

# Application note

## Linear and s-ramped velocity profiles

AN00118

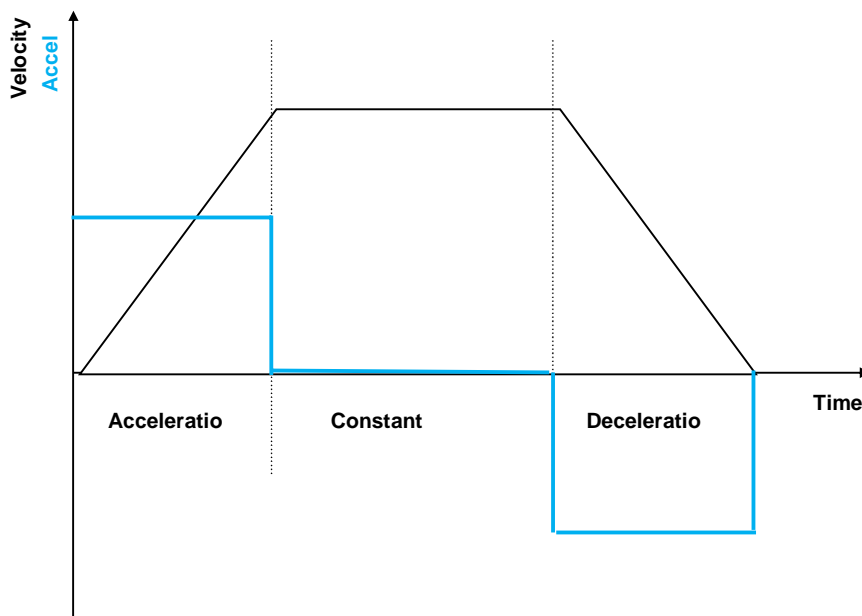
Rev B (EN)

The Mint motion profiler automatically calculates the required velocity profile for an axis based on a number of key settings such as SPEED, ACCEL and DECEL. This motion can either be achieved using a linear velocity profile (constant acceleration and deceleration) or an s-ramped velocity profile (where the rate of change of acceleration/deceleration is adjusted – this is often known as Jerk control)



### Trapezoidal profile

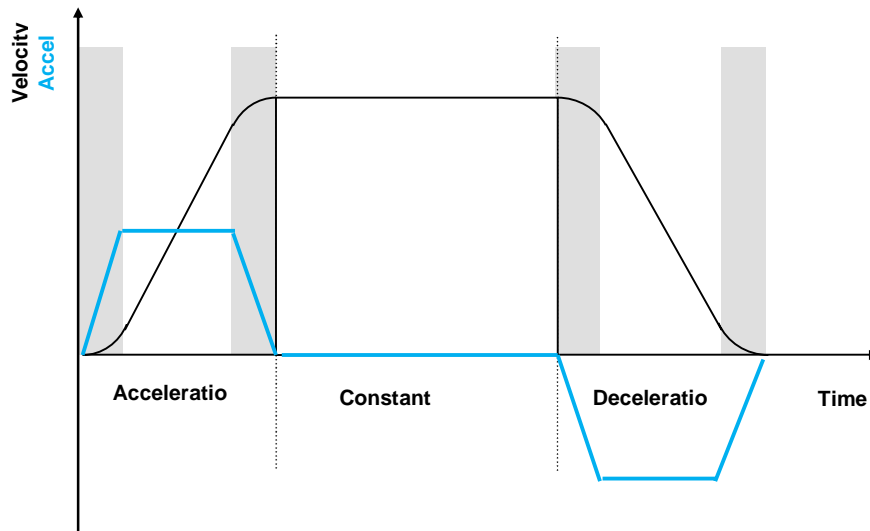
A trapezoidal velocity profile is typically made up of three sections, an acceleration phase, a constant velocity phase and a deceleration phase. The area under this graph equates to the distance travelled by the axis. For short moves the Mint profiler will automatically realise that the required distance can be achieved with just a triangular profile (a short acceleration and deceleration period). For the purposes of this application note we will just consider motion requiring a period of travel at constant speed, but the principles are identical for triangular profile moves too.



For a positional move from rest (e.g. MOVER command), the velocity increases at the rate defined by acceleration (ACCEL in Mint) until it reaches the slow speed (SPEED in Mint). The velocity will then remain constant until the deceleration point, where the velocity will then decrease to a halt at the rate specified by deceleration (DECEL in Mint). The blue trace above shows the acceleration (i.e. rate of change of velocity) during this move. It can be seen that there are step changes in this acceleration profile and it is these steps that give us the term “Jerk”....the step change in acceleration will jerk, or jolt, the motor/mechanical system and might, over time, give rise to premature wear/failure of some components for example.

## S-ramped profile

An s-ramped profile can be considered as a super set of the trapezoidal profile. It typically is made up of seven sections, four jerk phases, a constant acceleration phase, a constant velocity phase and a constant deceleration phase.



The graph above shows traces for velocity and acceleration when using the s-ramp profiler. The term “s-ramp” comes from the shape of the velocity trace during acceleration and deceleration. The shaded areas indicate the periods in time where the acceleration and deceleration are ramped to their maximum values (i.e. where jerk limitation is occurring). The rate of change of acceleration is defined as the jerk.

By eliminating the step changes in acceleration the resulting motion is much smoother kinder to the mechanical transmission system. Note though, that to achieve the same move time, it will be necessary to increase the acceleration and/or deceleration and/or slew speed.

Mint allows the parameters for this motion (speed, acceleration, deceleration, jerk) to be specified via a variety of keywords as we will describe in the following sections.

### Specifying motion profiles using Mint

Mint can generate either trapezoidal or s-ramped velocity profiles for most move types.

All motion parameters are specified on a per axis basis. The keywords for the motion parameters are:

**PROFILEMODE:** Determines whether an axis uses a linear or s-ramped profile (linear is the default if not specified)

**SPEED:** Sets the slew speed in user units per second.

**ACCEL:** Sets the acceleration rate in user units per second per second.

**DECEL:** Sets the deceleration rate in user units per second per second.

**ACCELTIME:** Sets the time to reach the defined SPEED from zero speed in ms

**DECELTIME:** Sets the time to reach zero speed from the defined SPEED in ms

**ACCELJERK:** Sets the jerk rate used on acceleration ramps in user units per second per second per second.

**DECELJERK:** Sets the jerk rate used on deceleration ramps in user units per second per second per second.

**ACCELJERKTIME:** Sets the time to reach the defined ACCEL in ms

**DECELJERKTIME:** Sets the time to reach zero acceleration from the defined DECEL in ms

Note that ACCEL/DECEL/ACCELJERK/DECELJERK define rates of change which will remain constant regardless of other motion settings whereas ACCELTIME/DECELTIME/ACCELJERKTIME/DECELJERKTIME use time to define the rate of change to the currently defined settings (so changing these other settings will modify the resulting rate).

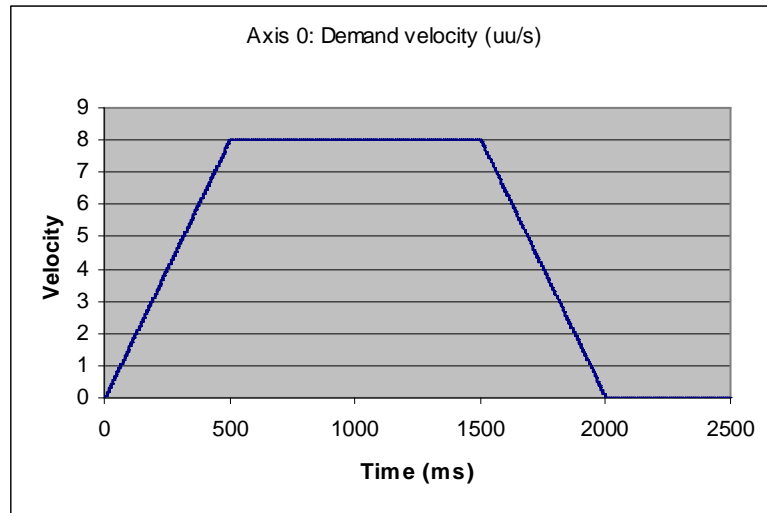
Some people prefer to use the rate of change related keywords, some prefer to use the time based keywords (as this can be easier to pre-determine the effect of the settings). Mint gives the user great flexibility.

Example:

To perform a trapezoidal move on axis 0 that is 12 user units long, reaching a speed of 8 user units per second, accelerating and decelerating at a rate of 16 user units per second per second, the following Mint code segment is required:

```
SPEED(0) = 8
ACCEL(0) = 16
DECEL(0) = 16
MOVER(0) = 12
GO(0)
```

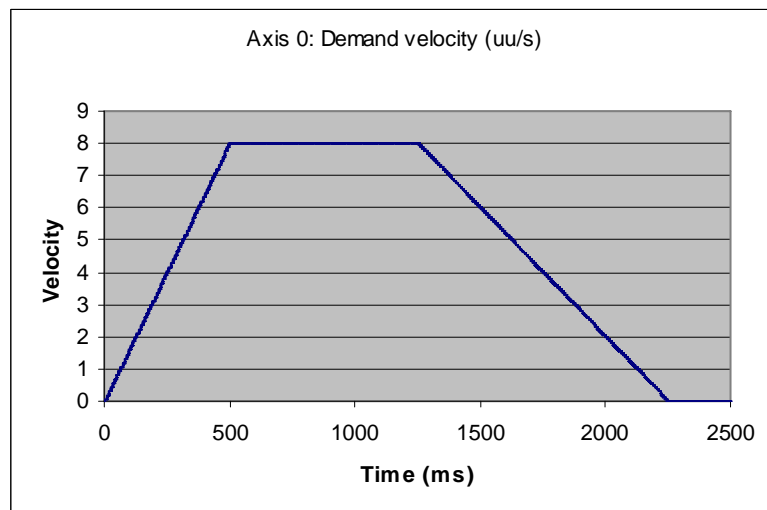
This will produce the following velocity profile with the default profile mode:



Increasing the acceleration will result in a steeper acceleration ramp, decreasing the acceleration will result in a shallower acceleration ramp. The same applies to deceleration. The acceleration and deceleration are independent values. Using a deceleration value of 8 user units per second per second:

```
SPEED(0) = 8
ACCEL(0) = 16
DECEL(0) = 8
MOVER(0) = 12
GO(0)
```

Will produce the velocity profile:

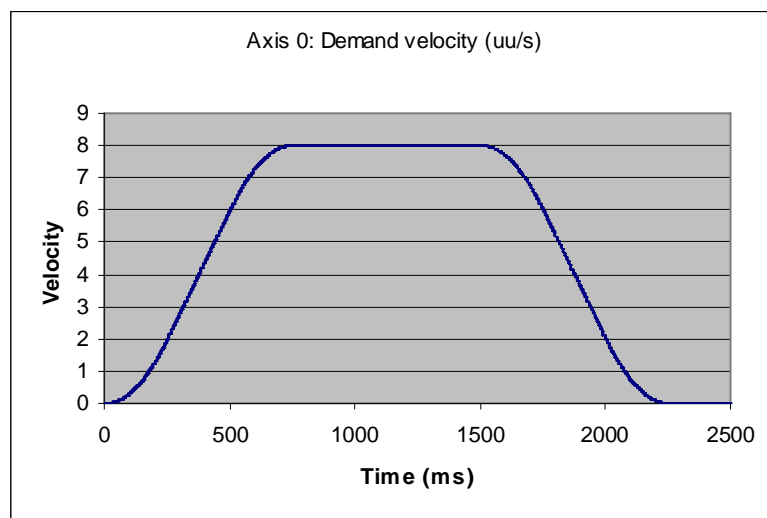


Notice the deceleration ramp is now much shallower due to the reduction of the deceleration value.

To perform a move on axis 0 that is 12 user units long, reaching a speed of 8 user units per second, accelerating and decelerating at a rate of 16 user units per second per second, with a jerk rate of 64 user units per second per second per second the following Mint code segment is required:

```
PROFILEMODE(0) = _pmS_RAMP
SPEED(0) = 8
ACCEL(0) = 16
DECEL(0) = 16
ACCELJERK(0) = 64
DECELJERK(0) = 64
MOVER(0) = 12
GO(0)
```

This will produce the velocity profile:



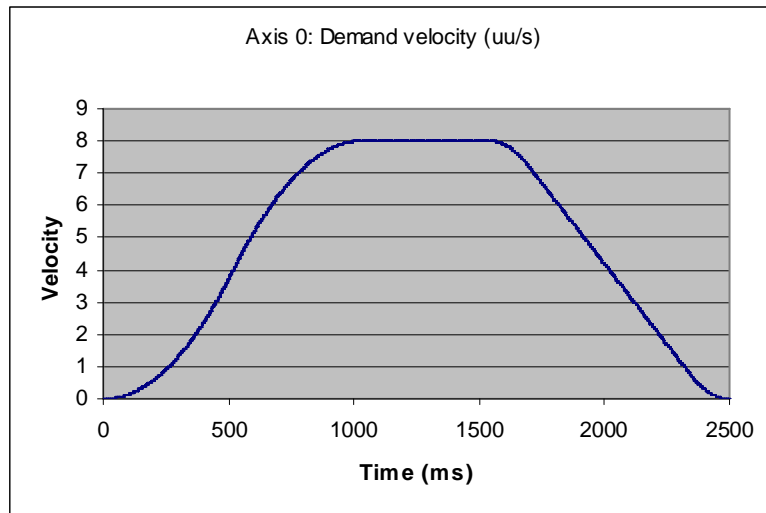
Increasing the acceleration will result in a steeper acceleration ramp, decreasing the acceleration will result in a shallower acceleration ramp. The same applies to deceleration.

Increasing the acceleration jerk will reduce the s-ramp portion of the acceleration ramp as the acceleration will up ramp faster. Decreasing the acceleration jerk will increase the s-ramp portion of the acceleration ramp. Reducing the jerk value will continue to extend the s-ramp portion of the acceleration ramp so that eventually the acceleration ramp is a complete 'S' shape. The acceleration, deceleration, acceleration jerk and deceleration jerk are independent values.

Using a deceleration value of 8 user units per second per second:

```
PROFILEMODE(0) = _pmS_RAMP
SPEED(0) = 8
ACCEL(0) = 16
DECEL(0) = 8
ACCELJERK(0) = 30
DECELJERK(0) = 64
MOVER(0) = 12
GO(0)
```

Will produce the velocity profile:



Notice the acceleration ramp is now a complete 'S' due to the smaller value of acceleration jerk. The deceleration ramp is shallower due to the reduction of the deceleration value.

These two profile modes are suitable for the majority of applications. In some cases it may be necessary to add an s-ramp to the acceleration/deceleration too (e.g. a "sine squared velocity profile") for even smoother motion. This might be necessary when moving very delicate materials for example. This is beyond the scope of this application note, please contact your local ABB motion support team for further information if necessary.

### Contact us

For more information please contact your local ABB representative or one of the following:

[new.abb.com/motion](http://new.abb.com/motion)  
[new.abb.com/drives](http://new.abb.com/drives)  
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