Differentiator

As its name implies a **Differentiator** is a circuit that is designed such that the output of the circuit is proportional to the time derivative of the input. The differentiator may be constructed from a basic inverting amplifier if an input resistor is replaced by a capacitor C.
There are two types of differentiator circuits, active and passive.

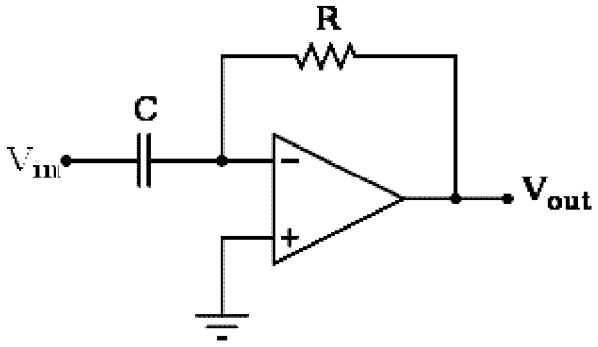

Figure 2.5

A differentiator circuit consists of an operational amplifier, resistors and capacitors. The circuit is based on the capacitors current to voltage relationship:

$$I = C\frac{dV}{dt}$$

where I is the current through the capacitor, C is the capacitance of the capacitor, and V is the voltage across the capacitor. The current flowing through the capacitor is then proportional to the derivative of the voltage across the capacitor. This current can then be connected to a resistor, which has the current to voltage relationship:

$$I = \frac{V}{R}$$

where R is the resistance of the resistor. If Vout is the voltage across the resistor and Vin is the voltage across the capacitor, we can rearrange these two equations to obtain the following equation:

$$V_{out} = -RC\frac{dV_{in}}{dt}$$

Thus, it can be shown that in an ideal situation the voltage across the resistor will be proportional to the derivative of the voltage across the capacitor with a gain of RC.

Differentiator circuits are mostly used in signal wave shaping applications, and can be used as a rate –of – change detector in FM modulators.