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RC Integrators - Application Note

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RC integrators are fundamental building blocks in a fast pulsed data acquisition system. They are used to process fast “derivative” signals and produce the original signal waveform from it. They have excellent reliability, and the signals always return to zero which allows the user to determine sensor failures inputs quickly. They are impervious to errors in osciloscope offset.

In the analysis below, if a signal is proportional to the rate of change of current V1(t) = kdI/dt, the signal displayed on an oscilloscope is V2(t) with the relationships given below:

$$V1(t) := k \cdot \left(\frac{d}{dt} I\right)$$

$$V2(t) := \frac{\left(\int V1(t)\,dt\right)}{RC}$$

$$V2(t) := \frac{k \cdot I}{RC}$$

Typical Application

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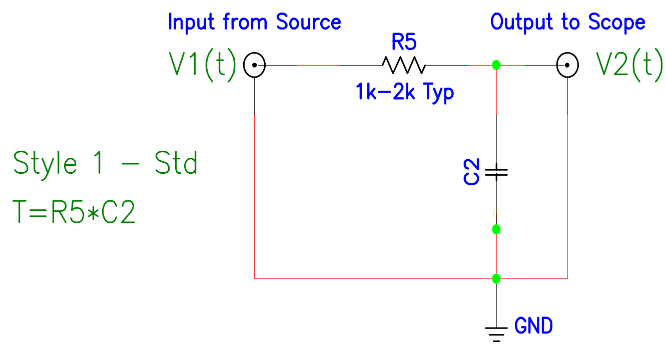
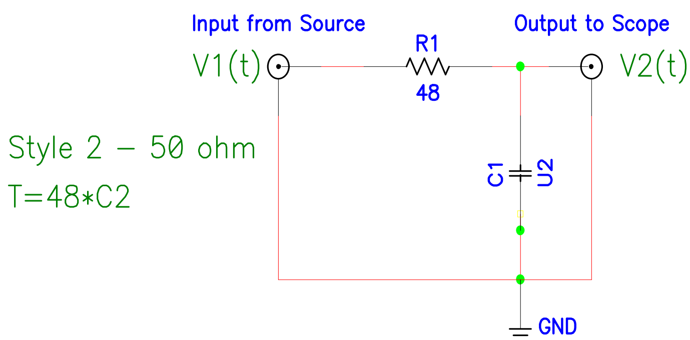
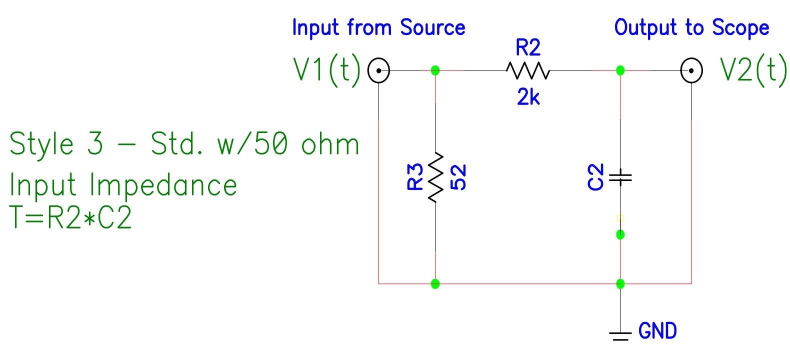






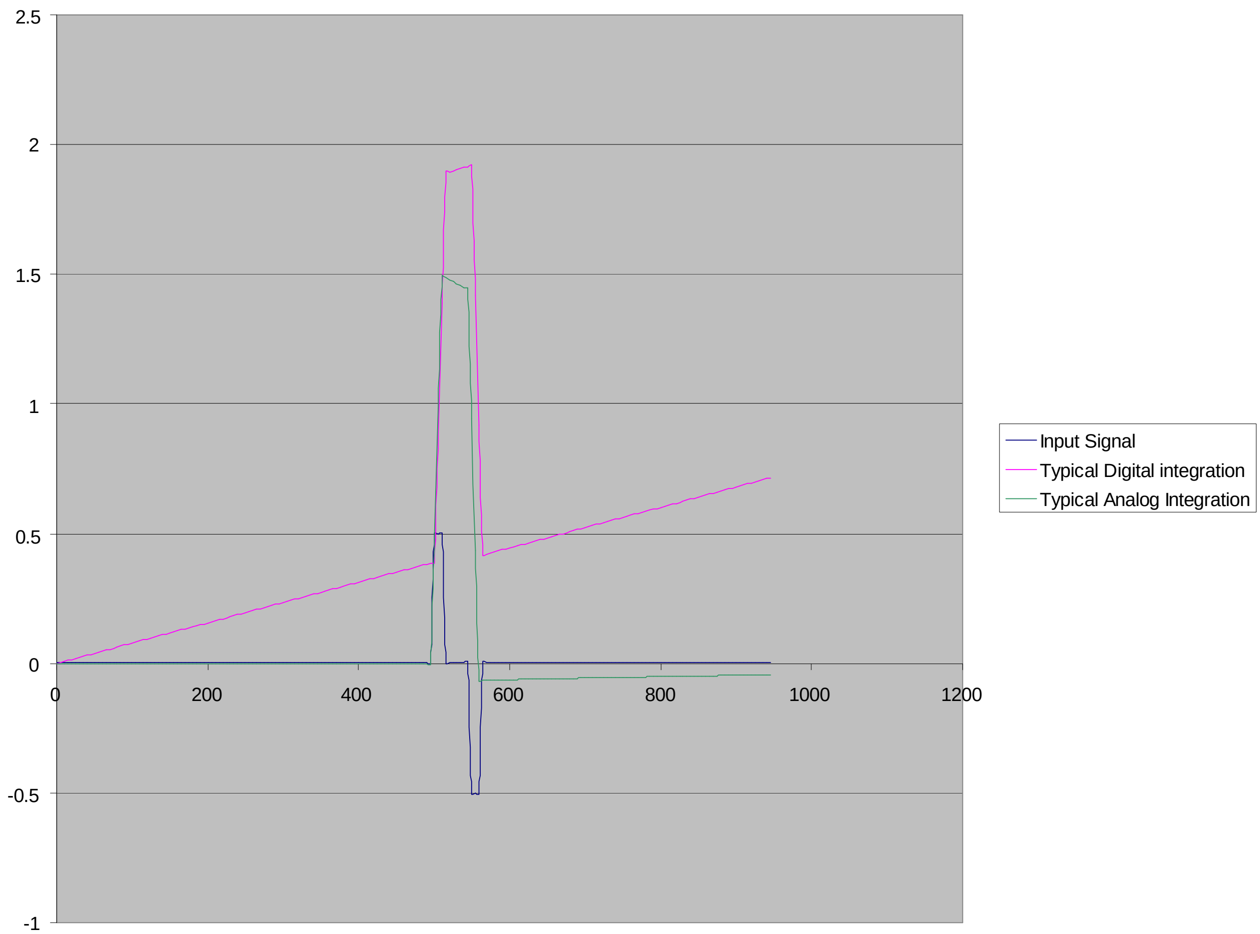
Style 1
Use in a system with a high impedance scope termination with a drive other than 50 ohm cable (or use your own 50 ohm cable termination).

Style 2
Use in a system with 50 ohm scope terminations exclusively or in a system with a low impedance drive. This style does not need to be placed at the oscilloscope, but it may be placed in line.

Style 3
Use in a system with 50 ohm cable and high impedance scope terminations exclusively.

RC Integration vs. Numerical Integration on a Scope

Derivative signals may be integrated on a scope, but the quality of the signal output is inferior at high freqeuency. Digital Oscilloscopes usually have ½ - 1 bit of offset which makes numerical integration problematic. For example, if there are 8 significant bits of information on a signal with ½ bit of offset, the offset is 1part in 512. Typical scope traces with analog integrators and digital integration are shown below. The longer the record length on the scope, the worse the offset problem. Analog integrators have a droop of 10 % every 0.1*RC which can be corrected by a very accurate numerical algorithm.



Digital integration also requires approximately 2X or greater bandwidth than an integrated signal as illustrated above. The rise time of the input signal is much faster than the risetime of the actual integrated signal.

Analog integration has significant advantages at low cost.