Excerpt from Chapter 3 - PLC Motion Blocks

3.2.3.1 Move Profiles

For Rockwell ControlLogix servo motion move blocks, there are basically two move profiles for the velocity – trapezoidal and S-curve. The performance of a move with a trapezoidal profile is shown first, followed by two examples of S-curve profiles.

The trapezoidal profile and the corresponding acceleration and jerk curves are shown in Figure 3.12. The maximum speed, acceleration rate and deceleration rate are operands in the move block. A trapezoidal move profile will get to the position end point in the fastest time for a given acceleration and maximum speed. However, the jerk is theoretically infinite when there is step-change in the acceleration. Though, it will be limited to the maximum jerk configured for the axis. This profile is typically very stressful on the motor.

The example in Figure 3.12 is for a MAM block for a 100 mm move in the positive direction for a trapezoidal velocity profile. The velocity is set to 200 mm/sec, and the acceleration and deceleration are set to 100,000 mm/sec^2. Note that the time scale is focused mainly on the acceleration and deceleration parts of the velocity profile. The acceleration and deceleration portions of the profile will be slightly more than 2 ms because of the jerk limit. The position is not shown, but it changes only 0.4 mm during the acceleration and deceleration portions of the velocity profile (total of 0.8 mm). So, the bulk of the move takes place while the velocity is 200 mm/sec and requires slightly less than 500 ms.

An S-curve profile places a limit on the jerk. One can specify the acceleration jerk limit and deceleration jerk limits as values in time or master time units, or as a percentage of the jerk limit. However, an easier is to specify the jerk units as "% of Time." The value of the jerk in "% of Time" basically specifies the percent of the time during the acceleration and deceleration portions of the profile that the acceleration/deceleration is changing. This generates a trapezoidal profile on the acceleration/deceleration, limiting the slope of the acceleration. The percentage is divided equally among the positive and negative slope parts of the acceleration/deceleration. Figure 3.13 shows a move with a jerk of 100% of Time. In the first 50% of the acceleration portion, the acceleration is ramped up to its value and in the last 50% of the acceleration portion; the acceleration is ramped down to zero. In Figure 3.13, the acceleration jerk and deceleration jerk are both 100%, though one could specify a different acceleration jerk and deceleration jerk. Figure 3.14 shows a move with a 25% of Time jerk for both the acceleration and deceleration. The 25% of Time is divided into two 12.5% periods, the first one at the beginning of the acceleration/deceleration profile and the second period at the end of the acceleration/deceleration trapezoid profile. During the middle 75% of the trapezoid, the acceleration is constant at the specified acceleration value.

The value of the jerk is calculated as (Rockwell, 2018b):

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Accel Jerk = (Max Accel^2 / Max Velocity) * [200/(% of Time) – 1]
Decel Jerk = (Max Decel^2 / Max Velocity) * [200/(% of Time) – 1]

The example profiles in Figure 3.13 and 3.14 are for a MAM that moves an actuator 100 mm in the positive direction. The velocity is set to 200 mm/sec, and the acceleration and deceleration are set to 100,000 mm/sec^2. In Figure 3.13, the Accel Jerk and Decel Jerk are both 100% of Time. Note that the time for the acceleration/deceleration portions of the velocity profile is twice as long as time for the trapezoidal profile. But, the jerk is significantly less. In Figure 3.14, the Accel Jerk and Decel Jerk are both 25% of Time. The jerk is seven times higher than the jerk for the 100% of Time profile. The time for the acceleration/deceleration portions of the velocity profile is about 15% longer than the time for the trapezoidal profile. The positive and negative slope parts of the acceleration trapezoid are both 0.29 ms and the middle portion is 1.71 ms, making the time for the velocity to reach 200 mm/sec to be 2.28 ms, compared to 2.0 ms for the trapezoidal velocity profile.

The position for the profiles in Figures 3.13 and 3.14 are not shown, but for the 100% of Time profile (Figure 3.13), the position changes 0.12 mm during the during the acceleration and deceleration portions of the velocity profile (total of 0.24 mm). For the 25% of Time profile (Figure 3.14), the position changes 0.15 mm during the during the acceleration and deceleration portions of the velocity profile (total of 0.3 mm). So, the bulk of the move takes place while the velocity is 200 mm/sec.

REFERENCES

Rockwell Automation, 2018b. *Logix5000 Controllers Motion Instructions Reference Manual*, Publication MOTION-RM002, Feb.

Note: From Chap3 rev20181005.doc

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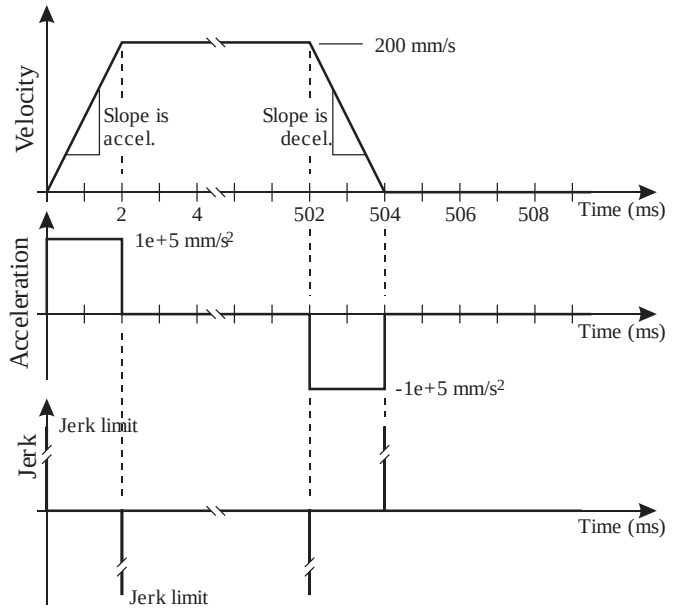

Figure 3.12. Motion profiles for trapezoidal velocity profile.

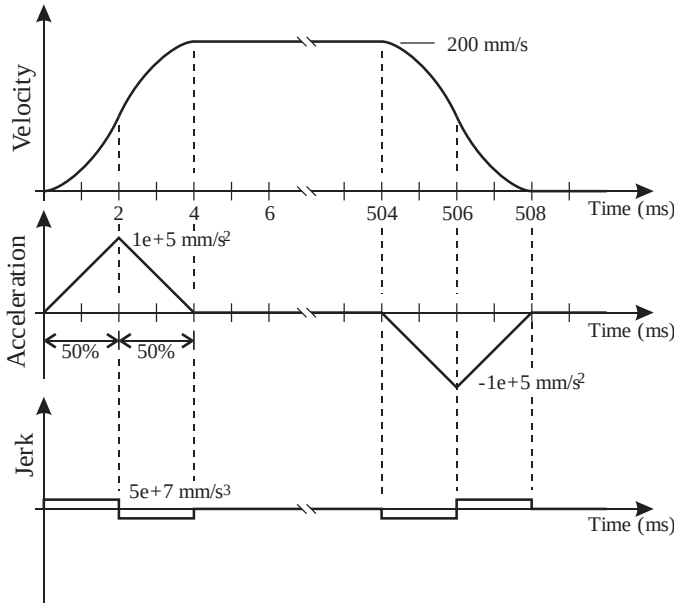

Figure 3.13. Motion profiles for S-curve velocity profile with Accel Jerk and Decel Jerk 100% of Time.

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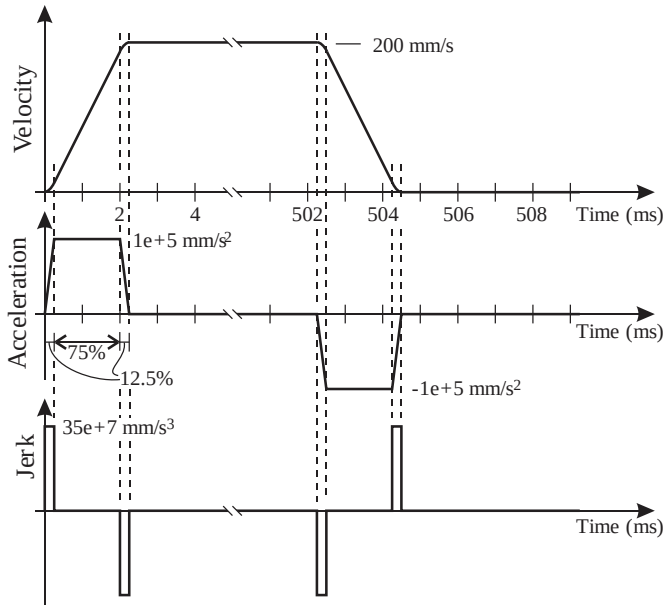

Figure 3.14. Motion profiles for S-curve velocity profile with Accel Jerk and Decel Jerk 25% of Time.

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