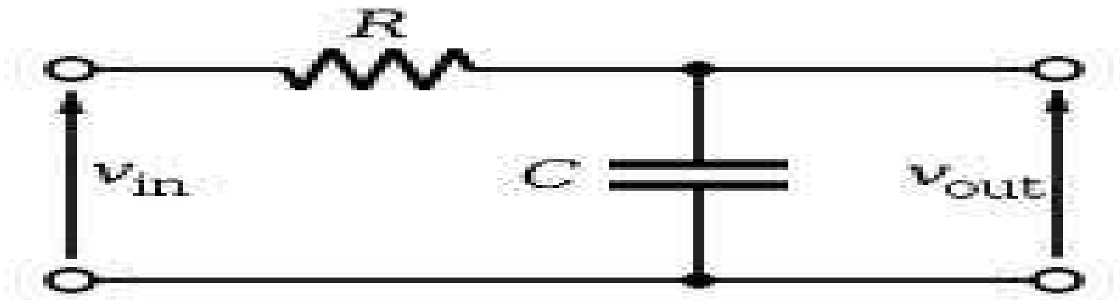
Different linear networks are

1. RC circuits
2. RL circuits
3. RLC circuits

RC circuits: 1.High pass RC circuit
1. Low pass RC circuit

1.High pass RC circuit: in an RC circuit if capacitor is in series with the input voltage signal and a resistor is in shunt with the output then that circuit is named as high pass RC circuit.
Operation : we know $X_c = 1/2\pi f C$
If frequency of input signal is low ,capacitive reactance is high ,then
Capacitor is replaced with an open circuit .so output voltage is zero.



Similarly If frequency of input signal is high ,capacitive reactance is low ,then Capacitor is replaced with an short circuit .so output voltage is same as input voltage.

Hence it behaves like a high pass RC circuit.

Sinusoidal input: the sinusoidal input is defined as $v_i(t)= V_m \sin\omega t$
Applying KVL around the loop

$$v_i(t)- 1/c \int i\, dt - i R =0$$

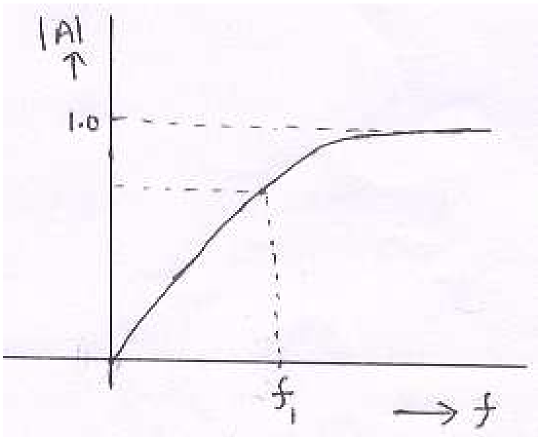
$$Vi(s) = I(s) [R+ 1/sc]$$
$$Vo(s) = I(s) R$$

$$Vo(s)/Vi(s) = 1/(1+1/sRC) = 1/(1-j(1/2\pi fR C))$$

So gain of a circuit is A= $1/\sqrt{(1+(f1/f)^2}$
Where f1 = $1/2\pi$ RC = lower cutoff frequency
Phase angle = $\tan^{-1}(f1/f)$

So for an high pass RC circuit if input is a sinusoidal then output is also sinusoidal.

Frequency response:



Note :

1. voltage across the capacitor does not changes instantaneously
2. capacitor takes some finite amount of time for its charging or discharging
3. The time required for the charging or discharging of a capacitor can be specified by a time constant of a circuit.
4. time constant is the product of total resistance and capacitance associated in the given circuit.

Step voltage input :

For an high pass RC circuit we know Vo = Vi –Vc,
Where Vc is the voltage across the capacitor.

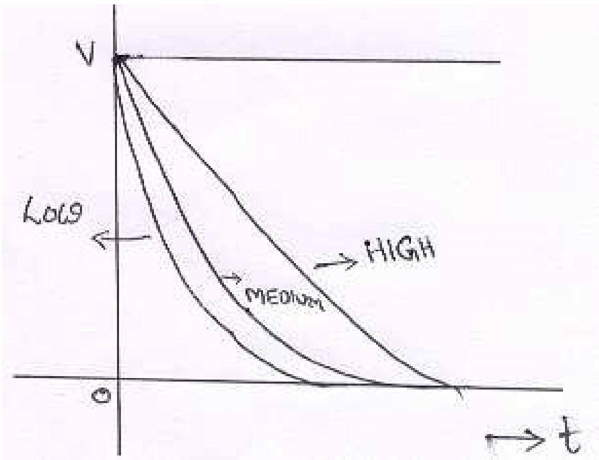
Case(i): for step voltage input we know for t<0 , Vi = 0 V , Vc = 0 V so Vo = 0 V

Case(ii): at $t=0^-$ (immediately before t=0)still output voltage is zero
but at $t=0^+$(immediately after t=0) , Vi = V Volts , Vc = 0 V so Vo = V Volts

case(iii): for t>0 , voltage across the capacitor increases exponentially(by doing mathematical analysis we can get current is in the form of exponential) so output is a decaying exponential.

Time constant of an high pass RC circuit is RC(by neglecting source resistance). If time constant is high then output takes more time to reach final value similarly If time constant is low then output takes less time to reach final value.

Output waveforms for different time constants is shown below



Pulse input to high pass RC circuit :

Case(i): for t<0 and also at $t=0^-$, Vi = 0 V , Vc = 0 V so Vo = 0 V

Case(ii): at $t=0^+$(immediately after t=0) , Vi = V Volts , Vc = 0 V so Vo = V Volts

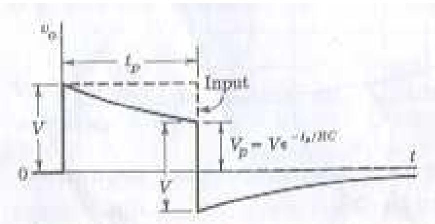
case(iii): during the interval 0 to t_p ,voltage across the capacitor increases exponentially(by doing mathematical analysis we can get current is in the form of exponential) so output is a decaying exponential.
Equation for output voltage during 0 to tp is $Vo(t) = Ve^{-t/RC}$
At $t = t_p^-$, $Vo(t) = Ve^{-tp/RC} = V_P$

Case(iv): at $t = t_p^+$, input voltage reduces by an amount of V volts so output will also
Reduces by the same amount (because Vc can not changes instantaneously).
So at $t = t_p^+$, $Vo(t) = V_P - V$ (it is a negative magnitude)

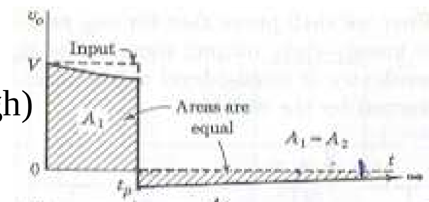
Case(v): for $t > t_p$, $Vi = 0$ V so capacitor will discharges then output will tries to approach zero volts.
We know equation for exponential signal is $Vo(t) = Vf + (Vi - Vf)\, e\text{-}(t-tx)/\tau$
For $t>tp$, $Vf = 0$ V , $tx = tp$, $Vi = V_P - V$ then $Vo(t) = (V_P - V)\, e^{-(t-tp)/RC}$

$$Vo(t) = V(e^{-tp/RC} - 1)\, e^{-(t-tp)/RC}$$

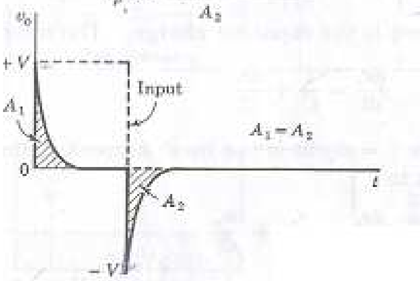
The waveforms for different time constants as shown below,
(Medium)



(high)



(low)



The process of converting pulses into spikes by means of a circuit having short time constant is known as a peaking.