



CNC Motion

Linear Segment Distance Limitation

Application Note



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Revision History

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1 Introduction

1.1 Background

When using very high-resolution encoders, values pertaining to counts may grow by factors of hundreds or thousands. This scales exponentially in internal calculations that use exponents. In certain features, memory catered for these calculations might be limited when too extreme values are used.

In most cases, the controller will warn the user when he sets a value that is out of range. However, there are some cases where such limitations might not be explicitly stated or have protection implemented for it yet.

One such limitation exists in CNC motion mode, for the linear segment. In particular, the segment distance (magnitude of segment vector) of linear segments is limited to a value of 23,726,566.

1.2 Scope

This document seeks to explain the limitation in using CNC Motion for large distances. It also explains and provides for an example on how to overcome this limitation.

2 Limitation

2.1 Limitation Description

CNC Motion linear segments only support a maximum segment distance of 23,726,566 counts.

The segment distance is equivalent to the root-sum-square of the distances of individual axes that are involved in the CNC motion.

Segment distance is defined as x ,

$$\text{where } x = \sqrt{\mathit{distA}^2 + \mathit{distB}^2 + \dots}$$

and distA is the distance travelled by axis A (Target-Initial Position)

and distB is the distance travelled by axis B (Target-Initial Position)

and so on....

When defining a linear segment, the user must that ensure $x \leq 23,726,566$.

For example, assume the start position to be at point A (100, 200, 300). If a user issues linear segment to move to point B (100,000, 200,000, 300,000), x can be calculated to be 373,791.573.

$$\mathit{distA} = 100,000 - 100 = 99,900$$

$$\mathit{distB} = 200,000 - 200 = 199,800$$

$$\mathit{distC} = 300,000 - 300 = 299,700$$

$$x = \sqrt{\mathit{distA}^2 + \mathit{distB}^2 + \dots} = \sqrt{99,900^2 + 199,800^2 + 299,700^2} = 373,791.573$$

Since 373,792 is less than ceiling value of 23,726,566, the linear motion is a valid one.

In event that the ceiling is exceeded, the internal buffers used for calculations would overflow and cause weird behaviors. Notably, the direction of motion might invert halfway, and or the user might keep getting a position error at that particular CNC step.

*Note that there are currently no protections to prevent the user from defining such an erroneous segment. Protections are in the pipeline and will be implemented in the future.

2.2 Workaround

To work around this limitation, the user should first check if the limitation is exceeded. And if it has exceeded, break down the segment into smaller segment with distances that do not exceed the limit. This has to be handled at the client side before the segments are parsed to the controller.

For example, assume the start position to be at point A (1e6, 2e6, 3e6). If a user issues linear segment to move to point B (17e6, 18e6, 19e6), x can be calculated to be 100,000-

$$distA = 17e6 - 1e6 = 16e6$$

$$distB = 18e6 - 2e6 = 16e6$$

$$distC = 19e6 - 3e6 = 16e6$$

$$x = \sqrt{distA^2 + distB^2 + \dots} = \sqrt{16e6^2 + 16e6^2 + 16e6^2} = 27,712,812.911$$

Since 27,712,812 is greater than ceiling value of 23,726,566, the linear motion is an invalid one.

In this case, the user should split the segment into two. First, from (1e6, 2e6, 3e6) to (9e6, 11e6, 12e6). Then, from (9e6, 11e6, 12e6) to (17e6, 18e6, 19e6). Note that the splitting of segments might not be trivial depending on the starting and ending speed and motion profile required.

2.3 Case Study

Initial code where segment distance exceeds limit (Not okay)

```
// A initial position = 0
// B initial position = 0
//
// Max segment distance = 23e6
// Segment distance = sqrt((A distance)^2 + (B distance)^2) = sqrt((20e6-0)^2 + (20e6-0)^2)= 40e6 >
23e6, too large.
// Segment index: 2
//
// Push Linear motion, involved: A, B
// Go to: A=20000000, B=20000000
// Velocity: 10000000
// End Velocity: 0
//
ACNCAPushType,16908287
ACNCAPushParam,20000000
ACNCAPushParam,20000000
ACNCAPushParam,10000000
```

ACNCAPushParam,0

Modified code to split segment into 2 (Okay)

```
// A initial position = 0
// B initial position = 0
//
// Max segment distance = 23e6
// Segment distance = sqrt((A distance)^2 + (B distance)^2) = sqrt((10e6-0)^2 + (10e6-0)^2)= 20e6 <
23e6, OK.
// Segment index: 2
//
// Push Linear motion, involved: A, B
// Go to: A=10000000, B=10000000
// Velocity: 10000000
// End Velocity: 10000000
//
ACNCAPushType,16908287
ACNCAPushParam,10000000
ACNCAPushParam,10000000
ACNCAPushParam,10000000
ACNCAPushParam,10000000

//
// A initial position = 10e6
// B initial position = 10e6
//
// Max segment distance = 23e6
// Segment distance = sqrt((A distance)^2 + (B distance)^2) = sqrt((20e6-10e6)^2 + (20e6-10e6)^2)=
20e6 < 23e6, OK.
// Segment index: 3
//
// Push Linear motion, involved: A, B
// Go to: A=20000000, B=20000000
// Velocity: 10000000
// End Velocity: 0
//
ACNCAPushType,16908287
ACNCAPushParam,20000000
ACNCAPushParam,20000000
ACNCAPushParam,10000000
ACNCAPushParam,0
```

