ADVANCED PULSE AND SWITCHING LAB

Studies on RC Low Pass Filter

Objectives

At the end of the module, the student would be able to

- Explain RC Voltage Dividers
- Explain RC Circuit as a Low Pass Filter
- Explain Bode plots

RC Circuit as Filters

RC circuits can also be used to "filter" a signal waveform, changing the relative amounts of low frequency and high frequency information in their output signals relative to their input signals. There are high-pass filter and low-pass filter and band-pass filter versions of this.

Impedance of a capacitor

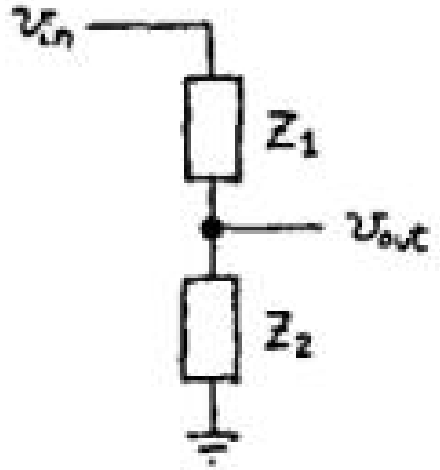
$$Z = 1 / wC$$

Z = Impedance of Capacitor

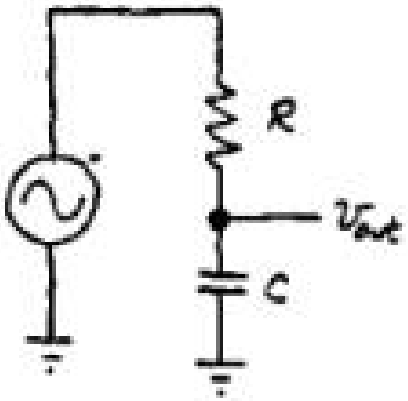
w = Angular Frequency

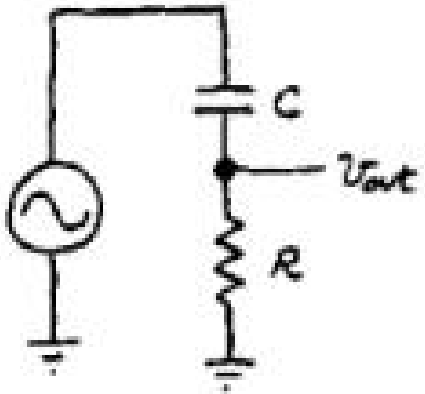
C = Capacitance

RC Voltage Dividers



generalized voltage divider

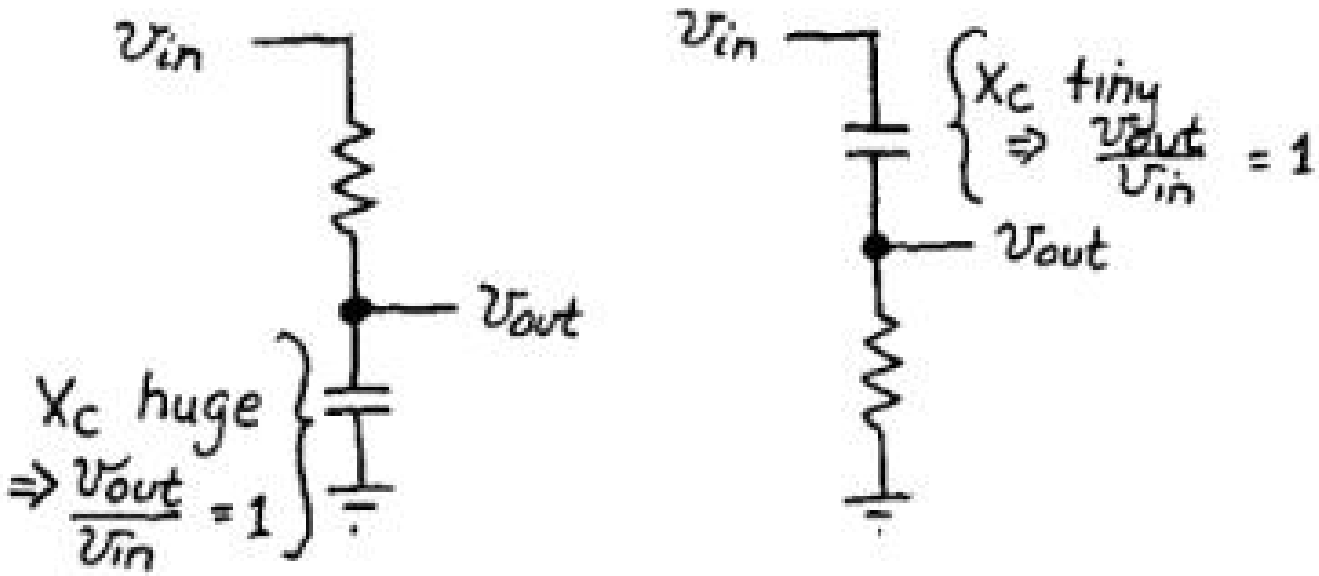




Let us consider RC circuits as voltage dividers to understand how they would perform as 'filters'. Note that Vout = (Z2/ Z1 + Z2)*Vin.

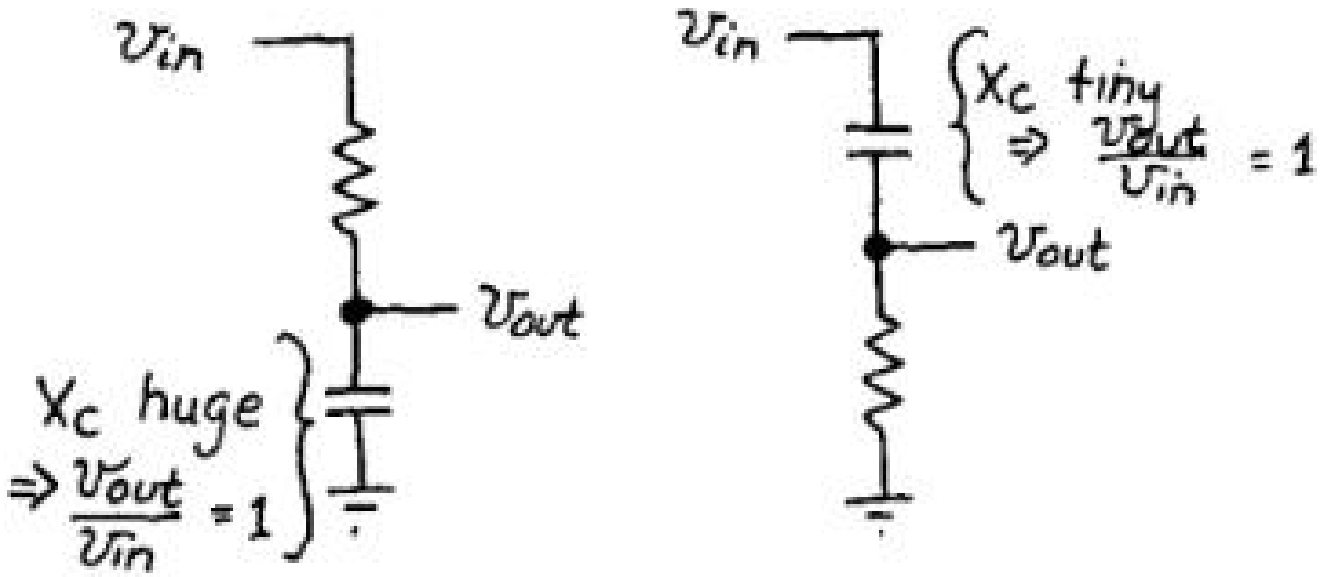
In this case – Since Z1 or Z2 is dependent upon frequency, the output is dependent upon the frequency of the input waveform.

RC Voltage Dividers



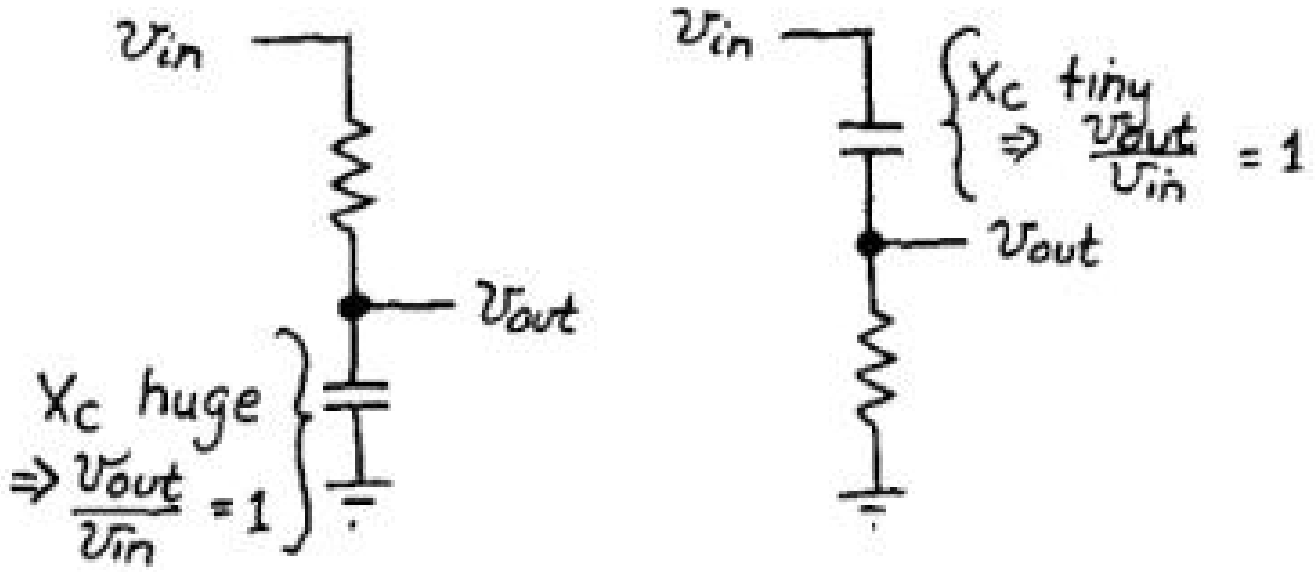
Consider the extreme cases. For the left one– at f = 0, Z2 = infinite (huge), thus allVout = Vin. The lower the 'f', the more Vout will resemble Vin. Thus this one easily passes lower frequency signals through.

RC Voltage Dividers



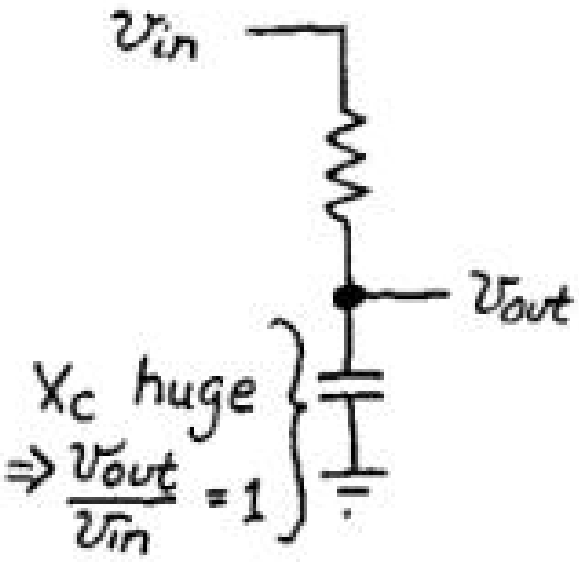
For the right one– at f = very high, Z1 = very small, thus all Vout = Vin. The higher the 'f', the more Vout will resemble Vin. Thus this one easily passes higher frequency signals through.

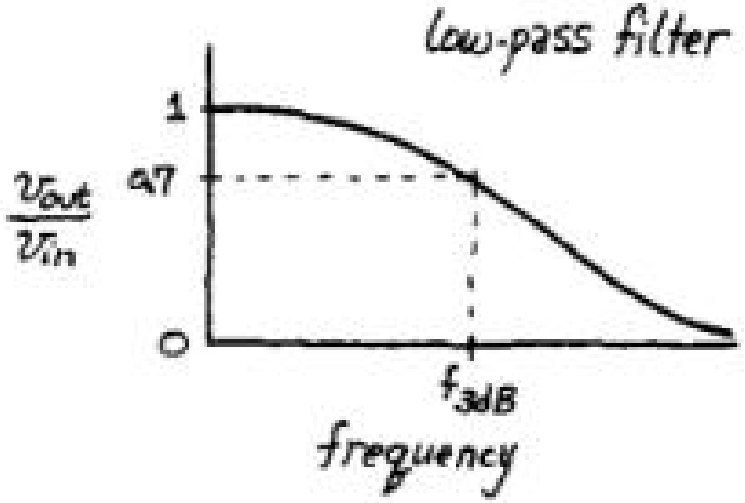
RC Voltage Dividers



Now let us determine, where the output turns the corner in each case. We will call this 'corner', where is the output is 3db less than the input. This is henceforth called the'3db' point. Let us look at how the Vout/Vin ratio will change wrt frequency for each now. The plot of this ratio tells us if the circuit behaves as a high pass or as a low pass filter.

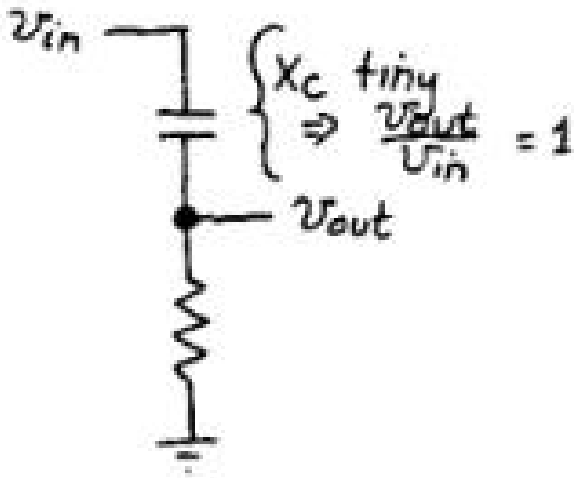
Low Pass Filter

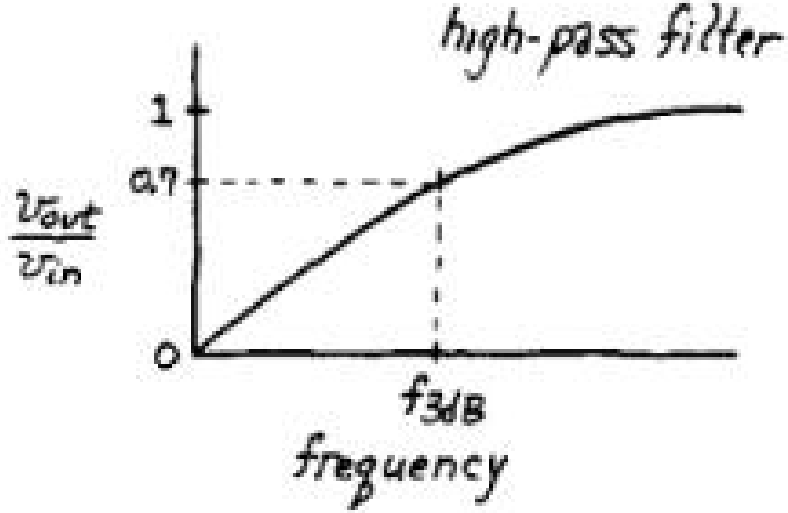




As frequency increases, the impedance of the capacitor (Z2) decreases, thus reducing the Vout (= (Z2/R + Z2)*Vin). At very high frequency, impedance Z2 = very tiny thus forcingVout to be nearly 0. The '3db' point is given by f 3db = 1/(2πR*C).

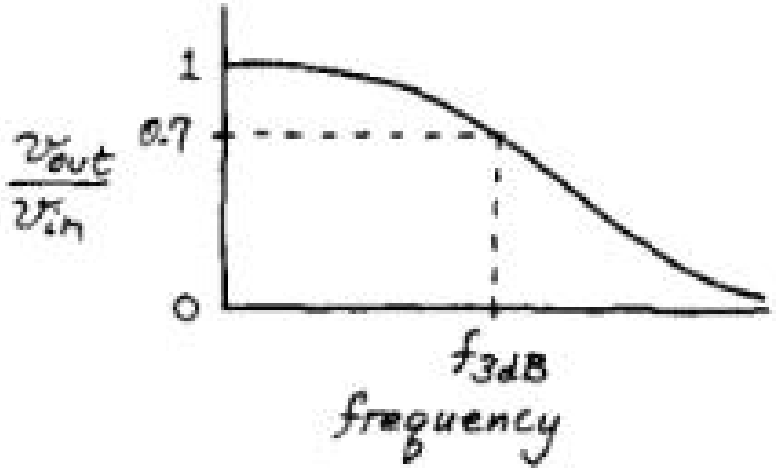
High Pass Filter

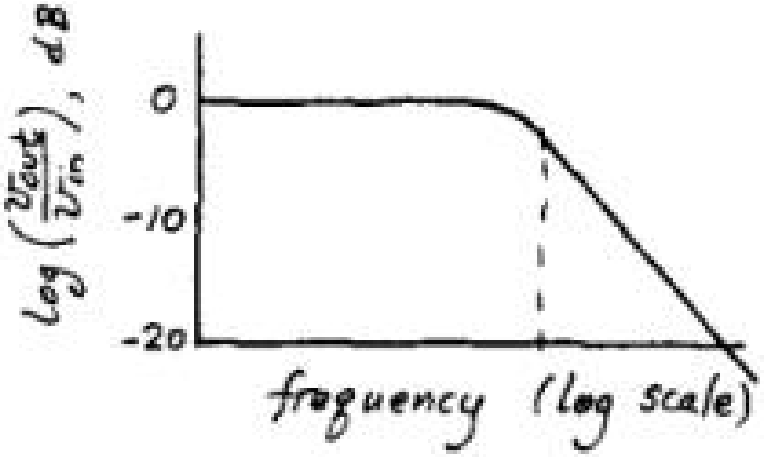




As frequency increases, the impedance of the capacitor decreases, thus increasing the Vout (= (R/Z1 + R)*Vin). At very high frequency, impedance Z1 = very tiny thus makingVout to be nearly equal to Vin. The '3db' point is given by f 3db = 1/(2ΠR*C).

Bode Plots





We have been plotting 'linear' plots – Gain (Vout/Vin) vs Frequency. Ideally both the axis are compressed and expressed in the log scale. This is known as 'bode-plots'.

RC as Low Pass filter

Conclusion

The circuit produces its greatest response at DC. As the frequency is increased, the response drops. Finally, the response drops to zero.

The RC circuit passes 'low' frequencies fairly well, but attenuates 'high' frequencies.

So, we can conclude that RC circuit acts a low-pass filter (LPF).

Example Frequency Response of RC Low Pass Filter