Allen-Bradley

Application Note

S-curve Creation with an Ultra3000 Indexer

Purpose:

The Ultra3000 indexing servo drive is a powerful and versatile servo controller with diverse functionality. The drive is limited to trapezoidal indexes, but has the capability to blend indexes together. This blending capability gives the user the ability to create complex profiles. By simply using the acceleration or deceleration portion of an index the user will be able to create an S-curve move profile with the correct parameters. This document along with the S-curves.exe program and S-curve Example.udb provides enough information to create a blended 10 index array of moves that approximates an S-curve profile. This document explains the use of the executable file, and how to import and setup an on-line or off-line drive to properly execute the move.

Requirements:

The operator must have a basic understanding of the use of the Ultra3000i Digital Servo Drive. Knowledge of setting up and performing indexes on the drive is fundamentally necessary.

Procedure:

Step 1: Open the S-curves.exe program and put the correct values into the four data registers, then press Calculate S-curve (See figure 1.1). Verify the Distance In units are the same as those setup in the Ultra3000 and the Time Entered is in seconds. Enter the proper number in Lines per Rev. This value is determined by the encoder manufacturer, if an incremental type, or 1024 if it is a single- or multi-turn Stegmann. For incremental encoders, the Interpolation Factor is 4 (quadrature). For single- and multi-turn encoders, the Motor Encoder Interpolation is selectable from the Encoders branch in Ultraware (See Figure 1.2).

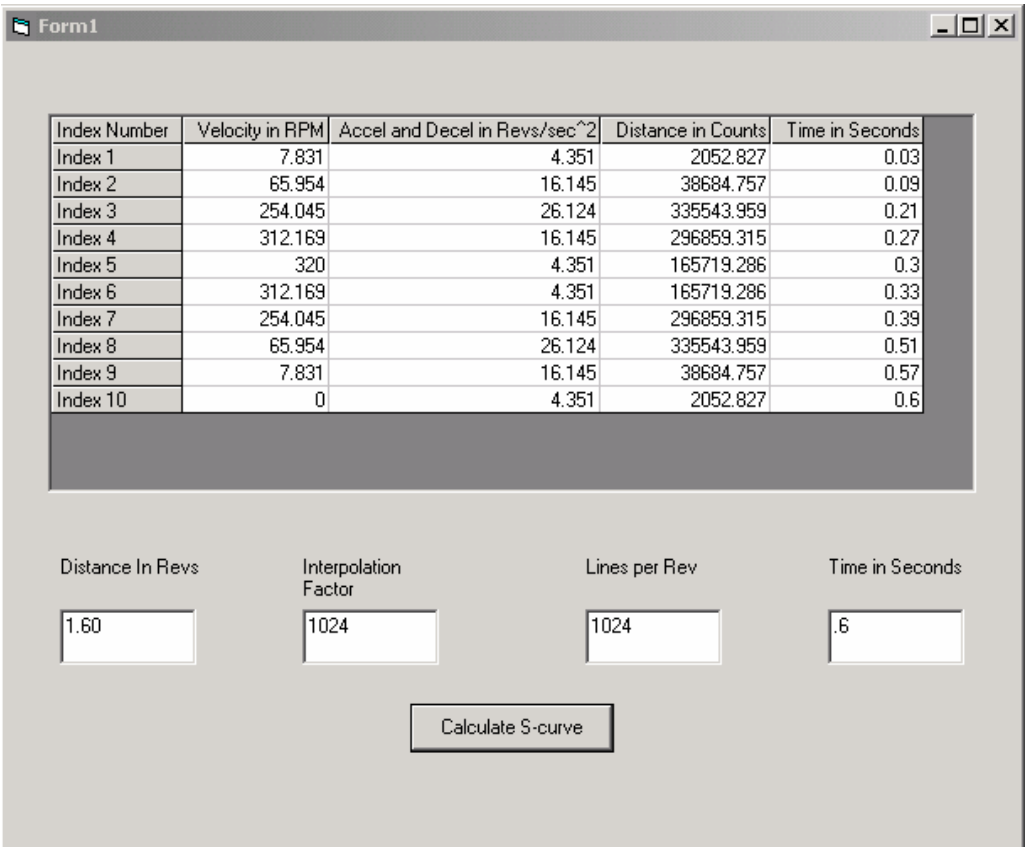


Figure 1.1 S-curves.exe program

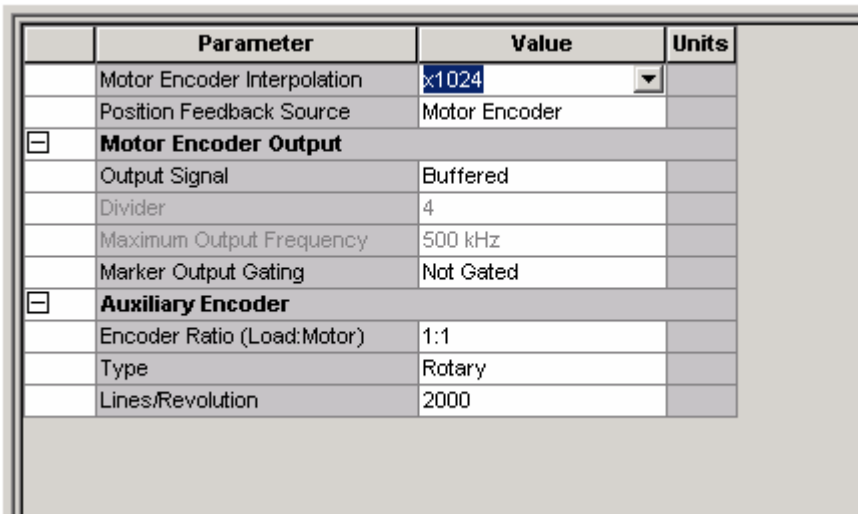


Figure 1.2 The Encoders branch found on or offline in Ultraware

Step 2: Open Ultraware and create a new offline Ultra3000 Indexer (2098-DSD-nnnX), or go online with the current Ultra3000 Indexer. If you have an online drive, you may want to right-click on the Drive>Commands>Reset EEPROM to Factory Settings.

Step 3: Go into the Indexing section found under Mode Configuration and manually import the data from the S-curves.exe program into the proper fields. Set the Index Type to Incremental and allow the Ultraware software to truncate the numbers automatically, an index of the proper length and time should still be produced. For Indexes 1-9 make sure you set the Next Index value to the next desired index (i.e., Index 2 is the Next Index for Index 1, etc.). Verify that the Action When Complete of indexes 1-9 is set to 'Start next without stopping', this ensures proper blending of the indexes (See Figures 3.1 and 3.2).

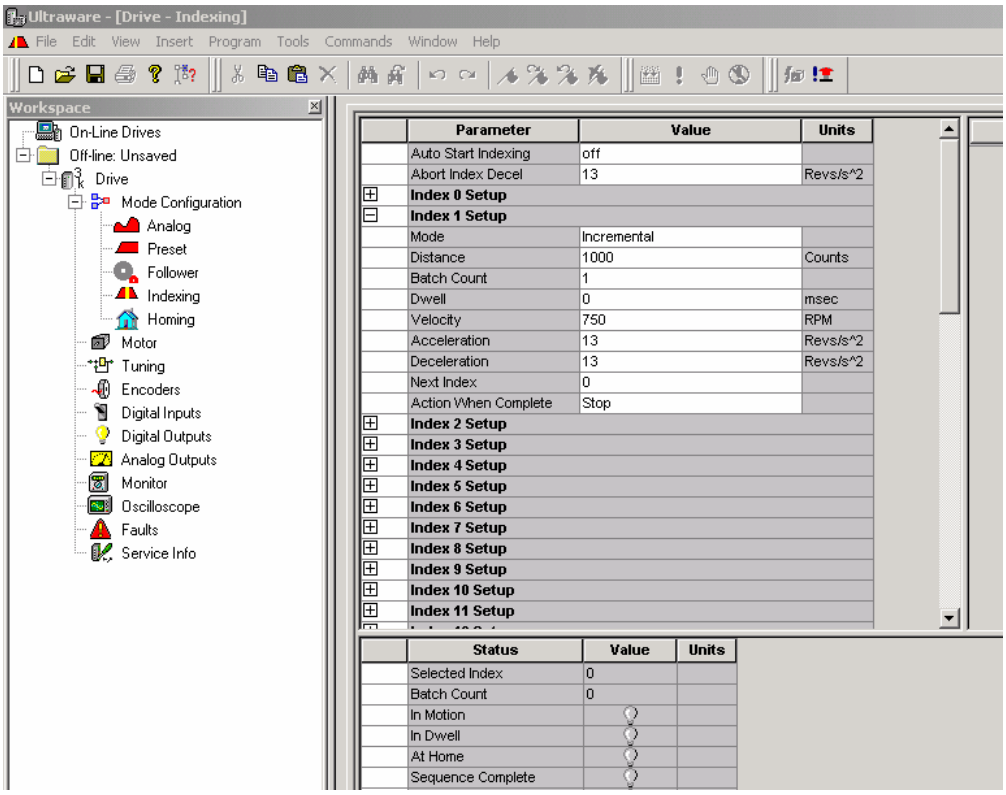
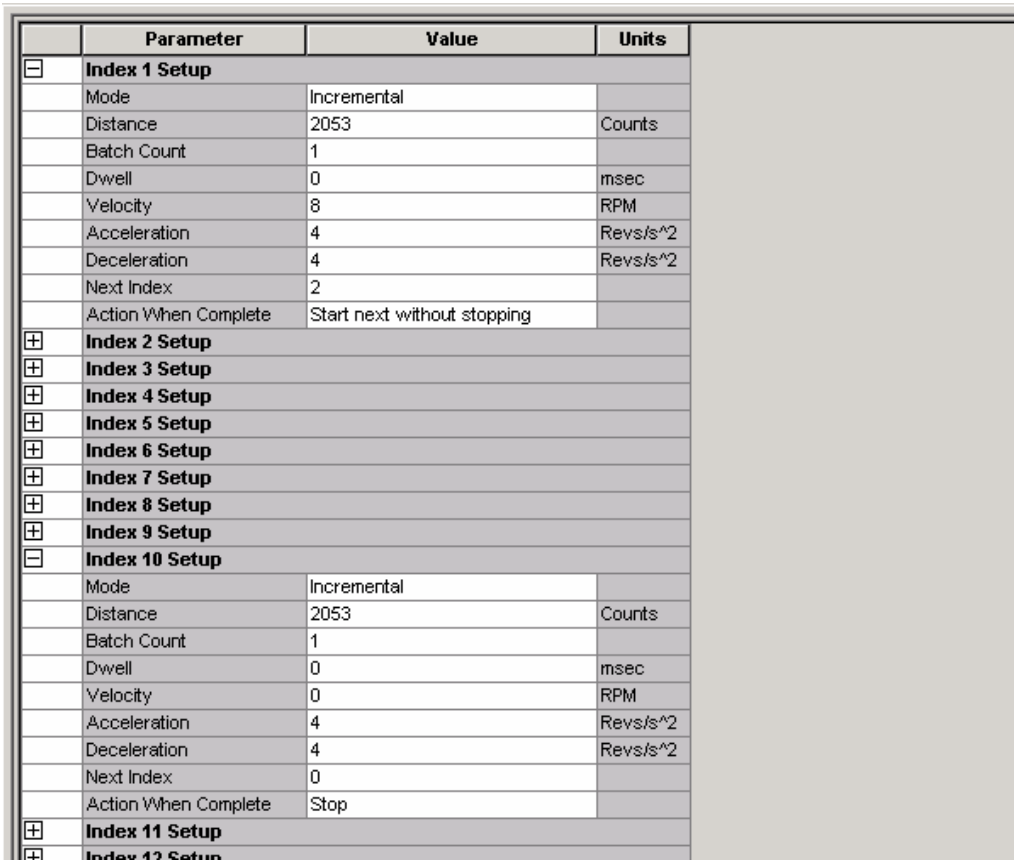


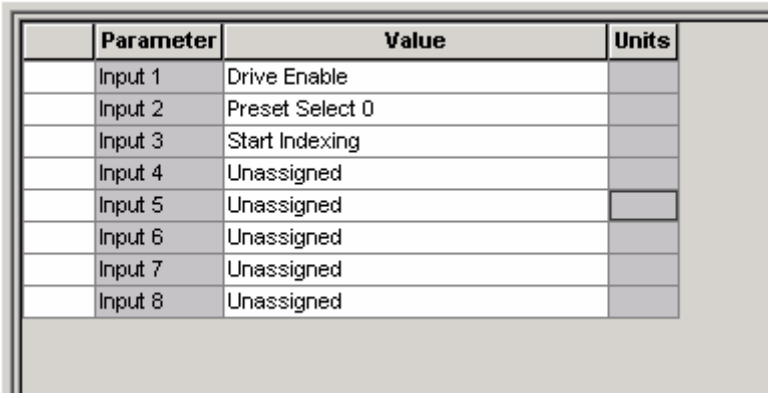
Figure 3.1 Default Indexing Drive Branch in Ultraware



	Parameter	Value	Units
⊟	**Index 1 Setup**		
	Mode	Incremental	
	Distance	2053	Counts
	Batch Count	1	
	Dwell	0	msec
	Velocity	8	RPM
	Acceleration	4	Revs/s^2
	Deceleration	4	Revs/s^2
	Next Index	2	
	Action When Complete	Start next without stopping	
⊞	**Index 2 Setup**		
⊞	**Index 3 Setup**		
⊞	**Index 4 Setup**		
⊞	**Index 5 Setup**		
⊞	**Index 6 Setup**		
⊞	**Index 7 Setup**		
⊞	**Index 8 Setup**		
⊞	**Index 9 Setup**		
⊟	**Index 10 Setup**		
	Mode	Incremental	
	Distance	2053	Counts
	Batch Count	1	
	Dwell	0	msec
	Velocity	0	RPM
	Acceleration	4	Revs/s^2
	Deceleration	4	Revs/s^2
	Next Index	0	
	Action When Complete	Stop	
⊞	**Index 11 Setup**		
⊞	**Index 12 Setup**		

Figure 3. 2 Indexing parameters manually imported into Ultraware

Step 4: Make sure the operation mode of the drive is set to Indexing (Right click Drive>Properties, then select Operation Modes, choose Indexing). Select the Digital Inputs tab and choose the correct selections to allow you to run the index (See Figure 4.1). You should now be able to start running S-curve indexes. A typical S-curve is shown below (See figure 4.2).



	Parameter	Value	Units
	Input 1	Drive Enable	
	Input 2	Preset Select 0	
	Input 3	Start Indexing	
	Input 4	Unassigned	
	Input 5	Unassigned	
	Input 6	Unassigned	
	Input 7	Unassigned	
	Input 8	Unassigned	

Figure 4.1 Typical Digital Input Selections

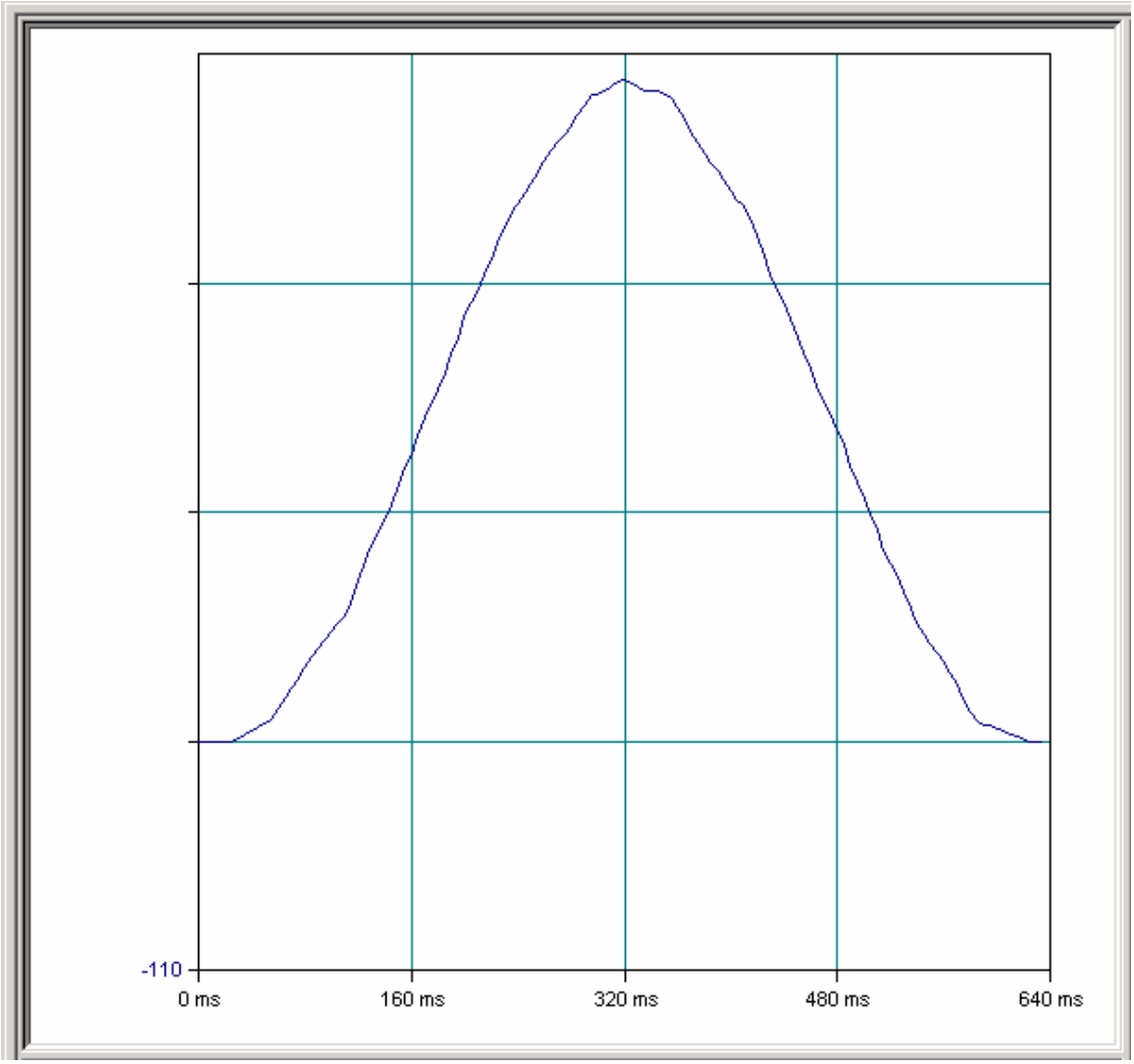


Figure 4.2 Typical Command Velocity Profile generated in Ultraware oscilloscope.

Special Notes:

The following information in this application note is for reference only.

You may use any form of S-curve profile to generate your own curves. Essentially an S-curve profile is simply defined as a cubic-spline equation (linear acceleration profile) with the acceleration in the middle of the curve going from 0 velocity to the desired velocity being twice that of a triangular profile. The velocity at the beginning and the end of the segment is assumed to be 0. The following equations are used to roughly estimate the curve for the associated program.

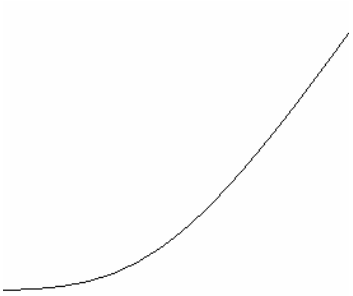


Figure A.1 Segment 1

For the above segment, known as Segment 1, the equations are as follows:

$V(t) = (8Vt^2/T^2)$, and $A(t) = (16Vt/T^2)$

where T is the total time for the entire move and V is the max velocity for the entire move

Note that the velocity at the end of Segment 1 ($t=\frac{1}{4}T$) is $\frac{1}{2}V$ and the acceleration is $\frac{1}{4}VT$

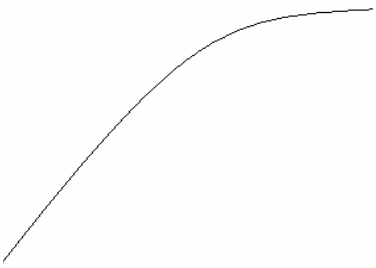


Figure A.2 Segment 2

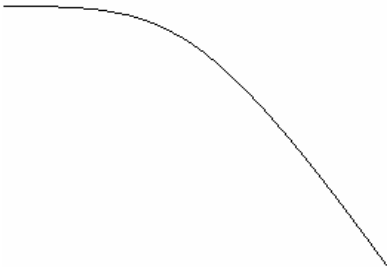


Figure A.3 Segment 3

For the above segments, known as Segments 2 and 3, the equations are the same and as follows:

$V(t) = [(-8Vt^2/T^2)+(8Vt/T) - V]$, and $A(t) = [(8V/T) - (16Vt/T^2)]$

where T is the total time for the entire move and V is the max velocity for the entire move

Note that the velocity at the end of Segment 2 ($t=\frac{1}{2}T$) is V and the acceleration is 0.

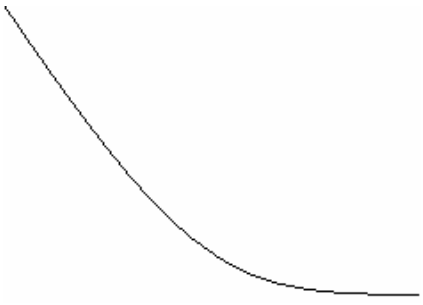


Figure 4 Segment 4

For the above segment, known as Segment 4 the equations are as follows:

$V(t) = [(8Vt^2/T^2) - (16Vt/T) + 8V]$, and $A(t) = [(16Vt/T^2) - (16V/T)]$

where T is the total time for the entire move and V is the max velocity for the entire move

Note that the velocity at the end of Segment 4 (t=T) is 0 and the acceleration is 0.

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