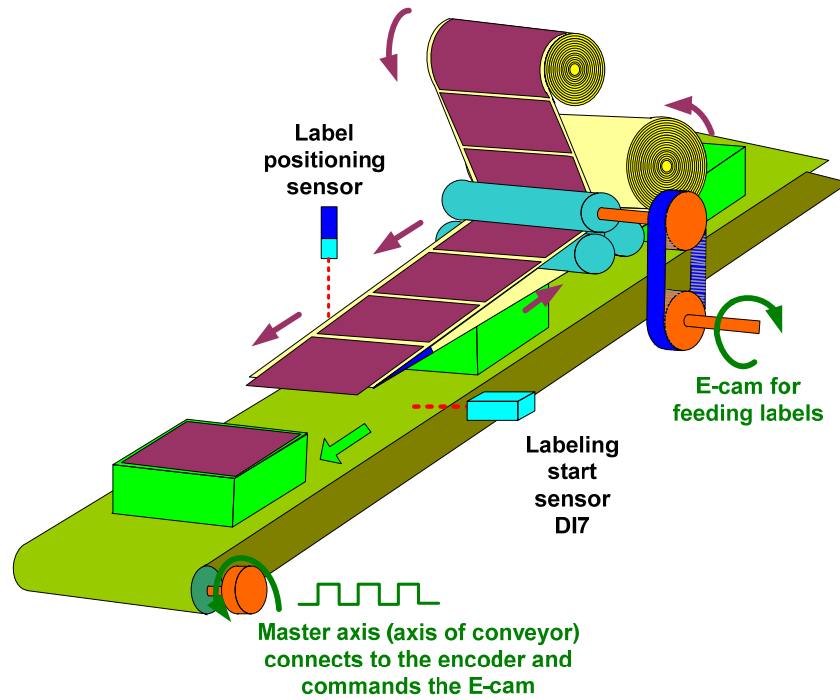


Note	Labeling Machine				
Issue by	SC	Date	NOV, 2013	Pages	24
Applicable to	ASD-A2 series AC servo motor and drive				



3.3 Application to Labeling Machine

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1. Description

This chapter is aiming at the application of ASDA-A2 on labeling machines. Electronic cam is applied to synchronize the speed of delivering labels with the product packages therefore this application could be classified as flying shear. The length of label should be adjustable, the position should be accurate when delivering labels and the delivering speed should be the same as the main conveyor where the packages are located. For the convenience of operator, only photoelectric switch is adjusted in this application, such as label location position and labeling start position. (No controller and HMI is in the system since ASDA-A2 is powerful enough to satisfy all demands.)

Besides the detailed description of labeling motion, this chapter will introduce how E-cam curve is created in speed section by Delta's ASDA soft. This curve has a very long constant speed section, which is the table creation basis in rotary cutoff and similar applications.

Together with PR commands, E-cam can easily satisfy the controlling demand in ASDA-A2.

2. System plan

The axis of conveyor is the master axis which is mainly for transporting objects. Camshaft axis is in charge of controlling the pace of labeling according to the pulse speed sent by master axis, see diagram 3.3.1. In this application, the label waiting position (controlled by label positioning sensor) has to be very accurate. The position error should within 1mm only each time. As for the design of E-cam curve and function, it must consider that the label length should be adjustable. Thus, the setting of E-cam should be set to the longest length for operation.

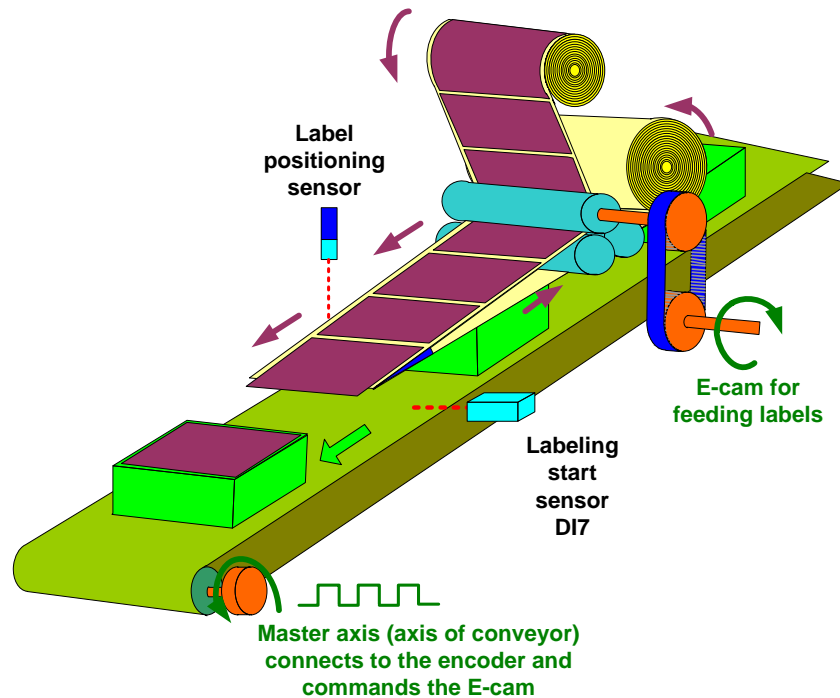


Diagram 3.3.1 Labeling machine system

2.1 Master axis – Axis of conveyor

It transports the to-be labeled objects, such as packing box. The pulse signals are sent out to command the camshaft axis simultaneously in order to control the labeling speed.

2.2 Camshaft axis – Label feeding axis

Following the command of master axis, the camshaft axis executes labeling according to the pace of master axis. When delivering the label, the pace should be accurate and stable. It should be controlled to operate the same speed with the master axis while labeling, otherwise the label will be pasted uneven.

2.3 Label positioning sensor

The label positioning sensor decides the outstretched length of label while the label is waiting to be pasted. It can be operated by moving the photoelectric switch (label positioning sensor).

2.4 Labeling start sensor

When DI7 receives the signal from labeling start sensor, it will control E-cam to engage and the camshaft axis will synchronize with the master axis. When E-cam starts to accelerate

and reach the same speed as master axis, the label will just be pasted on the to-be-labeled object. It will not disengage until the labeling is completed.

3. Setting of servo system

3.1 Camshaft is enabled and starts to label

When the object on the conveyor is detected by labeling start sensor, the camshaft is enabled. The label axis follows the master axis until the labeling is completed. Then, the camshaft disengages and its operation is controlled by label positioning sensor. See diagram 3.3.2 and 3.3.3.

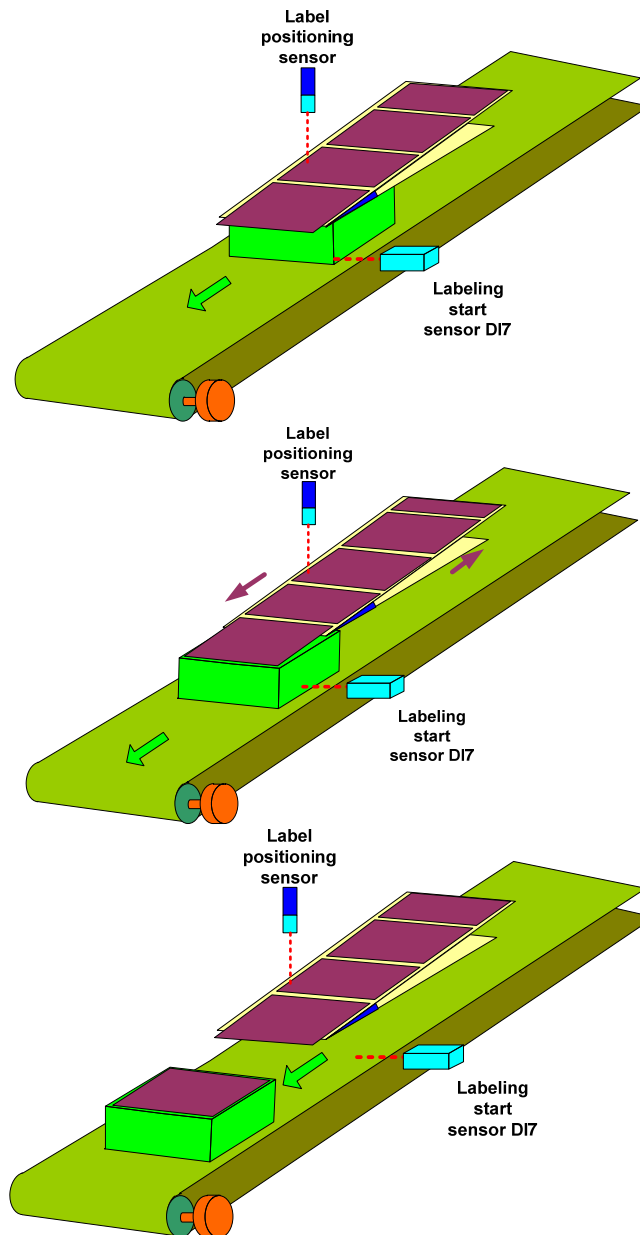


Diagram 3.3.2 Labeling start

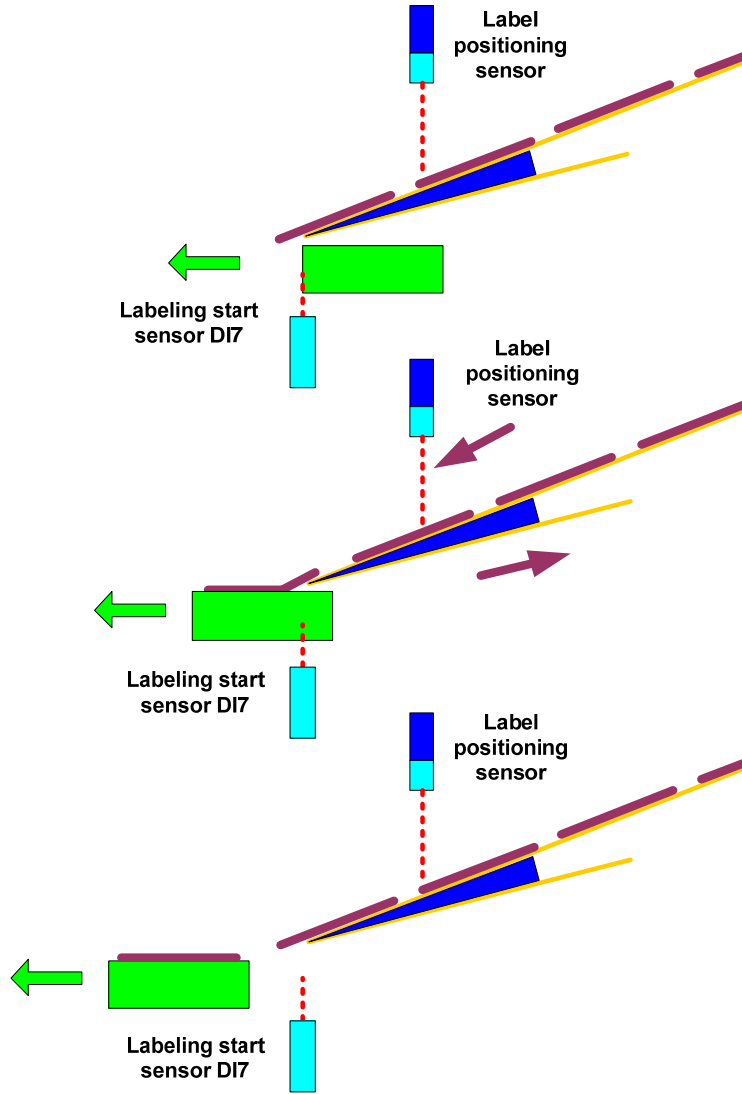


Diagram 3.3.3 Side view of labeling process

3.2 Camshaft is disabled and label positioning

The label positioning sensor determines the disengagement of camshaft and the outstretched part positioning. It can be adjusted by different label lengths and different demand. See diagram 3.3.4 for the adjustment of outstretched part positioning.

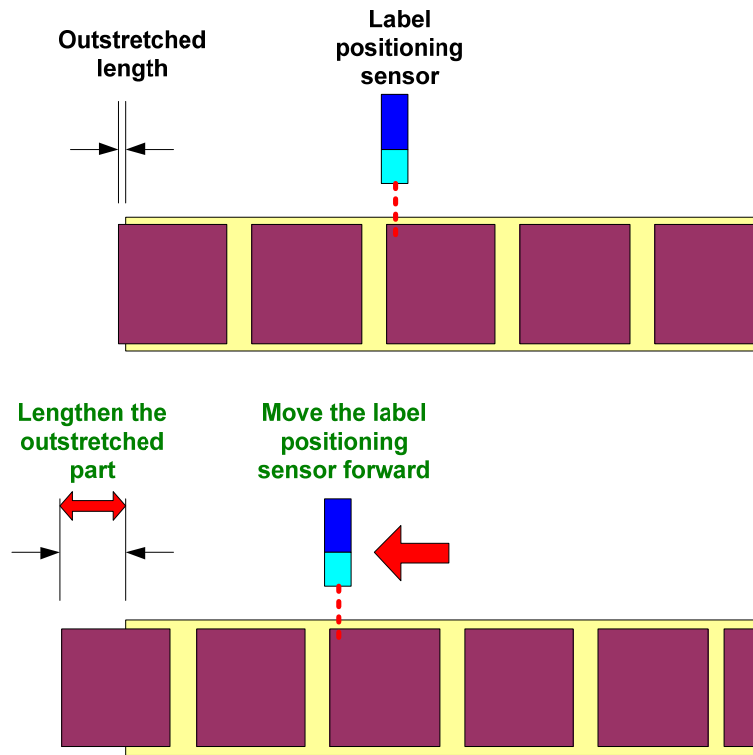


Diagram 3.3.4 Adjust the outstretched part positioning

The label positioning sensor is used to control the time the camshaft disengages, prepare the label for the next cycle and control its outstretched part positioning (the stop position). This signal sets up the trigger event and calls the corresponding PR to complete the disengaged control of the camshaft and the outstretched length of the label. See diagram 3.3.5.

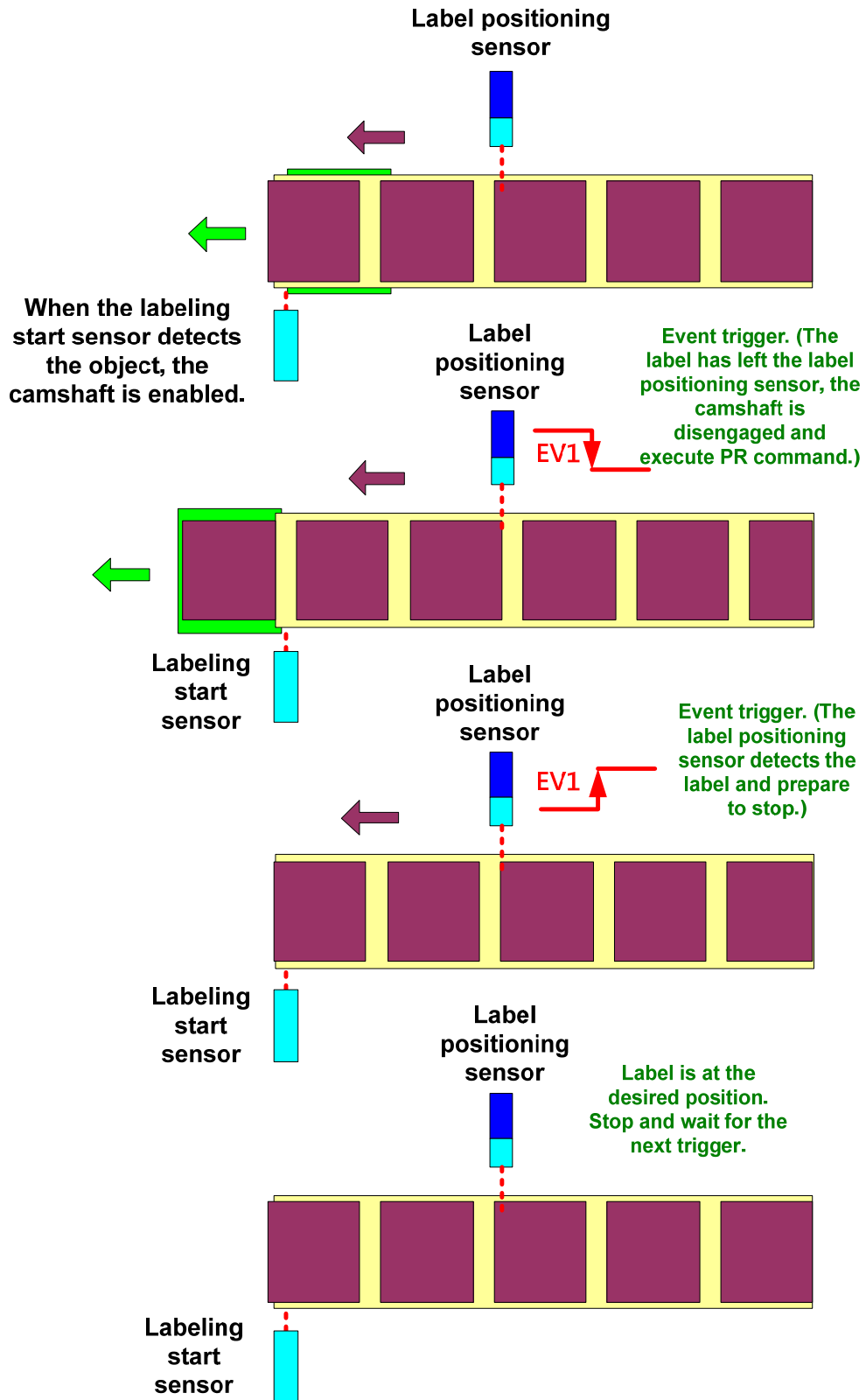


Diagram 3.3.5 Label outstretching and positioning

3.3 PR program and execution

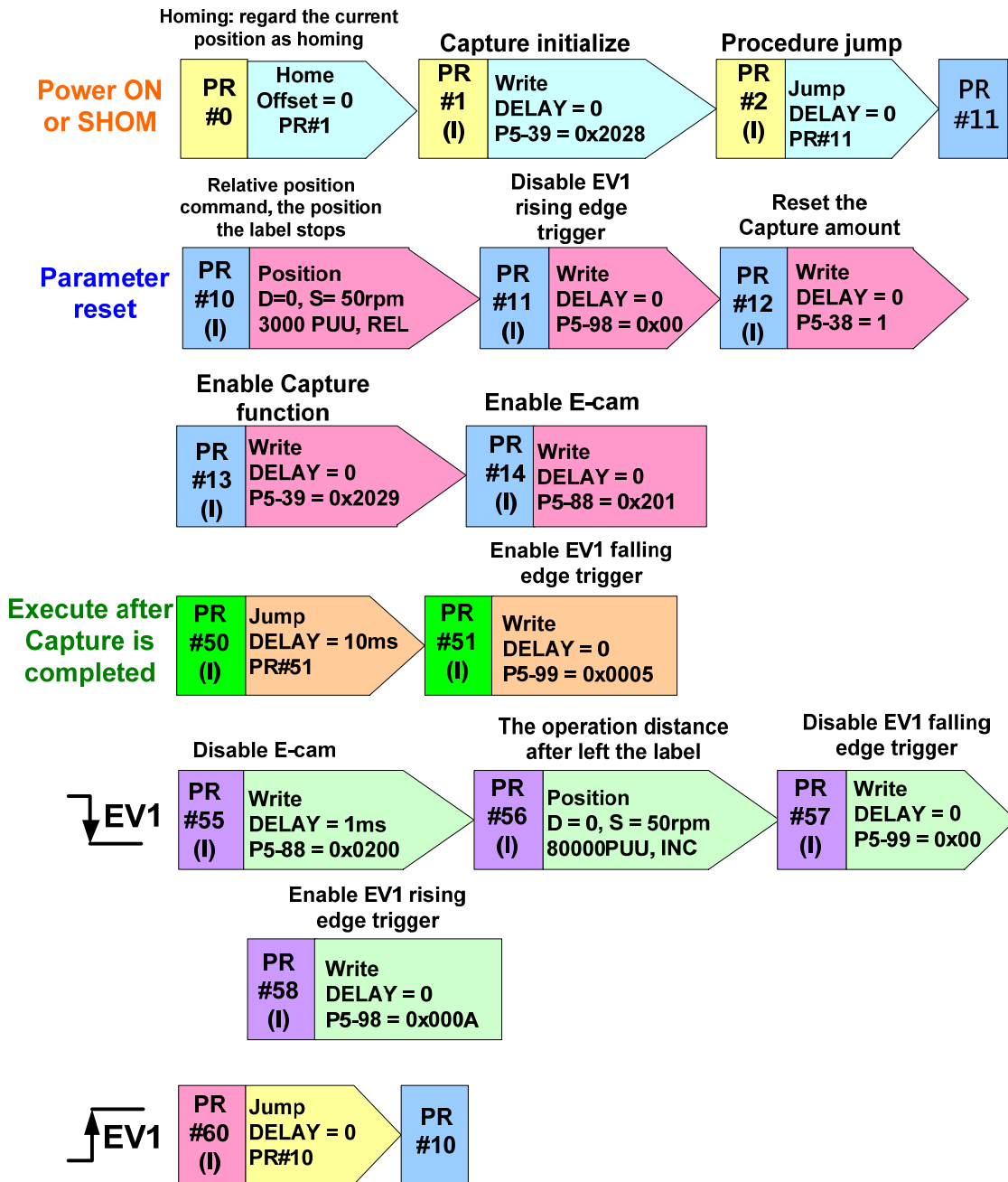


Diagram 3.3.6 PR program and execution

PR#0: Homing. Due to the design of mechanical structure, when enabling the function, regard the stop position as the homing position will do.

PR#1: Initialize Capture function. After Capture function is completed, call PR#50.

PR#2: Jump to the initialized program, PR#11.

PR#10: Relative position command controls the label stop position, see diagram 3.3.7. When the camshaft returns to the original point, this program will not be executed, unless it is in normal cycle.

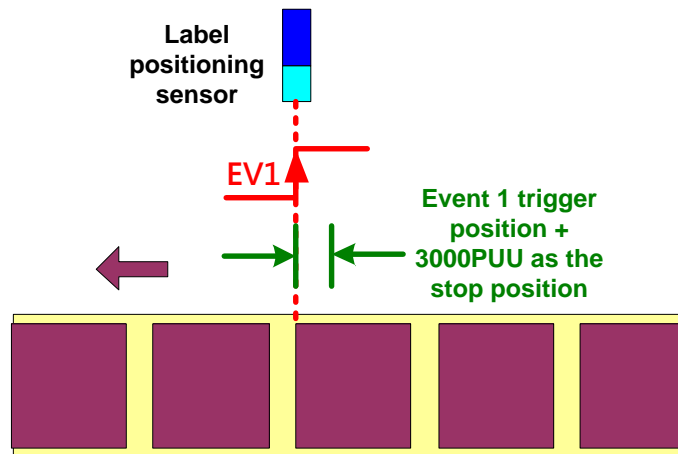


Diagram 3.3.7 Label stop position

PR#11: Setup parameter to disable EV1 rising edge trigger command in order to prevent the alarm occurs.

PR#12: Setup parameter to reset the Capture amount. Only one position is needed to capture for E-cam function. Thus, set this parameter to 1.

PR#13: Setup parameter to enable Capture function.

PR#14: Setup parameter to enable E-cam function. Use Capture function to engage the camshaft.

PR#50: After the Capture is completed, this PR command will be triggered. As a jump command, this PR will jump to the next one. The auto function is not applied here. When the capture is completed, next PR (disable EV1 falling edge trigger) will be executed with a delay.

PR#51: Enable EV1 falling edge trigger. The label positioning sensor has entered into label position. Thus, enable it to detect the label disengaged position (label's end).

PR#55: When label positioning sensor leaves the label, EV1 falling edge trigger will be activated. E-cam no long controls the system at the moment. Setup E-cam command to disengage camshaft.

PR#56: Incremental command, which is the traveling distance after disengaging from label. It should consider the maximum spacing between two labels. To setup the maximum spacing the machine may operate. See diagram 3.3.8.

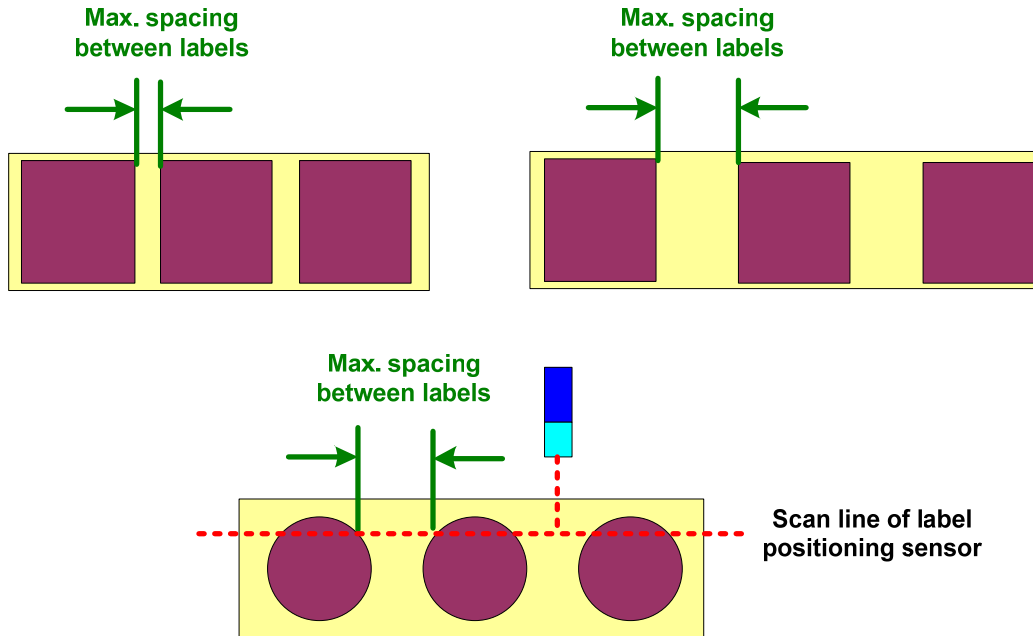


Diagram 3.3.8 Spacing between labels

PR#57: When executing this PR, the label positioning sensor has left label position. EV1 falling edge trigger will not continuously be triggered twice in control procedure. In order to prevent the error occurs, disable EV1 falling edge trigger first and enable it later by PR command at an appropriate time.

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

PR#60: Trigger EV1 rising edge trigger and jump to PR#10.

3.4 Structure of E-cam curve

When an object on conveyor is detected by labeling start sensor, the E-cam function is enabled. During the labeling process, the speed of master axis and camshaft axis must be the same. Otherwise, the label will be pasted uneven. See diagram 3.3.9 for cross reference of E-cam curve and the to-be-labeled object (e.g. packing box).

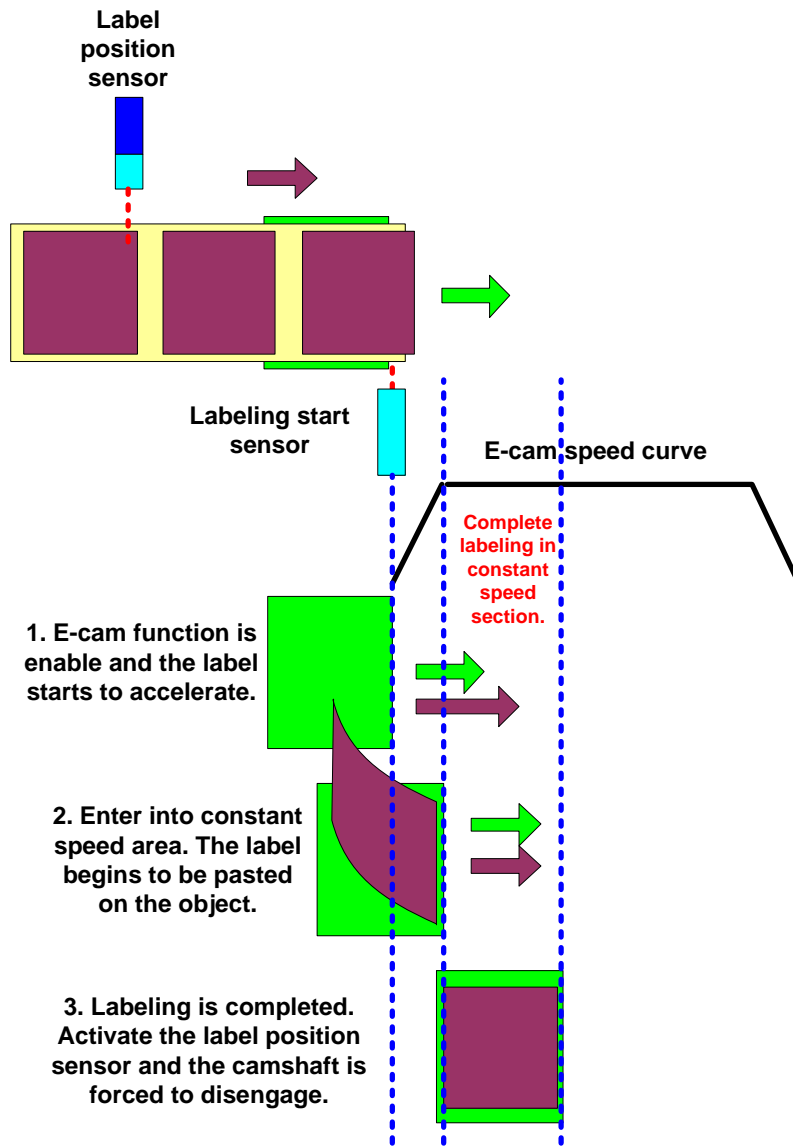


Diagram 3.3.9 Labeling and E-cam curve

From diagram 3.3.9, a long constant speed section is needed in E-cam curve. Thus, the maximum label length the machine may operate should be considered. See diagram 3.3.10.

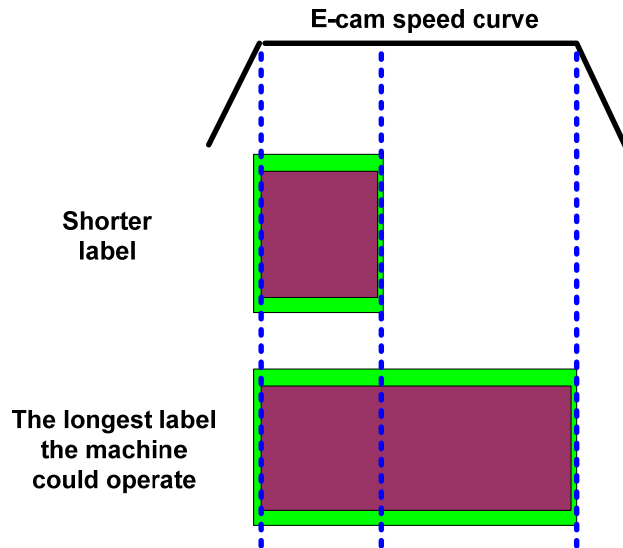


Diagram 3.3.10 labeling length and E-cam curve

3.5 E-cam curve creation

According to the actual machine, the roller diameter of master axis is 5cm. The encoder sends out 1600 pulses for each revolution. See diagram 3.3.11. Thus, the pulse number sent by master axis per revolution is:

$$1600 \text{ pulse} / (\pi * 50\text{mm}) = 10.185916 \text{ (pulse/mm)}$$

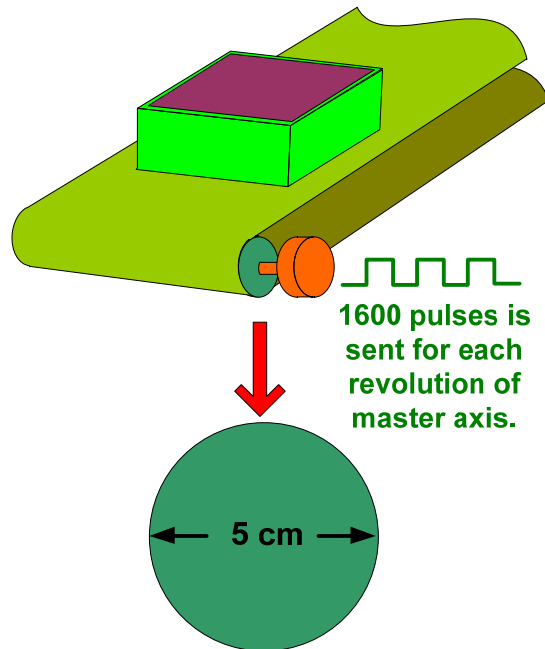


Diagram 3.3.11 Roller of master axis and encoder specification

As for camshaft axis, the roller diameter is 5cm and the electronic gear ratio is 1:1, which is shown in diagram 3.3.12.

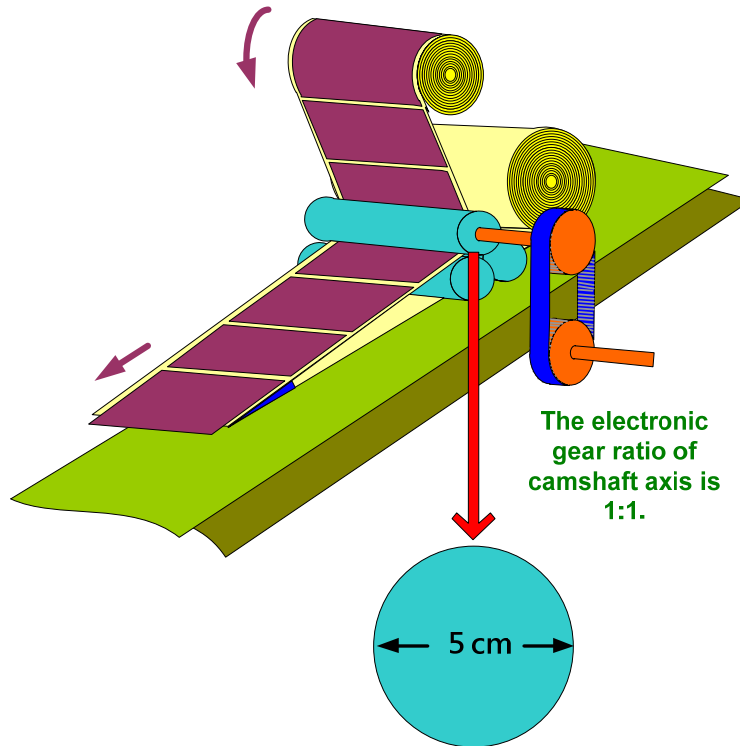


Diagram 3.3.12 Dimension of camshaft axis

From the above diagram 3.3.12, the label length brought by each roller revolution is $\pi \cdot 5 \text{ cm} = 15.708 \text{ cm}$. To meet the requirement of maximum 23cm, the curve must be longer than 23cm since the acceleration / deceleration time should be left. 23cm is the traveling distance that master axis and camshaft axis operates at the same speed. Then, to create the E-cam curve based on this value. In diagram 3.3.13, master axis is at constant speed while camshaft axis has acceleration and deceleration. Thus, within the same time, considering the acceleration and deceleration time of camshaft, master axis travels farther than camshaft axis. In actual operation, camshaft axis must be enabled in advance so as to complete labeling in constant speed section. That is to say, from diagram 3.3.13, the traveling distance is Constant Speed Area < Camshaft axis < Master axis. The creation of E-cam curve will be introduced in the following parts.

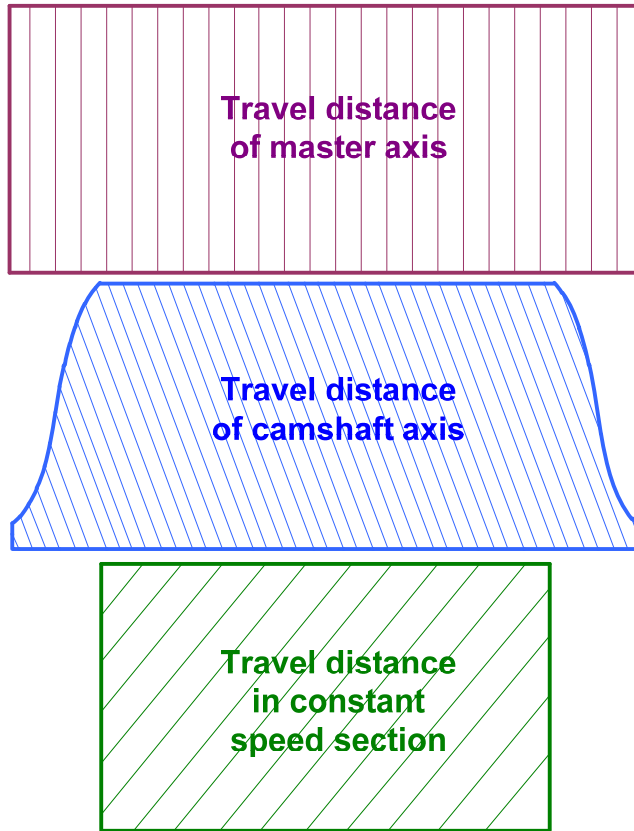
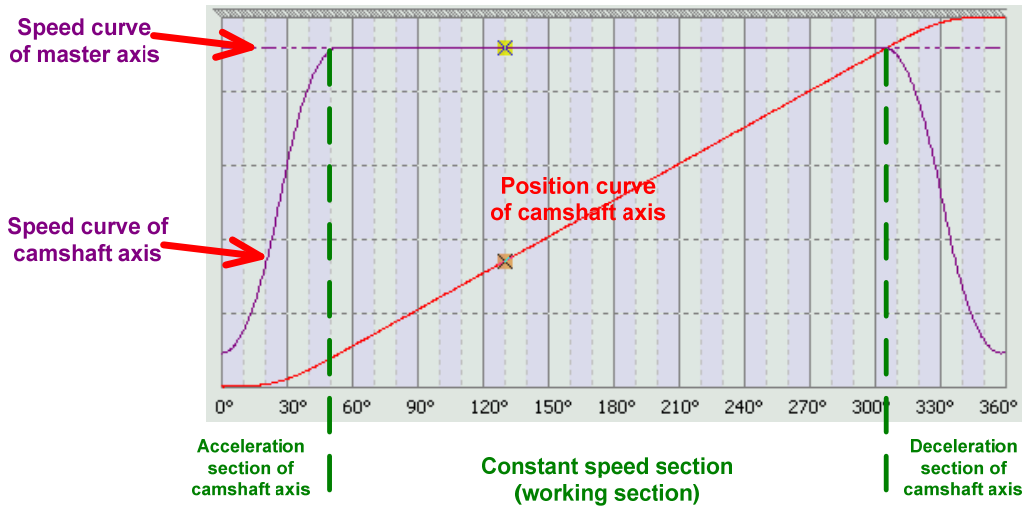


Diagram 3.3.13 E-cam curve

Through the setting of electronic gear ratio, system not only can consist with the command resolution, but increase its readability. In this example, the traveling distance for each camshaft axis resolution is $\pi * 5 \text{ cm} = 15.708 \text{ cm}$. In order to make the data more readable, users can set 157080PUU for each cycle the camshaft travels, which is 0.001mm per PUU.

Thus, set P1-44 to 128000 and P1-45 to 15708. When P5-19 is set to 1 (E-cam curve scaling), the relative pulse command is $(157080\text{PUU} / 15.708\text{cm}) = 1000\text{PUU/mm}$ of each mm on camshaft axis. See diagram 3.3.14.

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)

Diagram 3.3.14 E-gear setting

If users desire to create a curve of 31.416cm (314.16mm), then $314.16\text{ (mm)} * 1000(\text{PUU/mm}) = 314160\text{ PUU}$.

In ASDA-A2, Speed Section is used to create E-cam table. Please refer to the following steps.

a. Select the way to create E-cam table

Select **Speed Section** to create E-cam table. See diagram 3.3.15.

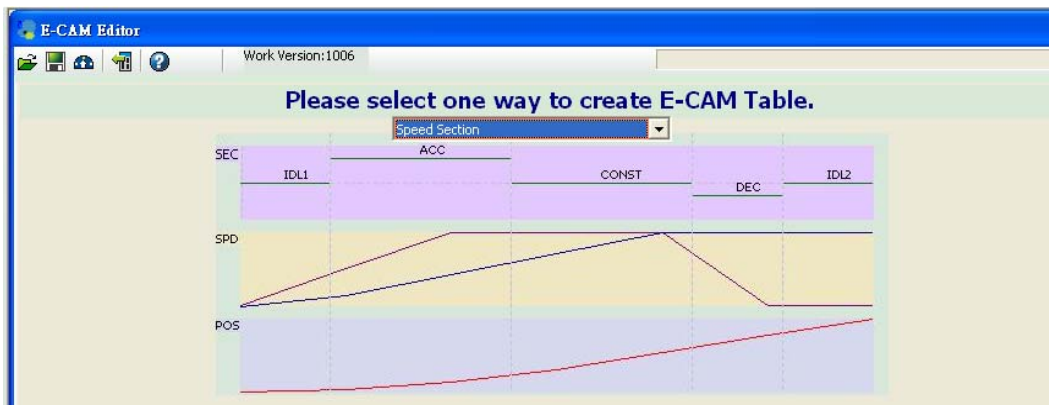


Diagram 3.3.15 Select **Speed Section**

b. Setup the actual machine dimensions

Master axis is 10.185916 Pulse/mm and camshaft axis is 1000 PUU/mm. When creating E-cam curve, the system will refer to the above simulation data. Please make sure the information is correct, which is the pulse number and PUU the system needs when master axis and camshaft axis moves 1mm. See diagram 3.3.16.

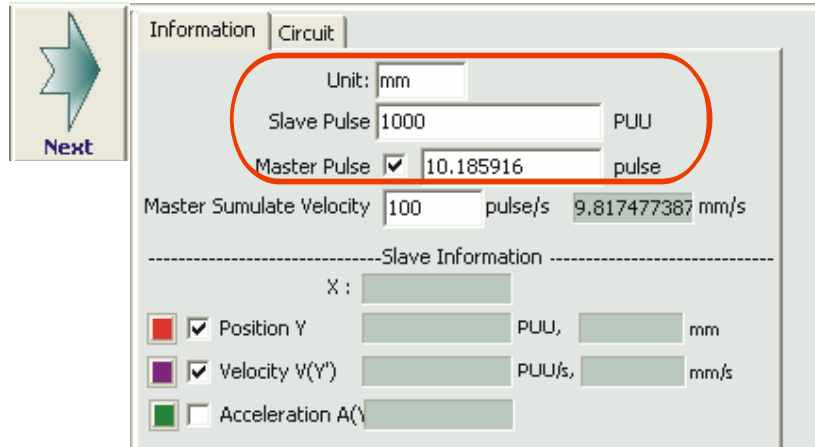


Diagram 3.3.16 Simulation information

c. Set slave axis lead

Setup the longest lead of labeling, 23cm and consider the acceleration / deceleration section, this curve must be designed longer than 23cm. According to the previous experience, take 30cm for a rough estimation (About 10% more, including 5% of acceleration and 5% of deceleration). Thus, the calculation is $300(\text{mm}) * 1000 (\text{Pulse/mm}) = 300000 \text{ Pulse}$. Fill this value into **Lead**. In addition, fill 100 into P5-81, Data Array start position, which can be set according to the actual condition.

Fill 200 into P5-82, E-CAM Areas: N(5~720). The bigger the value is, the smoother the curve will be. It is suggested to fill in 200 at least. Users can set different values to see different results. See diagram 3.3.17.

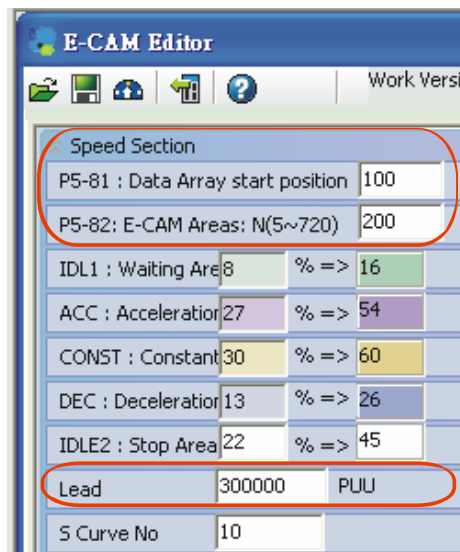
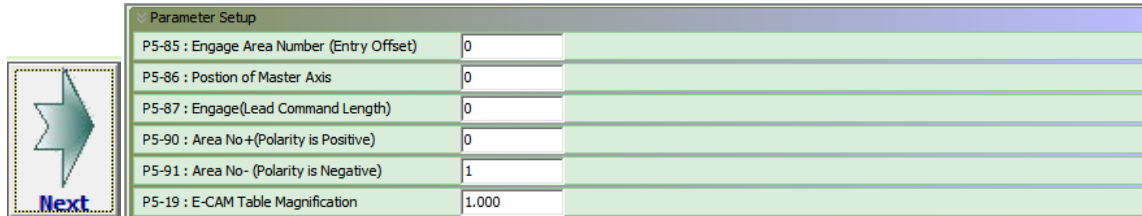


Diagram 3.3.17 Setting of E-cam lead

d. Set master axis lead

It is estimated that master axis will travel 33cm (10% more). Therefore, if P5-83 is set to 1, then $P5-84 = 10.185916(\text{pulse/mm}) \times 330(\text{mm}) = 3361$.



Parameter Setup		
P5-85 : Engage Area Number (Entry Offset)	0	
P5-86 : Postion of Master Axis	0	
P5-87 : Engage(Lead Command Length)	0	
P5-90 : Area No+(Polarity is Positive)	0	
P5-91 : Area No- (Polarity is Negative)	1	
P5-19 : E-CAM Table Magnification	1.000	

Diagram 3.3.18 Pulse number setting of master axis

e. Create E-cam curve

Refer to mark 1 in diagram 3.3.19, setup **Waiting Area, Acceleration Area, Constant Speed Area, Deceleration Area** and **Stop Area**. Among the setting, motor inertia ought to be considered in **Acceleration / Deceleration Area**. If the motor inertia is larger, the acceleration / deceleration curve will be sharper which might result in command delay, motor overload or regeneration error. Thus, if acceleration / deceleration cannot be calculated precisely, do field test first. In addition, when creating curve, a longer **Constant Speed Area** is more ideal, since it is applied in real working area. Meanwhile, it is better to leave some time for **Stop Area**; otherwise, it might be unable to complete homing. See mark 2 in diagram 3.3.19, the setting of S Curve No. is for smooth E-cam curve so that the command will not be changed dramatically. The ideal setting value is equal to the value of **Stop Area**, such as 10. Then, press **Create Table** which is marked 3, the system will create the table and the curve.

Mark 4 shows the speed of master axis is 9.817477387, which is the target speed the camshaft needs to follow (This value varies with Master Simulation Speed, but it will not influence the curve creating.). Move the cursor to **Constant Speed Area**, see mark 5. In speed field, the value is 9.867 (>9.8174477387, Master Simulation Speed). Thus, the speed of camshaft axis is slightly faster than master axis. Users can adjust **Acceleration / Deceleration Area** or master / slave axis lead to make the two values the same.

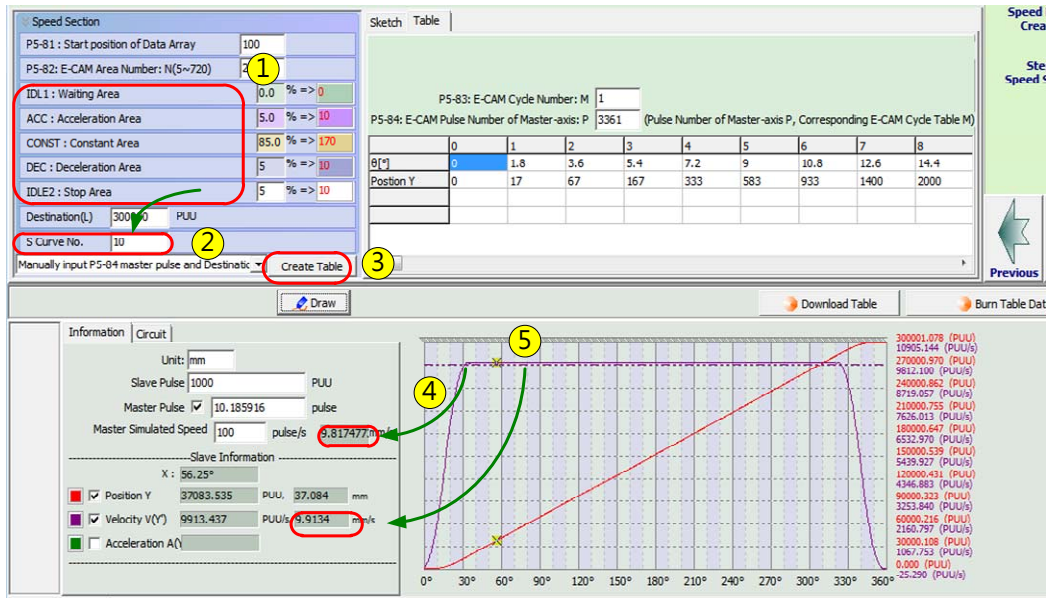


Diagram 3.3.19 Create E-cam curve

f. Use camshaft axis to adjust the speed in Constant Speed Area

To adjust the curve by **Acceleration / Deceleration Area** or slave axis lead will be introduced here (Both can be adjusted simultaneously.). In diagram 3.3.20, after adjusting **Acceleration / Deceleration Area**, the **Constant Speed Area** of camshaft axis can comply with the speed of master axis (Please see the result in mark 4 and 5 in diagram 3.3.20.). During the process, several times of trying for a proper value are needed. This method is suitable for unchangeable pulse number of master axis (P5-84). Without saying, the value of P5-84 can be changed in the application of labeling machine. From diagram 3.3.21, users can acquire the desired speed curve by adjusting camshaft axis lead (mark 1). From mark 4 and 5 in 3.3.21, users could know that the speed of master axis is 9.817477387 \approx which is the same as slave axis in **Constant Speed Area**.

In diagram 3.3.20, the length of **Constant Speed Area** is $300000 \text{ PUU} * (360^\circ - 60^\circ) / 360^\circ / 1000(\text{PUU}/\text{mm}) = 250 \text{ (mm)}$, which is longer than 23cm. 60° is the time for **Acceleration / Deceleration Area**.

In diagram 3.3.21, the length of **Constant Speed Area** is $298600 \text{ PUU} * (360^\circ - 65^\circ) / 360^\circ / 1000(\text{PUU}/\text{mm}) = 244.69 \text{ (mm)}$, which is longer than 23cm. 65° is the time for

Acceleration / Deceleration Area.

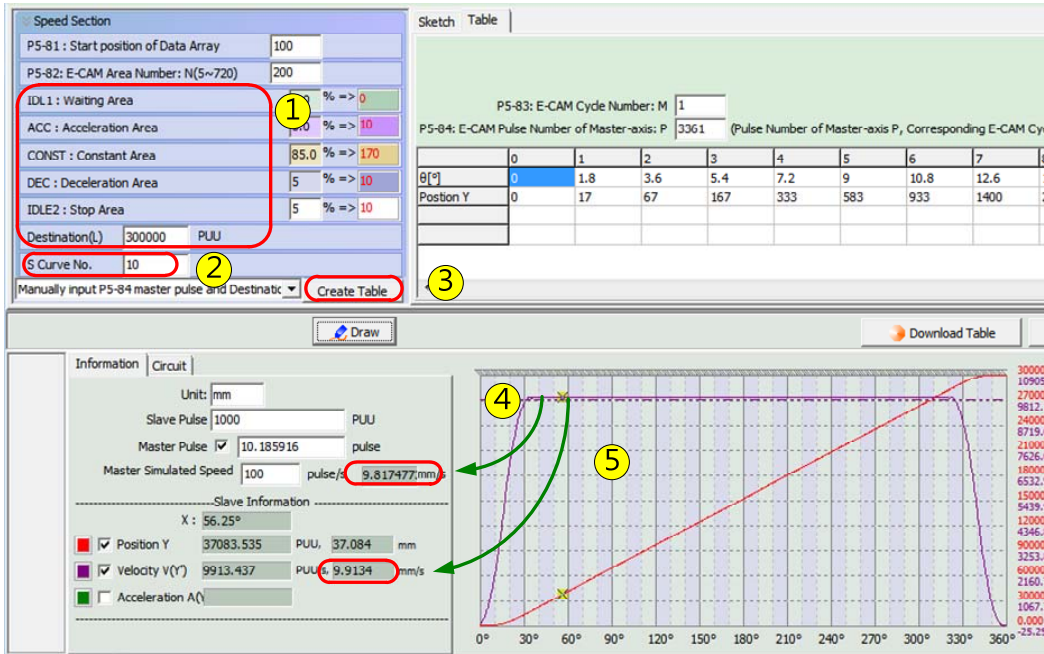


Diagram 3.3.20 Adjust the E-cam curve in Acceleration / Deceleration Area

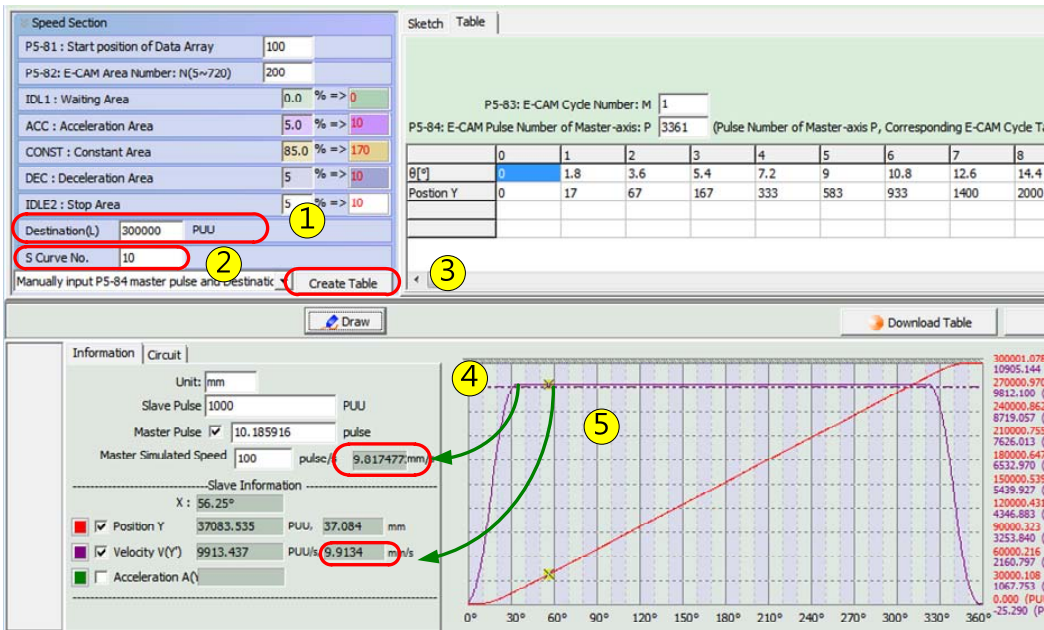


Diagram 3.3.21 Adjust the E-cam curve of camshaft axis lead

g. Adjust the speed in Constant Speed Area by master axis

Data showed in diagram 3.3.22, mark 1 is the same as diagram 3.3.19. Here, adjust the pulse of master axis (P5-84) in diagram 3.3.18 from 3361 to 3376 (the result after trying several times) which is shown in diagram 3.3.22. After adjusting, the curve of constant speed can be seen in mark 4 and 5 of diagram 3.3.22. The curves consist with the design of the system. Curves in diagram 3.3.20 and diagram 3.3.22 can be used as the E-cam curve of this labeling machine but with different adjustment. One of them cannot adjust the pulse from master axis while the other one cannot adjust the pulse from slave axis.

In diagram 3.3.22, the length of **Constant Speed Area** is $300000 \text{ PUU} * (360^\circ - 65^\circ) / 360^\circ / 1000(\text{PUU}/\text{mm}) = 245.8 \text{ (mm)}$, which is longer than 23cm. 65° is the time for **Acceleration / Deceleration Area**.

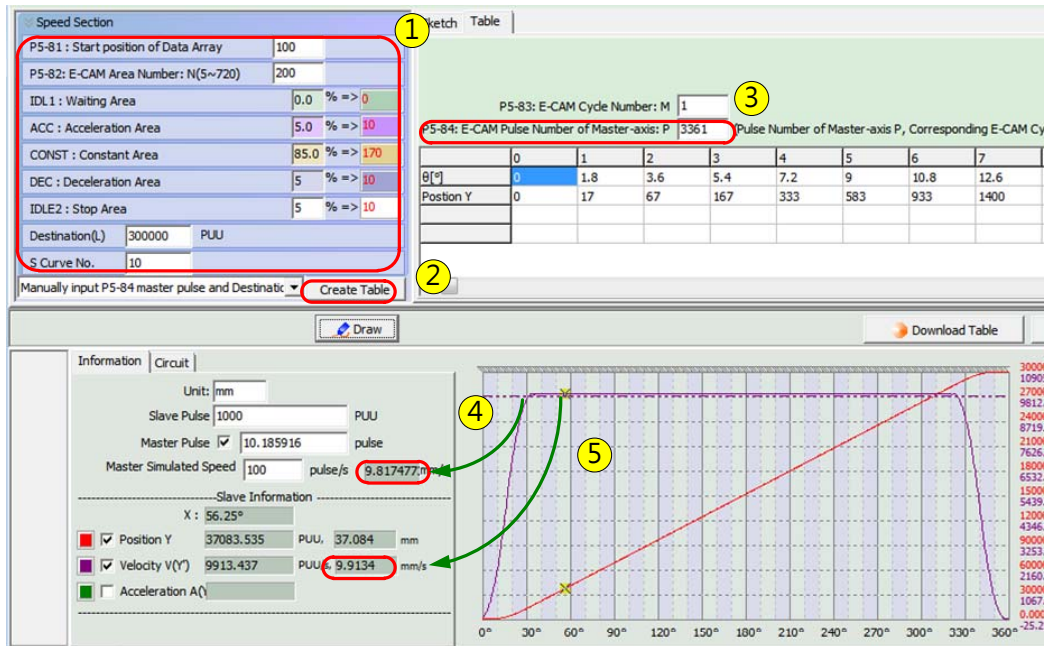


Diagram 3.3.22 Adjust the E-cam curve of master axis lead



3.6 Analysis of E-cam curve

In diagram 3.3.23, mark 5 shows the traveling distance of master axis and camshaft axis at 30° (before entering the **Constant Speed Area**).

Master axis: $3376 \times (30/360) = 281.333$ (pulse), $281.333 / 10.185916$ (Diagram 3.3.23, mark 4) = 27.62 mm.

Slave axis (Move the cursor to 30° and access the position field): 15744.672 (Diagram 3.3.23, mark 5) / 1000 (Diagram 3.3.23, mark 4) = 15.74mm.

From the above calculation, master axis travels 27.62mm while slave axis only travels 15.74mm before entering the **Constant Speed Area**. The difference between both influence the position of labeling start sensor, see diagram 3.3.24.

Before the camshaft enters the **Constant Speed Area**, it will travel 15.74mm. If the highest speed of master axis is S (the highest speed the labeling machine could operate), then it will take T time (= $27.62/S$) to travel 27.62mm. Before entering the **Constant Speed Area**, the acceleration A of camshaft axis in **Acceleration Area** is:

$$A \text{ (Acceleration)} = (S \text{ (target speed)} - 0 \text{ (accelerate from 0)}) / T$$

$$\alpha \text{ (angular acceleration)} = A / r \text{ (rotary shaft radius)}$$

$$T \text{ (torque)} = J \text{ (inertia)} * \alpha \text{ (angular acceleration)}$$

From the above calculation, T (the torque needed during acceleration) can see if this E-cam curve can meet the requirements or not.

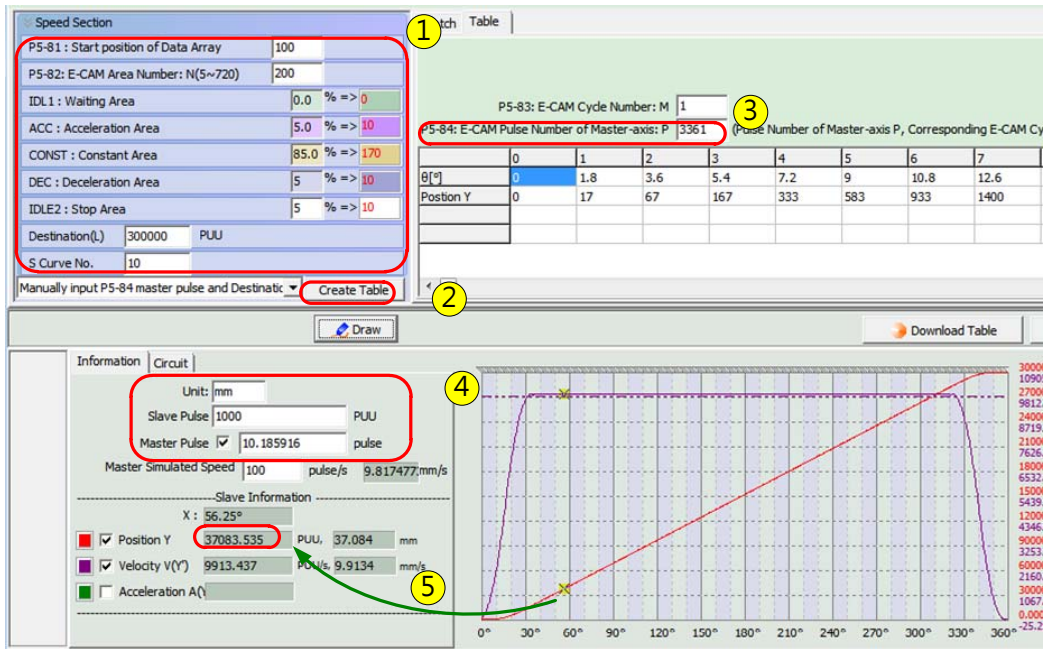


Diagram 3.3.23 Analysis of E-cam curve

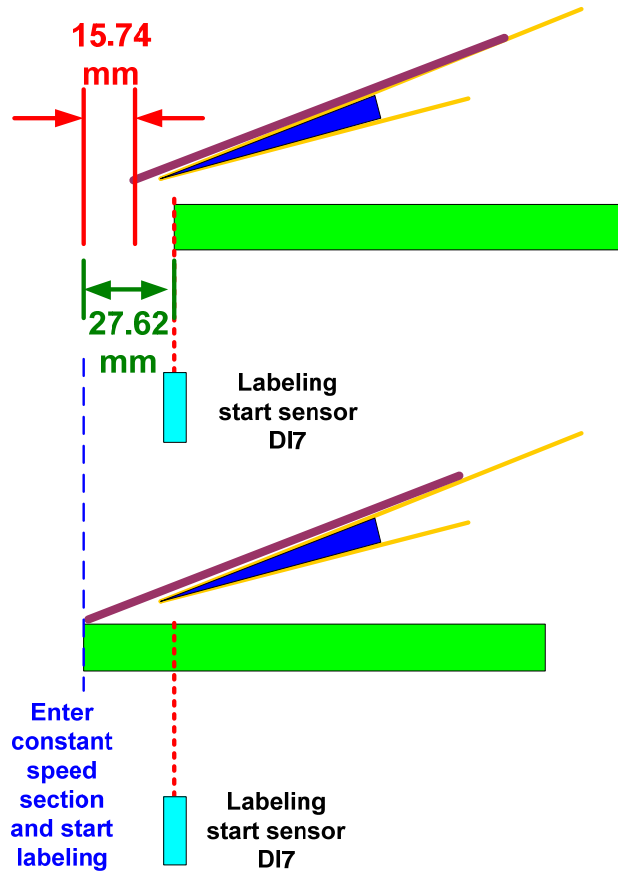


Diagram 3.3.24 Acceleration Area and labeling start sensor



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