Application Example of Delta ASDA A2 in Labeling Machine

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Chapter 1 Introduction

This article mainly introduces the application of Delta ASDA A2 in labeling machine. Using E-CAM (electronic cam), label feeding speed is controlled to be same as to-be-labeled object on conveyor, thus, labeling can be done, so this application can be classified as rotary cutoff.

This system is demanded to meet the following requirements:

1. Label length is adjustable.
2. Label must be fed to a precise position.
3. Feeding speed is same as master conveyor.

For easy operation, all adjustments in this example are the position of photoelectric sensor (In this system, no host controller, no human machine interface. Only one Delta ASDA A2 is enough for all functions.), e.g. label locating position, labeling start position.

Besides detailed analysis of labeling motion, this article will introduce how to use “speed section “of Delta ASDA Soft to create E-CAM curve. This curve has a very long constant speed section, which is the table creation basis in rotary cutoff and similar applications.

Using E-CAM together with various PR commands, Delta ASDA A2 can easily satisfy this control requirement.

Chapter 2 System Layout

Master axis is the axis of conveyor, transporting objects. E-CAM axis controls the pace of labeling machine according to the pulse speed master axis gives. Refer to figure 1. In this application, label waiting position (controlled by label positioning detector) must be very precise. Each time the position error should be within 1mm. What's more, E-CAM curve and its function design must consider adjustable label length, so E-CAM will be set according to the longest label this system will operate.

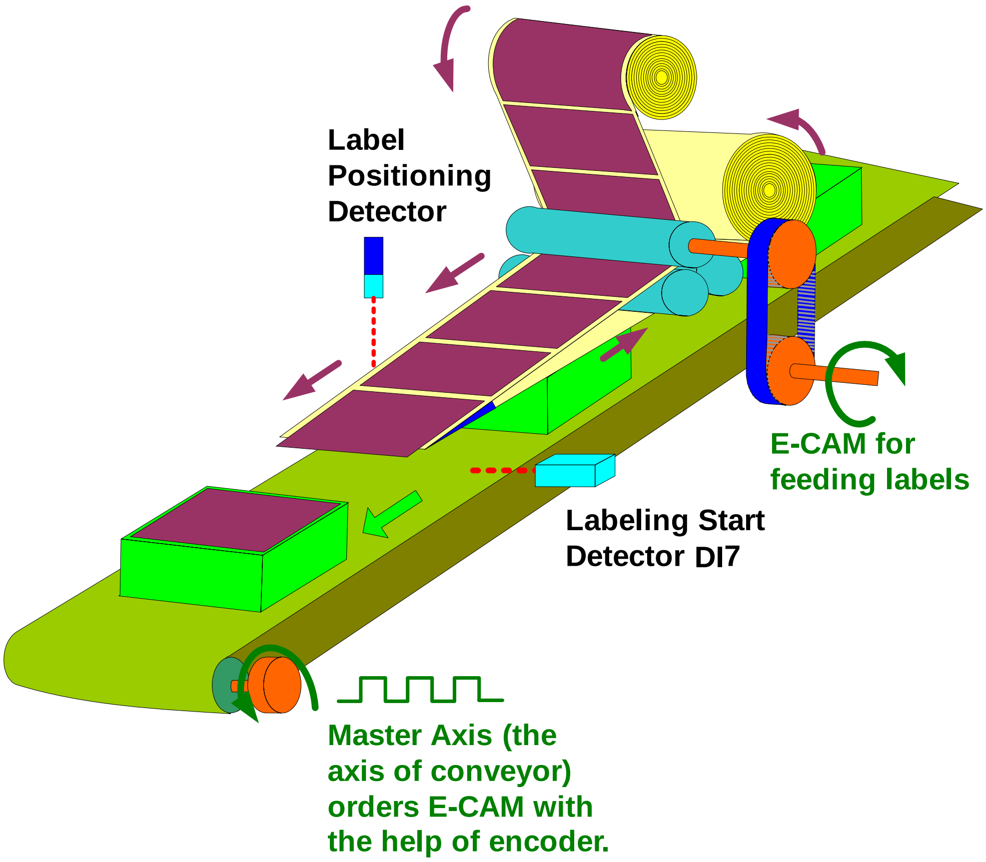

Figure 1 Labeling Machine System

2.1 Master Axis --- the axis of conveyor

Transport the to-be labeled objects (e.g. packing box). While transporting, pulse signals are given at the same time to order E-CAM axis, further to control labeling speed.

2.2 E-CAM Axis --- label feeding axis

E-CAM axis will obey master axis's orders and execute labeling according to the pace of master axis. It should be precise and stable while transporting label. And label transporting speed must be same as master axis while labeling, or else, the label will be pasted uneven.

2.3 Label Positioning Detector

While label is waiting to paste, label positioning detector decides its outstretched length, which can be changed by adjusting the position of photoelectric sensor (label positioning detector).

2.4 Labeling Start Detector

When DI7 receives the signal from labeling start detector, it will control the electronic gear engaged, thus, E-CAM axis will be synchronized with master axis. When E-CAM starts to accelerate and reaches the speed same as master axis, label is just beginning to paste on the to-be-labeled object. The electronic gear won't be disengaged until labeling has been finished.

Chapter 3 Motion Analysis and PR Setting

3.1 Enable E-CAM function to label

When the object on conveyor touches labeling start detector, E-CAM function is enabled and label axis follows master axis motion till labeling is finished. It is controlled by label positioning detector that the electronic gear changes to be disengaged. Refer to figure 2 and figure 3.

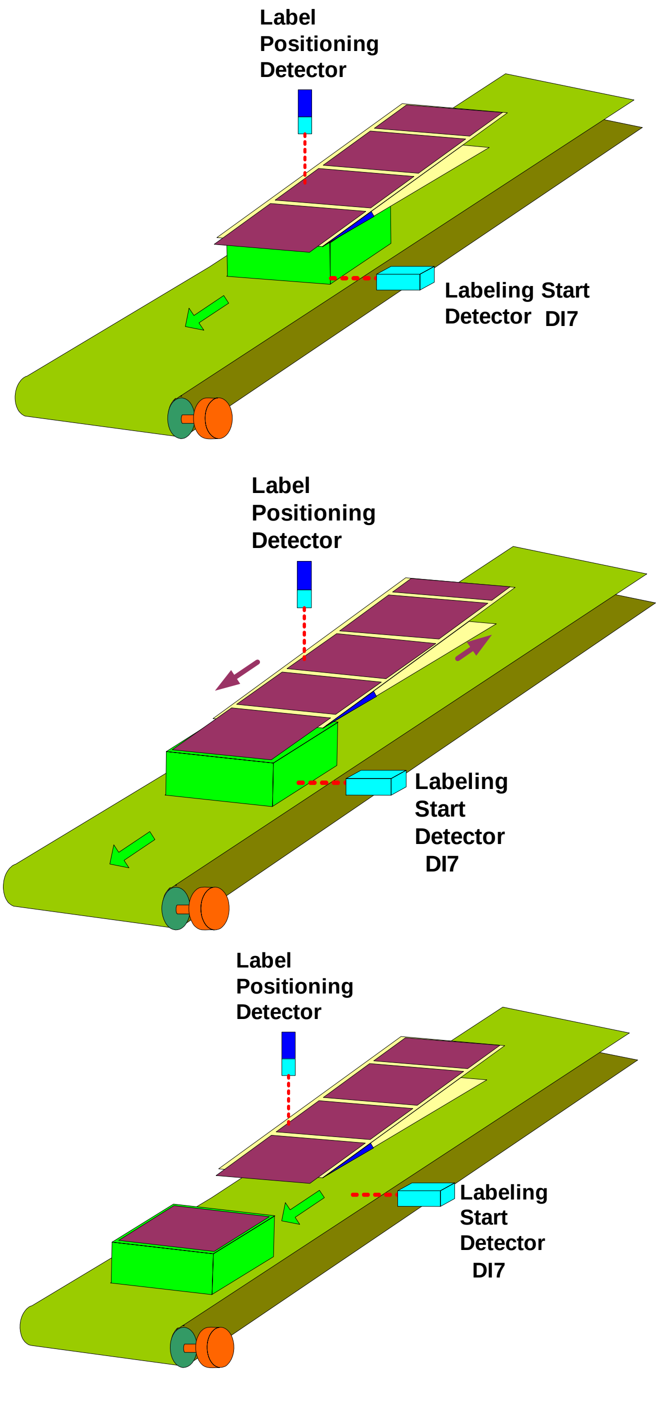

Figure 2 Labeling Start

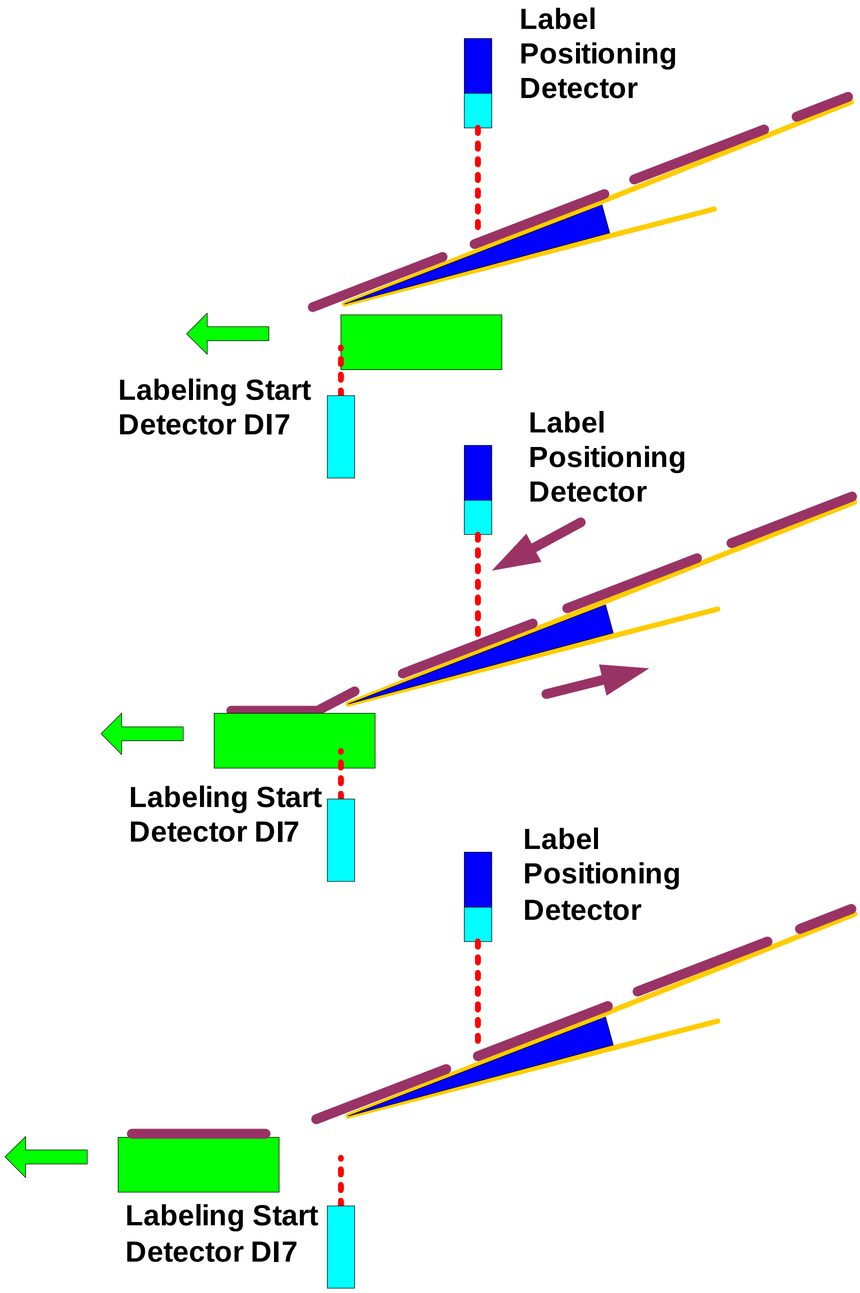

Figure 3 Side View Labeling process

3.2 E-CAM Function Disabled and Label Positioning

The disengagement of electronic gear and the outstretched part positioning are decided by label positioning detector, whose position can be adjusted according to different label lengths and different needs. Refer to figure 4 for adjustment of outstretched part positioning.

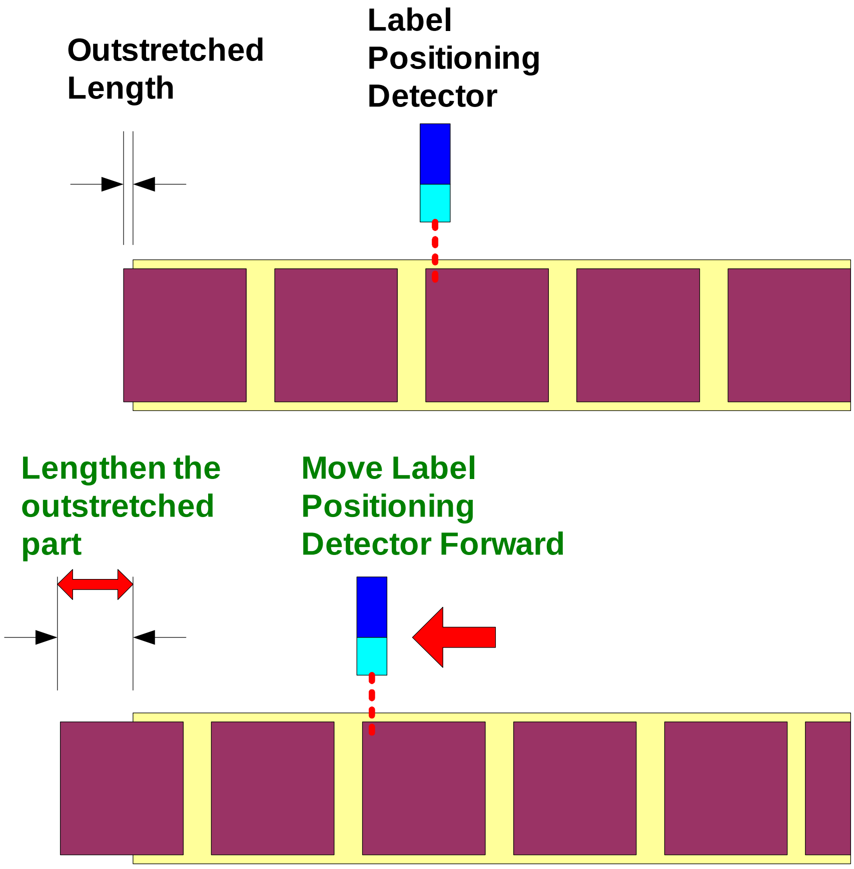

Figure 4 Adjustment of outstretched Part Positioning

Label positioning detector is used to control the disengagement time of electronic gear, prepare next label for next cycle and control outstretched part positioning (label waiting position). This signal sets trigger event, triggering the following correspondent Pr commands to control disengagement of electronic gear and outstretched length of the label. Refer to figure 5 and figure 6.

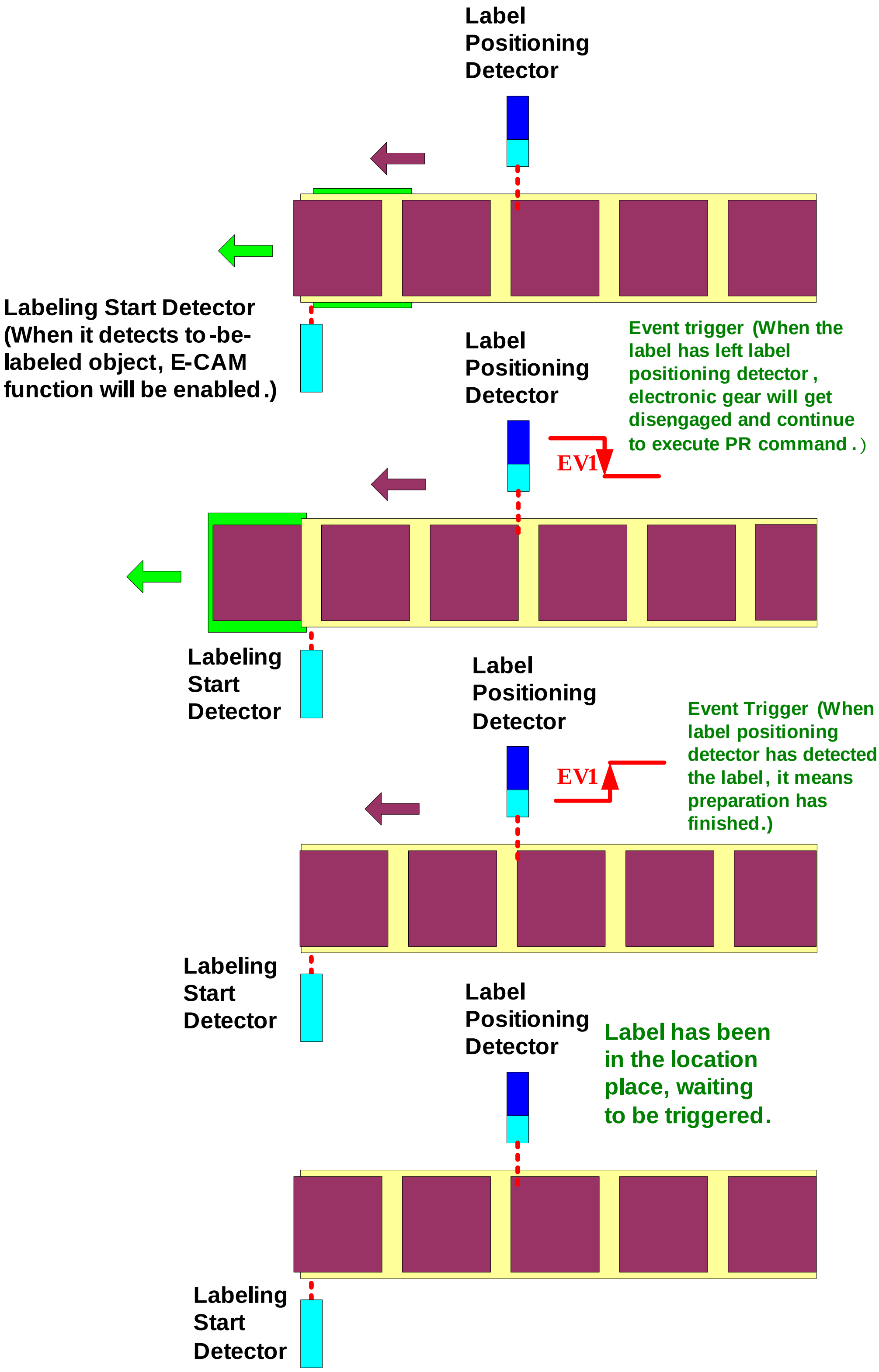

Figure 5 Label Outstretching and Positioning

3.3 PR Commands Layout

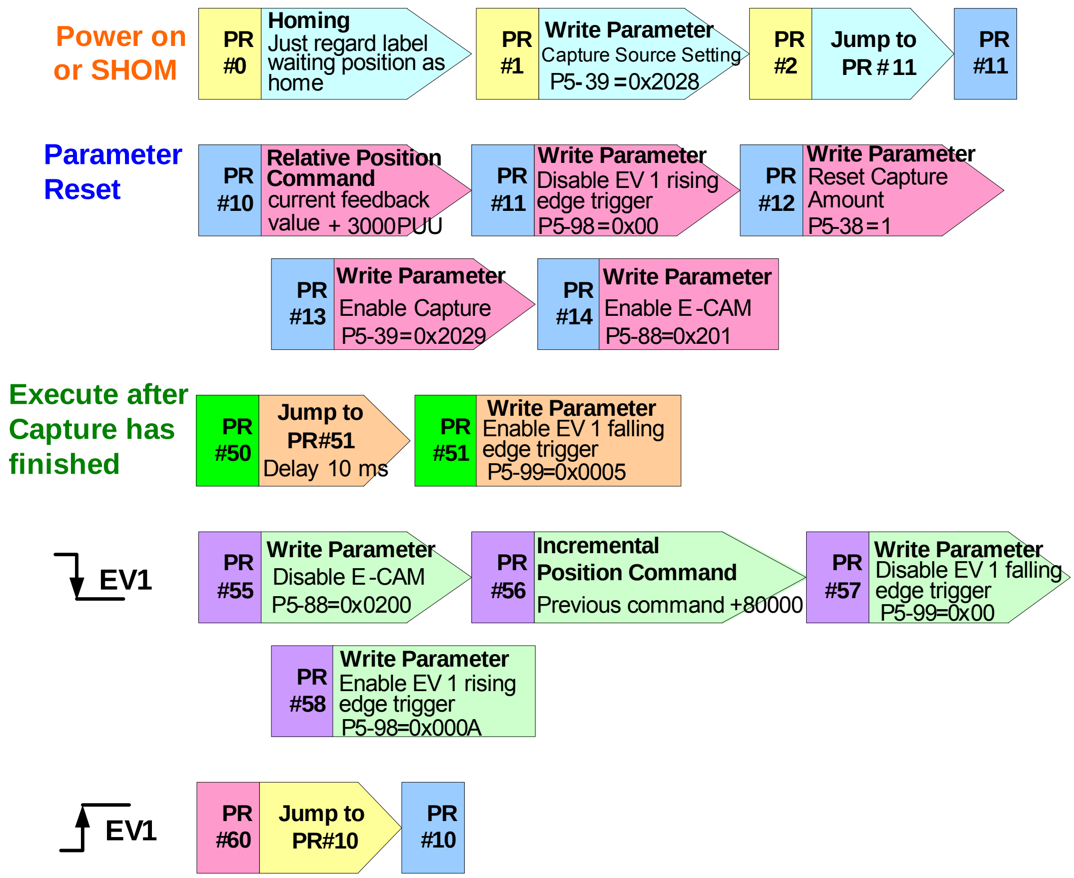

Figure 6 PR Commands Layout

PR#0: Homing. Due to mechanical structure design, after starting, just regard label waiting position as home.

PR#1: Capture Source Setting. Set that the position command Pr #50 will be triggered immediately after capture operation is completed.

PR#2: Jump to PR #11.

PR#10: Relative Position Command. It is used to control label waiting position. Refer to figure 7. After E-CAM returns to “Home”, PR#10 won’t be executed until normal cycle.

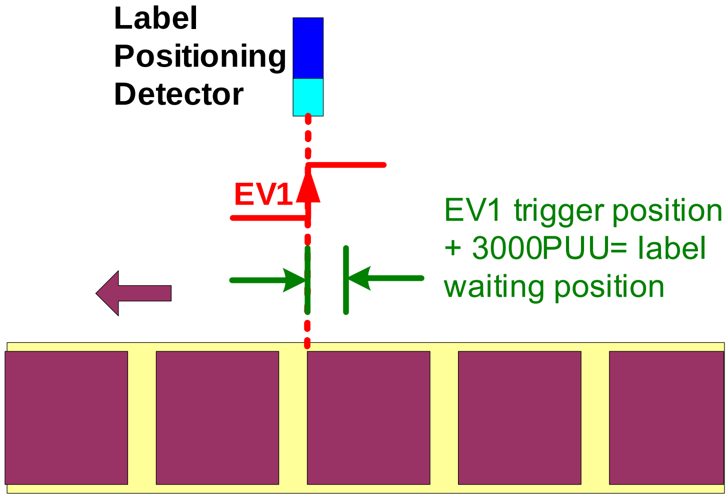

Figure 7 Label Waiting Position

PR#11: Write the parameter that can disable EV1 rising edge trigger command so as to prevent erroneous actions.

PR#12: Write the parameter that can reset capture amount. As only one position is needed to capture for E-CAM function, this parameter is reset to 1.

PR#13: Write the parameter that can enable capture function.

PR#14: Write the parameter that can enable E-CAM function. Set that the electronic gear will be engaged by capture function.

PR#50: After capture operation is completed, the position command PR#50 will be triggered immediately. PR#50, a jump command, will jump to next PR command, here Auto function isn't used but jump command is used for delay time, therefore, after capture operation is completed, next position command (Enable EV1 falling edge trigger) will be executed with a delay.

PR#51: Enable EV1 falling edge trigger. Label positioning detector has entered into label position, so enable it to detect label's disengagement position (label's end).

PR#55: When label positioning detector leaves the label, EV1 falling edge trigger will be active and electronic gear will be controlled to be disengaged. By writing E-CAM commands, PR#55 is used to disable E-CAM function and disengage electronic gear.

PR#56: Incremental Position Command, that is, the travel distance after disengaging from label. This distance ought to be more than the maximum label spacing that this machine may operate, considering the maximum space between two labels. Refer to figure 8.

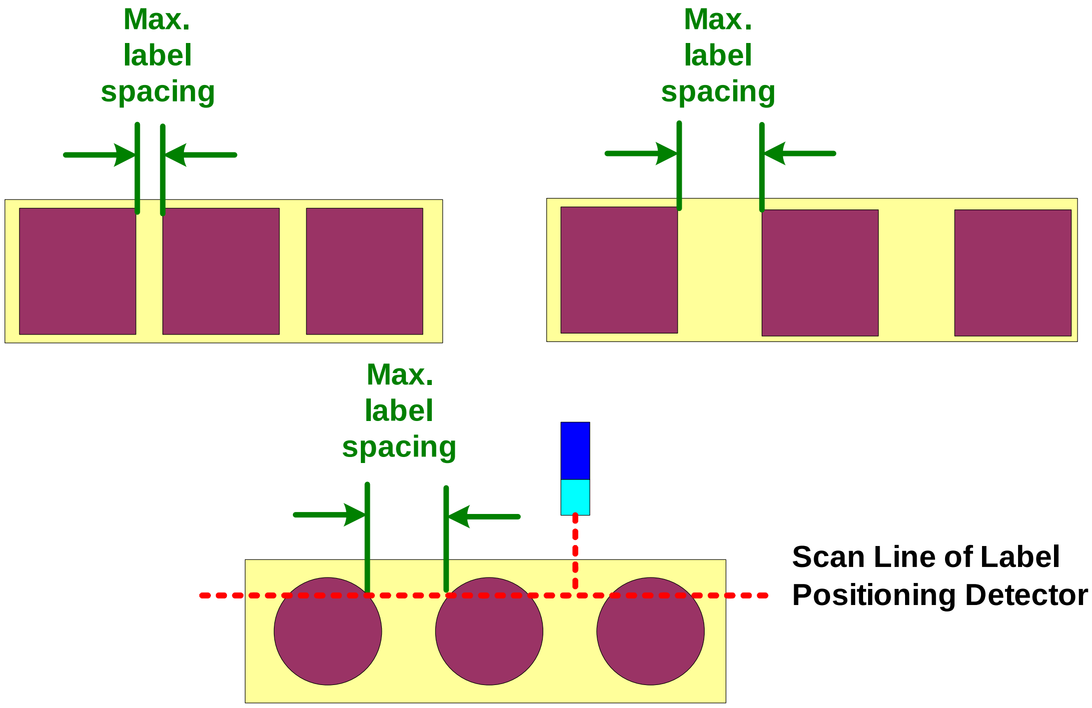

Figure 8 Label Spacing

PR#57: When PR#57 is executing, label positioning detector has left label position, and EV1 falling edge trigger won't continuously occur twice in timing. In order to prevent erroneous actions, first disable EV1 falling edge trigger, then enable it later by PR command at an appropriate time.

PR#58: Enable detection for rising edge trigger to prepare next label, so re-enable detection for EV1 rising edge trigger.

PR#60: Jump to PR#10 after EV1 rising edge trigger.

Chapter 4 E-CAM Curve Design

4.1 E-CAM Curve Frame

When the object on conveyor touches labeling start detector, E-CAM function is enabled, thus, the speed of master axis and E-CAM must be same, or else, the label will be pasted with tight/loose stretch. See figure 9 for cross reference of E-CAM curve and the to-be-labeled object (e.g. packing box).

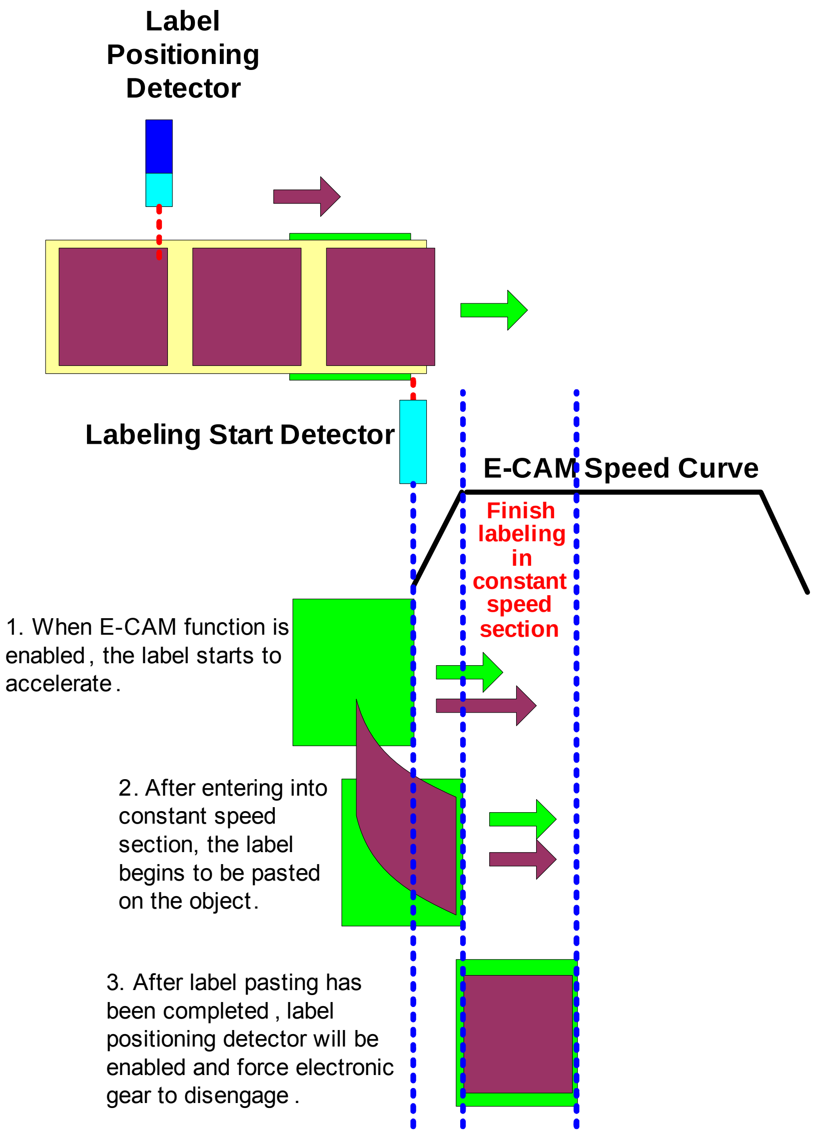

Figure 9 Labeling and E-CAM Curve

From figure 9 above, there is a very long constant speed section in E-CAM curve; moreover, this curve should consider the maximum label length that the machine may operate. See figure 10.

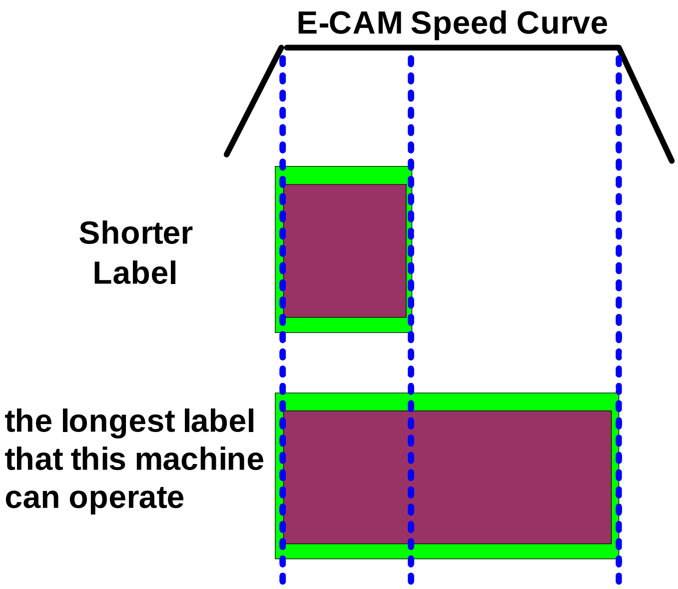

Figure 10 Relations between Label Length and E-CAM Curve

4.2 E-CAM Curve Creation

According to actual machine, the roller diameter of master axis is 5cm, and encoder will output 1600 pulses for each revolution of master axis. Refer to figure 11. Therefore, master pulse per millimeter is: 1600 pulse / (π*50mm) = 10.185916 (pulse/mm).

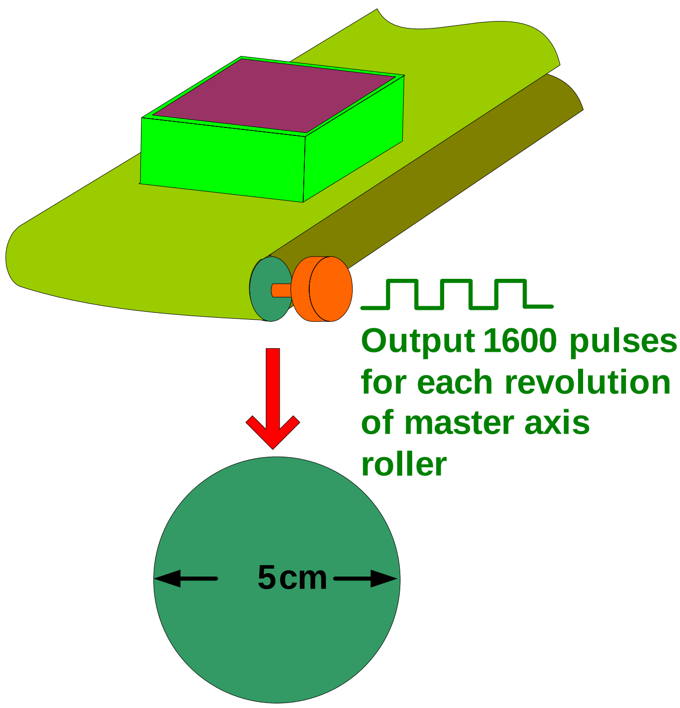

Figure 11 Specifications of Master Axis Roller and Encoder

As for E-CAM axis, the roller diameter is 5cm, and electronic gear ratio is 1:1. Refer to figure 12.

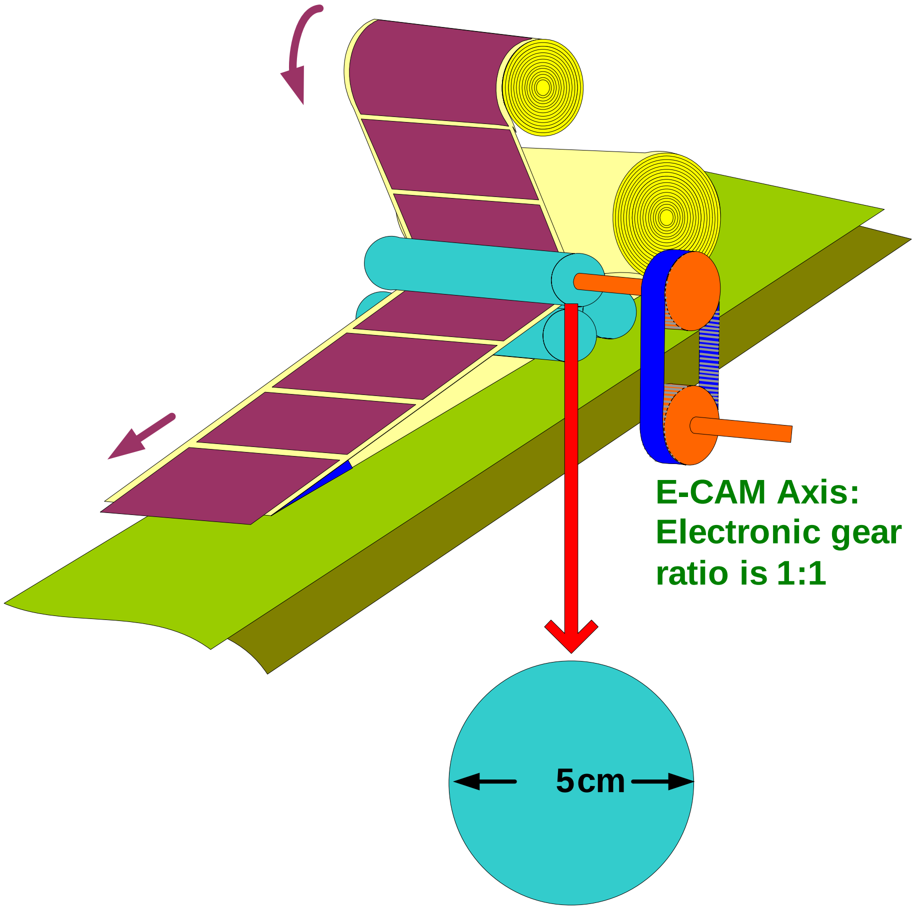

Figure 12 E-CAM Axis Dimensions

According to figure 12, the label length brought by each roller revolution is: π*5 cm =15.708 cm. To meet the requirements of maximum 23cm, the curve must be longer than 23cm because there should be some time for acceleration and deceleration. Here, 23cm is the travel distance that master axis and E-AM axis runs at the same speed, based on which to create E-CAM curve in this example.

From figure 13, we can see master axis is constant speed all the time while E-CAM axis also has acceleration and deceleration, therefore, in the same period, considering of E-CAM accel./decel. time, master axis travels farther than E-CAM axis, thus, E-CAM function must be enabled in advance so as to finish labeling during constant speed section. In conclusion, the relations of travel distances are: constant speed section < E-CAM axis < master axis. How to create this E-CAM curve will be introduced in the following pages.

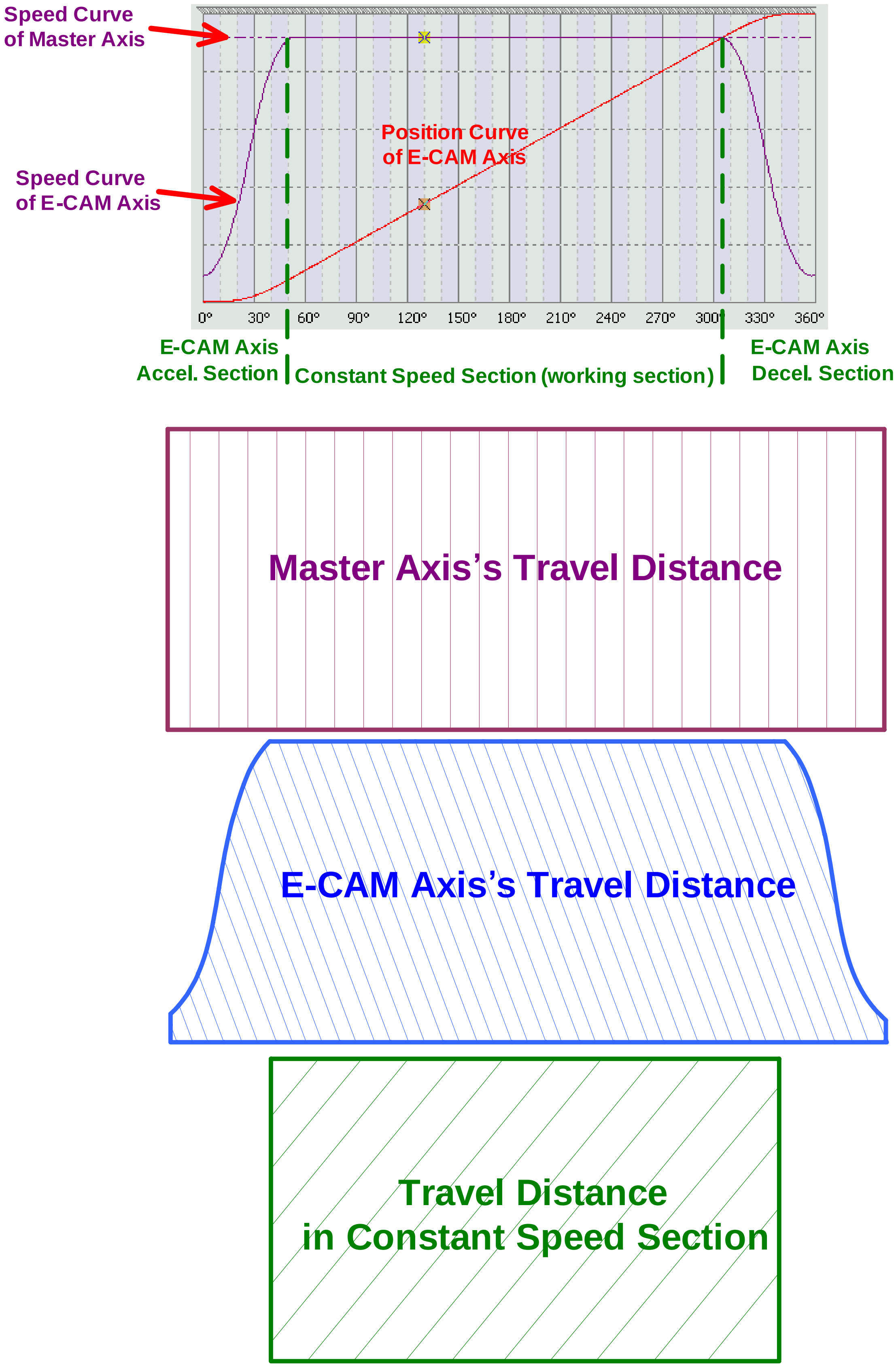

Figure 13 E-CAM Curve

By setting electronic gear ratio, the system not only satisfies the required precision but also increases its readability. In this example, the travel distance for each E-CAM axis revolution is: π*5 cm =15.708 cm. In order to make this data more readable, it can be set to 15708 PUU, so each PUU means 0.001mm, thus, set Pr.1-44 to 128000 and Pr.1-45 to 15708, therefore, when E-CAM table magnification (Pr.5-19) is set to 1, E-CAM pulse is: (15708PUU / 15.708cm) = 1000 PUU/mm. Refer to figure 14.

P1 - 44		GR1	128000	*	pulse	1	536870911	128	電子齒輪比分子 (N1)
P1 - 45	▲	GR2	15708		pulse	1	2147483647	10	電子齒輪比分母 (M)

Figure 14 Electronic Gear Ratio Setting

According to analysis above, to create a curve of 31.416cm (314.16mm), 314160 PUU is needed because 314.16 (mm)* 1000(PUU/mm) = 314160 PUU.

In ASDA A2 Soft, we use "speed section" to create E-CAM table, refer to the following steps for operation.

a. Select one way to create E-CAM Table

Select "Speed Section" to create E-CAM table. See figure 15.

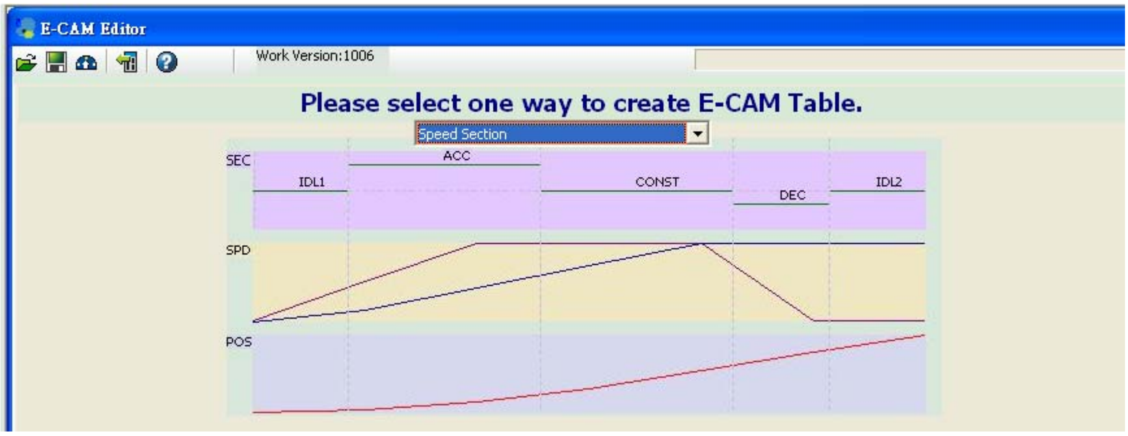

Figure 15 "Speed Section" Way

b. Set Actual Machine Dimensions

Master axis: 10.185916 Pulse/mm; E-CAM axis: 1000 PUU/mm. When creating E-CAM curve, system will refer to these simulation data, so please make sure these information is correct: Unit, Master Pulse and Slave Pulse. See figure 16.

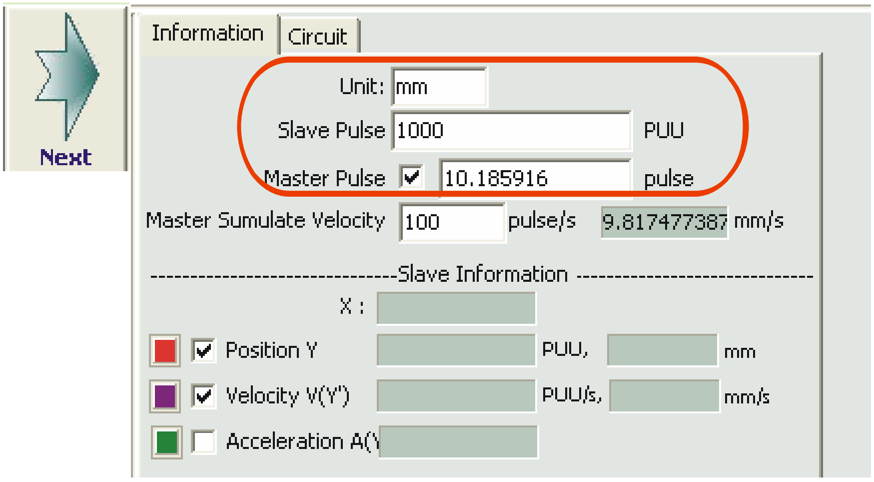

Figure 16 Simulation Information

c. Set Slave Axis Lead

In this example, the longest lead of labeling is 23cm. Considering of Accel./Decel. Section, this curve must be designed longer than 23cm. According to previous experiences, take 30cm for a rough estimation (about 10% more, including 5% acceleration and 5% deceleration), thus, 300(mm)* 1000 (Pulse/mm) = 300000 Pulse, fill this value into “Lead”. In addition, fill 100 into Pr.5-81(Data Array start Address), which can be set according to actual conditions. Fill 200 into Pr.5-82 (E-CAM Areas: N(5~720)), the bigger this value is, the more beautiful the curve will be. It is recommended to set a value more than 200 in this example. User can set different values to see different effects. Refer to figure 17.

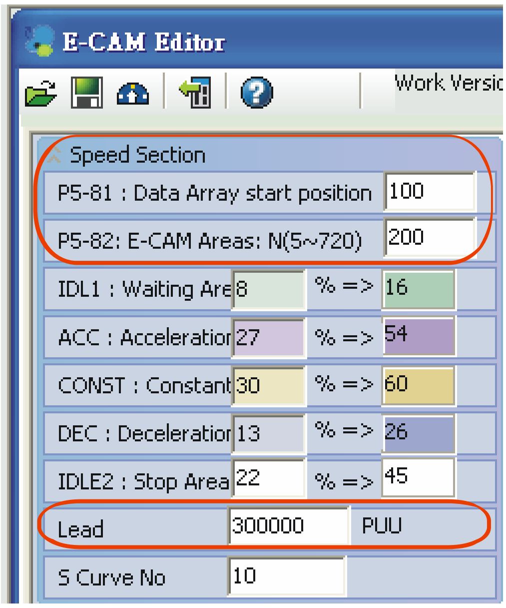

Figure 17 E-CAM Lead Setting

d. Set Master Axis Lead

According to previous experiences, it is estimated master axis will travel 33cm (10% more), therefore, if Pr.5-83 is set to 1, Pr.5-84=10.185916(pulse/mm)*330(mm)=3361.

Figure 18 Pulse Number Setting of Master Axis

e. Create E-CAM Curve

Refer to Mark 1 in figure 19, please set “Waiting Area”, “Acceleration Area”, “Constant Speed Area”, “Deceleration Area” and “Stop Area”. To set accel./decel. area, motor inertia ought to be considered. If motor inertia is larger and accel./decel. curve is steeper, it may result in command delay, motor overload or regeneration error, therefore, if accel./decel. can’t be calculated precisely, please do field test first. In addition, during creating curve, constant speed area should be as long as possible because it is the real working area. Meanwhile, it’s better to leave some time for stop area, or else, maybe homing can’t be completed at times.

Refer to Mark 2 in figure 19, please set “S Curve No” so as to smooth E-CAM curve. Its ideal value is equal to that of stop area. We can see both S Curve No and Stop Area are filled 10.

After finishing all settings above, press “Create Table” which is marked 3, system will create the table and curve.

Mark 4 in figure 19 displays master speed is 9.817477387, which is the target speed E-CAM searches (master speed varies with “Master Simulation Speed”, but different Master Simulation speed won’t influent curve creating).

Then move the cursor to constant speed area which is marked 5. We can see the value is 9.867(>9.8174477387, Master Simulation Speed), thus, E-CAM axis speed is a little higher than master axis, you can adjust accel./decel. area or master/slave axis lead to make these two values equal. Refer to following explanations for details.

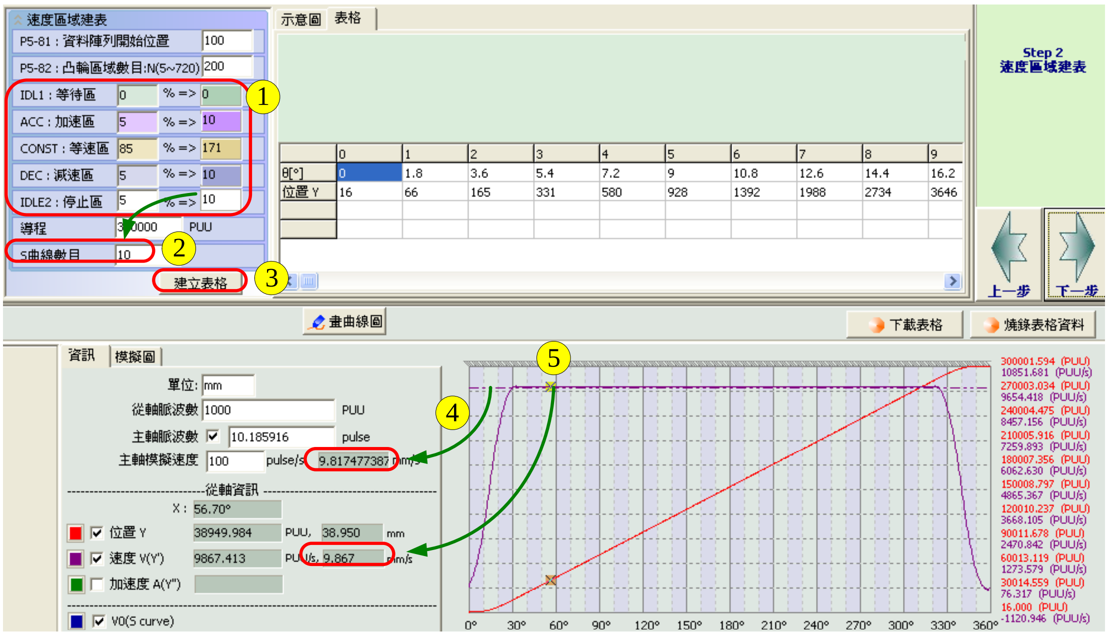

Figure 19 Create E-CAM Curve

f. Adjust the Speed in Constant Section through E-CAM Axis

Here I will introduce how to adjust curve through accel./decel. section or E-CAM lead (Both can be adjusted at the same time). Refer to figure 20. Through adjusting accel./decel. section, E-CAM constant speed section can meet the requirements of master axis speed, which is seen from Mark 4 and Mark 5 in figure 20. Certainly you need to try several times for a proper value while adjusting. This method is suitable for unchangeable Pr.5-84 (Pulse Number of Master Axis). Of course, Pr. 5-84 can be changed in this application of labeling machine.

From figure 21, we can see the desired speed curve is also obtained by adjusting E-CAM lead (Mark 1). From Mark 4 and Mark 5 in figure 21, we can see master axis speed (9.817477387) is equal to slave axis speed in constant speed section (9.818).

In figure 20, the length of constant speed section is: 300000 PUU * (360° − 60°) / 360° / 1000(PUU/mm) = 250 (mm), more than 23cm. 60° is the time for accel./decel. section.

In figure 21, the length of constant speed section is: 298600 PUU * (360° − 65°) / 360° / 1000(PUU/mm) = 244.69 (mm), more than 23cm. 65° is the time for accel./decel. section.

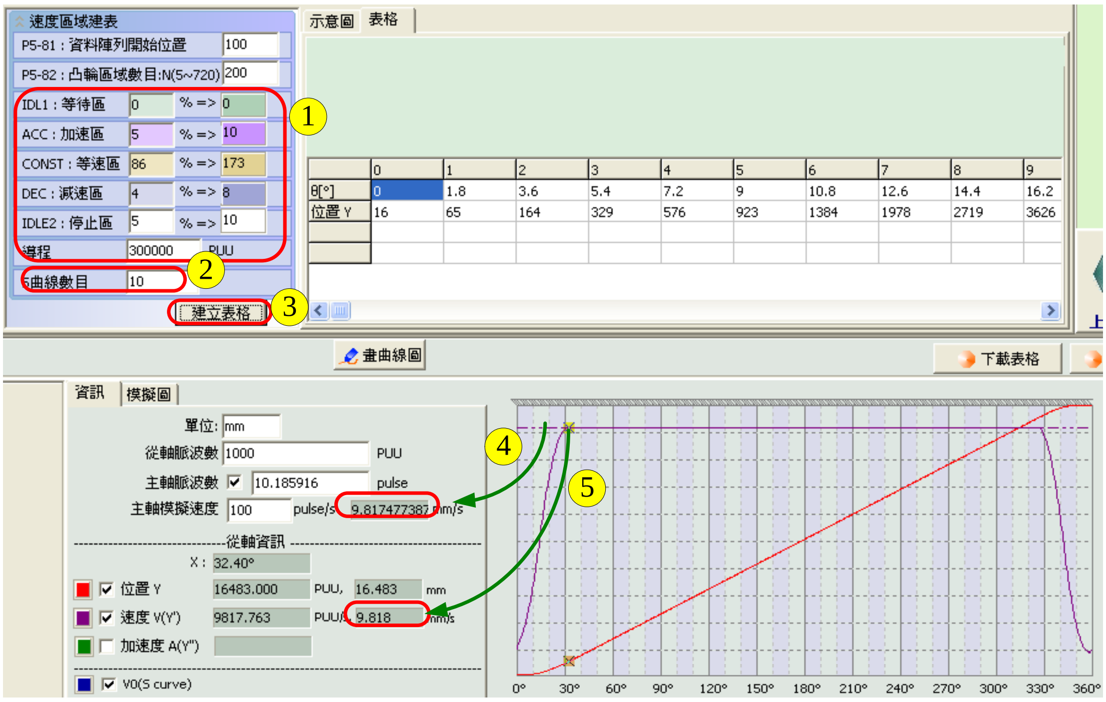

Figure 20 Accel./Decel. Section Adjustments

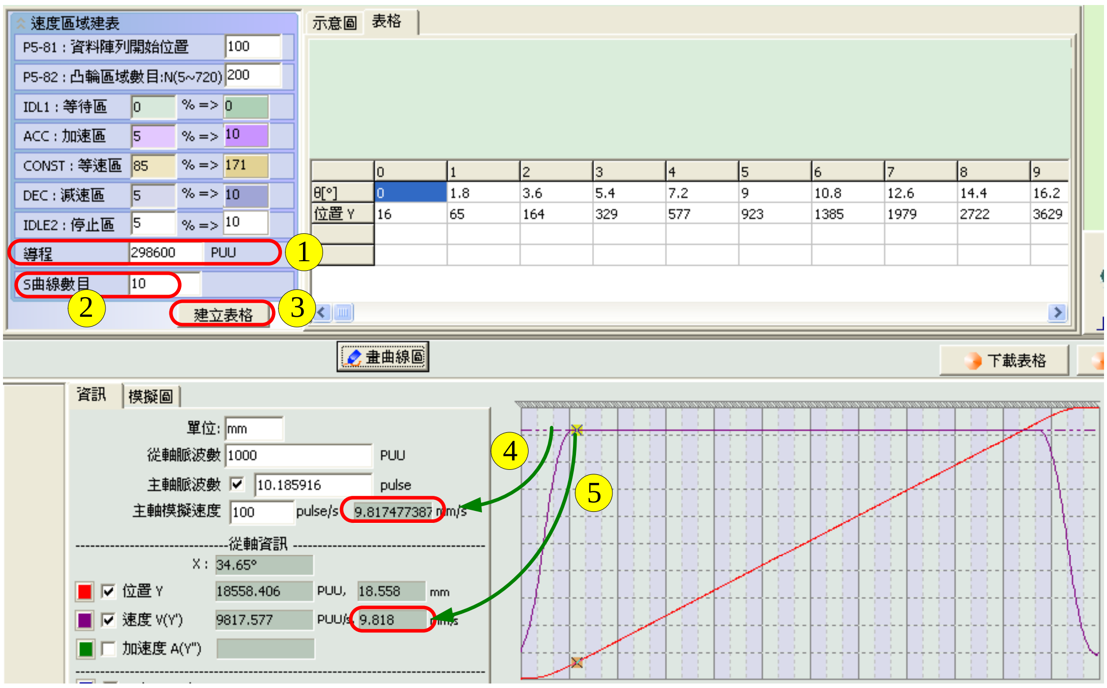

Figure 21 E-CAM Axis Lead Adjustments

g. Adjust the Speed in Constant Section through Master Axis

Mark 1 data in figure 22 is same as figure 19 above. Here, adjust Pr.5-84 (Pulse Number of Master Axis) in figure 18 from 3361 to 3376 as Mark 3 in figure 22 (3376 is the result after several tries). After finishing adjustment, the desired curve is seen from Mark 4 and Mark 5 in figure 22. Therefore, all three (figure 20~22) have achieved the desired E-CAM curve of this labeling machine, but they are different in adjustment method because of unchangeable pulse number of master axis or slave axis. Two ways are selected according to actual conditions; of course, both can be adjusted in this case.

In figure 22, the length of constant speed section is: 300000 PUU * (360°－65°) / 360° / 1000(PUU/mm) = 245.8 (mm), more than23cm. 65° is the time for accel./decel. section.

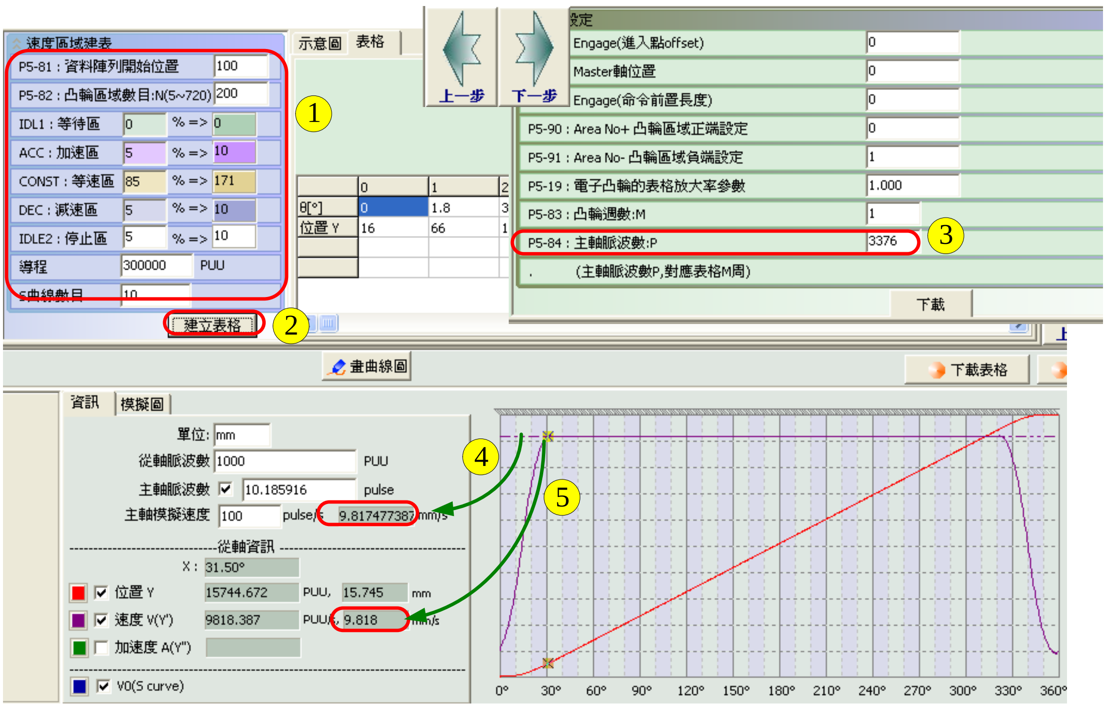

Figure 22 Master Axis Lead Adjustments

4.3 E-CAM Curve Analysis

From Mark 5 in figure 23, E-CAM enters into constant speed section at 30° position. Before entering, the travel distances of master axis and E-CAM axis are as follows:

Master Axis:

3376*(30/360)=281.333 (pulse), 281.333 / 10.185916 (Mark 4 in figure 23)=27.62 mm

Slave Axis (Move cursor to 30° position and read its correspondent position data):

15744.672(Mark 5 in figure23) / 1000 (Mark 4 in figure 23)=15.74mm

From calculations above, before entering into constant speed section, master axis travels 27.62mm while slave axis travels only 15.74mm. This difference will affect the location of labeling start detector, see figure 24.

Before entering into constant speed section, E-CAM axis will travel 15.74mm. If max. speed of master axis is S (the max.speed this labeling machine can run), master axis will take the time of T(=27.62/S) to complete 27.62mm distance at the speed of S, therefore, the acceleration A of E-CAM axis in acceleration section is:

A(acceleration) ＝ (S(target speed) – 0（accelerate from 0）) / T

α(Angular acceleration)= A / r (rotary shaft radius)

T (torque) ＝ J(inertia) * α (Angular acceleration)

From calculations above, T (the torque needed during acceleration) can also judge E-CAM curve satisfies the motor requirements or not.

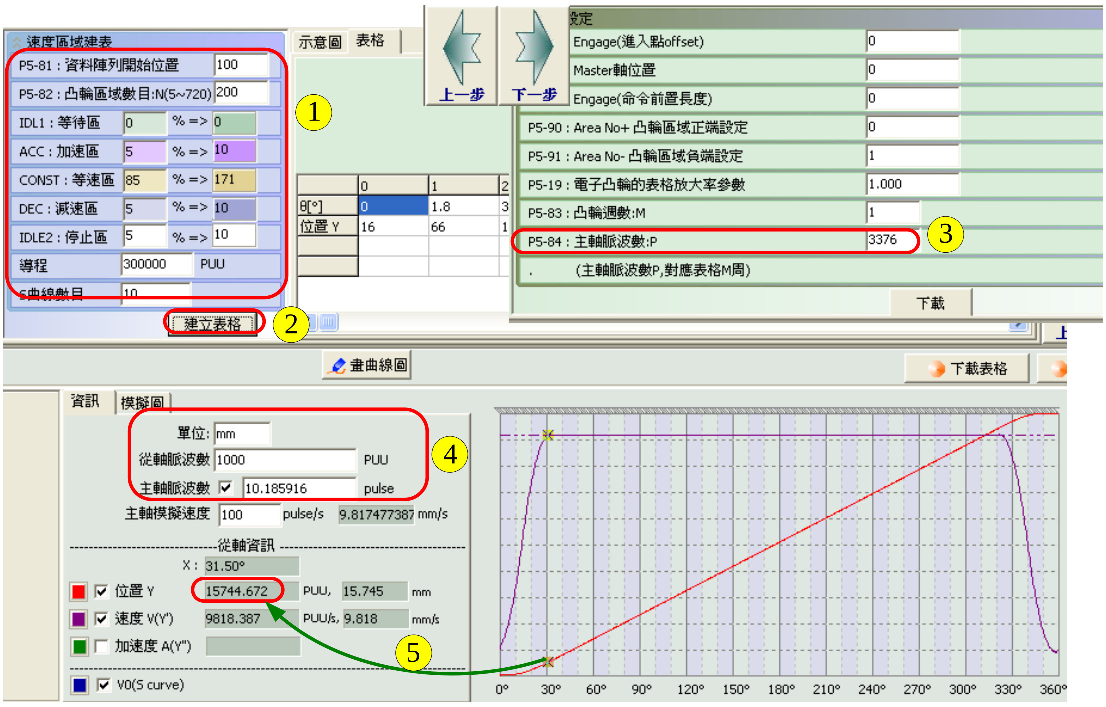

Figure 23 E-CAM Curve Analysis

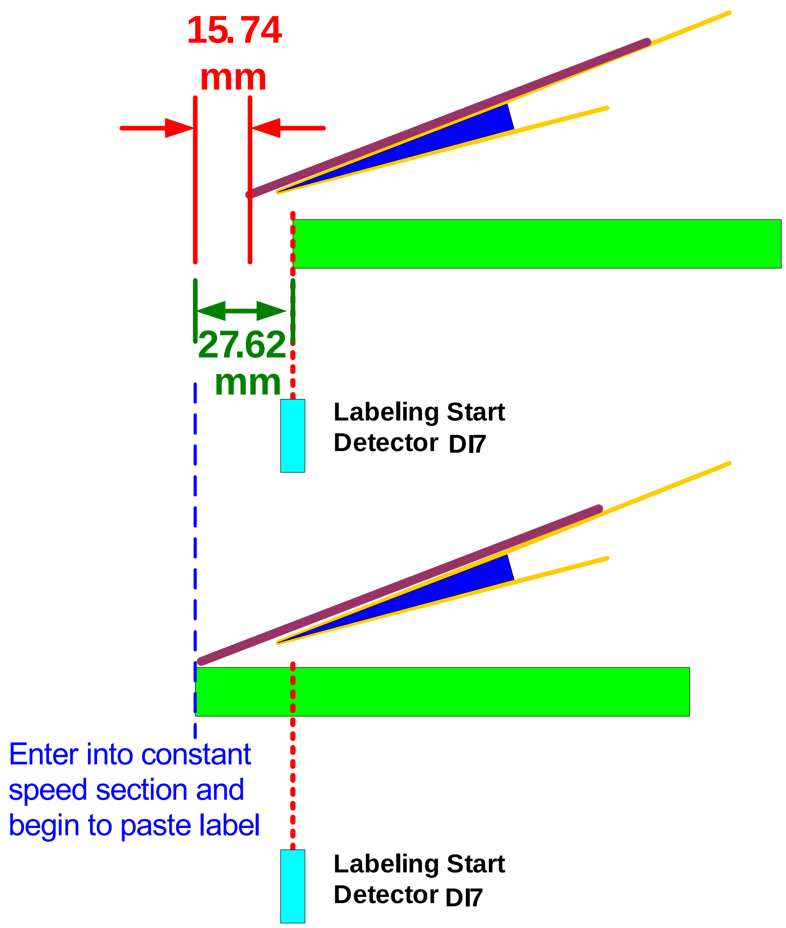

Figure 24 Relations between Acceleration Section and Labeling Start Detector