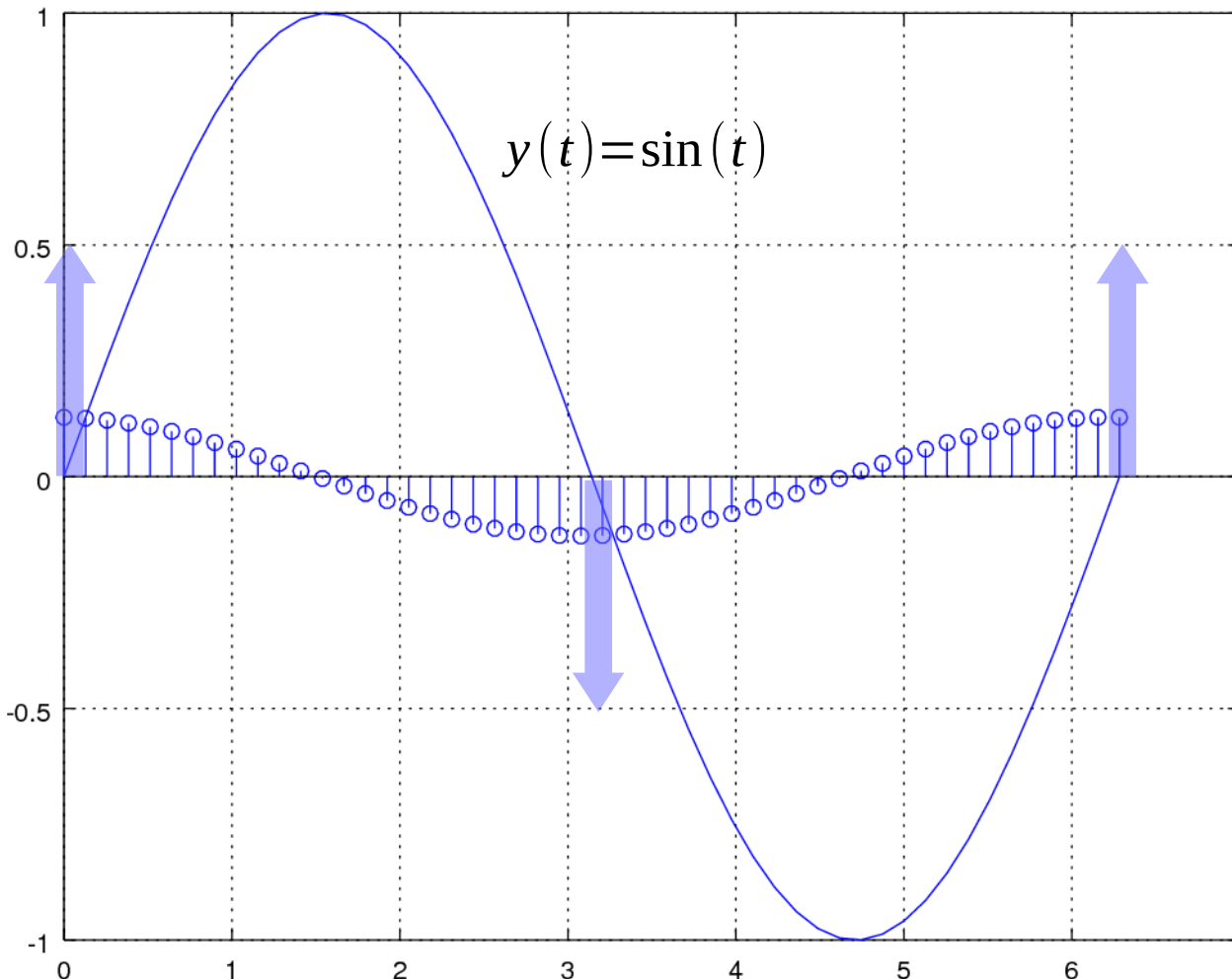


# Fully Discharged : Large Current

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



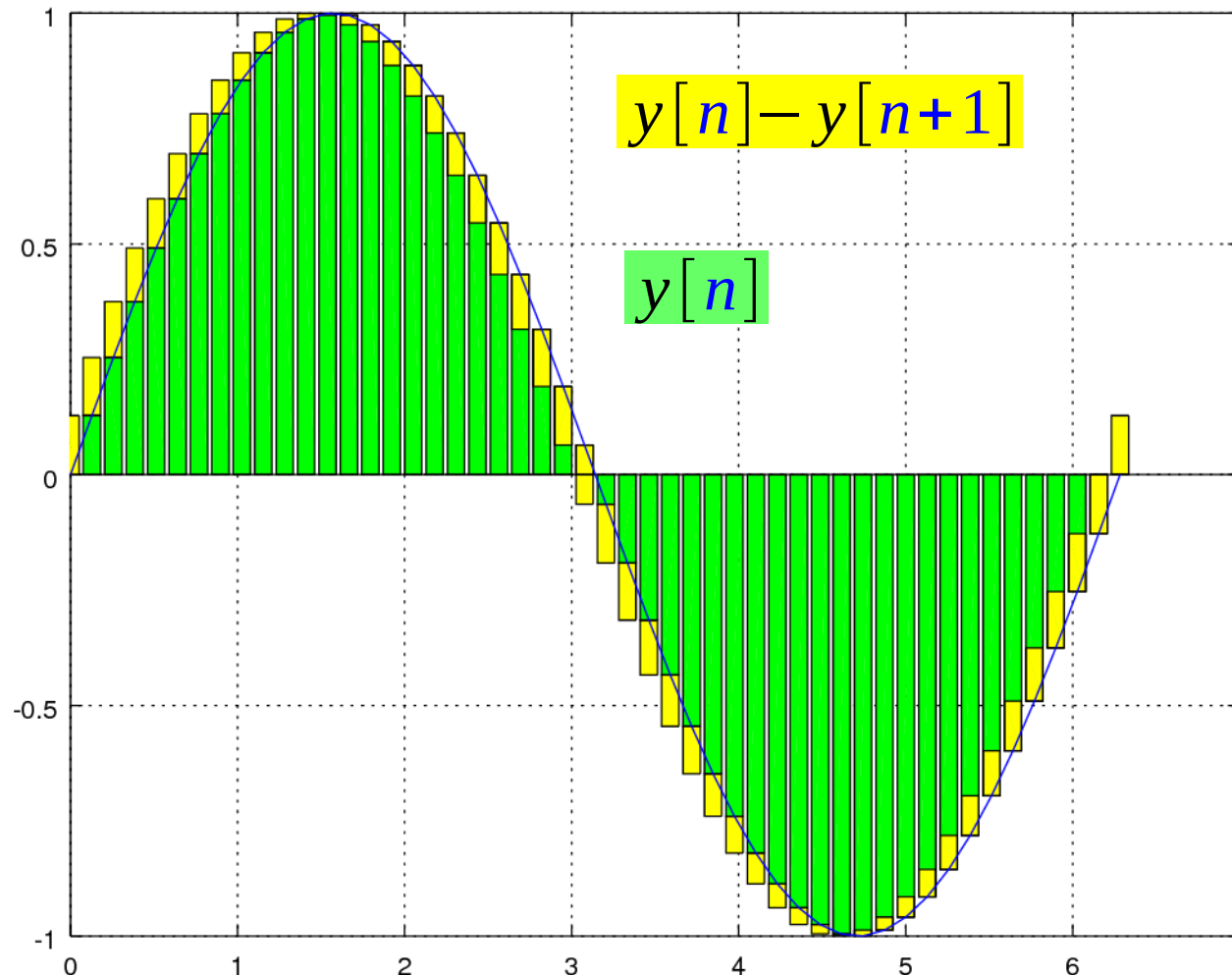
# $y[n+1] - y[n]$



```
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

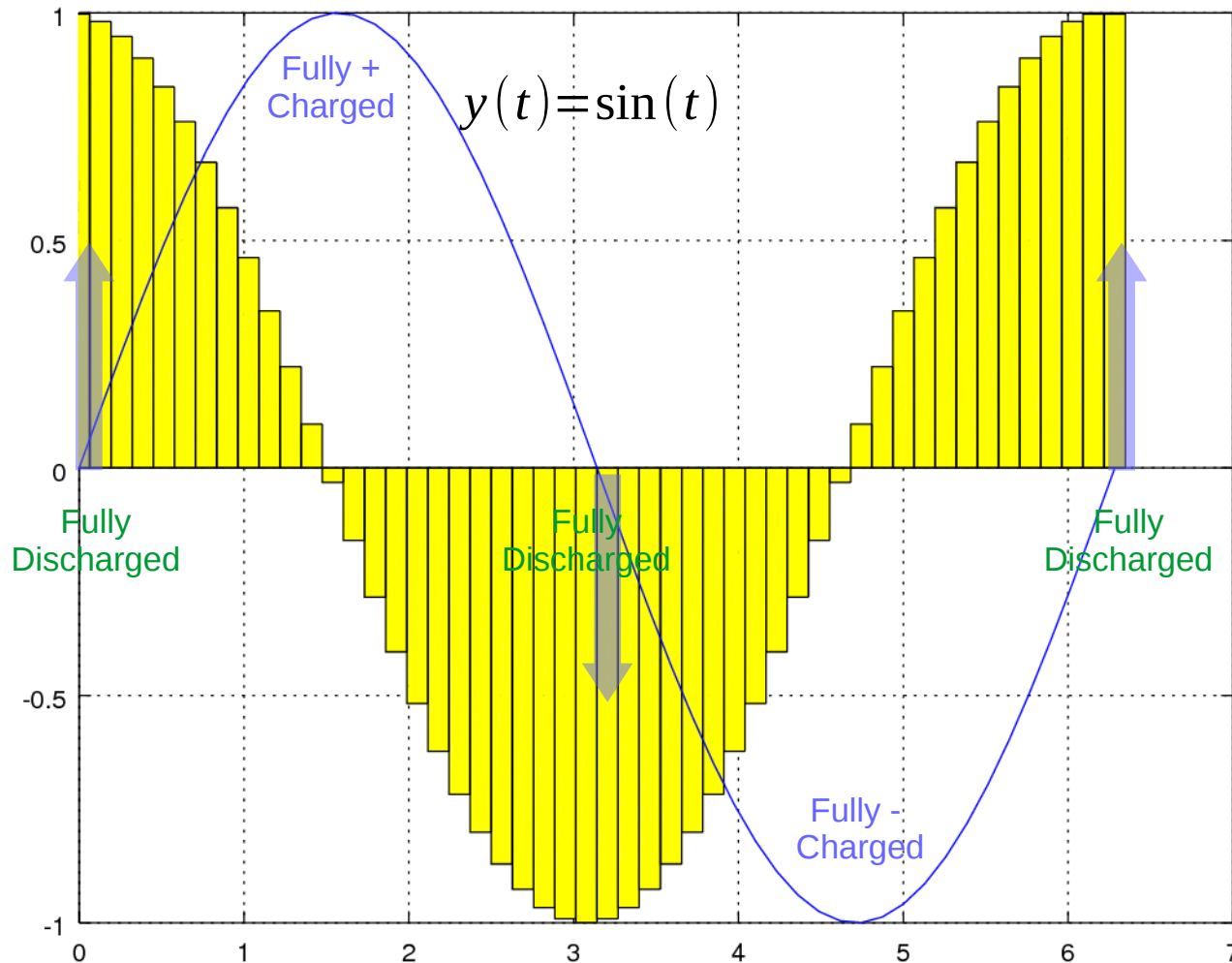


```

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

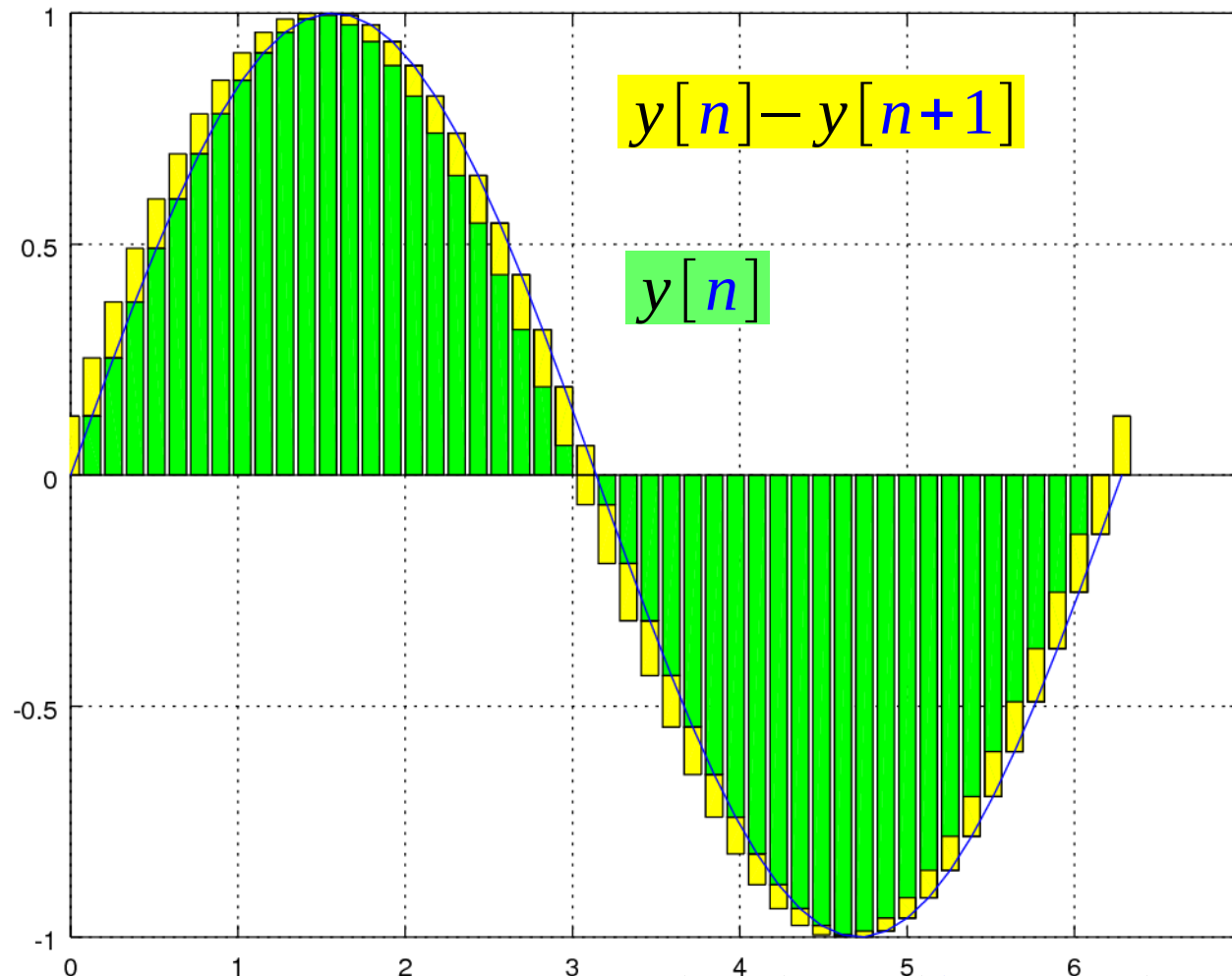


```
h = bar(t1, y2/t(2), "hist")
set(h(1), "facecolor", "y");
hold on
plot(t1, y1)
axis([0 7 -1 1]);
```

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

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

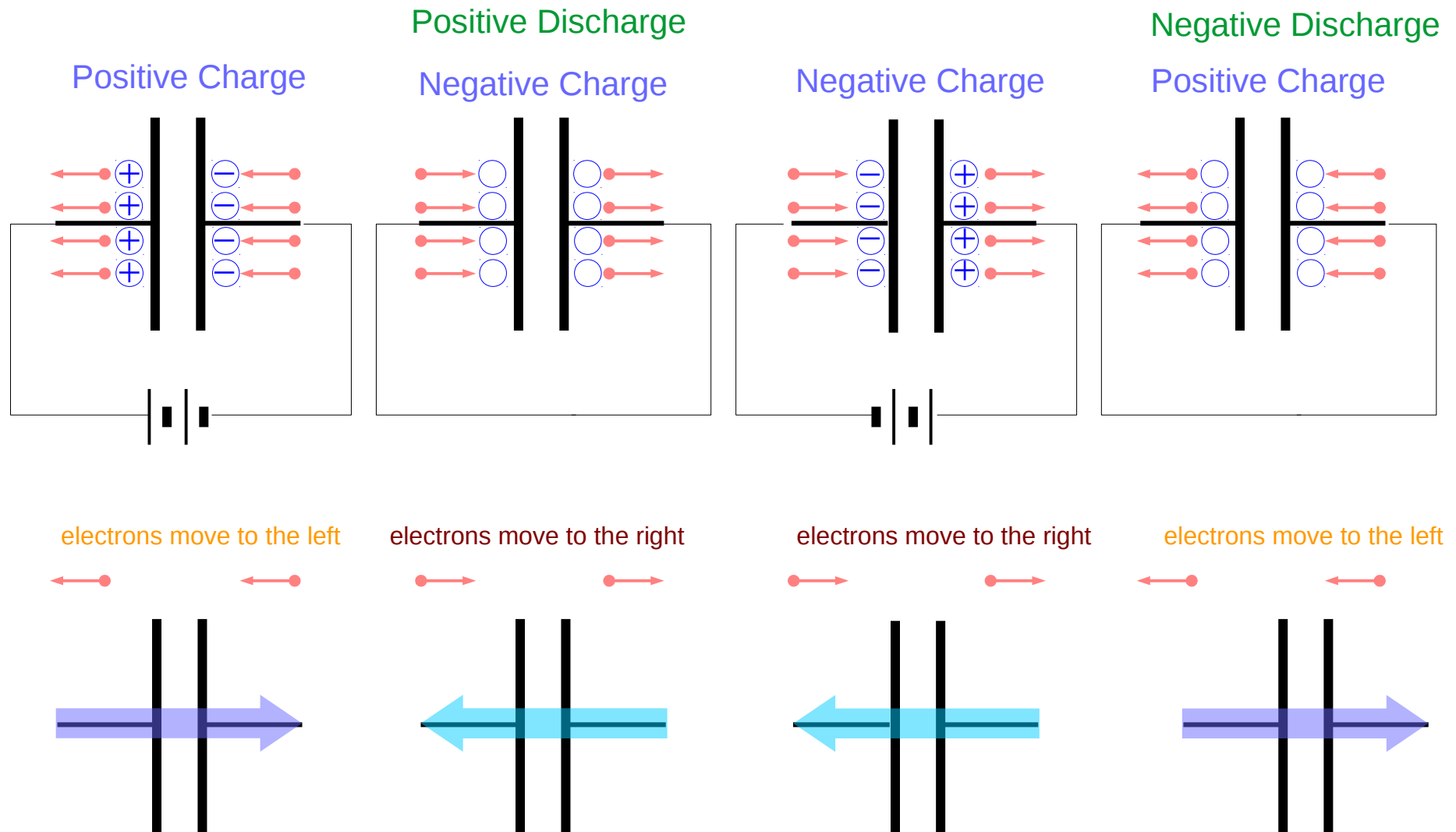
# Fully Charged and Fully Discharged



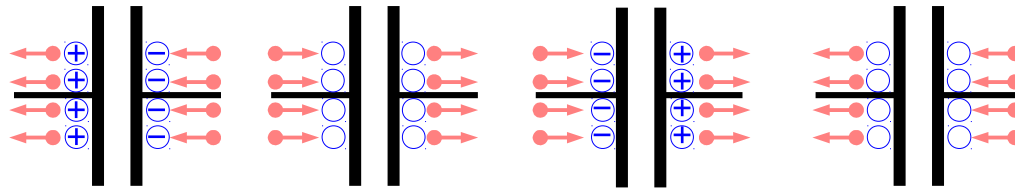
```
h = bar(t1, [y1' y2'],  
"stacked")  
set(h(1), "facecolor", "g");  
set(h(2), "facecolor", "y");  
hold on  
plot(t1, y1)  
axis([0 pi]);
```

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

# Everchanging signal pairs

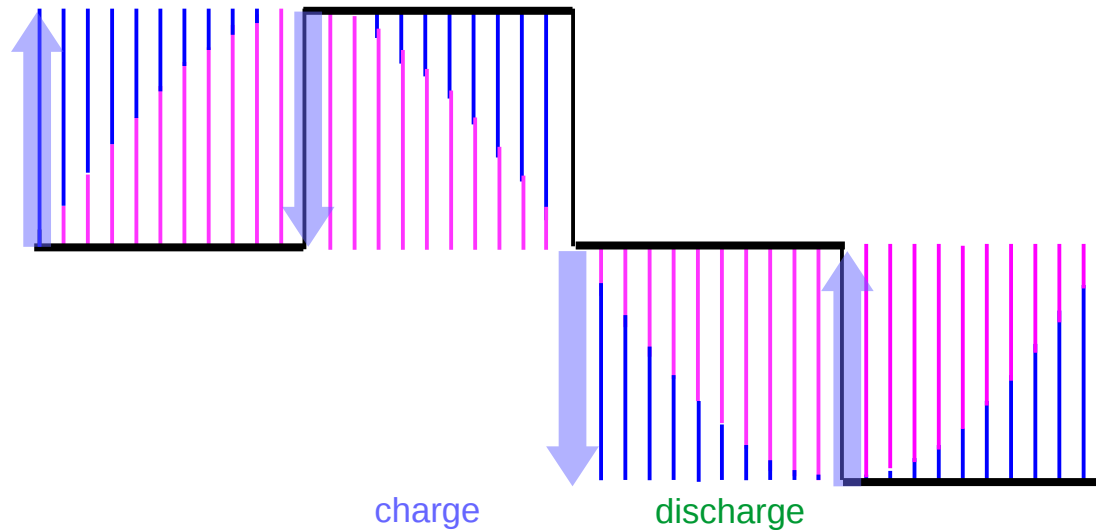


# Everchanging signal pairs



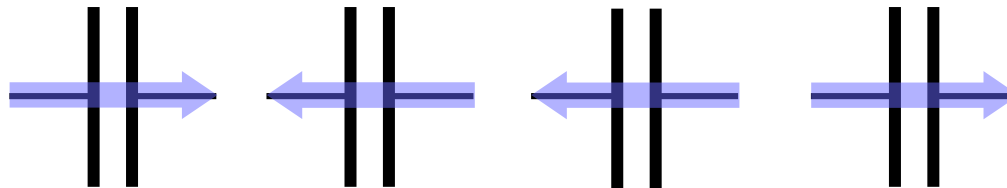
charge

discharge

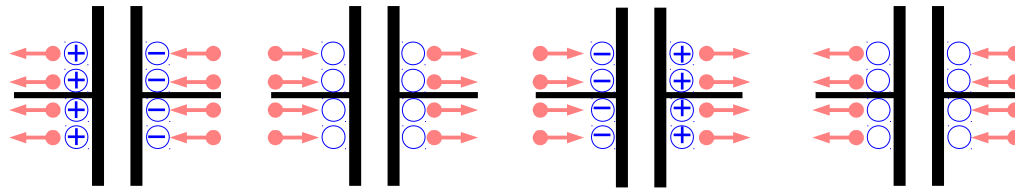


charge

discharge

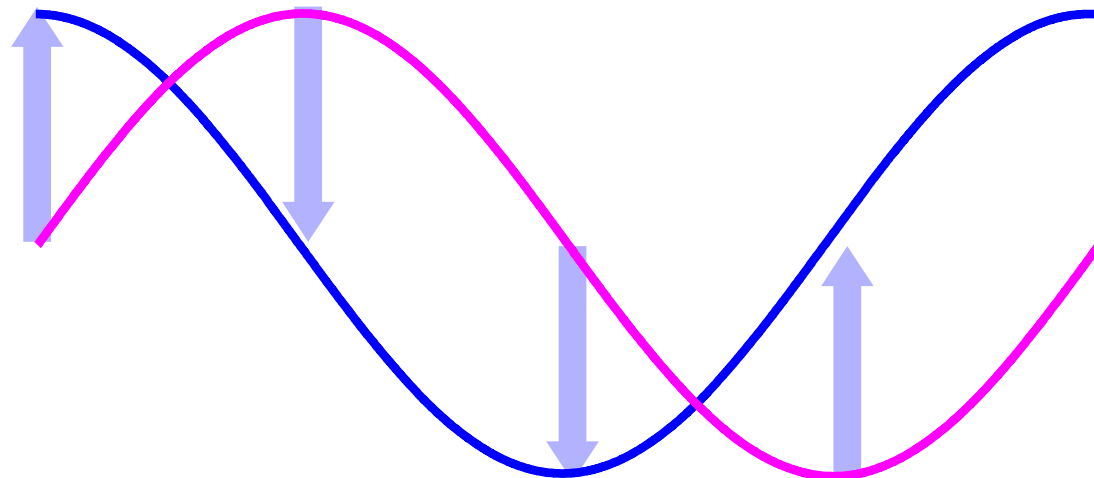


# Everchanging signal pairs



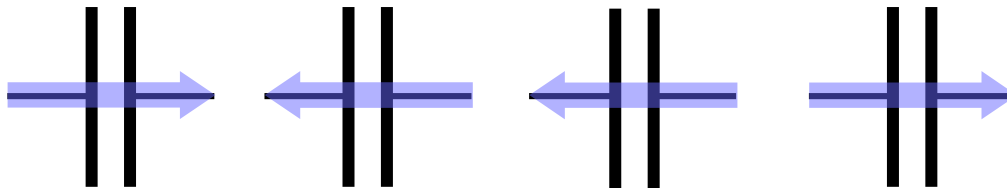
charge

discharge



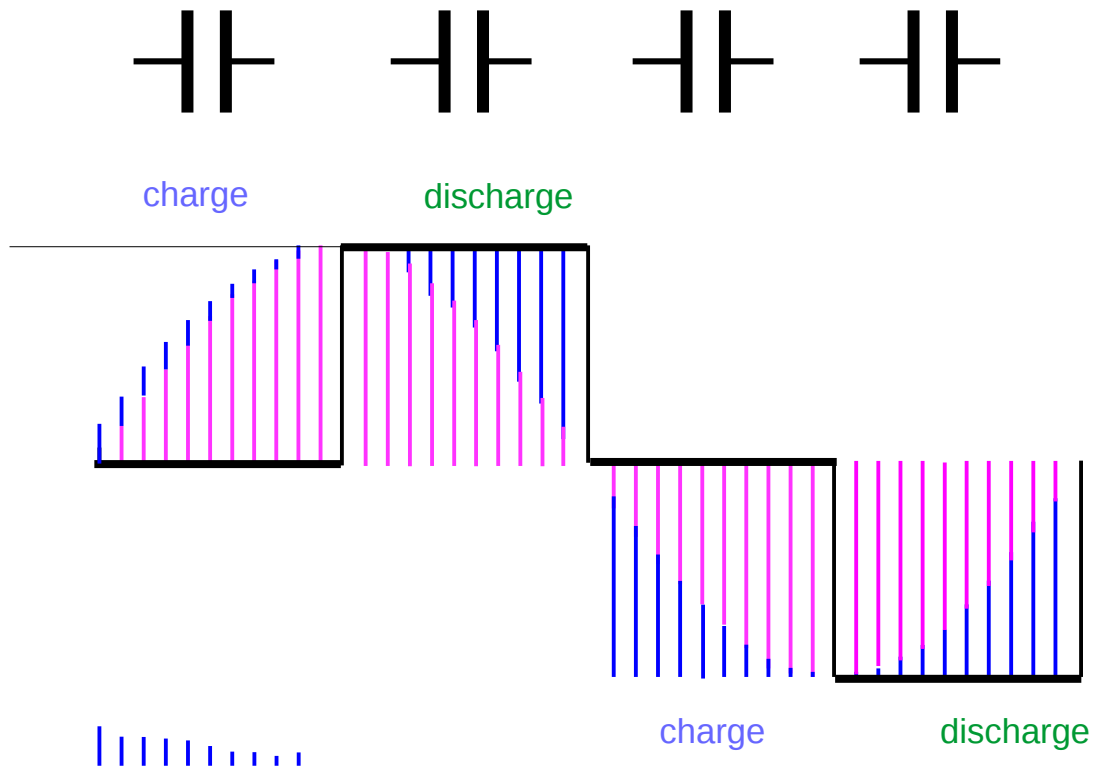
charge

discharge

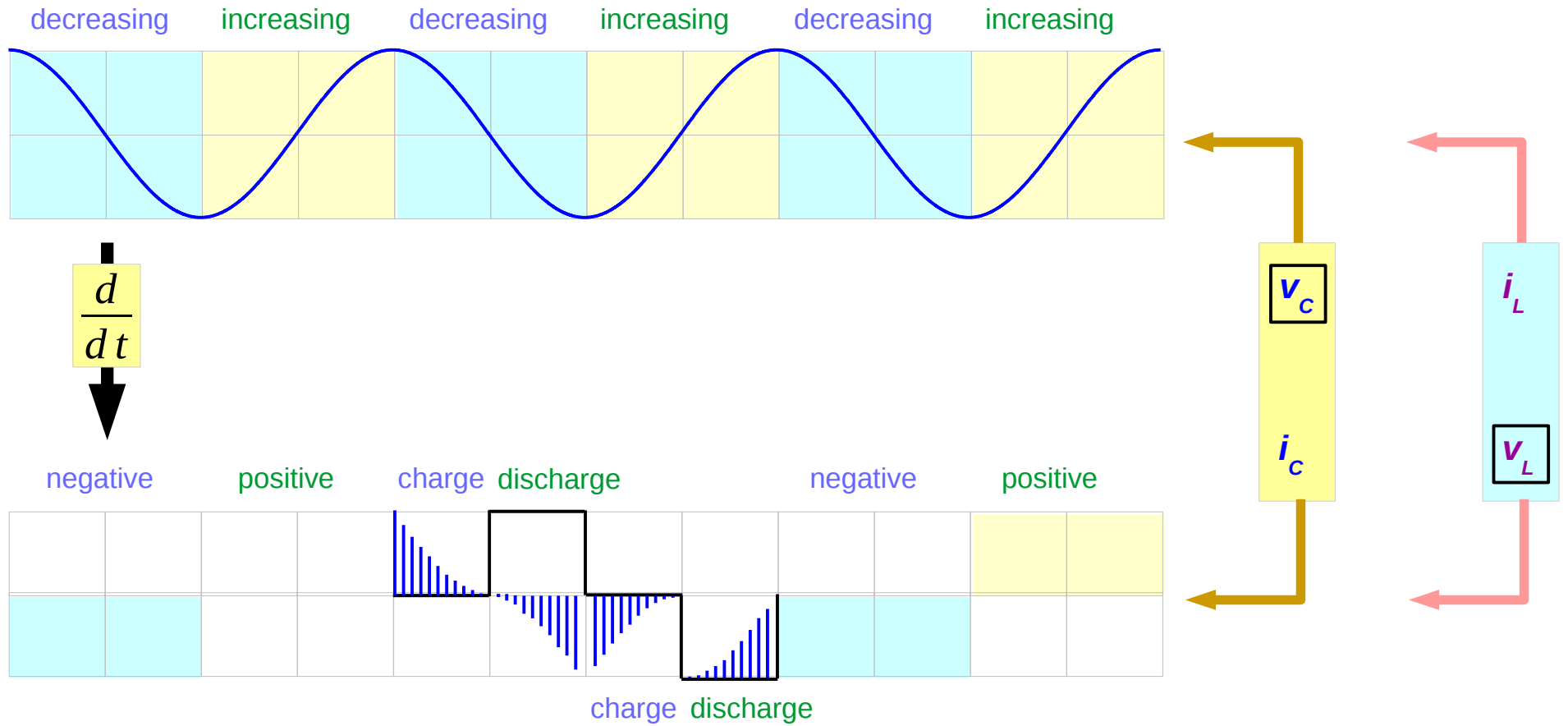




# Everchanging signal pairs

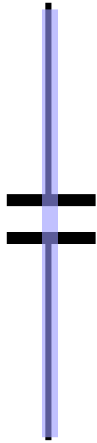


# Everchanging signal pairs



# I leads V by 90°

*Initial  
charge*

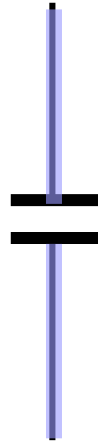


*SHORT*

*V = 0*

*I : peak*

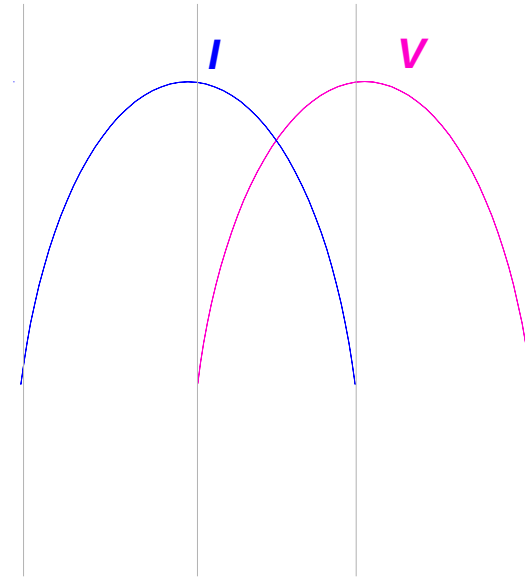
*Full  
charge*



*OPEN*

*I = 0*

*V : peak*



## References

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

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