Motion Planner, Version 16.03

Introduction

This application solution explains the differences between versions 16 and 16.03 of the Motion Planner as viewed in RSLogix 5000 programming software.

The new Motion Planner performance is enabled by the controller's firmware, and requires Logix firmware version 16.20 or later, the firmware delivered with version 16.03 of RSLogix 5000 programming software.

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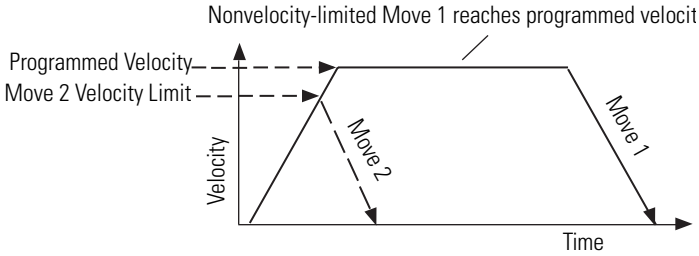
Motion Planner Changes

We have improved the performance of version 16.03 of the Motion Planner in revision 16.20 of the controller's firmware. In particular, you may see minor differences in the velocity and path profiles in some blended and merged moves.

IMPORTANT

To best understand these changes to your Motion Planner, you must first understand velocity-limited moves. The maximum achievable velocity for a move is based on the move's length, acceleration, and deceleration values. As the move's length is decreased, the maximum achievable velocity is also decreased. This can be seen in the following illustration of two moves with the same programmed velocity and acceleration and deceleration values.



Symmetric Trajectories for Velocity-limited Moves

In versions 16 and 16.03 of the Motion Planner, moves that are not limited by velocity are symmetric.

You can program acceleration and deceleration rates to produce symmetric profiles if all acceleration and decelerations are not equal, as illustrated below. However, in version 16 of the Motion Planner, you cannot program acceleration and deceleration rates to produce symmetric profiles if the moves are velocity limited.

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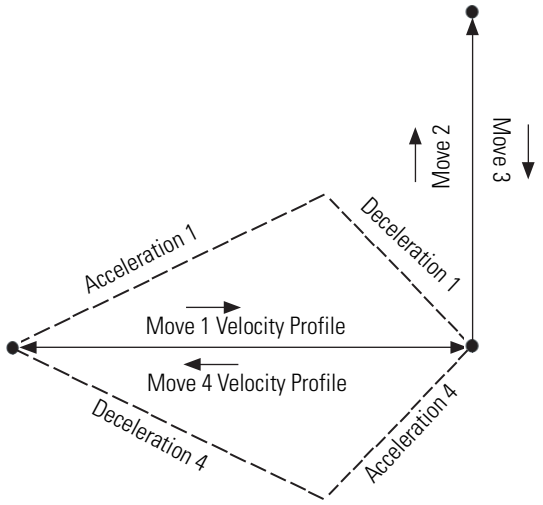
Symmetric Profiles with Unequal Acceleration and Deceleration Values

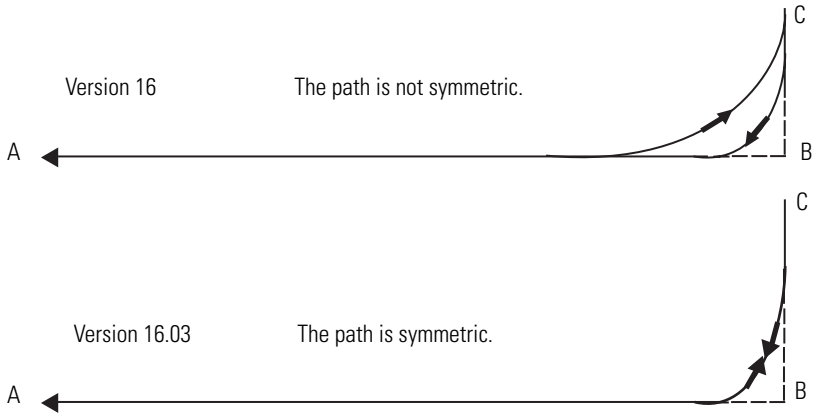


Acceleration 1 = Deceleration 4
Deceleration 1 = Acceleration 4
Acceleration 2 = Deceleration 3
Deceleration 2 = Acceleration 3

Important: For most cases, all accelerations and decelerations are equal.

Version	If you program the rates of acceleration and deceleration	The paths are
16	As shown in the illustration above	Not symmetric
16.03		Symmetric

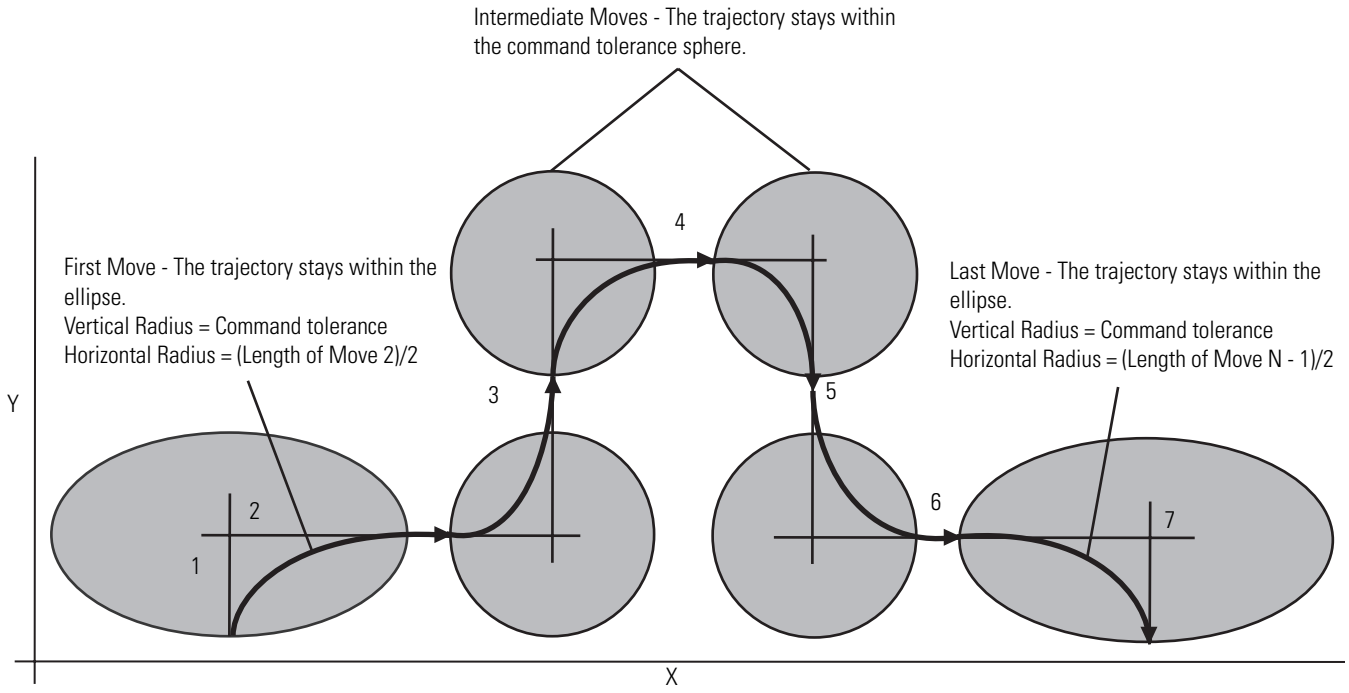
Motion Planner - System Trajectories for Velocity-limited Moves



Command Tolerance Termination Type 2 Blending

Version	Blending Radius of First Move	Blending Radius of Next to Last Move	Blending Radius of All Other Moves
16	50% of the move's length or the configured Command Tolerance for all moves, whichever is smaller		
16.03	100% of the first move's length or the configured Command Tolerance, whichever is smaller	100% of the last move's length or the configured Command Tolerance, whichever is smaller	50% of the move's length or the configured Command Tolerance, whichever is smaller

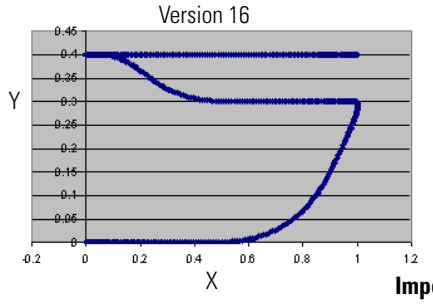
Blending Radius for Version 16.03



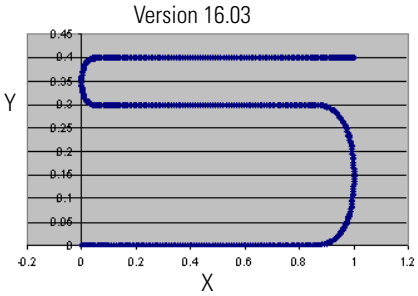
Blending Path Profiles

Version	Velocity-limited Moves	Nonvelocity-limited Moves
16	The path profile does not follow the programmed path as closely during the blending of two moves. Consequently, the execution time is slightly shorter.	The profiles are almost identical.
16.03	The path profile more closely follows the programmed path during the blending of two moves. Consequently, the execution time is slightly longer.	

Motion Planner - Blended Path for Velocity-limited Profiles



Important: These are extreme examples of velocity-limited moves at very slow rates of acceleration and deceleration. Most of the time, the differences will not be this extreme.



Important:
These graphs illustrate a path generated by these instructions:

1. MCLM1 to (1, 0.0)
2. MCLM2 to (1, 0.3)
3. MCLM3 to (0, 0.4)
4. MCLM4 to (1, 0.4)

Move Type = Absolute,
Termination Type = No Decel (3),
Speed =10 units/s

Acceleration = 5 units/s^2
Deceleration = 5units/s^2
Profile = Trapezoidal

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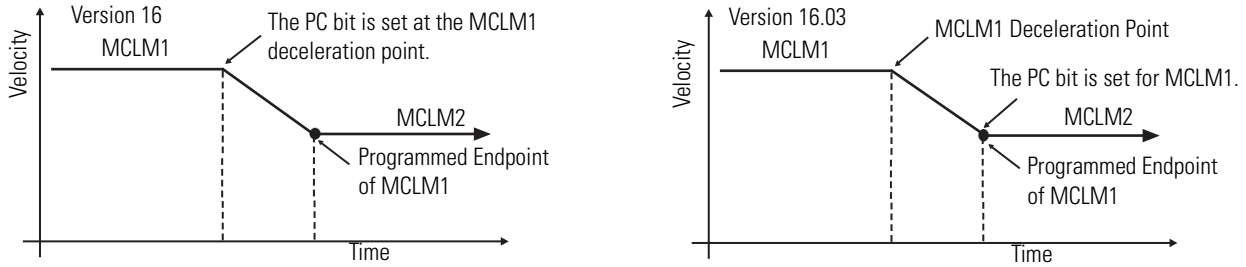
Co-linear Moves in No Decel Termination Type

Version	Setting of PC Bit	Termination of First Move
16	The PC bit is set when the first move begins to decelerate.	The first move is over when it begins to decelerate.
16.03	The PC bit is set when the first move has decelerated to the programmed velocity of the second move.	The first move is over when the first move has decelerated to the programmed velocity of the second move.

Motion Planner - Co-linear Moves



Most co-linear moves will be identical. However, some may run more quickly or more slowly in version 16.03 of RSLogix 5000 programming software because a move's velocity is not limited to a maximum velocity based on its length.

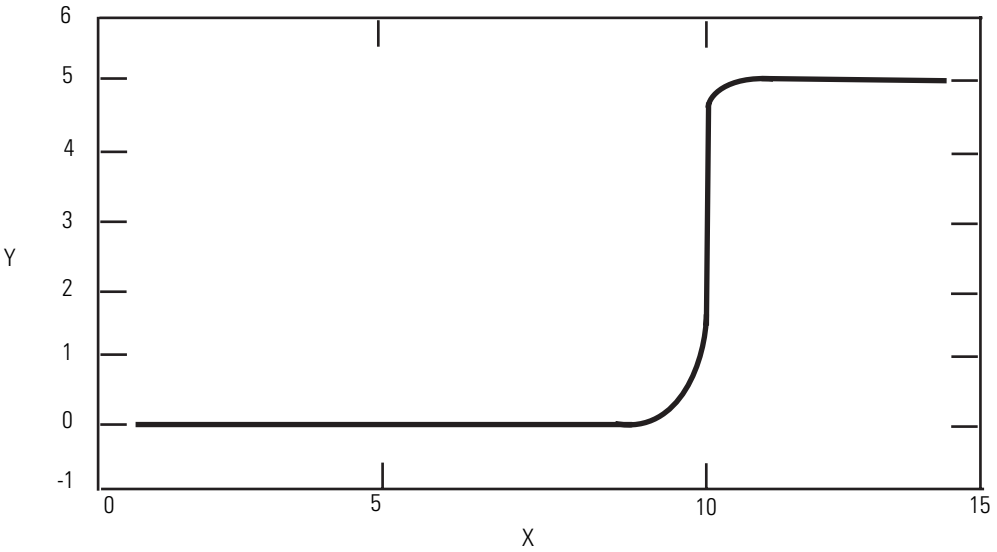
Computation of Jerk

Version	S-curve Moves	S-curve Zero Speed Moves
16	Motion Planner computes a maximum velocity for each move based on its length. This produces a greater or lesser jerk, depending on the length of the move. **Important:** For a nonvelocity-limited move, the jerk is identical to that computed in version 16.03. However, for a velocity-limited move, the jerk will be greater in version 16 since the velocity used to compute the jerk is limited to a maximum value based on the move's length.	Motion Planner uses the configured coordinate system maximum speed to compute a jerk value. Consequently, it may take longer to decelerate to zero than it does in version 16.03.
16.03	Motion Planner computes a jerk based on the programmed velocity, acceleration, and deceleration in the instruction in your program. Consequently, the move's length has no effect on the computed jerk. Therefore, velocity-limited moves take longer to execute if the programmed velocity is increased.	Motion Planner uses the programmed speed of the previous instruction to compute a jerk value. Consequently, if the programmed maximum speed is less than the coordinate system maximum speed, it will take less time to decelerate to zero in version 16.03 than in version 16.

Acceleration Steps

Version	Merged Moves	Velocity-limited Moves
16	Merged moves with S-curve velocity profiles sometimes contain acceleration steps because a new move must always accelerate from a speed of zero.	Velocity profiles of velocity-limited moves with S-curve velocity profiles in Termination Type 5 sometimes contain acceleration steps.
16.03	Acceleration steps have been eliminated.	

Example X vs. Y Position Profile for Acceleration Steps



All Three Moves
Speed = 50
Acceleration = 25
Deceleration = 25
Mode = Absolute
Profile = S-Curve
Termination Type = 3

MCLM 1
Axis 1 = 10
Axis 2 = 0

MCLM 2
Axis 1 = 10
Axis 2 = 5

MCLM 3
Axis 1 = 15
Axis 2 = 5

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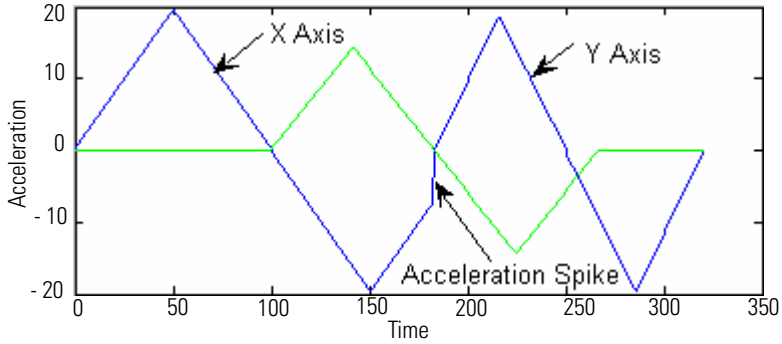
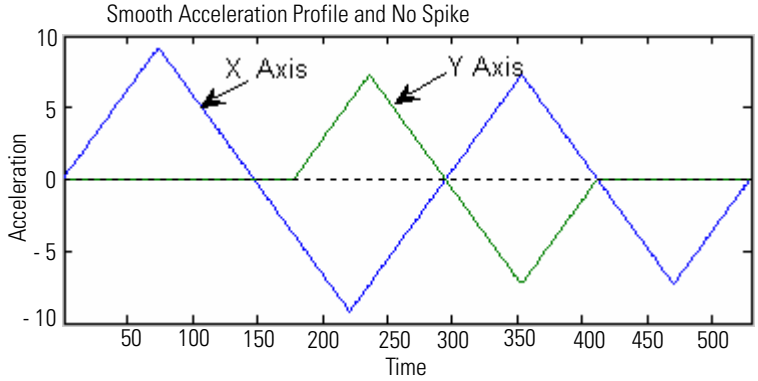
Acceleration Profiles

Version 16 - Acceleration Profile Showing Acceleration Spike



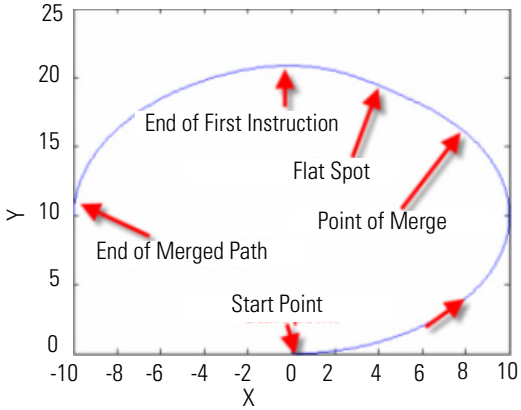
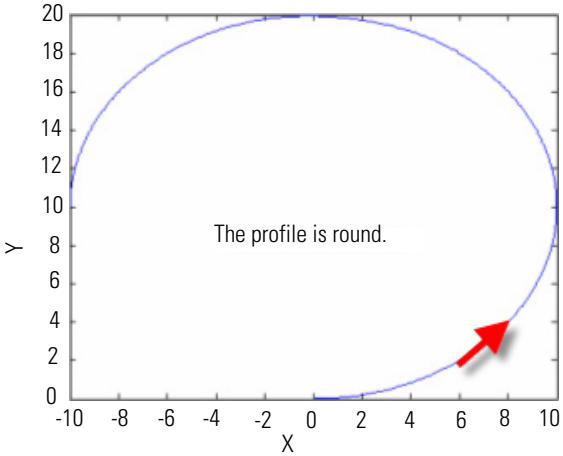
Version 16.03 - Identical Acceleration Profile Showing Smooth Acceleration Profile and No Spike



Changes to the Merge Path

In version 16.03 of the Motion Planner, the path for a merged move may slightly differ from that in version 16, especially for circular moves.

Blended Move Comparisons - Versions 16 and 16.03

Version	Blended Moves
16	The Motion Planner decelerates the old move in a straight line tangential to the circular path at the point of the merge, while simultaneously beginning the new move toward the new end point. The resultant motion is the blended path generated by these two moves. 
16.03	The Motion Planner decelerates the old move along its programmed circular path and simultaneously begins a new move toward the new end point. The resultant motion is the blended path generated by these two moves. 

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Changes to Merged Moves to Make Profiles More Optimal

The resultant path for a merged move from version 16 to version 16.03 of the Motion Planner may slightly differ for all moves except for co-linear moves in the same direction. The difference is more pronounced when the acceleration and deceleration values in the new move differ from each other. When they are the same, the change in the merged path is minor.

In both version 16 and version 16.03 the resultant path for a merged move is the superimposed motion of the old move being decelerated from its current speed to the speed of the next move speed and an acceleration of the new move as programmed from zero speed to its programmed speed. The superimposed motion begins at the instant the Merge move is detected.

Version 16

The deceleration of the first move and the acceleration of the second move are made with the following heuristic:

- The deceleration of the first move and acceleration of the second move at the point of the merge is performed based on the programmed acceleration and deceleration rate of the second move. Both are started simultaneously at the point of the merge.
- When the deceleration of the first move is complete, acceleration of the second move continues (if not already up to speed) at its programmed acceleration rate. Consequently, the vector velocity profile is not optimal in version 16.

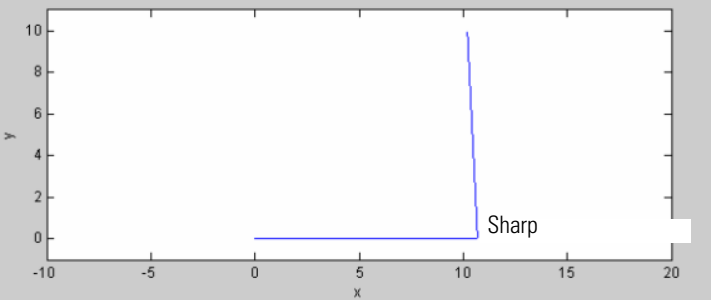
Case 1

Note the vector velocity decrease during the merge due to acceleration and deceleration time mismatch.

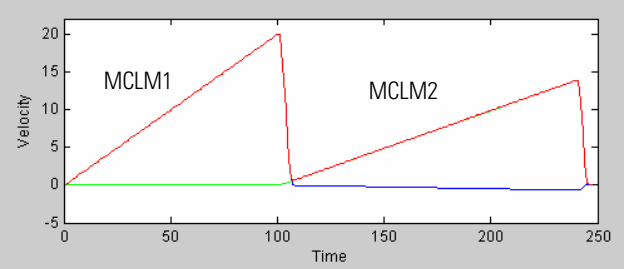
MCLM1 = (20, 0) Speed = 20 Acc = 20Dec = 20
Move Type = IncrementalMerge = Disabled

MCLM2 = (0, 10) Speed 20 Acc=10 Dec = 400
Move Type = IncrementalMerge = Coordinated or All

Version 16 Position Profile



Version 16 Velocity Profile



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Version 16.03

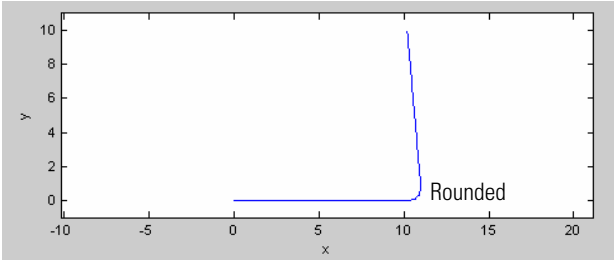
The deceleration of the first move and the acceleration of the second move are computed simultaneously based on the ratios of the programmed velocity of the first and second moves and the programmed acceleration and the deceleration of the second move. The acceleration and deceleration values are computed using these heuristics:

- The end position of the first move is not overshot.
- The velocity limit of the second move is not overshot.
- The rate of vector velocity increase does not exceed the acceleration rate of the second move.
- The rate of vector velocity decrease does not exceed the deceleration rate of the second move.
- The deceleration time of the first move matches the acceleration time of the second move.

Case 2

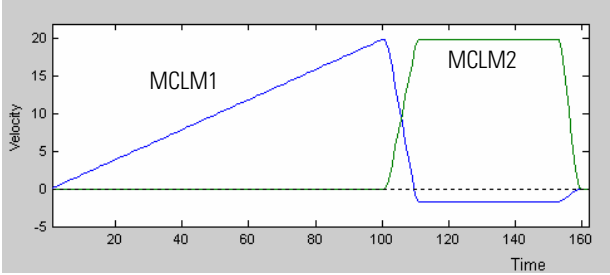
The same MCLM1 and MCLM2 parameters as in version 16 are used in this use case. Note that the merge completes faster without exceeding its velocity, acceleration and deceleration limits.

Version 16.03 Position Profile



The original horizontal extension was 20, the programmed end point of MCLM1.

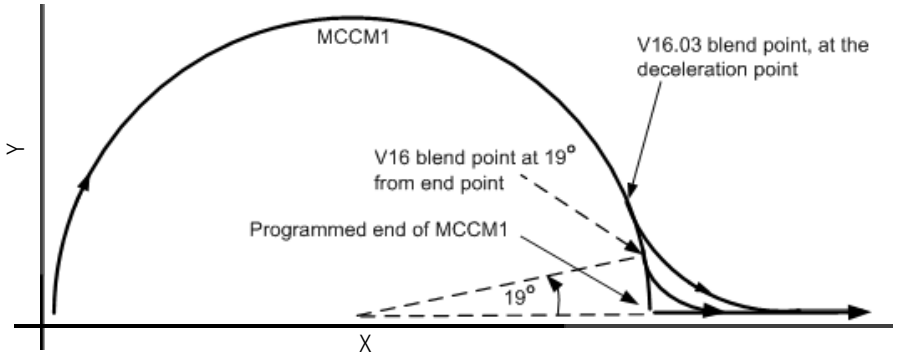
Version 16.03 Velocity Profile



Blending Restriction for Circular Moves

In version 16.03 of the Motion Planner, circular moves no longer must come within 19 degrees of their endpoint before a blend can begin.

Blending Restriction



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