

Subject: S Curve Velocity Profiling

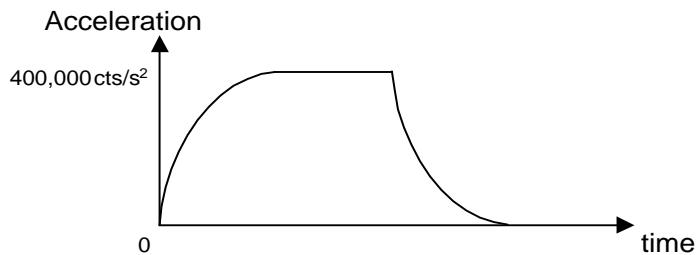
Product: SMC2000/3010

Summary: This document describes how to use the IT and VT commands in the SMC2000 or SMC3010 to produce S-Curve Velocity Profiling.

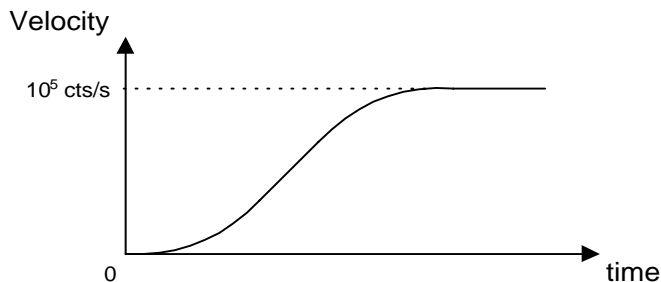
A trapezoidal move profile has a step acceleration profile. With this type of profile, the motor is commanded to instantly accelerate up to speed. The step shape of the acceleration is the source of the sharp discontinuities at the beginning of the move. These sharp corners can cause a sharp jerk in the mechanical motion; a preferable velocity profile would gradually roll on the acceleration and roll off when the desired speed is reached.

This smooth roll on and roll off of acceleration is where the S-curve profile is needed. For our example program using the Jog mode of motion, the IT command can provide smoother transitions during the acceleration of the motor. The S-curve profiling is achieved by the use of an algorithm that smoothes the square pulse of acceleration with a single time constant digital filter.

If the acceleration step is filtered by a single time constant low pass filter, the acceleration versus time graph will look like this:



This is the same effect that an electrical RC filter has on a step shaped voltage versus time. The filtering of the acceleration versus time will of course change the velocity versus time into this shape:



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The velocity versus time is now S-shaped, hence the name S-curve profiling. With an SMC controller, the amount of smoothing of the acceleration is set with the IT command. The IT command works with acceleration and deceleration of independent axis motion commands, there is a corresponding command VT for smoothing the vector acceleration and deceleration in coordinated or linear interpolation motion.

<u>Command</u>	<u>Effect</u>
IT	smoothes AC, DC phase of motion due to JG, IP, PR, PA commands.
VT	smoothes VA, VD phase of motion due to VP, CR, LI commands.

The S curve digital filter is modeled in the z plane by this equation:

$$F(z) = \frac{z}{z - e^{-T/\tau}}$$

where T is the sample time, fixed at 2 milliseconds on an SMC controller, and τ is the time constant. The IT command sets the pole of the S-curve filter:

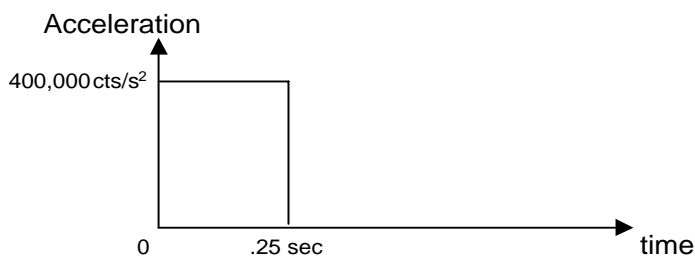
$$1 - IT = e^{-T/\tau}$$

Solving the above equation for the time constant τ , and substituting the 2 millisecond sample time for T:

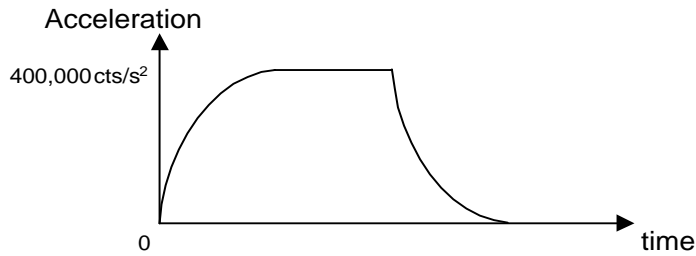
$$\tau = \frac{-.002}{\ln(1 - IT)}$$

The equation above shows how the IT setting affects the S-curve filter's time constant τ . The IT setting on an SMC controller defaults to 1.0, which results in an infinitely short time constant and no filtering effect. Decreasing IT causes the time constant to increase, and the acceleration and deceleration is then smoother. Substitute VT for IT in the above equation to determine the vector acceleration time constant.

The time constant of the S-curve filter changes the amount of time to ramp up and ramp down the acceleration in our motion example. If the S-curve time constant were 0, then the acceleration ramps up and down nearly instantaneously:



If we decrease the IT value the time constant will increase, and the amount of time for the acceleration to reach the set value will also increase:



The amount of time for the acceleration to ramp up is approximately equal to the time constant multiplied by 2.2. Since the equation for the time constant is exponential, the ramp time is an approximation. Experimentation is the only method to obtain an exact time value. The amount of time for the acceleration to ramp up to the set value and the time for the acceleration to ramp down from the set value back to zero are equal.