EGR 103 LEC. #4 Capacitance, Inductance & Diodes

Properties of Capacitors, Inductors, and Diodes

There are three basic components used in passive electronic circuits. Resistance, Capacitance, and Inductance. (Inductance will be covered in a later course.)

Resistance R: Opposes the flow of DC or AC current through it. Resistance does not change with frequency.

Capacitance C: Opposes any change in the voltage across it.

Since AC is a changing voltage the capacitor has resistance to AC voltage. This resistance is frequency dependent.

At high frequency the capacitor is a short;
at low frequencies or DC the capacitor is an open.

A capacitor has the following properties:

1. Acts as a short circuit to AC.
2. Acts as an open circuit to DC
3. Stores charge or DC voltage for short periods of time.

The unit of measurement for capacitance is the Farad.
Common values of capacitors are measured in μF (1×10^{-6} F).

Capacitor General Construction:

Has two parallel plates with an insulator (dielectric) in between.

Capacitor General Operation:

The cap stores electrostatic charge on each plate.
∴Has a separation of positive and negative charge.
∴Capacitors store voltage.

Objective : **Apply the capacitance properties to a circuit that has both a DC and a Hi frequency AC wave form.**

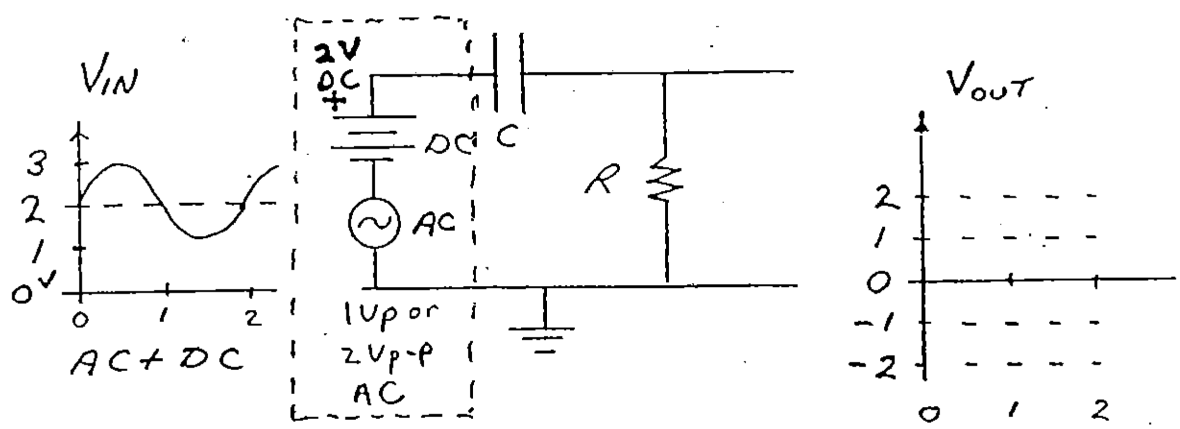
1. **Coupling Cap** RC network is a Series cap network

Application: Transistor amps can only work with a DC waveforms.
Input and output transducers such as mikes and speakers work only with AC.
The coupling cap isolates the DC in the transistor amp from getting into the transducers while allowing the AC to go from the mike to the amp's input, and the AC to go from the amp's output to the speaker without DC.

Coupling Cap - is a Series cap network

General Cap Properties	Coupling Cap Properties
A Cap is a Open to DC –	**Coupling Cap** Blocks DC voltage
A Cap is a Short to AC –	**Coupling Cap** Passes AC voltage

EX: Apply an AC & DC wave form to a coupling capacitor circuit and draw the input V_{in} and output V_{out} wave forms.



If X_C is < 1/10 R_C the cap is a short to AC and all of AC signal will go through.
Pick value of C & X_C so 90% of AC signal will go through at the lowest frequency.
This means set X_C = R at the Lowest frequency.

2. **Bypass Cap** RC network generally is a Parallel Cap Network with R_{LOAD}.

Applications: 1. Power supply Hum Filter

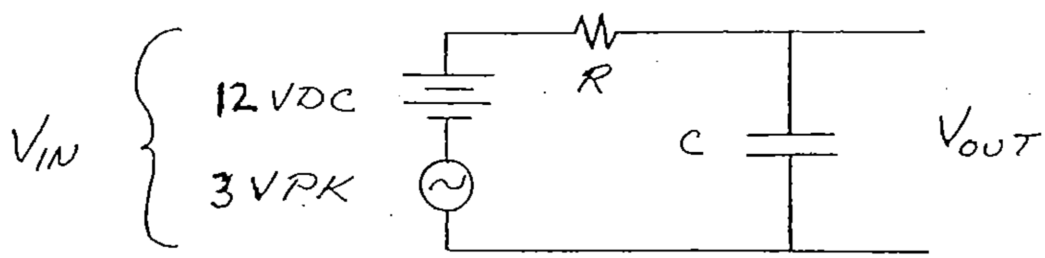
2. Transistor Amp Emitter CKT to increase AC Gain.

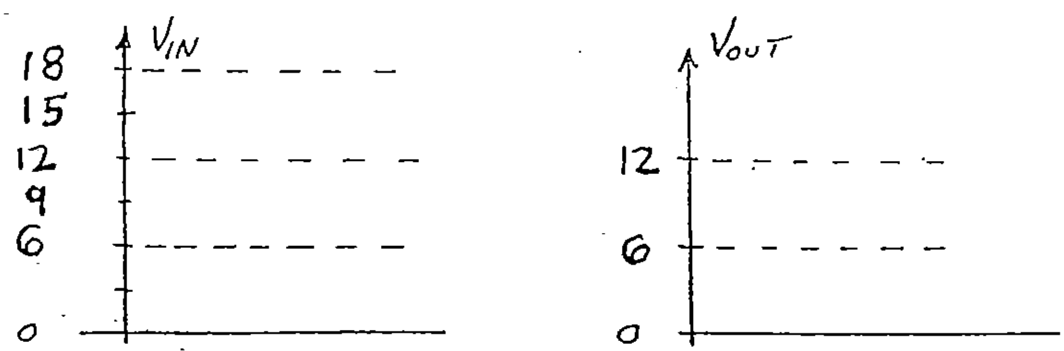
3. Auto Ignition noise filter.

Bypass Cap - Is a Parallel cap network

General Cap Properties	Bypass Cap Properties
A Cap is a Open to DC -	**Bypass Cap** passes DC voltage to the load
A Cap is a Short to AC -	**Bypass Cap** Shorts the AC signal to Gnd.

EX: Apply an AC & DC wave form to a Bypass capacitor circuit and draw the input V_{in} and output V_{out} wave forms.





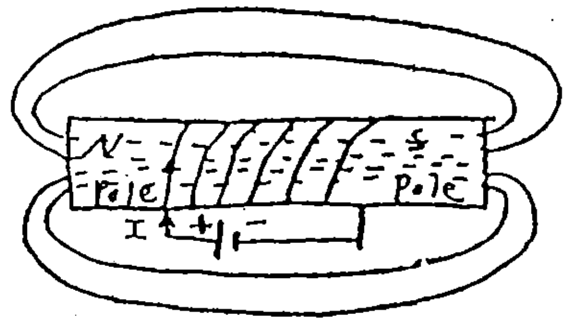
Oscillation is when an amplifier or transistor SW produces a high frequency sine wave out without an input signal.

Oscillation in amplifiers is an undesirable internally generated very high frequency sine wave that must be eliminated. This is done by using small ceramic bypass caps to ground that are a short circuit to the Hi Frequency Oscillation, but an open circuit to the low Frequency desirable audio signal.

Inductance:

Inductance is dependent on the magnetic field generated by the wire in the inductor.

Inductance Construction:



Multiple turns around <u>a core</u> will concentrate the field more. thus increasing Inductance.
The electromagnetic pattern is the same as a bar magnet.

A cap stores Energy in its Electric (E) Field
When SW is closed the Cap Elec. Field inc. to E.

An Ind. Stores Energy in its Magnetic (M) Field
When SW is closed the Ind. Magnetic Field inc. to I_L.max

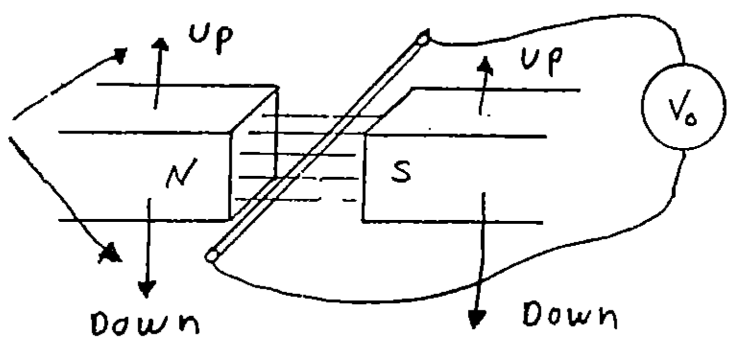
ELECTROMAGNETIC INDUCTION

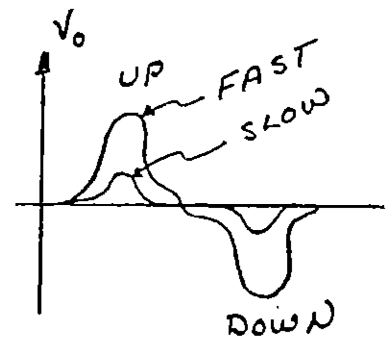
Generation of an EMF Voltage called Induced EMF Voltage occurs when a moving magnetic Field cuts across a wire.

Faraday's Law:

The Magnitude of Induced EMF voltage is Proportional to the Speed of the moving magnetic field.

The Polarity of the Induced Emf voltage depends on the direction of the magnetic field. Up (Pos), or Down (Neg).



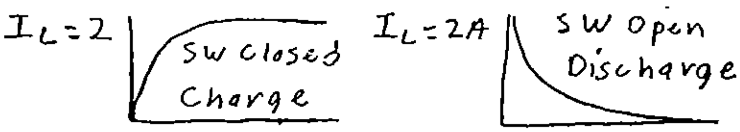


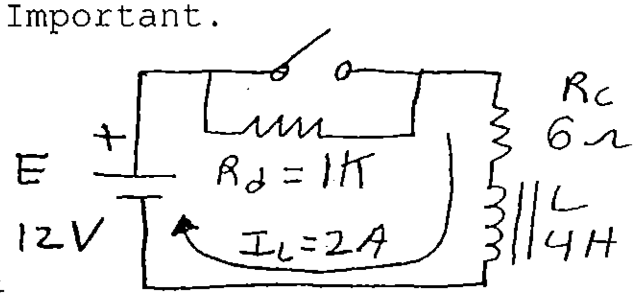
Note: If the wire is stationary but the magnetic field is rapidly collapsing, it will generate a very large Neg. Voltage due to the Hi Speed of the Collapsing field.

This is the principal of operation that causes the High Voltage CEMF Voltage Spike that occurs when a SW is opened with an Inductive Load.

Inductor current (I) discharge properties and Calculation of the Large Inductor CEMF Voltage when Discharging

With an Inductor the Charge Circuit is of little importance but the Discharge Circuit can be Very Important.





<u>Inductance opposes any change in I</u>

With switch closed Inductor current I_L will fully charge to

$\mathbf{I_{FINAL} = I_M = E/R} = 12/6\Omega = 2A$

When switch is opened the inductor opposes any change in I and will initially maintain $I_L = 2A$.

NOTE:

A Cap Stores Voltage & the I. Changes direction when V is Discharging.

An **<u>Ind</u>**. **<u>Stores Current</u>** & the **<u>V. Changes direction</u>** **<u>when</u>** **<u>I is Decaying</u>**.

NOTE: The Direction of I thru $R_{DISCHARGE}$ changed direction when discharging the Coil even though I thru the Coil remained in the Same direction.

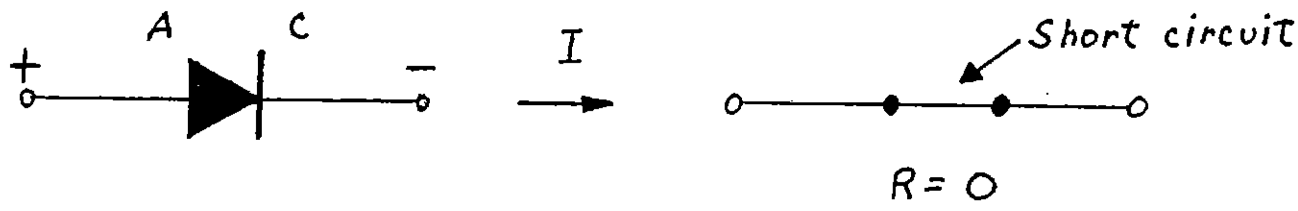
But with $I_L = 2A$ and $R_{DISCHARGE}$ $(R_d) = 1K$;

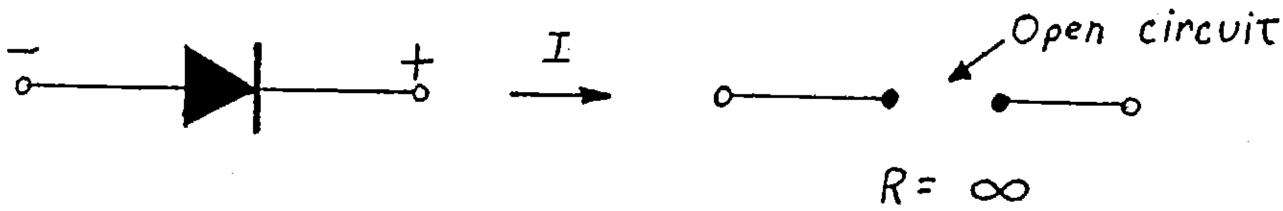
$V_{Rd} = IR_d = (2A)(1K) = 2000V$.

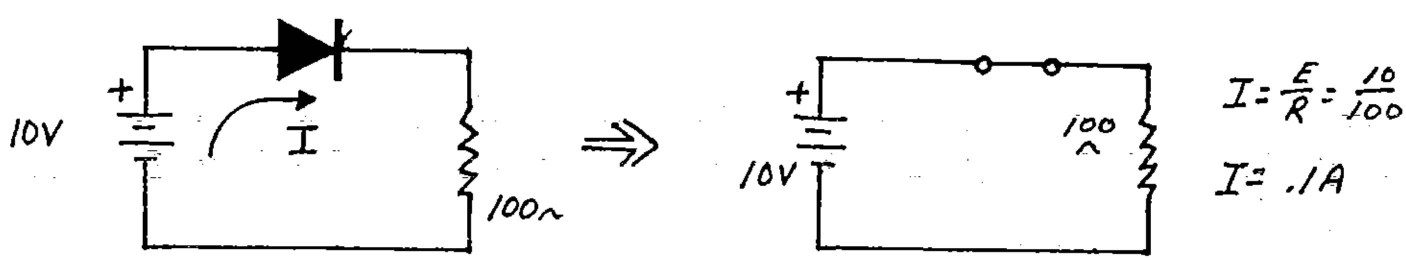
This Hi voltage is of very short duration.

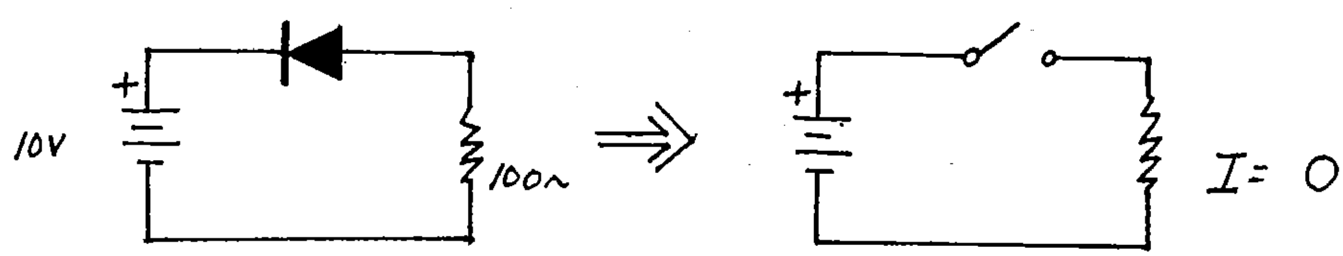
This Hi CEMF is generated by the rapidly collapsing field.

This principal is used in Auto ignition.


A
C
+
−
I
Short circuit
R= O


−
+
I
Open circuit
R= ∞


+
10V
I
100Ω
+
10V
100Ω
I= E/R = 10/100
I= .1A


+
10V
100Ω
+
I= O

Use of a Diode to limit Discharge CEMF Large Neg. Voltage Spike.

NOTE: This method **works with DC Voltages only.**

A diode is a short to current flow in one direction and an open in other direction. Specifically, the diode is an open to the charge current I_C direction and a short to the discharge current I_d direction.

Conventional
Current flow

This method is used when switching inductant type loads to DC, not AC voltage. Examples of inductive loads: motor, relay, etc.
