Tech Note #2:
Creating CAM tables for the I2T line of motion controllers from Spreadsheet Programs

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Abstract

I²T's line of motion controllers allows a servo axis to execute arbitrary axis distance vs. pacer distance cams with the cam motion defined through a cam table. The creation of this cam table can be performed using I²T's Motion Controller Setup Software or for larger cam profiles this creation can be simplified through the use of a spreadsheet program and then exported to a tab-delimited file that can later be downloaded to the motion controller. This document will describe how to design a cam motion, then how to create it in a spreadsheet, and export it to a file. This document assumes that the reader is familiar with a spreadsheet program and I²T's Motion Controller Setup Software.

Points and segments:

Cam tables are entered as a series of up to 4000 segments. A segment describes the current position of the axis with the distance traveled during a segment equal to the difference between the current and previous segment's positions. Each segment is executed over a defined distance traveled for the Master axis. When executing these segments, the profiling software in the controller will fit a smooth curve to the data with a velocity profile that is updated every millisecond.

Curve Smoothing:

Curve smoothing only occurs if the segment is selected to use a cubic spline, and reduces the jerk produced from abrupt acceleration rate changes. Linear segments will result in more system jerk, as the resulting velocity profile will be a straight-line velocity curve between two points. The cubic spline has two major characteristics:

1) The curve will pass through every point defined in the cam table.
2) The first and second derivates are continuous across each point resulting in a smooth velocity change across table position points.

Stringing together a series of cubic polynomials that have been constructed to pass through three adjacent points assembles the final cam motion.

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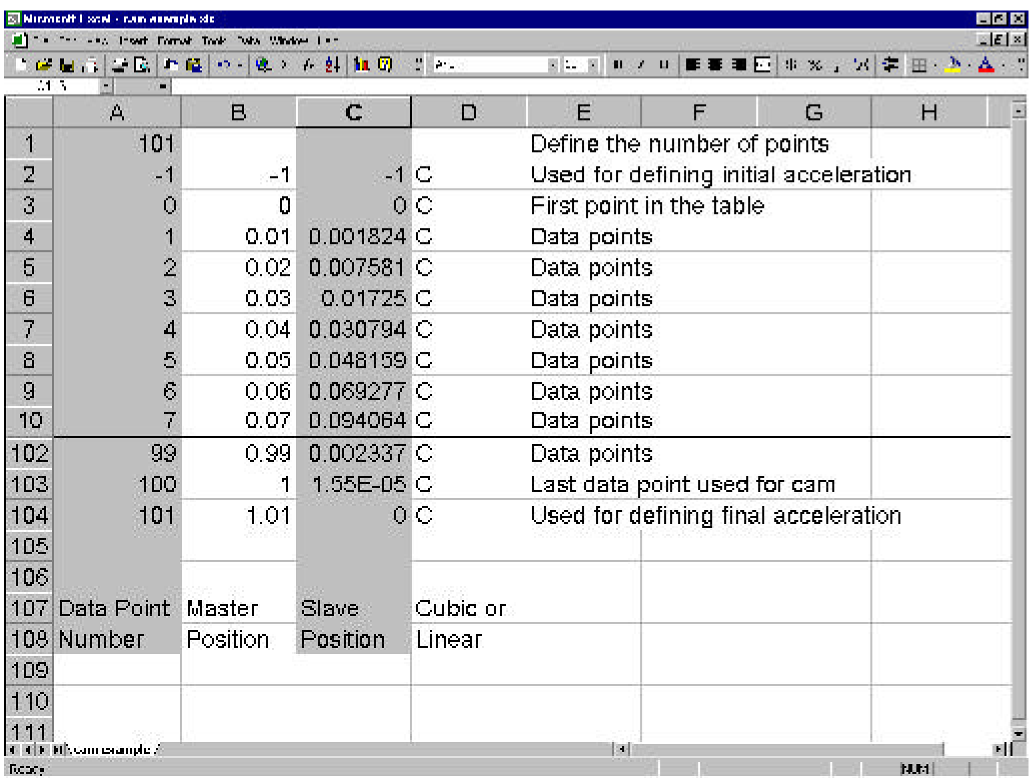
Entering a cam into a spreadsheet program:

Create a spreadsheet with 4 columns of data. The first row will be empty except for the first row of the first column which will have the total number of points in the spline after the 0 point.

Starting on the second row the first column will list the segment number starting at –1 and progressing incrementally to the last point. The second column will contain the Master axis's incremental positions with the difference between these positions defining the Master distance for this particular segment. The third column will contain the slave's incremental positions in axis user units with the difference between these positions defined in the distance that the slave will travel for a given master distance. The fourth and final column will contain either the letter "l" or "c" to indicate if the curve fitting for this segment should be **L**inear or **C**ubic, respectively.

There should be no other information on the spreadsheet other than these columns of data including column or row headings. If the goal is to retain heading information in the spreadsheet then the data should be cut and paste into a separate spreadsheet after calculation and saved separately.



	A	B	C	D	E	F	G	H
1	101				Define the number of points			
2	-1	-1	-1	C	Used for defining initial acceleration			
3	0	0	0	C	First point in the table			
4	1	0.01	0.001824	C	Data points			
5	2	0.02	0.007581	C	Data points			
6	3	0.03	0.01725	C	Data points			
7	4	0.04	0.030794	C	Data points			
8	5	0.05	0.048159	C	Data points			
9	6	0.06	0.069277	C	Data points			
10	7	0.07	0.094064	C	Data points			
102	99	0.99	0.002337	C	Data points			
103	100	1	1.55E-05	C	Last data point used for cam			
104	101	1.01	0	C	Used for defining final acceleration			
105								
106								
107	Data Point	Master	Slave	Cubic or				
108	Number	Position	Position	Linear				
109								
110								
111								

Sample spreadsheet image:

The image above shows how a spreadsheet may look with the data for export to the motion controller. Note that the slave's produced curve will not pass through the positions defined in segments –1 and 101. These positions only define the final slope of the velocity curve at points 0 and 100, respectively. The text added in column "E" and rows 107 through 108 cannot be in your final spreadsheet. This text is added for descriptive purposes, only.

The creation of the data points in Column "C" were produced using an equation that produces a complete sin wave output of the slave axis for each revolution of the master axis. The development of this equation and plots of both the resulting slave position and velocity profiles are included at the end of this document.

Requirements and Constraints:

?? All units are in axis user units
?? Columns represent accumulated axis positions
?? The master position must always increase
?? While a decreasing slave position is allowed, the slave position must always be positive.
?? The difference in the master position cannot exceed 32767 encoder counts. This will require knowledge on the scale for counts to user units.
?? The first and last entries into the cam table are used to define the final acceleration rate at the last cam point. **The slave axis will not pass through these points.**
?? The cam table will automatically repeat itself

Saving the data to a text file:

After the data is entered into the spreadsheet it can now be saved in a tab-delimited text file with a "*.CAM" extension and closed. The I2T MMI software can then read this file and download it to the controller. Note that some spreadsheet programs may require that the file be closed before the MMI software will be allowed to access the file contents.

Cam example:

Produce a cam table that commands the slave to produce a full sin wave for every revolution of the Master axis.

Set the sin offset so that we start the profile at a minimum

? ?? .75??2??   ? ? 270 deg

Set the desired aplitude of the sin wave

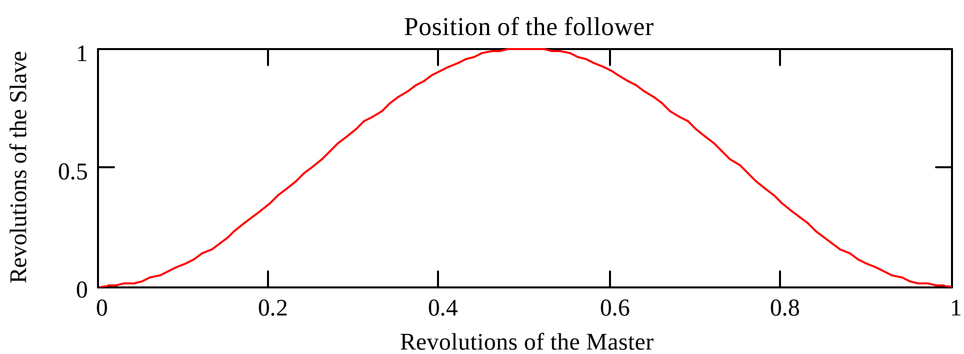
Magnitude ?? 1

Define the equation to produce the desired profile, where x is the position of the master axis with a value of 1 representing 1 full revolution.
Note that a value of 1 is added to the output of the sin function. This is required because the cam table only excepts positive position values for the Slave axis.

F(x) ?? .5?Magnitude??1 ? sin??2?? ?x ? ? ??

x ?? 0?.01 ??1

This graph shows the resulting motion of the slave axis for each revolution of the master axis. Again, notice that all positions in the profile are positive.



This graph shows the resulting proportional velocity of the slave axis for as a function of the master axis's position. Note that the velocity becomes negative to move the Slave back too its intial starting position.