APPLICATION NOTE

Note	Application Note for Custom Curve profiles using ASDA-A2				
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Applicable to	ASD-A2 series AC servo motor and drive				

Application Note for Custom curve profiles on the ASDA-A2 servo drive

Contents

3/21/2014	Original Rev	Original
10/27/2014	Rev. A	Added section 3.2.5 on varying the Cycle count for ECAM/PR curve.

Industrial Automation Business Group

1 Description

Some applications require the servo to perform non-standard move profiles unlike a trapezoidal or s-curve profile. When done as a slave to a master axis, an ECAM control of the motor would be used to create the profile. In some cases, the axis is acting independently without a master pulse. In those cases, we can use the internal ECAM master on the A2 servo drive to control the motion profile that is desired. Because of the built-in functions for gearing and scaling of ECAM, we can take a single curve equation and modify it easily to fit the customer's application without requiring a complex controller to recalculate the motion profile. We can also setup the A2 servo drive to switch between ECAM and standard PR control for more complex motion profiles.

An A2 servo with an HMI for user interaction and parameter modification can sufficiently solve this application.

2 System theorum and setting

For these applications, it is understood that the customer requires a specific motion profile or equation to be followed by the motor, rather than simply requiring smooth accel/decel from S-curve profiling or low pass filters. In this case, we can get a close approximization of the curves with ECAM points using cubic interpolation between points. The points for the curve can be imported to the ASDA-A2 servo drive during commissioning through the ASDASoft software
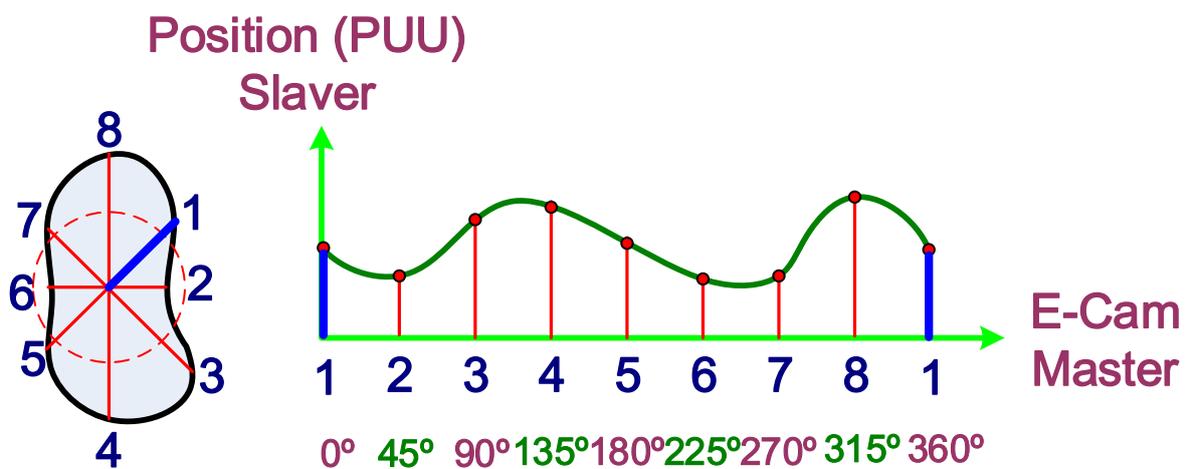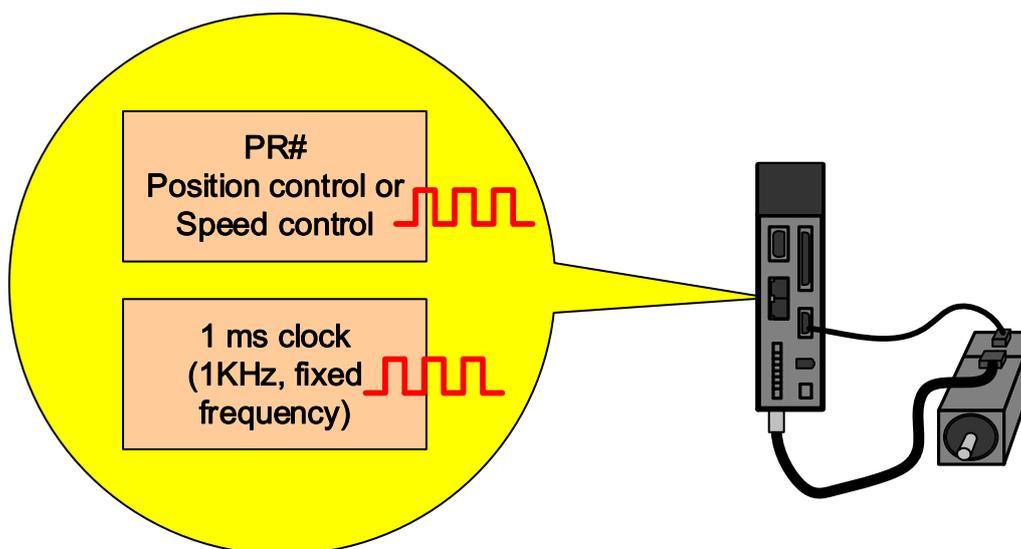

Figure 1: Arbitrary motion curve relative to a master axis (ECAM)

2.1 Master Axis (virtual master)

In this application, the master axis will be the internal PR mode of the A2 servo drive (setting of P5-88.Y = 3). The internal 1msec timer can also be used if the customer does not need to adjust the frequency of the master profiles for a more simplistic setup (setting of P5-88.Y = 4).

Figure 2: Two different options for internal ECAM master on ASDA-A2 servo

2.2 Slave Axis (physical axis)

The slave axis is the physical motor axis of the A2 servo drive that is being driven by the ECAM profile loaded into the drive and internal PR master. At times, the ECAM may be disengaged, in which case the master PR move will control the physical motor axis directly.

3 Servo system setting

3.1 Example 1: Sine wave profile using ECAM

The first example we will demonstrate uses a standard sine curve as the motion profile. This example requires the drive to be in ECAM control with the profile loaded into the array space, and the drive to command the motion using internal PR control for the ECAM master.

The graph below displays the data points for this curve from an Excel spreadsheet.
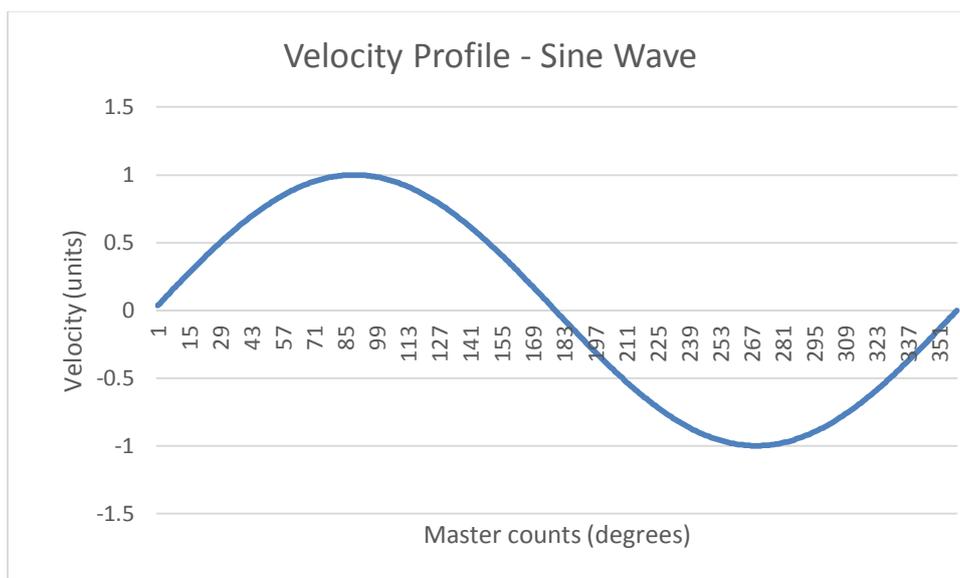
Figure 3: Unit-less velocity curve of a sinusoidal profile

Once we have the data for the ECAM prepared, we can take our A2 servo drive and configure it into PR mode (P1-01 = 1, reset the drive)

After importing the points to the drive (see section 4), we will configure the drive for the following parameters to setup the sine wave control via ECAM:

    P5-81 = X
    P5-82 = N
    P5-83 = 1
    P5-84 = Y

Where
X = the first array location in memory for the first ECAM point
N = the total number of ECAM points in memory
Y = the desired master pulse count

For the master axis, we will use PR#1 as the master move to control the ECAM profile. We configure the parameters as below:

    P6-02 = 0x00000012
    P6-03 = P5-84 (set the position value equal to P5-84 for 1 cycle)
    P5-20 = 1 (this ensures the master command accel/decel is minimized for maximum constant speed)

At this point, the drive can be commanded to move by executing PR#1. This can be done two ways:

Communication: Set P5-07 to 1.

Digital Inputs: Set P2-17 to 0x08, then toggle DI8.

3.1.1 Varying the frequency

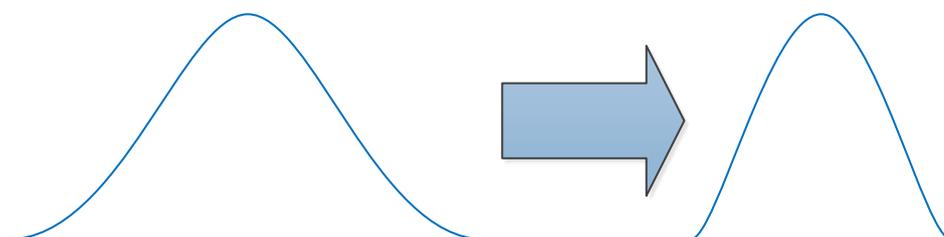Varying the frequency that the sine wave runs adjusts how fast or slow the curve is executed.

Figure 4: Going from a lower frequency to higher frequency motion

If the user wants to vary the frequency of the sine wave, they can specify a new speed for the PR#1 move. This new speed can simply be adjusted by changing P5-60. The frequency of the profile can be defined by the following equation

Frequency = (P1-45*1280000/P1-44)*(P5-60/60) / P5-84

If you use the default values for P1-44 and P1-45, this can be simplified to the following:

Frequency = (100000*P5-60)/(60*P5-84)

Example: If P5-84 = 2500, and we command a speed of 6RPM, then the frequency output would be Frequency = (100000*6)/(60*2500) = 4 Hz

3.1.2 Varying the amplitude

To adjust the amplitude of the sine curve, you can adjust parameter P5-19, which is the ECAM slave gearing. Adjusting this gain adjusts the amplitude of the sine curve proportionally.

Example: If we want to increase the amplitude of the curve 300%, then we would increase the value of P5-19 by 3 times the current value. If it is at the default value of 1.0, then we would change the parameter to 3.0.

3.1.3   Varying the number of cycles

To increase the number of cycles that are executed in a single operation, the position data from PR#1 can be adjusted. The number of cycles performed is P6-03/P5-84.

Example: To perform 7 cycles in one move, with P5-84 = 2500, set P6-03 to P5-84 * 7, or P6-03 = 17500.

Note that if you perform a PR move that does not complete a full cycle, the next motion will begin at the point on the ECAM curve where the last motion completed. If it is required for the profile to always begin at 0 degrees and the PR only completes a partial ECAM cycle, you can disengage the ECAM and re-engage the ECAM to reset the slave to restart at the beginning of the ECAM cycle for the next move.

3.2 Example 2: Bell curve with constant speed section using ECAM and PR mode

The next example application uses a normal distribution, or bell curve that is split at the peak by a section of constant speed. This is similar to a Constant Speed ECAM wizard, but this particular application requires that the accel/decel portion follow a specific bell curve equation path during acceleration. If the user does not require a specific profile during acceleration, then the built-in ECAM wizards of the ASDASoft software for Constant speed applications would be sufficient for this application.
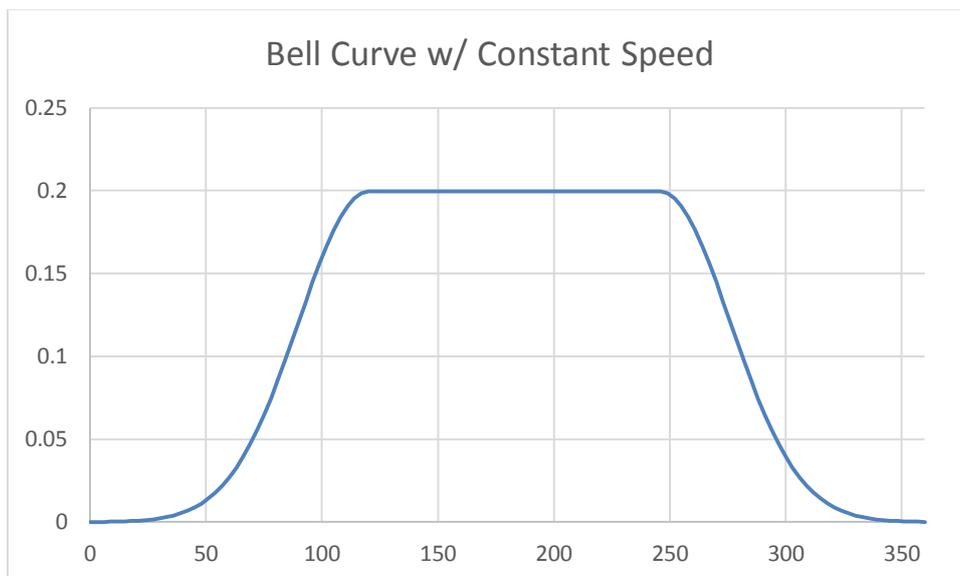
Figure 5: Unit-less velocity profile of full motion path

For this application, we will input only the ECAM points for the actual bell curve, as shown below. The constant speed section will be performed using a PR move instead of ECAM to allow more flexible control of speed and length of time.

Below you can see the ECAM curve that will using as the base for the accel/decel motion.
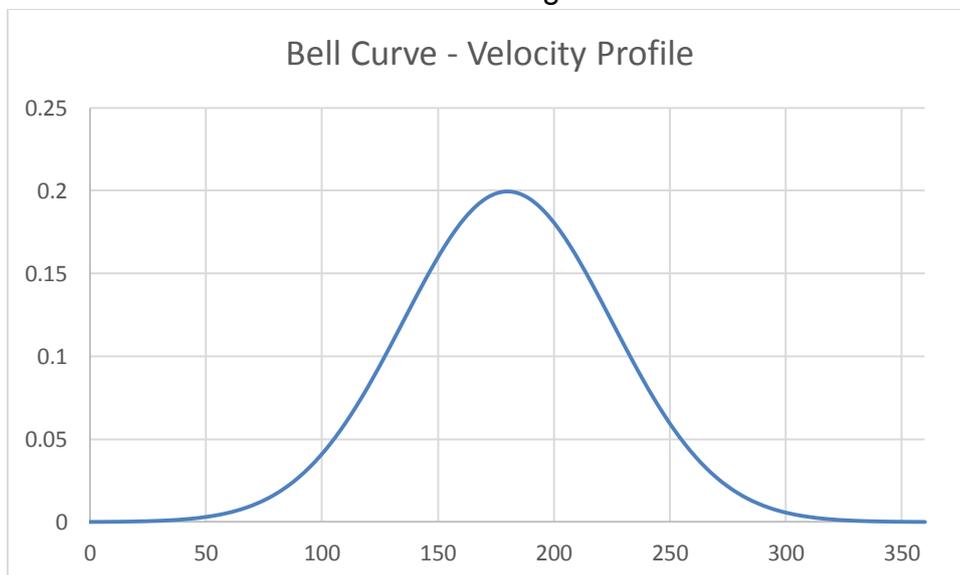

Figure 6: Unit-less velocity profile of the ECAM portion of the motion profile

When the curve is input to the drive, we will need to enable the ECAM profile to disengage at the peak of the curve and immediately move into a PR for a constant speed move. This disengage point will occur at the halfway point of our ECAM cycle, or P5-84/2.

When the motion restarts, the axis will start at the halfway point of the bell curve. In order to ensure smooth start, we will need to make sure the speed at the end of the move matches the beginning. The easiest way to do that is to add another ½ bell curve to the end of the profile to ensure the move is smooth. Below will show the actual total curve loaded into the A2 drive to ensure a full contiguous cycle is available for the acceleration and deceleration portion of the move. Notice that both the 1st and 2nd cycle both have matching speeds at beginning and end, but both will actually disengage at the halfway point of their individual cycles.
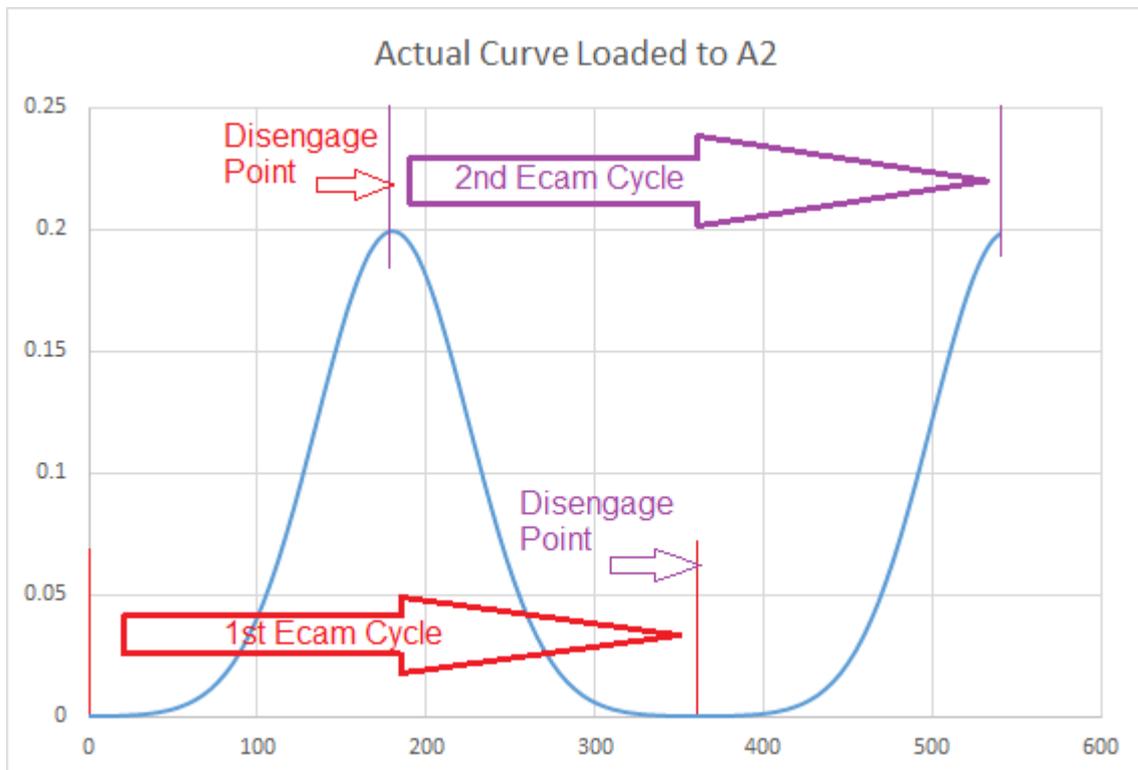
Figure 7: Actual curve loaded into ECAM table of A2 drive is 1 ½ actual curves

3.2.1 PR Map and Explanation

To make the PR move, we will use the function of the drive to call a PR upon disengaging. When this occurs, one of two processes will occur:
1. If the motion is at the peak of the bell curve, the drive will execute a constant speed move equal to the speed at the peak, and after the time for the move has elapsed, the drive will reengage the ECAM at the halfway point of the curve
2. If the motion of the bell curve is ended, the drive will wait the allotted time, then re-engage the ECAM at the beginning of the bell curve

We will switch back and forth by using a jump at the first PR to the section we want to execute. The PR map for this application is shown below:

Execute Once to start App

Engage ECAM mode
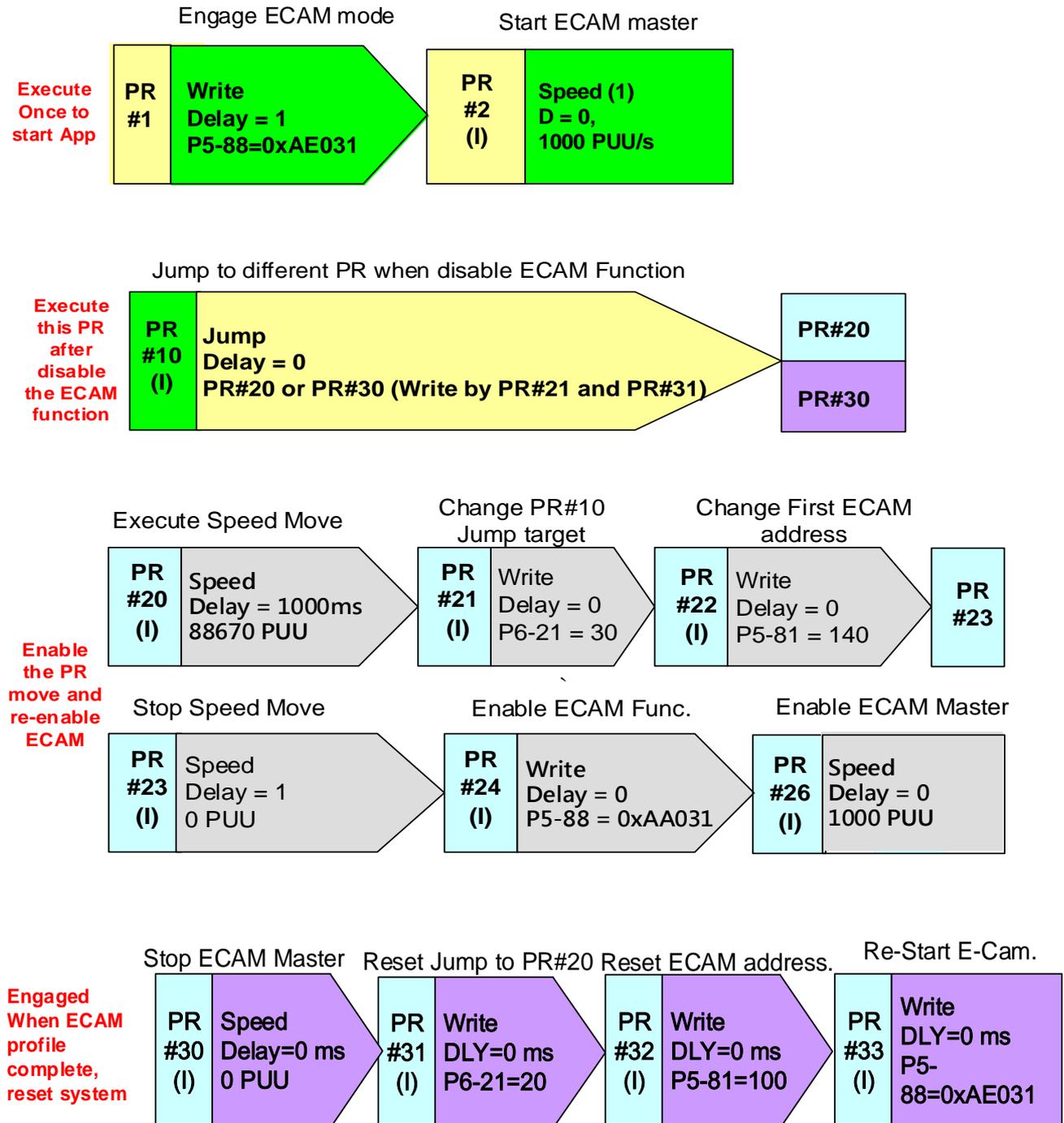| PR #1 | Write Delay = 1 P5-88=0xAE031 |

Start ECAM master
| PR #2 (I) | Speed (1) D = 0, 1000 PUU/s |

Execute this PR after disable the ECAM function

Jump to different PR when disable ECAM Function
| PR #10 (I) | Jump Delay = 0 PR#20 or PR#30 (Write by PR#21 and PR#31) |

| PR#20 |
| PR#30 |

Enable the PR move and re-enable ECAM

Execute Speed Move
| PR #20 (I) | Speed Delay = 1000ms 88670 PUU |

Change PR#10 Jump target
| PR #21 (I) | Write Delay = 0 P6-21 = 30 |

Change First ECAM address
| PR #22 (I) | Write Delay = 0 P5-81 = 140 |

| PR #23 |

Stop Speed Move
| PR #23 (I) | Speed Delay = 1 0 PUU |

Enable ECAM Func.
| PR #24 (I) | Write Delay = 0 P5-88 = 0xAA031 |

Enable ECAM Master
| PR #26 (I) | Speed Delay = 0 1000 PUU |

Engaged When ECAM profile complete, reset system

Stop ECAM Master
| PR #30 (I) | Speed Delay=0 ms 0 PUU |

Reset Jump to PR#20
| PR #31 (I) | Write DLY=0 ms P6-21=20 |

Reset ECAM address.
| PR #32 (I) | Write DLY=0 ms P5-81=100 |

Re-Start E-Cam.
| PR #33 (I) | Write DLY=0 ms P5-88=0xAE031 |

Figure 8: PR Map for controlling the motion path required for Example 2

The main function of the PR commands is as follows:

1. Execute PR#1 on startup to engage system
   a. This will engage the ECAM for the first half of the bell curve move, and execute a speed command to set our master ECAM pulse counting at 1000 PUU/sec. Our default master pulse is set to 3600, so our disengage point for this example would be 1800.
2. When the ECAM completes, execute PR#10. The first time it will jump to PR#20 where the constant speed move will be executed to match the top speed of the bell curve.
   a. During this PR stretch, the drive will set the next jump to PR#30 and reset P5-81 to start at the second half of the ECAM. For our example:

      P5-81 = 100, P5-82 = 80

      So for the second half, we will set P5-81 = 140, or P5-81+(P5-82/2). P5-82 will remain at 80.
3. When the second ECAM motion completes, PR#10 will now jump to PR#30, where we will stop the master ECAM axis, and re-engage for another cycle. To restart motion, we simply need to call PR#2 from a communication, or Digital input trigger.

3.2.4 Varying the length of the constant speed section

In order to change the constant speed length of time, you will simply need to adjust the delay time that is used in PR#20. This can be changed directly from the delay parameter used from P5-40-P5-55, or you can change the delay parameter being referenced in PR#20.

- For example, if we use DL06 (P5-46) for a delay time of 1000msec, and we want to change it to 2000msec, we can either set P5-46 to 2000, or we can change P6-40 from 0x00600061 to 0x00800061 to select DLY08, which is set to 2000msec by default.

3.2.4 Varying the length of the accel/decel section

If the time for the bell curve section needs to be adjusted but the final speed does not need to be changed, then you will need to change the following.

1. First, while disengaged, change parameter P5-84 to the new master pulse count. Increasing the parameter Increases the length of the bell curve section, and decreasing the parameter decreases the length of the accel/decel section
2. Then, adjust P5-19 using the following ratio
   a. P5-19(new) = P5-19(old) * (P5-84(new)/P5-84(old))

      This ensures that the speed at the bell curve is not affected by

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shortening/lengthening the ECAM time using the ECAM gearing ratio

3.2.4   Varying the amplitude

If you desire to increase/decrease the amplitude, or speed of the curve, then the following steps must be taken.

1. First, adjust P5-19 to increase or decrease the speed by your desired amount.
2. Next, adjust the speed of PR#20 to match the adjustment to P5-19.

    For example, if you want to double the speed, and P5-19 is currently set to 1.0, then you would set P5-19 to 2.0, and you would double the current speed of PR#20 from 88670, to 177340.

3.2.5   Varying the Cycle count

In the above application example, the ECAM/PR curve are intended to run continuously. If the application requires the profile to only run a certain number of times, then a batch count function is required to maintain the cycle count. This can be done with the following changes.

- Configure one output to be controlled by P4-06 (Ex: DO1 = 0x0130), DI7 will loop back into this input and be configured as the Capture function. Batch count will be placed in the Capture counter (P5-38) upon initialization of the system, then the Capture function will be enabled
- Every time an ECAM cycle is completed, DO1 will be fired from a PR to count down the Capture function. Once the DO1 has fired the number of times for the Capture counter register, PR#50 will trigger to end the ECAM cycle.

For more information on this capability, please read Delta's application note on Batch count (A2-A006).

4 Building the ECAM curve in ASDASoft

To input the ECAM data, we must first create the dataset, and put it into a format that can be imported easily into ASDASoft for loading. This can be easily achieved using a spreadsheet software like Excel.

For many applications, the equation that describes the motion profile can be executed and the points created in a column of Excel. A sine wave, for example, is a standard equation in Excel.

1. First, create a column that defines the resolution of your points, x. For example, with a sine wave, you can specify the distance between points in degrees from 0-360.
2. Next, create a column with equation for your curve, F(x), that references your input
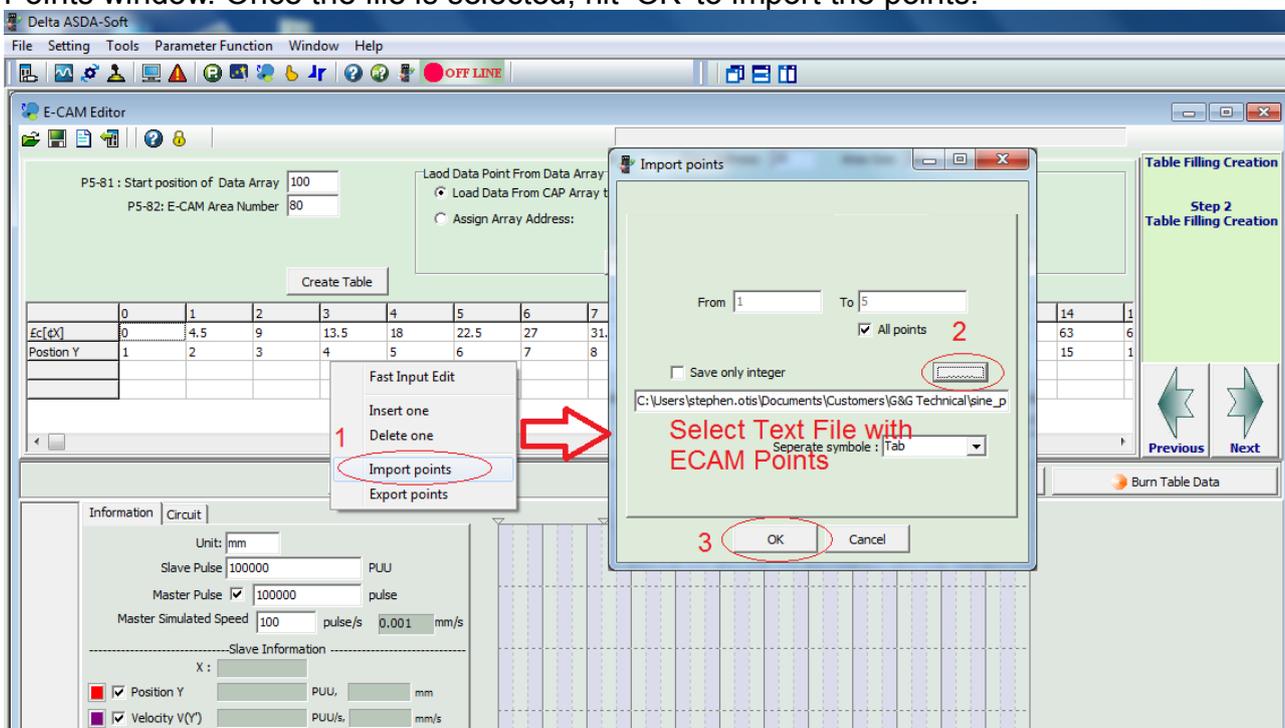
points, x

3. If the curve you created defines the velocity of the curve only, then we need to integrate the velocity to get position. This is easy to do by creating a column next to your velocity column that sums up the velocity, and the previous column entry.

Velocity	Position
6.69151E-05	6.69151E-05
9.93277E-05	0.000166243
0.000145973	0.000312216

4. Once you have a column with your position data, copy and paste it into a blank text file. Save the text file and close.

Now, open ASDASoft and the ECAM Wizard into Table Creation Method. Create a table with the number of points equal to what was created in your text file. Then, right-click and select "Import Points", then select your text file from the saved location using the Inport Points window. Once the file is selected, hit 'OK' to import the points.

Figure 9: Importing points from external dataset

Once imported, you can use the 'Fast Input Edit' to scale the points to the correct distance for your application. Below shows the ECAM graph for the Sine Wave, example 1
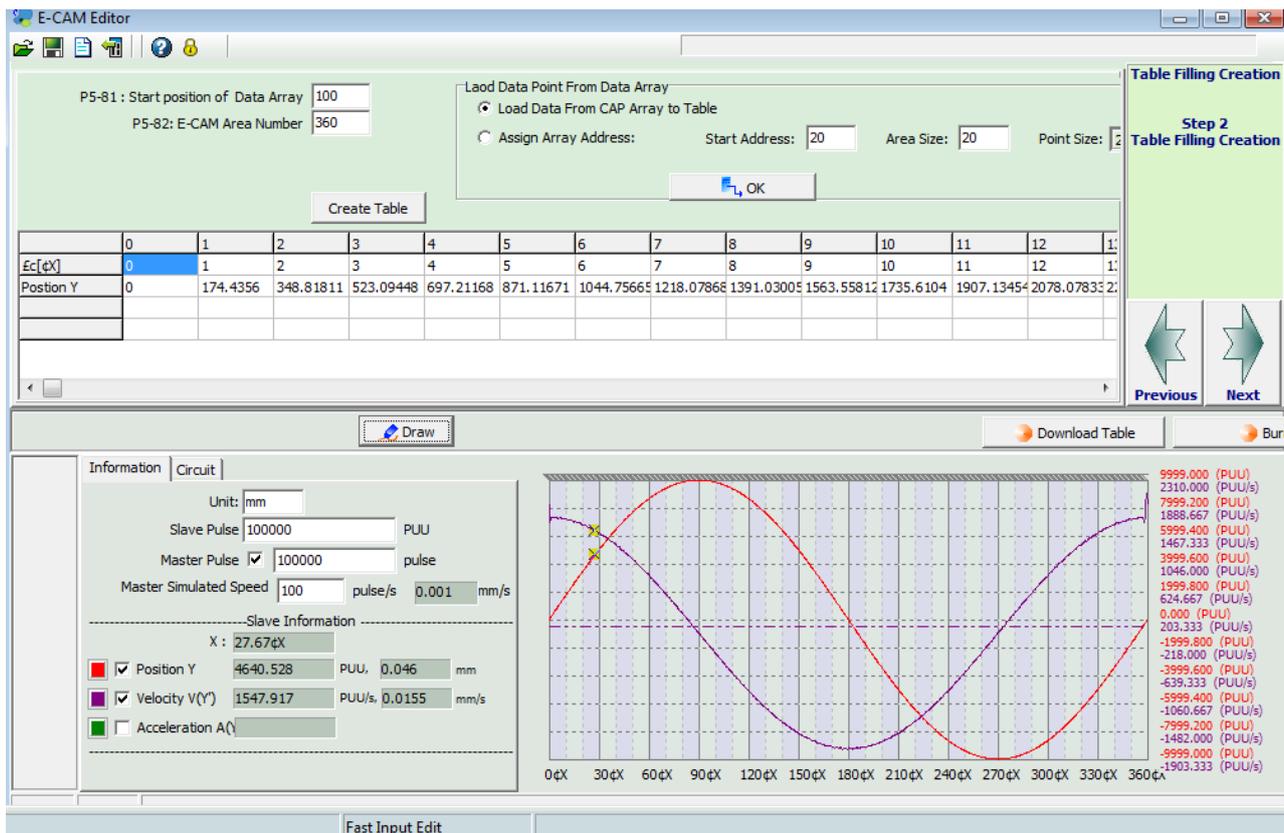
Figure 10: ECAM wizard displaying the sine curve for Example 1

Below shows the ECAM graph for the Bell curve graph, example 2

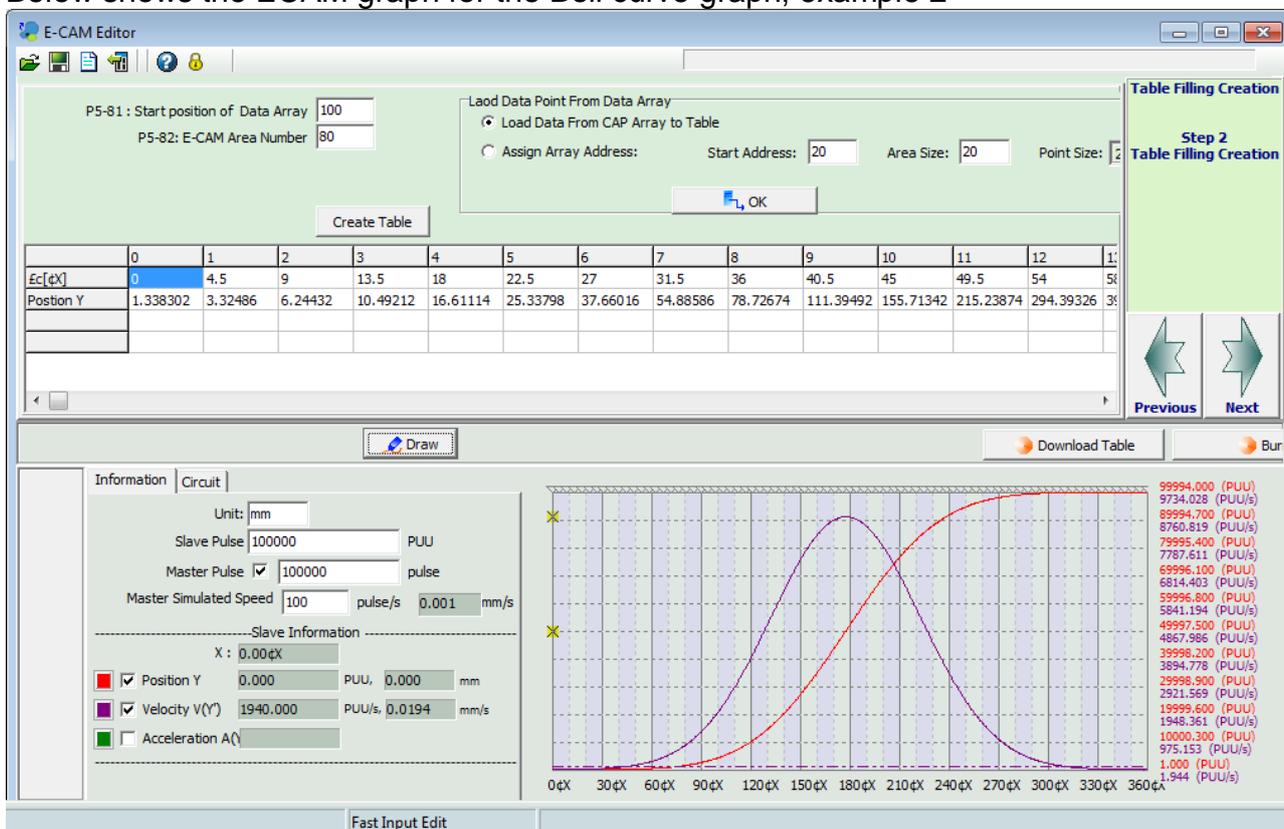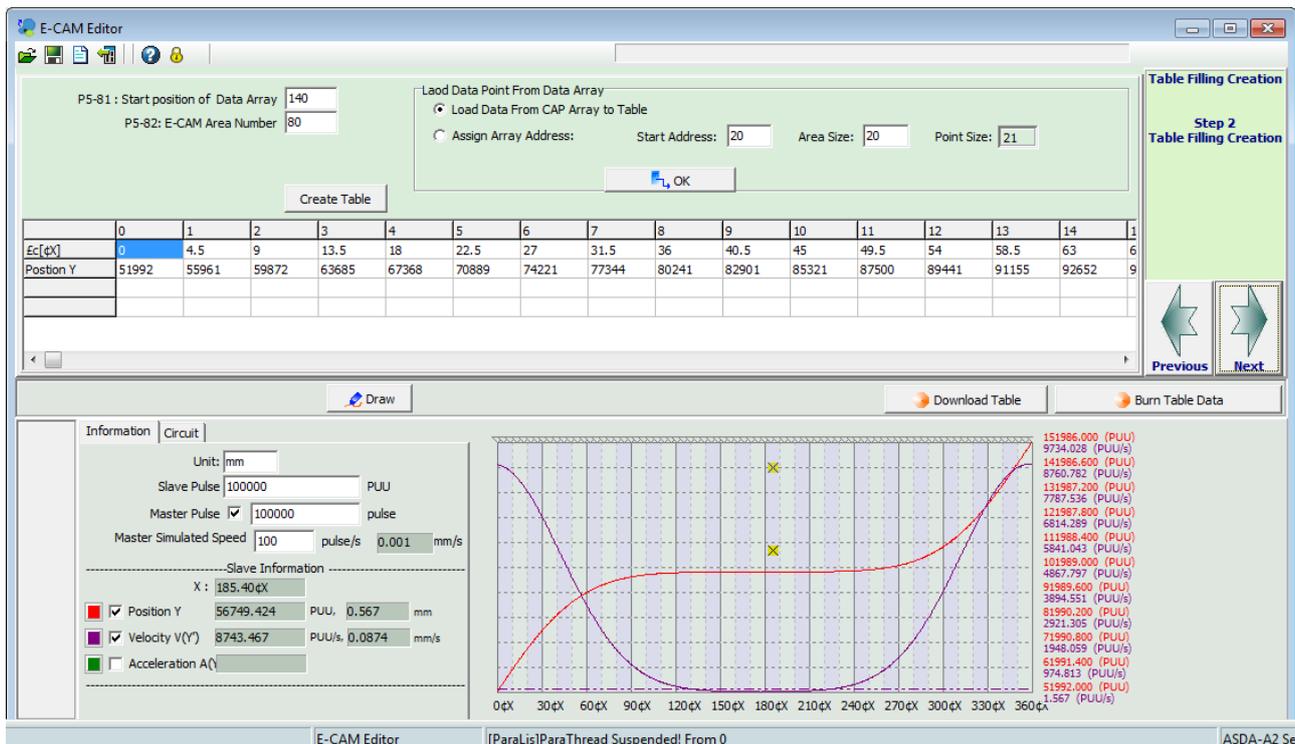*Figure 11: ECAM Wizard showing the full curve for the first half of the bell curve motion*

Figure 12: The second half of the bell curve, example 2, displayed in ECAM Wizard

Delta Products Corporation

Industrial Automation Business Group

5101 Davis Drive, RTP NC 27709
T: 919 767 3913