1. Introduction of E-Cams

A traditional mechanical cam is composed of cam, follower and frame. A mechanical cam is a rotating sliding piece with irregular shape. In general, it is an input object which rotates at a uniform speed. Which can transfer motion to the follower, and make the follower moving regularly. The follower is a part driven by a mechanical cam. In general, it is an output object which can generate variable speed , inconsecutive or irregular motions.

Compared with a traditional cam, an electronic cam has the following advantages:

①More friendly user interface

②Different products require different cam curves. Users can modify the electronic cam data of an electronic cam by software. the mechanical structure need not be modified.

③Higher acceleration.

④Smoother operation.

2. Detailed description

1.Creating E-cam Data

There are three methods of creating electronic data in LX3VP.

Method 1: Use DMOV instruction to write electronic cam data into the data area.

Method 2: Use ECAMTBX instruction to create electronic cam data directly.

Method 3: Use the electronic cam chart in PLCEditor to draw the cam curve.

2.Master axis setting

LX3VP has three optional registers for master axis of E-cam: C register, D register and virtual timeline K. High-speed output from outside is input into the input terminal of high speed counter of PLC; it supports one-way single counter, one-way double counter, and two-way double counter. Please refer the mannual of high-speed counter in help document for allotting counters.

When high-speed counter is used, master axis obtains pulse from internal, When the value of register is modified would affect the real pulse value.

When common counter or D register is used, master axis obtains pulse from PLC register, when modified the value of register would affect the real pulse value.

When K type register is used, it means using internal virtual timeline, its minimum unit is 100us, K1=100us, K10=1ms.

3.Enable electronic cam configuration

DECAM is the instruction of PLC to configure E-cam.

Instruction	Function	bits	Pulse type	Format	Steps
DECAM	E-cam configuration	32	No	DECAM S1 S2 S3 D1 D2	21

```
   M0
──┤ ├──────────[DECAM  C231 D2000 X000 Y000 Y001]
```

(1)Parameters of DECAM

S1: Master axis input, please use C register, K register;

S2:Parameters' address of E-cam, please use D register;

S3:External start signal, please use X register, M register;

D1:Salve axis output pulse, please use Y0~Y3;

D2:Slave axis output direction, please use Y register.

(2)Description

When M0 is turned on ,PLC enables E-cam function, but the cam is not running at this point. This instruction configures parameters and some others data that E-cam need, and enables this function, but can't make E-CAM run. Running/stopping is controlled by setting address in S2.

Please refer to【E-CAM function registers】for E-CAM parameters registers.

(3)Error

If an error occurs when instruction is running, PLC will show error message, please find the error basic on "PLC error message".

6781: Parameter error;

6782: The form is out of range;

6783: The number of cam is out of range;

Electronic cam would not work when error happens.

(4)Sign：

D8141 (high byte), D8140 (low byte): The number of output pulse in Y000. It would be reduced during reversal. (32-bit)

D8143（high byte）, D8142（low byte): The number of output pulse in Y001. It would be reduced during reversal.(32-bit)

D8151 (high byte), D8150 (low byte): The number of output pulse in Y002. It would be reduced during reversal.(32-bit)

D8153 (high byte), D8152 (low byte): The number of output pulse in Y003. It would be reduced during reversal. (32-bit)

M8145: Stop output pulse in Y000 (stop immediately)
M8146: Stop output pulse in Y001 (stop immediately)
M8152: Stop output pulse in Y002 (stop immediately)
M8153: Stop output pulse in Y003 (stop immediately)

M8147: Monitoring the output pulse in Y000 (BUSY/READY)
M8148: Monitoring the output pulse in Y001 (BUSY/READY)
M8149: Monitoring the output pulse in Y002 (BUSY/READY)
M8150: Monitoring the output pulse in Y003 (BUSY/READY)

4.Starting/Stopping E-cam

## 4.1 Starting/Stopping a Cyclic E-cam

Cyclic E-cam is that the slave axis of the E-cam moves in accordance with electronic cam data when the master axis moves. E-cam data defines only one cycle. The relation between the positions of master axis and slave axis is the repeated extension of E-cam data.

Electronic cam data
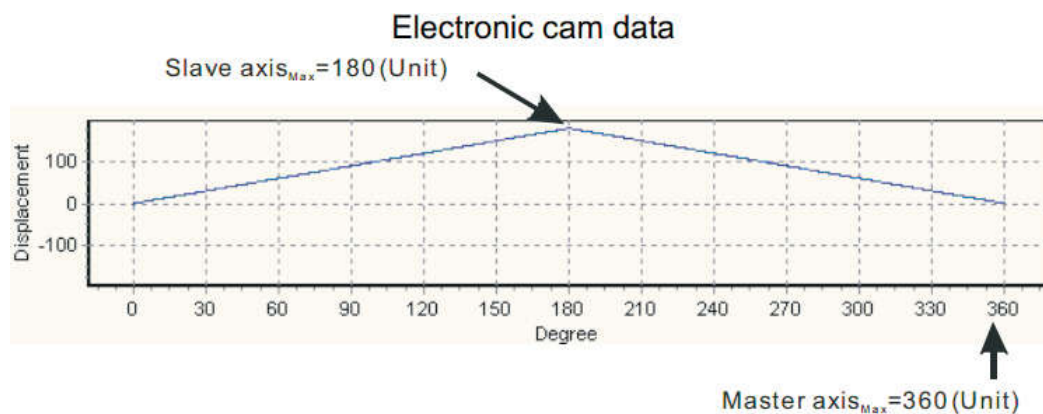
4.1.1 Starting a cyclic electronic cam

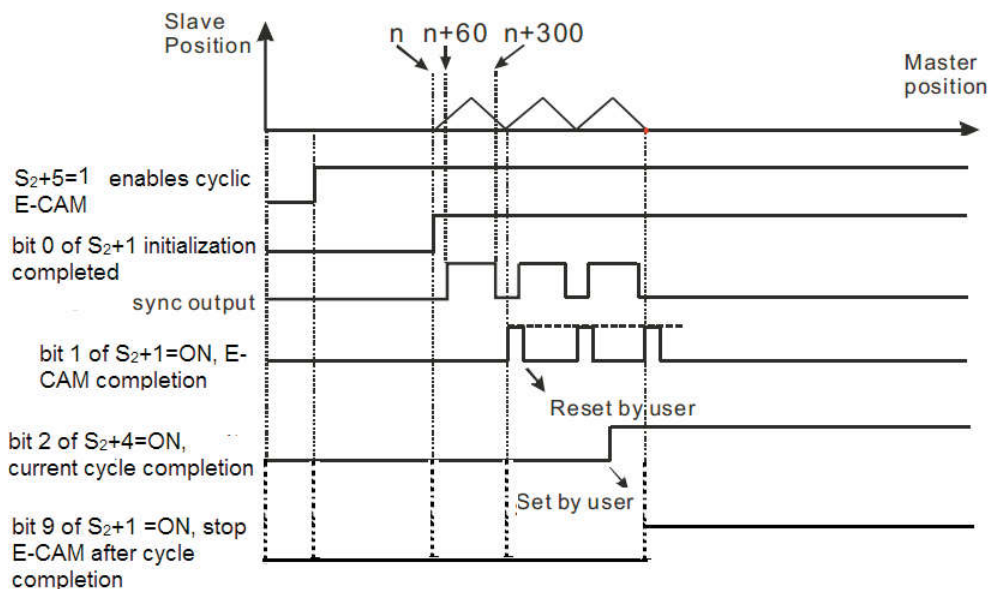The steps of starting a cyclic electronic cam are as follows.

(1).In T1,S2+5=1,cyclic electronic cam is enabled. S2 is for setting parameters for E-CAM, S2+5 means the 5th address of S2.

(2).After the interval of T2,bit 0 of S2+1 is NO indicates E-cam initialization is finished.

(3).In T3, E-cam initialization was finished , cyclic running starts after bit 0 of S2+1 is ON. Slave axis will follow motions of master axis constantly according to the data from E-cam form.

(4).When bit 1 of S2+1 is ON, an E-cam cycle is completed. this flag need to be reset , which can help this flag to market the next circle of E-cam.
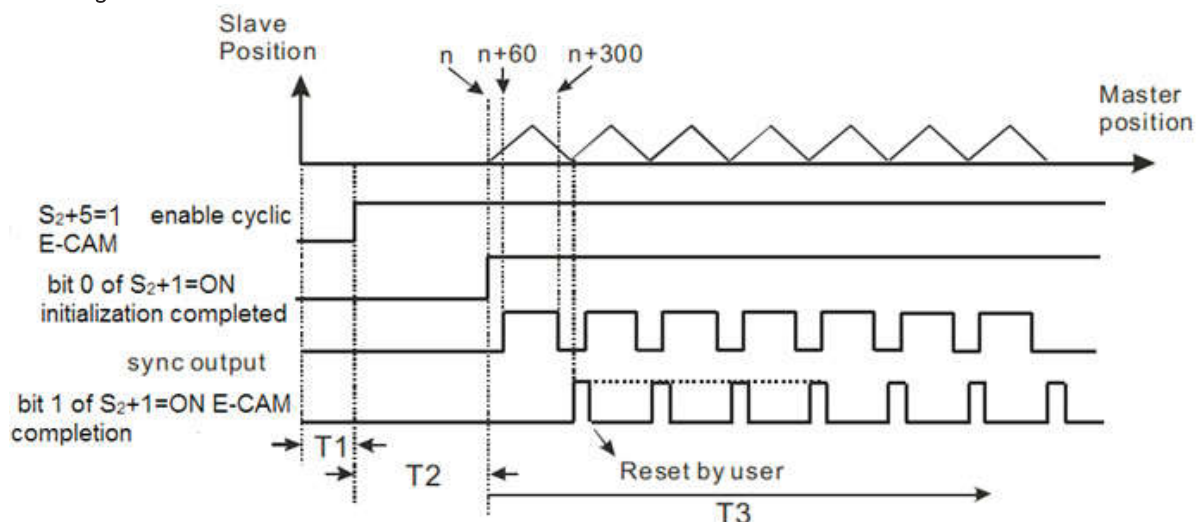
4.1.2 Stopping a cyclic electronic cam

The steps of stopping a cyclic electronic cam are as follows.

(1).When S2+5 (enabling cyclic electronic cam)=0, the electronic cam stops immediately.

(2).When bit1 of S2+4 (indicates E-cam is completed) is ON during electronic cam execution, Slave of electronic cam will stop as soon as the current electronic cam cycle is completed. As the following picture shows. If users want to restart E-cam,S2+5 needs to be set OFF, and holding this value for more than 100us, and then cyclic E-cam would be restart after S2+5 is set to ON.

Slave Position — n n+60 n+300 — Master position

$S_2+5=1$ enables cyclic E-CAM

bit 0 of S_2+1 initialization completed

sync output

bit 1 of S_2+1=ON, E-CAM completion

Reset by user

bit 2 of S_2+4=ON, current cycle completion

Set by user

bit 9 of S_2+1 =ON, stop E-CAM after cycle completion

4.1.3 Example

The figure shown below is an example of E-cam data.

E-cam cycle: Master position 50000. Output unit: pulse. Sync range: 20000~30000.When PLC runs at sync rang, sync terminal has signal, which could be used as control signal. (About how to create E-cam data, please refer to 2.5 Create datasheet for E-cam).

Hardware circuit: Y1 pulse output terminal is connected with X0. In this case, the input signals of the master axis comes from output signals of the Y1.
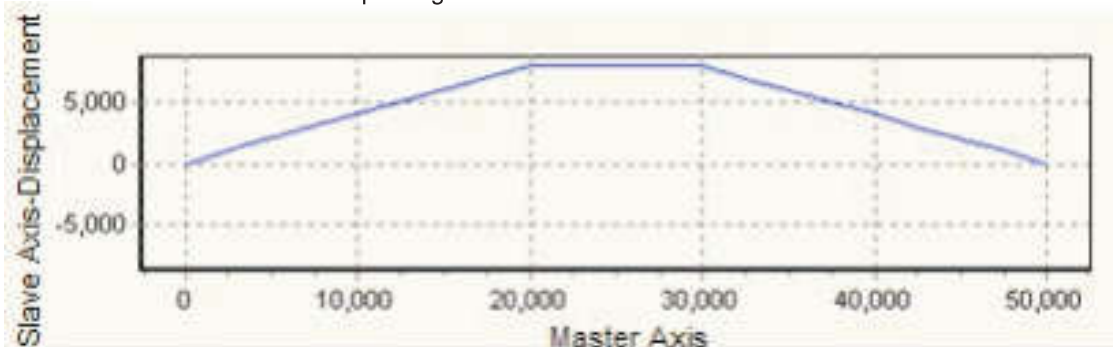
In this example, the E-cam data was created by PLCEditor.

【Steps】

1.Set special registers. The parameters set are as follows.

1)Clear the content in registers D8140, D8141, Y0;

2)Enable high-speed counter C231 to receive high-speed pulse from X0;

2.Set M0 to ON to enable cyclic electronic cam. Y works with variable speed, Master starts to receive the variable speed pulses from Y axis, and Slave operates according to the above E-CAM data curve. In addition, Y7=ON during Master position 20000~30000.

How to configure special registers before E-cam starts:

Note:Set up lower and upper bound of CAM sync output D2010=20000, D2012=30000, and set up sync No. in D2008, and bit 0 of D2004 is ON, one cycle has 5000 pulses, between Master position 20000~30000 (can be monitored by D2015, D2026), sync terminal is ON.

3.Reset M0 to stop E-cam.

【PLC ladder】

```
                                              ─[DMOV    K30000   D2012  ]
                                                                sync upp
                                                                er
                                              ─[MOV     K7       D2008  ]
                                                                sync No.
                                              ─[MOV     K1       D2004  ]
                                                                set func
                                                                tion
         M0
60 ──────┤├────[DECAM   C231    D2000   X001    Y000    Y002  ]
   enable E          receive  para add start si slave pu slave di
   -CAM              from Y1  ress    gnal    lse     rection
         M0
82 ──────┤├──────────────────[DPLSY   D0      D2      Y001  ]
   enable E                          Y1's pul Y1's pul
   -CAM                               se freq  se No.
         M0
96 ──────┤↑├─────────────────────────[MOV     K1       D2005  ]
   enable E                                              start re
   -CAM                                                  gister
         M0
103 ─────┤↓├───────────────────────────────────[RST     D2005  ]
   enable E                                              start re
   -CAM                                                  gister
```
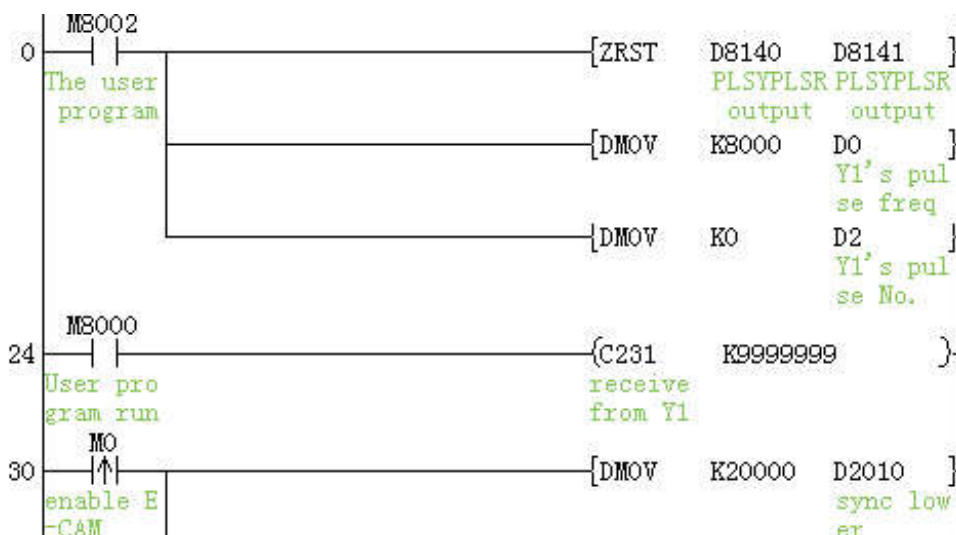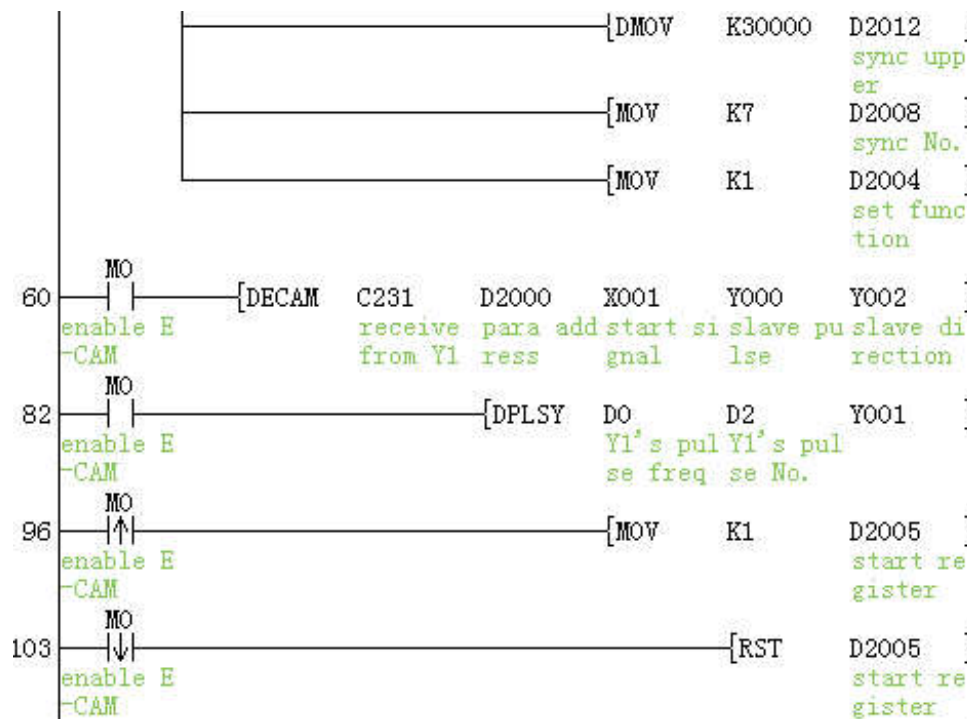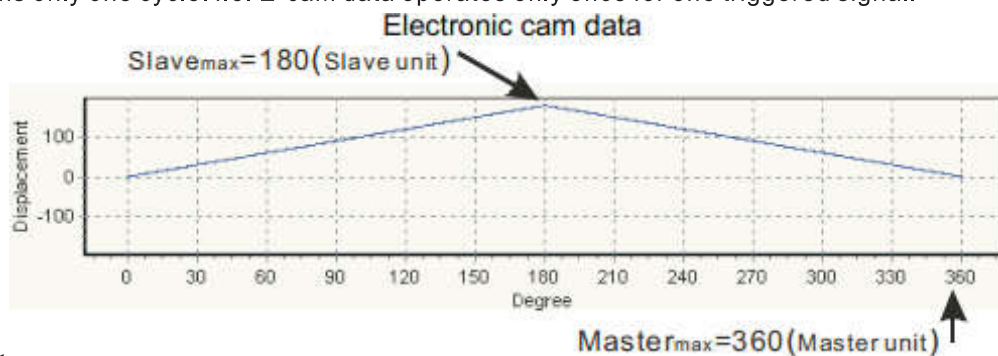
4.2 Starting/Stopping noncyclical E-cam

In noncyclical electronic cam, Master and Slave operate according to the user-defined electronic cam data only when electronic cam start signal is triggered. Unlike cyclic electronic cam, noncyclical electronic cam runs only one cycle. i.e. E-cam data operates only once for one triggered signal.

Electronic cam data

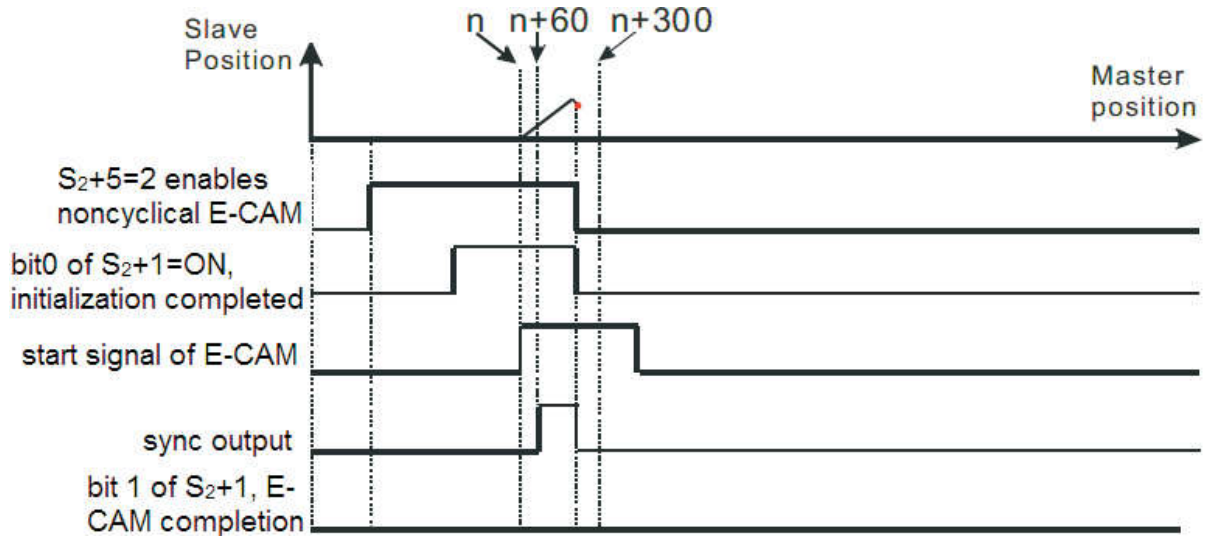### 4.2.1 Starting a noncyclical electronic cam

The steps of starting a noncyclical electronic cam are as follows.
1. In T1, S2+5=2, noncyclical E-cam is enabled
2. After the initialization interval of T2,bit 0 of S2+1 set to ON to indicate initialization is finished. At this time, Slave is still not activated.
3. In T3, the start signal of E-cam sets to ON, Slave starts to move one circle, the motion follows with master based the position relationship from the E-cam datasheet.
4. When the cycle is finished at T4, PLC will clear the state of bit 0 of S2+1. at the same time, users can get status of E-cam by bit 1 of S2+1.
5. In T5,users can decide whether to set ON to bit 1 of S2+1 for getting the status of E-can next time.
6. In T6 and T7, same motions in T3~T4 would be repeated. Please note that the interval for enabling noncyclical E- cam should be no less than 5ms.
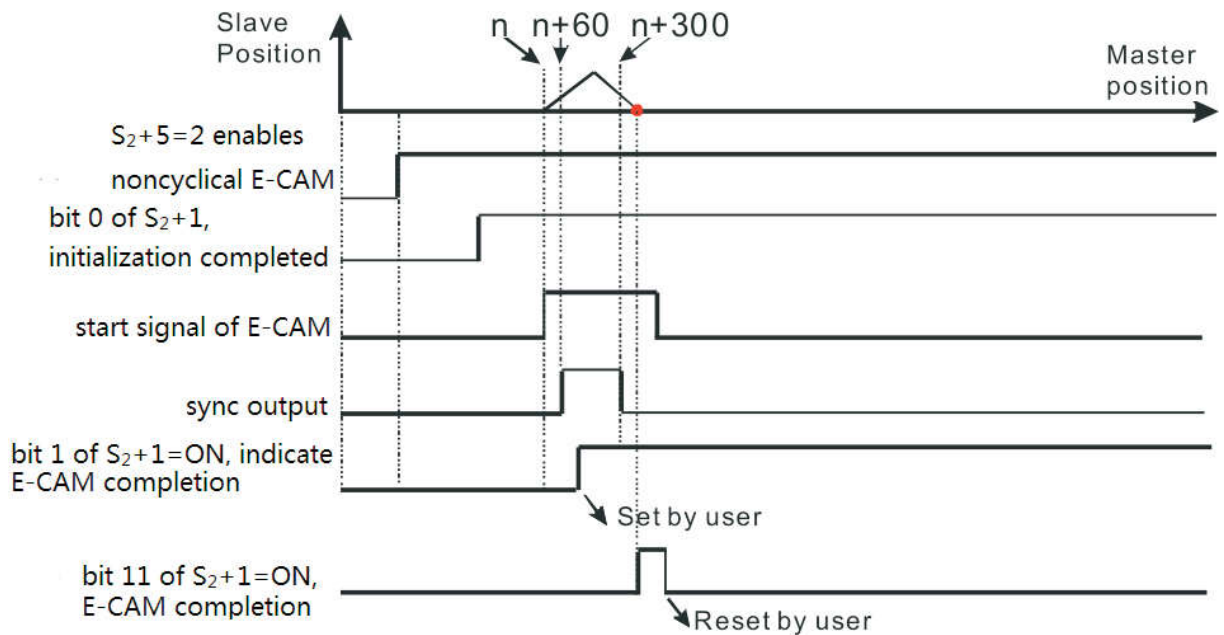7. Sync outputs terminal outputs signal.
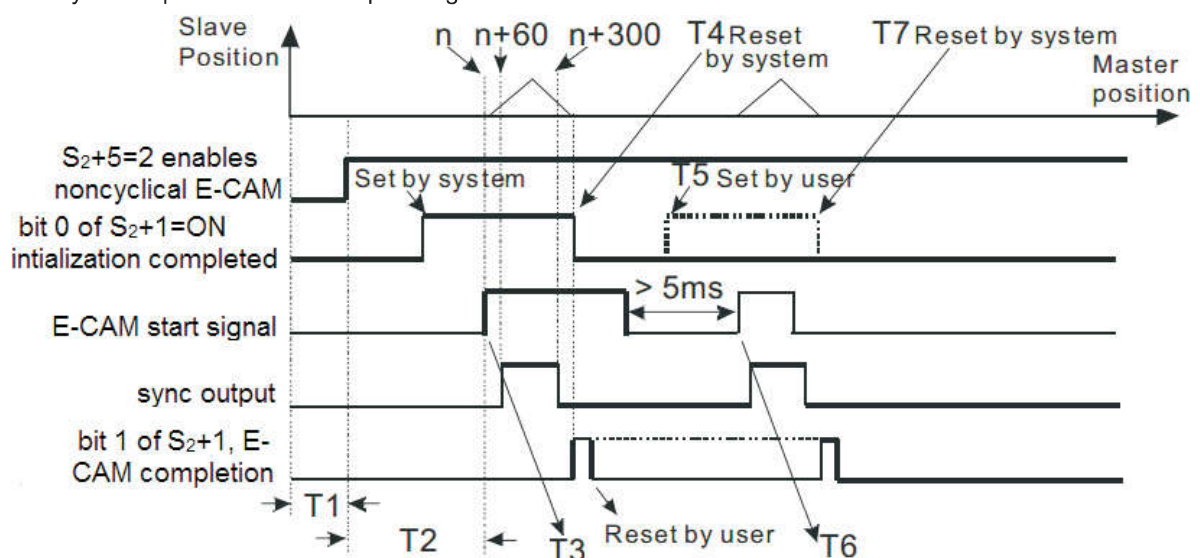
4.2.2 Stopping a noncyclical electronic cam

1. When S2+5 sets to zero, Slave of E-cam stops immediately.

Slave Position

n n+60 n+300

Master position

S₂+5=2 enables noncyclical E-CAM

bit0 of S₂+1=ON, initialization completed

start signal of E-CAM

sync output

bit 1 of S₂+1, E-CAM completion

2. When bit 1 of S2+4 (indicate electronic cam completion) sets to ON during E-cam, Slave of E-cam will not stop until the current cam cycle is over. 。

Slave Position

n n+60 n+300

Master position

S₂+5=2 enables noncyclical E-CAM

bit 0 of S₂+1, initialization completed

start signal of E-CAM

sync output

bit 1 of S₂+1=ON, indicate E-CAM completion

Set by user

bit 11 of S₂+1=ON, E-CAM completion

Reset by user

4.2.3 Example

The following chart is the datasheet of E-cam(Master length $0\sim100000$ as one circle), its ouput is the number of pulse, it is triggered when the outside signal X2 from OFF to ON, three circles would be executed after triggered.

Slave position

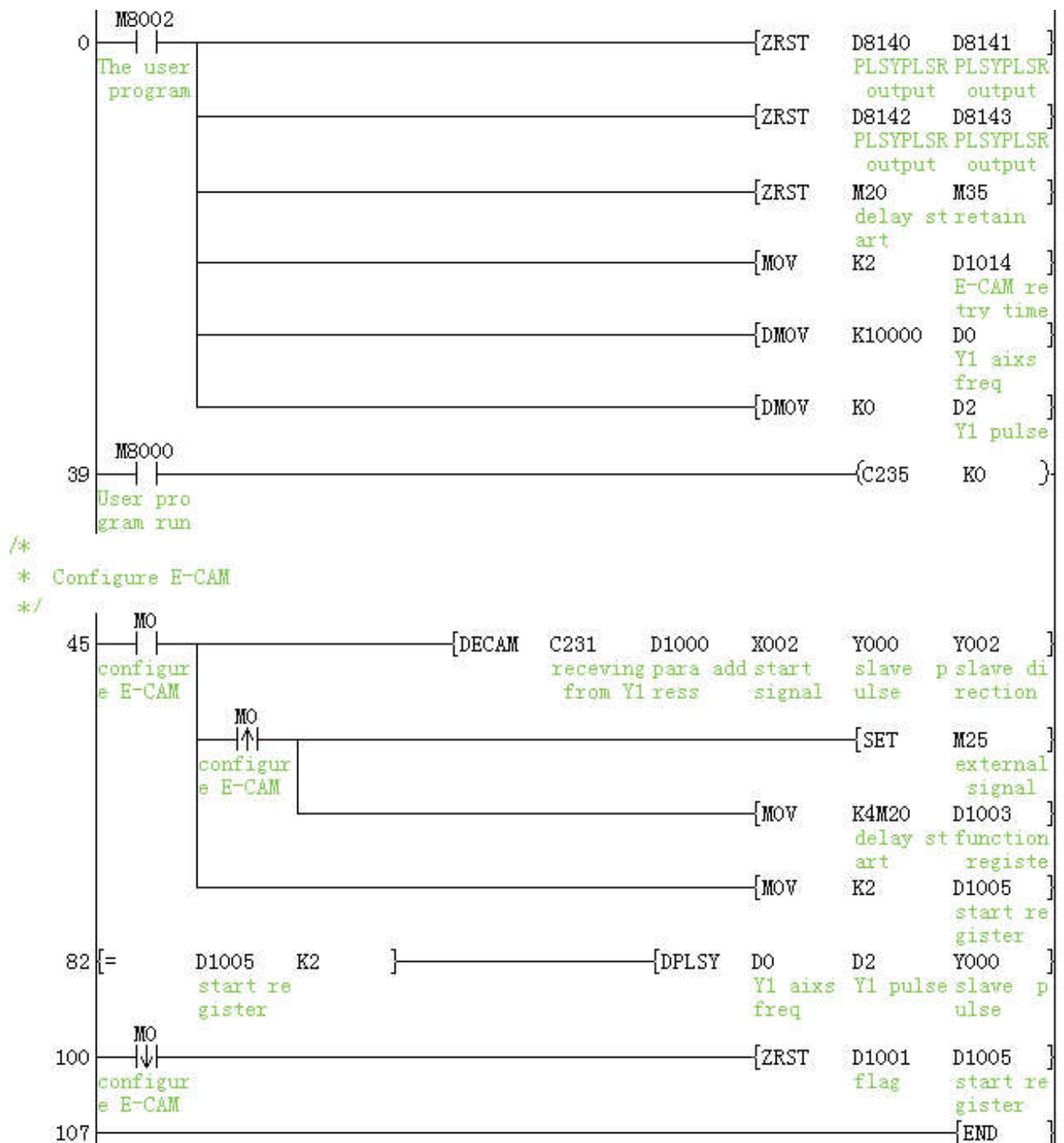| 1 | | | | | |
0.8					
0.6					
0.4					
0.2					
0					
	0	0.2	0.4	0.6	0.8	1
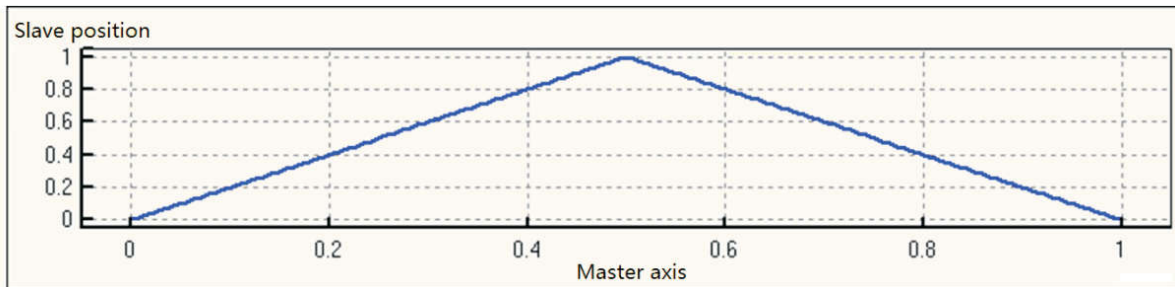
Master axis

In this example, the datasheet was created by PLCEditor.(2.5 Create datasheet for E-cam)
Hardware circuit: Y1 outputs pulses to X0, which means the input of master axis is from the pulses of Y1.

【Steps】
1. Set special registers. The parameters set are as follows.
   1)Set registers D8140, D8141, D8142, and D8143 to zero;
   2)Set D1014=2 (which means E-cam would run two times).
   3)Set the speed of Y1
2. Set M0 to set and enable noncyclical E-cam, set bit5 of D1003 as start signal. When D1005=2, Y1 variable speed operation is enabled but Y0 is not yet executed.
3. Trigger Y0 will be activated and executes the E-cam data for 3 cycles. Y0 stops output.
4. Reset M0 to close E-cam, if E-cam still is running, Y0 will stop output right now.
【PLC Ladder】

```
         M8002
    0 ───┤ ├────────────────────────────────────────[ZRST    D8140    D8141   ]
         The user                                            PLSYPLSR PLSYPLSR
         program                                              output   output

                    ──────────────────────────────────[ZRST    D8142    D8143   ]
                                                              PLSYPLSR PLSYPLSR
                                                               output   output

                    ──────────────────────────────────[ZRST    M20      M35     ]
                                                              delay st  retain
                                                              art

                    ──────────────────────────────────[MOV     K2       D1014   ]
                                                                       E-CAM re
                                                                       try time

                    ──────────────────────────────────[DMOV    K10000   D0      ]
                                                                       Y1 aixs
                                                                       freq

                    ──────────────────────────────────[DMOV    K0       D2      ]
                                                                       Y1 pulse

         M8000
   39 ───┤ ├──────────────────────────────────────────────────────(C235    K0    )
         User pro
         gram run
```

```
/*
*  Configure E-CAM
*/
```

```
          M0
   45 ───┤ ├────────────────────[DECAM  C231    D1000    X002    Y000    Y002  ]
         configur                        receiving para add start slave p slave di
         e E-CAM                         from Y1 ress     signal  ulse    rection

                  M0
                ──┤↑├──────────────────────────────────────────[SET    M25    ]
                  configur                                            external
                  e E-CAM                                             signal

                          ──────────────────────────────[MOV    K4M20   D1003  ]
                                                                delay st function
                                                                art      registe

                          ──────────────────────────────[MOV    K2      D1005  ]
                                                                        start re
                                                                        gister

   82 [=     D1005    K2  ]────────────────────[DPLSY   D0      D2      Y000  ]
            start re                                    Y1 aixs Y1 pulse slave p
            gister                                      freq             ulse

          M0
  100 ───┤↓├──────────────────────────────────────────[ZRST   D1001    D1005  ]
         configur                                              flag     start re
         e E-CAM                                                        gister

  107 ──────────────────────────────────────────────────────────────[END    ]
```

5. Registers for E-cam

Offset	Function	Explanation
0	Version number of Chart	Display the version of E-cam
1	Flag register	Bit0-Flag bit : completion of initialization. After start signal is enabled, the bit will on ON after E-cam finishes the calculation of E-cam, this signal should be reset manually.
		Bit1-Flag bit, completion of cyclic E-cam. Bit1 will be ON when cyclic electronic cam is completed. To restart the cyclic electronic cam, this signal should be reset manually.
		Bit2-Flag bit,Pulse outputs was delayed Bit3-Flag bit,something is Error, E-cam stop running. Bit4-Flag bit,Parameter error, E-cam stop running Bit5-Flag bit,datasheet error, E-cam stop running Bit6-Flag bit,Cyclic cam Bit7-Flag bit,Noncyclic cam Bit9-Flag bit,Completion of current cycle. Bit10-Flag bit,In synch area Bit11-Flag bit,Time shaft

Offset	Function	Explanation	Initial	Range
2	Error register	Parameter error: display error code Datasheet error: display the section number of datasheet	0	—
3	Function register (it need to set before using E-CAM)	Bit0 - delay start Bit1 –starts at specified position Bit2 - master axis zoom Bit3 - vice-axis zoom Bit5 - start signal is from outside Bit6 - Start from the current position	0	—
4	Function register (it could be changed during E-cam execution)	Bit1 - Enable sync signal Bit2 - Stop E-cam after current cycle finished	0	—
5	Start register	0- Stop E-cam immediately 1- Enable cyclic E-cam 2- Enable noncyclical E-cam Others: Stop E-cam immediately	0	—
6	Maximum frequency of E-cam (Low bit)	Maximum frequency of E-cam If frequency>200K or frequency<0, then the frequency value is 200K.	200000	0-200000
7	Maximum frequency of E-cam (High bit)			
8	Terminal number of synch-Y axis	Output terminal ID. Set the ID of the ouput terminal Y, range 0 ~ 255, when sync function starts, Yid would output sync signal.	0	0-65535
9	Low threshold value of the synchronized position of E-CAM (Low word)	Setting the Low/High threshold of the synchronized position of E-CAM When lower threshold≦master axis position≦higher threshold and the synch signal enable and the synch-signal of Y-port set to ON.	0	32-bit unsigned integer
10	High threshold value of the synchronized position of E-CAM (High word)			
11	Low threshold value of the synchronized position of E-CAM (Low word)		0	32-bit unsigned integer
12	High threshold value of the synchronized position of E-CAM (High word)			
13	Number of remaining pulses sent by the master axis of E-cam	Reserved	—	—
14	Repeated times of noncyclical E-cam	Reserved for cyclic E-cam. For noncyclical E-cam:The repeated time for E-cam. When the value=0X0000, E-cam runs only once, When value=0X0001, E-cam run two Cycles.Other value is by the same way.If value=HFFFF, the noncyclical E-cam will turn into cyclic mode.	0	0-65535
15	Setting delay-pulse of E-cam(Low word)	It is only for noncyclical E-cam: (Delay pulse output could be started by set S3+bit0 to ON) When noncyclical E-cam runs, a start signal of E-cam is accepted, if E-cam does not run immediately,it needs some pulses delayed to run E-cam,, the data of this register is the number of delayed pulses. When PLC accept a start signal, master axis will run for the specified pulses,and then,E-cam starts to run.	0	32-bit unsigned integer
16	Setting delay-pulse of E-CAM(High word)			
17	Master axis' start position (Low word)	It only for noncyclical E-cam: If you want start the specified position start function, please use Register 3, Bit1 of this datasheet.	0	32-bit unsigned integer
18	Master axis' start position (High word)			
19	Current position of slave axis (Low word)	current position of Slave axis(after zooming) during E-cam running.		32-bit unsigned integer
20	Current position of slave axis (High word)		0	

Offset	Function	Explanation	Initial	Range
21	Current position of Slave axis (Low word)	current position of Slave axis (before zooming) during E-cam running.	0	32-bit integer
22	Current position of Slave axis (High word)			
23	Ratio denominator of Slave axis	Zoom magnification of Slave axis	1	1-65535
24	Ratio Numerator of Slave axis		1	1-65535
25	Current position of master axis(Low word)	current position of Master axis (after zooming) during E-cam running	0	32-bit unsigned integer
26	Current position of master axis (High word)			
27	Current position of master axis(Low word)	current position of master axis (before zooming) during E-cam running.	0	32-bit unsigned integer
28	Current position of master axis(High word)			
29	Ratio denominator of Master axis	Zoom magnification of Master axis	1	1-65535
30	Ratio Numerator of Master axis		1	1-65535
31	Reserved	Reserved	—	—
32	Reserved	Reserved	—	—
33	Reserved	Reserved	—	—
34	Reserved	Reserved	—	—
35	Reserved	Reserved	—	—
36	Reserved	Reserved	—	—
37	Reserved	Reserved	—	—
38	Number of datasheet sections	Data sections of E-cam datasheet	0	0-512
39	Starting offset of datasheet	Offset address of E-cam datasheet	40	40
40	Section 0 of master axis(Low word)	The master axis' position of section 0	0	32-bit integer
41	Section 0 of master axis(High word)			
42	Section 0 of slave axis(Low word)	The slave axis' position of section 0	0	32-bit integer
43	Section 0 of slave axis(High word)			
44	Section 1 of master axis(Low word)	The master axis' position of section 1	0	32-bit integer
45	Section 1 of master axis(High word)			
46	Section 1 of slave axis(Low word)	The slave axis' position of section 1	0	32-bit integer
47	Section 1 of slave axis(High word)			
40+N*4	Section N of master axis(Low word)	The master axis' position of section N	0	32-bit integer
40+N*4+1	Section N of master axis(High word)			
40+N*4+2	Section N of slave axis(Low word)	The slave axis' position of section N	0	32-bit integer
40+N*4+3	Section N of slave axis(High word)			

5.1 Registers Description of E-cam

(1)No. 3 Function Register

These bits are set ON to enable specified functions for E-cam.

Bit6:Start from the current position

Master and slave axis will be started from the current position. When this function is enabled, master axis will be started from the position specified in No.27&28 registers（before conversion）, slave axis will be started from the position specified in No.19&20 registers(after conversion).

(2)No. 4 Function Register

Bit0:Enable sync signal

When master position enters synchronized output section between Lower bound and Higher bound, bit 0 will be set to ON. Synchronized terminal will output(specified in address No.8)

Bit1:Stop EGEAR after operation cyclic completed

When this bit is set to ON, after the execution of cyclic E-cam finished,E-cam stops immediately.

(3)No. 5 Start Register

For cyclic E-cam, When No.5 is set to 1,E-cam will be started, but it will stop when this bit was reset. For noncyclic E-cam, when No.5 is set to 2, E-cam will be started, but it will stop when this was rest.

When PLC changes from Cyclic E-cam and noncyclic E-cam, No.5=1 and then No.5=0 and then No.5=2, the interval should be at least 100us.

（4）No.8 Synch-signal of Y axis

This register is used for the ID of output terminal. When low threshold ≦ master axis position ≦ high threshold and the bit 0 of No. 4 is set to ON, the terminal of synch-signal of Y axis specified by this register outputs signal.

（5）No. 9~12 Lower/Higher threshold value of E-cam synchronized location

NO.	Function	Range
NO. 9	Low threshold of E-cam synchronized output function（LOW WORD）	32-bit
NO. 10	Low threshold of E-cam synchronized output function (HIGH WORD)	integer
NO. 11	High threshold of E-cam synchronized output function （LOW WORD）	32-bit
NO. 12	Low threshold of E-cam synchronized output function （HIGH WORD）	integer

When low threshold ≦ the location of master axis ≦ high threshold and the bit 0 of No.4 is set to ON, the synch-signal of Y axis output pulses.
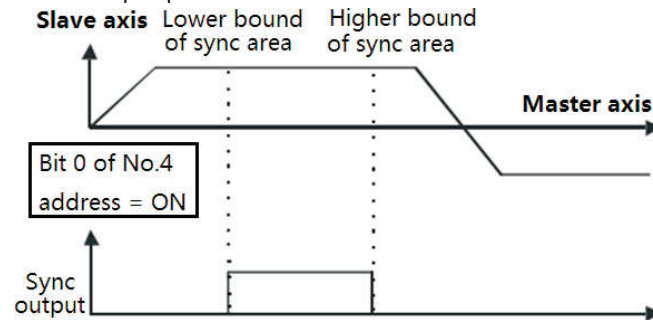
（6）No.14 Repeated times for noncyclic E-cam

When the value=0x0000, it means noncyclical E-cam runs only once. When value=0x0001, it means noncyclical E-cam runs two cycles.
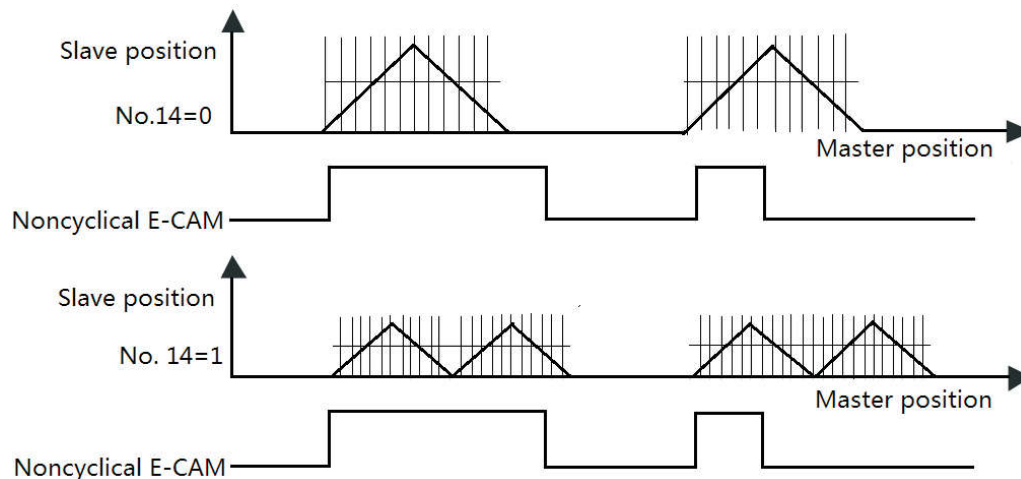
（7）No.15~16 delay-pulse settings of E-cam

For noncyclical E-cam, PLC could delay pulse output(if No.3, Bit0 is set to ON), when a start signal is accepted by slave axis, but E-cam should not start immediately, it needs some pulses delayed to run E-cam, these registers are for the number of delayed pulses, as the following shows, when system accepts a start signal, after the master axis runs the delayed pulses, the salve starts immediately.
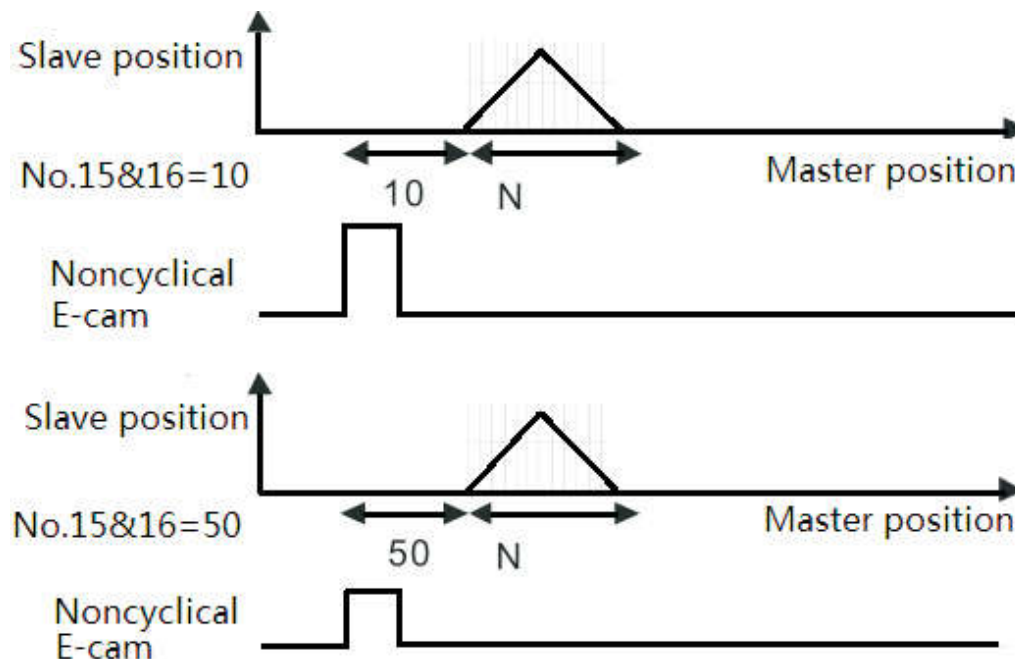
(8)No.17~18 Master axis starts at specified location

NO.	Function	Range
NO.17	It only for noncyclical CAM:	32-bit unsigned integer
NO.18	used for setting start position.	

Slave position

Slave position
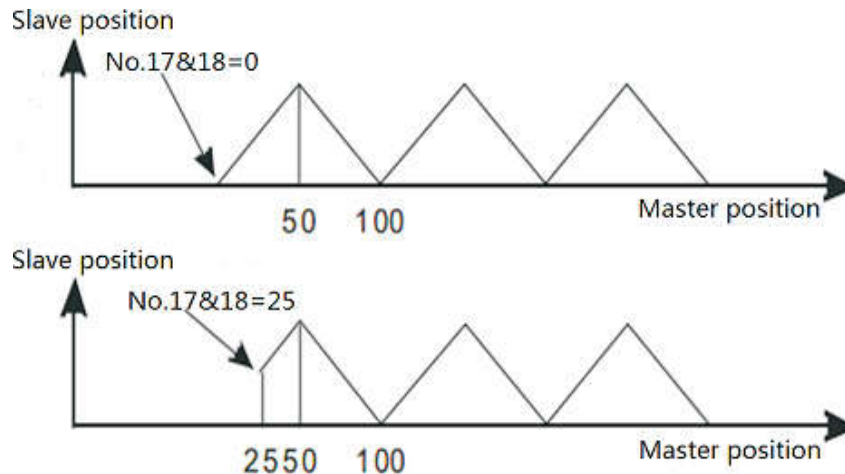
6. Create datasheet for E-cam

6.1 single datasheet edit for E-cam

Datasheet of E-cam can be edited by DMOV instruction, the offset address of the ID of section of datasheet is 38.
As the following shows,

```
MO
0 ┤↑├                                    ─[MOV    K3    D2038]
                                          ─[DMOV   K0    D2040]
                                          ─[DMOV   K0    D2042]
                                          ─[DMOV   K100  D2044]
                                          ─[DMOV   K100  D2046]
                                          ─[DMOV   K200  D2048]
                                          ─[DMOV   K0    D2050]
     MO
61 ┤ ├──[DECAM  C235  D2000   X000   Y000  Y001 ]
83 ─────────────────────────────────────[END ]
```
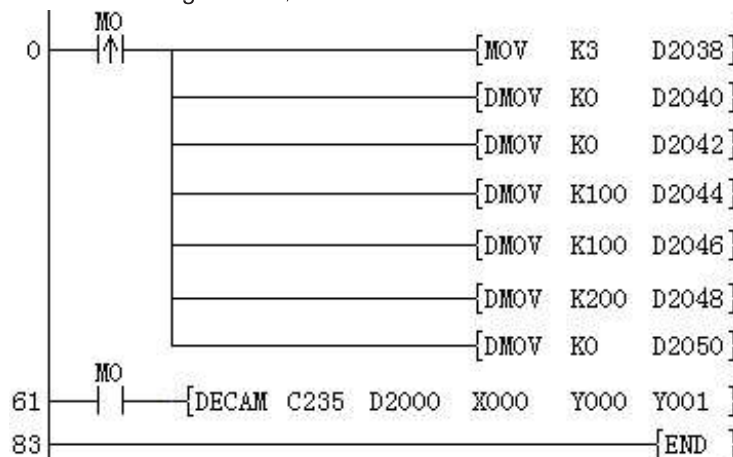
6.2 Generate datasheet from PLC Editor

The datasheet of E-cam has defined the relationship between master axis and slave axis. There are two methods to define the datasheet of E-cam.
Method 1: the relationship of both of th m is described by mathematical function.
Method 2: the relationship of both of them is described by arrays of X and Y.
There are also two methods for generating the datasheet for E-cam:
Method 1:datasheet is generated from mathematical function of master axis and slave axis.
Method 1:datasheet is a collectionof all points(X and Y), which are from measuring during field testing.

E-cam can have more than one datasheet, the location of slave axis is defined by the master axis based on the datasheet, the following is sine wave E-cam.
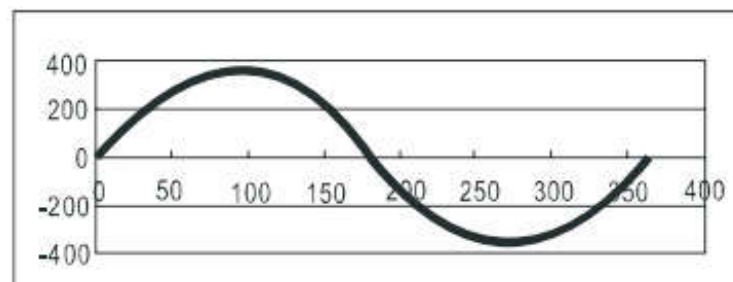
Please click【Project Properties】-> 【Extension Function】-> 【E-cam datasheet】
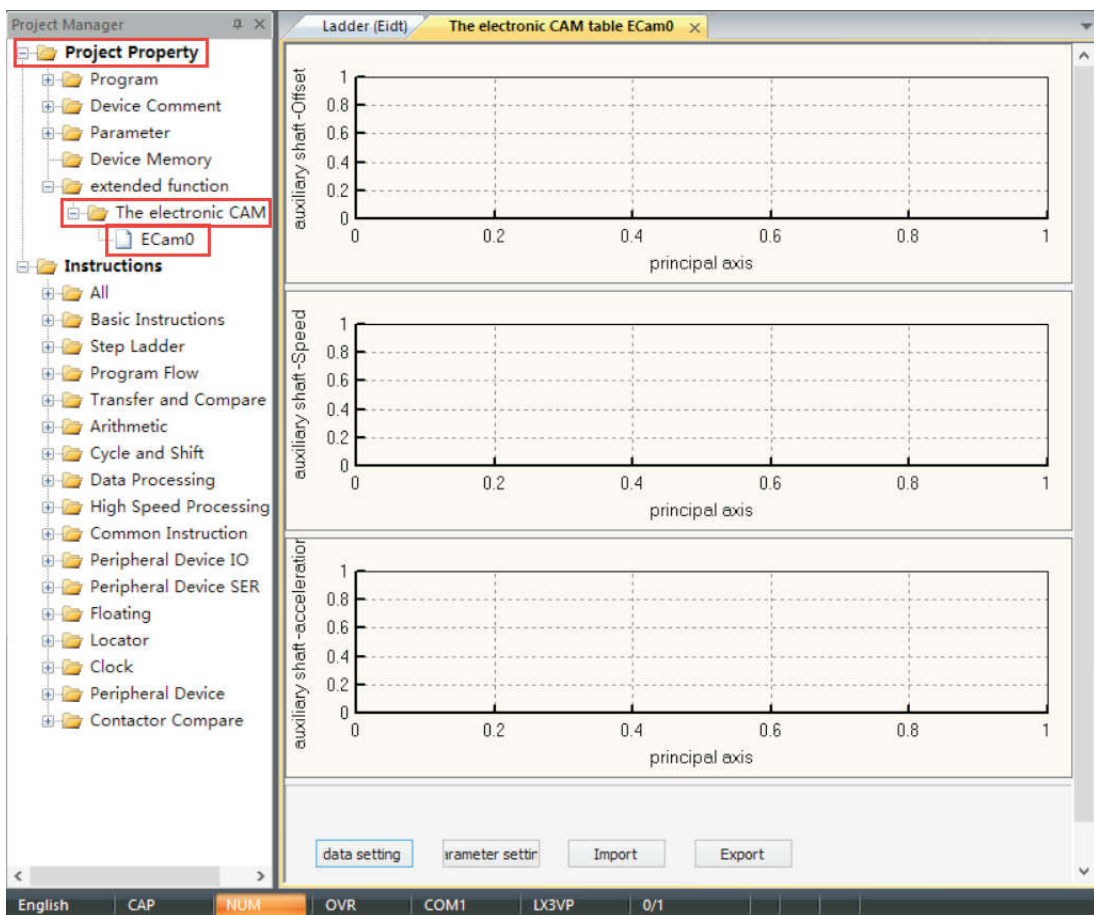
The above figures contain four contents.

    Displacement:The relationship between the master axis and the slave axis is described by displacement.

    Velocity:The relationship between the master axis and the slave axis is described by speed.

    Acceleration:The relationship between the master axis and the slave axis is described by acceleration.

Data setting area:

    1.Resolution:Users can set the count of points required in the E-cam datasheet. The count of points should be between 10 and 512. And one point occupies 4 words soft elements.

    2.Data setting : the displacement relationship of master and slave is described by mathematical function

    3.Import:Importing the displacement relationship from the relationship of point to point from datasheet.

    4.Export:Exporting the relationship between the master axis and the lave axis in terms of displacement

6.2.1 The relationship of master and slave described by mathematical function.

    Please select 【data setting】 to pop-up setting windows as following shows.

Users can define the relationship between the master axis and the slave axis in every section.

1.Master axis: the displacement of master axis, the value should be over 0,

2.Slave axis: the displacement of master axis, the value could be positive or negative.

3.CAM Curve:The mathematical function for the current section.

4.Resolution:Users can set the number of data points used for current section.The number of data points should be in the range of 10 to 512. One point occupies 4 word devices. If the users do not set resolution for sections, the number of data points left will be distributed equally to this section. Resolution could be defined based on the requirement of your products. The resolution is higher, the motion is more smooth. And the more soft elements is indeed.

6.3 Creating a E-cam datasheet by ECAMTBX instruction

Instruction	Function	bits	Pluse type	Format	Steps
ECAMTBX	Create E-cam datasheet	32	NO	ECAMTBX S0 S1 D1 D2	17

S0—Soft element D type could be used as Parameters' address.

Note:it used for creating E-cam chart, please refer to the 【Appendix】/【Parameters List】for detailed.

S1—the type of E-cam Chart, D register or H, K could be used;

Note:

K0~K1: Create S type of acceleration and deceleration chart

K100: Create rotary saw chart.

K101: Create fly saw chart.

D0—First address of E-cam parameters.

Note: Data for Chart stored in D0+40, sections for Chart stored in D0+38.

D1—The result of chart.

Note:

D1<0:Error in chart generating.

D1>0 : Chart created successfully.

D1 : Totally number of current chart sections.

3. Application of a rotary cut

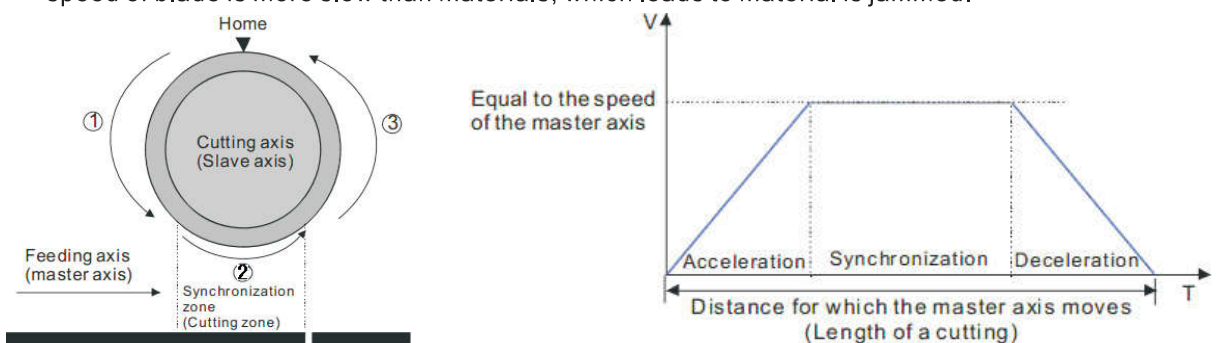## 1 Operation of rotary saw
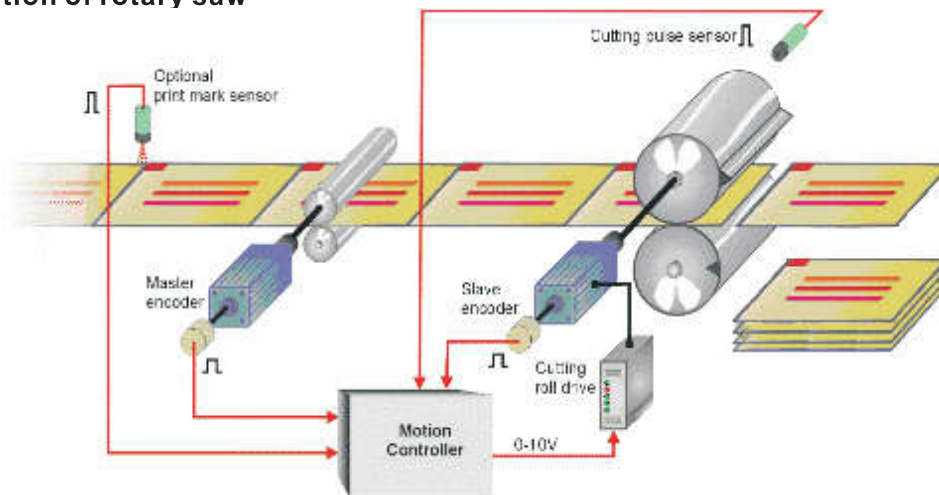
1.1 The application of rotary saw

(1)In the application of rotary saw, the cutting roller of rotary saw rotates in the same direction. A material is cut when the blade When the blade touches the material. The feeding roller feeds materials at uniform speed continuously. The relationship between motions of rotary saw and output are shown below.

①.At first, the slave axis accelerates and moves to the synchronized area;

②.the speed of slave is same with master, Cutting signal outputs(CLR0 is ON) during the synchronized area.
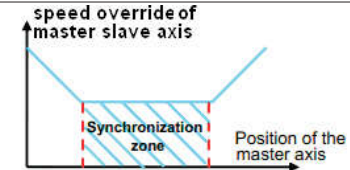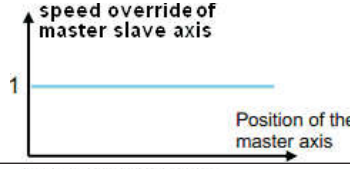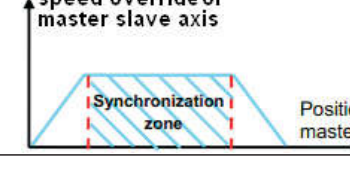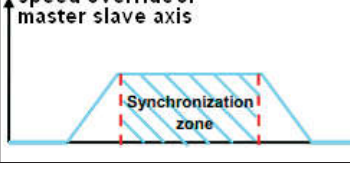
③.After the slave axis leaves the synchronization zone, it decelerates and go back to zero point. A cycle of rotary saw is finished,

(2).During the processing of rotary saw, the most important is synchronization. When the bladed touches the material, the speed of the blade must be the same as materials. If the speed of blade is higher, the materials would be pulled by blade, which leads to the material is cut smoothly. If the speed of blade is more slow than materials, which leads to material is jammed.

(3).The design of a synchronized area is important for the performance of equipment. In one cycle of rotary saw, The bigger of synchronized area, Less time for acceleration/deceleration of slave axis. If equipment needs to accelerate/decelerate in a short time, there would have great impact on motor, frames and blade,on the other side, it is easy for servo controller overflow.

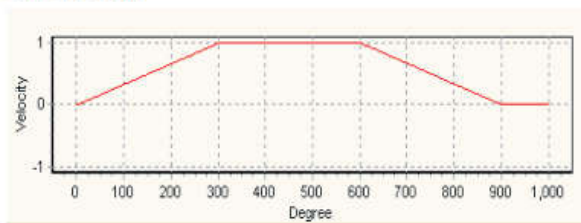(4) Relationship between the length of cut and the circumference of a blade is as the following：

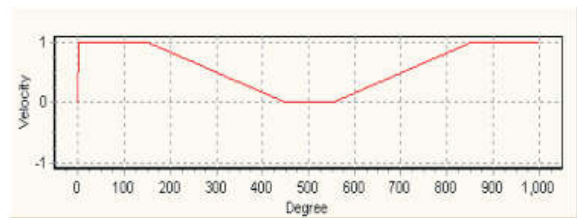|	
Length of cut< Circumference of the blade: The line speed of blade is the same with the feeding speed during synchronized area. After synchronized area, the cutting roller need to be accelerated to catch the next cycle.。	speed override of master slave axis. Synchronization zone. Position of the master axis
Length of a cutting=Circumference of the blade: The cutting roller rotates at a uniform speed.	speed override of master slave axis. 1. Position of the master axis
One time of circumference of the blade<Length of cut<Two times of circumference of blade: After cut actions finishes in cutting in the synchronized area, the cut roller will decelerate and then accelerate to synchronization for the next cut.	speed override of master slave axis. Synchronization zone. Position of the master axis
Length of cut>Two times of circumference of the blade: The length of cut is greater than two times the circumference of the blade. (It is a common situation.) After cutting roller finishes cutting in the synchronized area, it will decelerate to stop , the rotary saw will start in the specified length of materials pass through.	speed override of master slave axis. Synchronization zone. Position of the master

1.2 Chart for rotary saw

PLCEditor can create Chart for rotary saw by instruction automatically, About the parameters settings, please refer to Appendix P6 sets up the rotary saw acceleration curves and the E-cam curves, and the examples of each curve are as below.

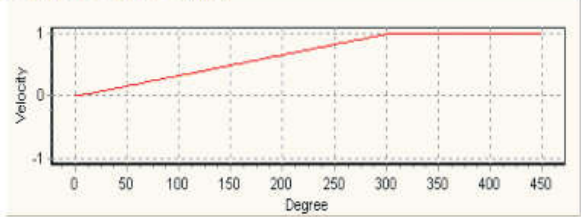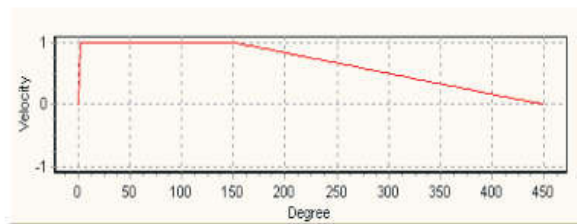| Rotary cut parameters settings					
Parameter	Offset	Data	Format	Explanation	Default
P1	NO.0	Length of Master	32-bit Integer	Length of the material feeding axis. Unit: pulse	3000
	NO.1	Length of Slave			
P2	NO.2	Length of Slave/ Sync start position	32-bit Integer	Length of the cutting axis (cutter length included). Unit: pulse. When sync function is enabled, the register sets up the sync start position.	1000
	NO.3				
P3	NO.4	Length of Slave/ Sync end position	32-bit Integer	Length of sync area. Unit: pulse When sync function is enabled, the register sets up the sync end position	300
	NO.5				
P4	NO.6	Magnification ratio	Floating	The speed of master and slave is synchronized in sync area. Calculation method of magnification ratio $V_1 = V_2 \Rightarrow \dfrac{F_1 \times 3.14 \times D_1}{R_1} = \dfrac{F_2 \times 3.14 \times D_2}{R_2} \Rightarrow \dfrac{F_2}{F_1} = \dfrac{R_2/D_2}{R_1/D_1}$ V1(V2)=Master(Slave)speed（mm/sec）; F1(F2)=Master(Slave) frequency (Hz); D1(D2)=Master(Slave) diameter; R1(R2)=Master(Slave)pulses of single round	5/3
	NO.7				
P5	NO.8	Max magnification ratio	Floating		
	NO.9				
P6	NO.10	Acceleration curve	Integer	Electronic cam acceleration setting: 0: Uniform curve 1: Uniform acceleration curve 2: B type curve	
	NO.11	Cam curve	Integer	Cam curve selection for different sections in sync area, e.g. start, end: 0: leftCAM: Sync area is on the left side of cam curve 1: midCAMall 2: midCAMbegin 3: midCAMend (If the curve is selected, electronic cam stops automatically when completed.) 5: rightCAM: Sync area is on the right side of cam curve.	
P7	NO.12	Resolution	Integer		
P8	NO.13~ NO.19	Reserved	Reserved	Reserved	

0: leftCAM

1: midCAMall

2: midCAMbegin

3: midCAMend

5: right CAM
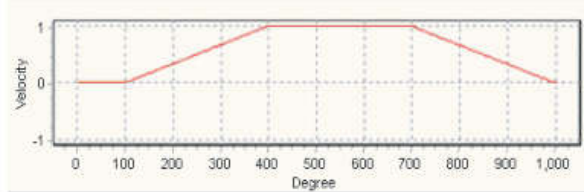
1.3 Demo for rotary saw

(1) Requirements：

　　①.Create E-cam data automatically from rotary saw chart.

　　②.Cut axis and feeding axis for this device, and servo parameter is 1000 pulse/rev.

　　③.Other Parameters:

　　　Length of cut material: 1000mm

　　　Circumference of cur axis: 60π mm

　　　Circumference of feed axis: 100π mm

　　　Speed of feed axis: 1,000 Hz

(2) Parameters

　　Parameter 1: the length of material in master axis, in this demo, the length is 1,000mm, in pulses 1000*1000/1000Pi=3183(pulse).

　　Parameter 2: the circumference of slave axis,the count pulses for slave making a round:1000(pulse).

　　Parameter 3: Sync length of slave axis, it is about 1/3 of circumference (pulses):1000/3=333(pulse).

　　Parameter 4: velocity ratio between master axis and slave axis: $\dfrac{F_{\blacksquare}}{F_{\blacksquare}}=\dfrac{R2/D2}{R1/D1}=\dfrac{1000/30}{1000/50}=\dfrac{5}{3}$(Floating)
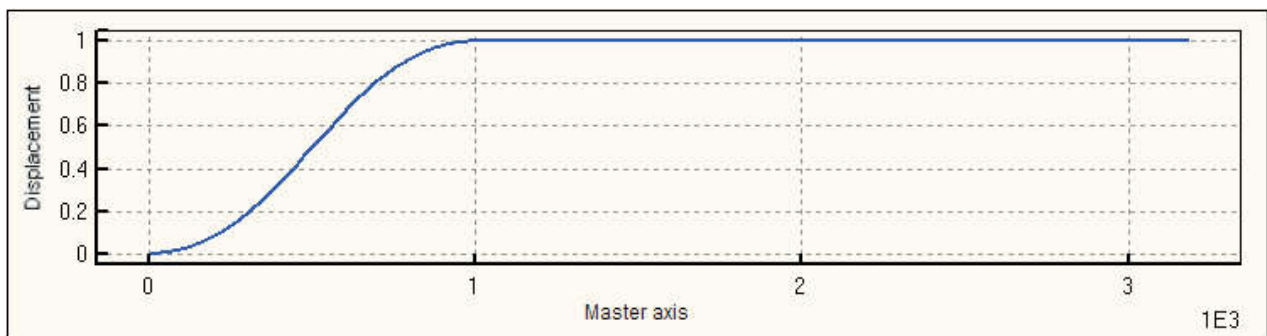
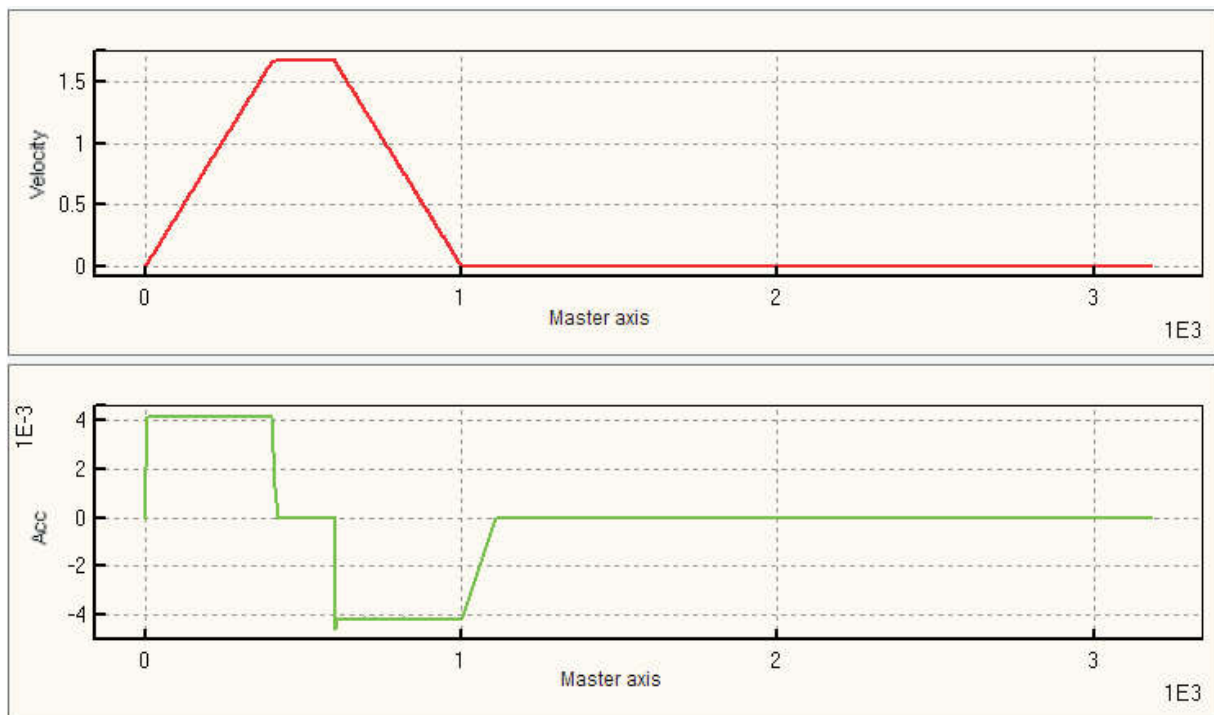　　Parameter 5: High threshold of ratio: it is 10 times of sync velocity ratio(50/3)(Floating)

　　Parameter 6: Low word=0: Uniform acceleration

　　　　　　High word=0: LEFTCAM mode.

　　Parameter 7: the result of Chart: 0

(3)Creating Chart Instruction:

```
 M10
─┤ ├──────[ECAMTBX  D100  D10  D1000  D30 ]
     │                          [RST    M10 ]
```
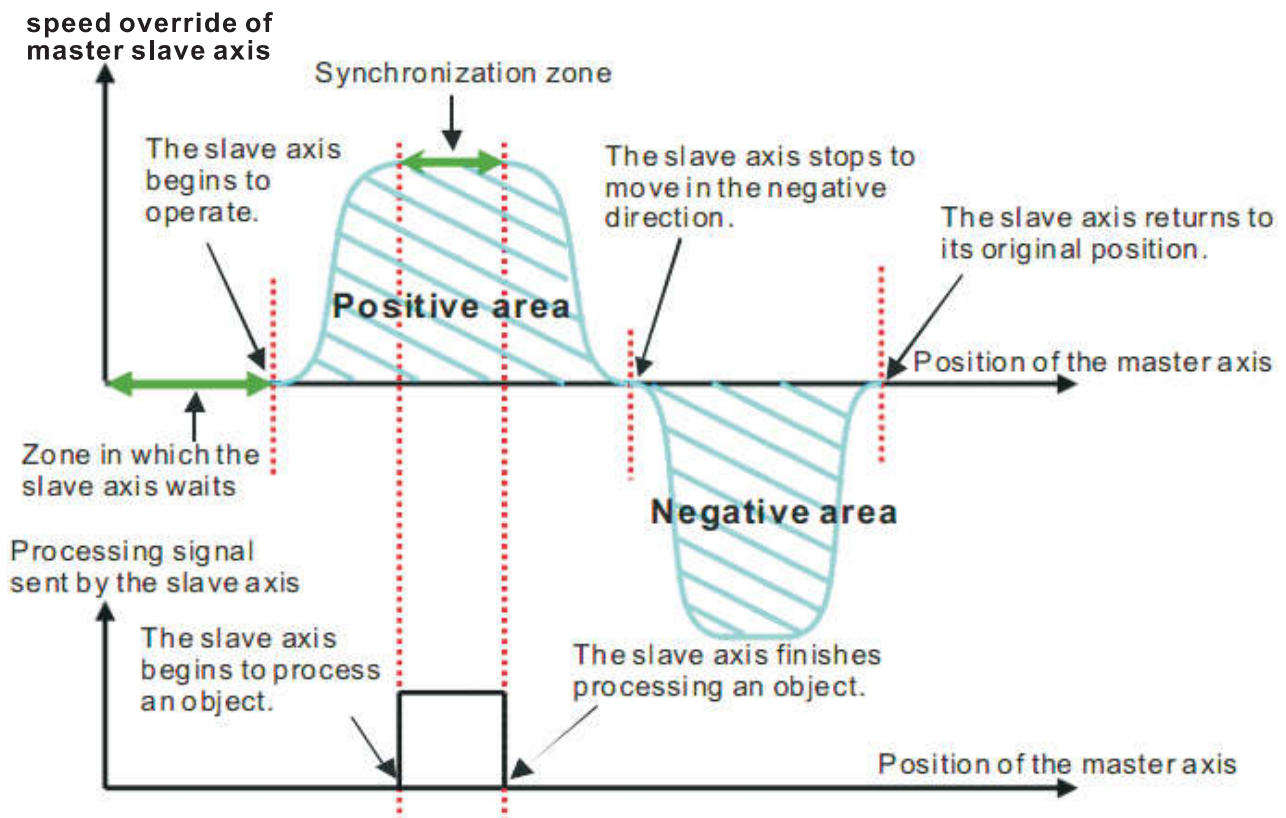
2 The application of fly show

The feeding axis will not stop when the fly saw works in fly saw control system, E-cam should be the same speed with feeding axis, and the time of synchronization should be long enough to finish cutting and move to the safety place, E-cam should move the cutter and its framework at the same speed with the master axis.

2.1 Motions of fly saw

The operation and circuit of fly saw is illustrated as belows. Positions 1, 2, 3 and 4 respectively indicate starting position, sync-start position, sync-end position and ready position. When master (Y axis) executes, Slave (X axis) accelerates from position 1 to position 2, reaching the synchronizing speed. The sync speed is hold from position 2 to position 3. After position3, Slave decelerates in reverse direction and returns to position 4 (Same as position 1). The cycle repeats for continuous flying saw operation.
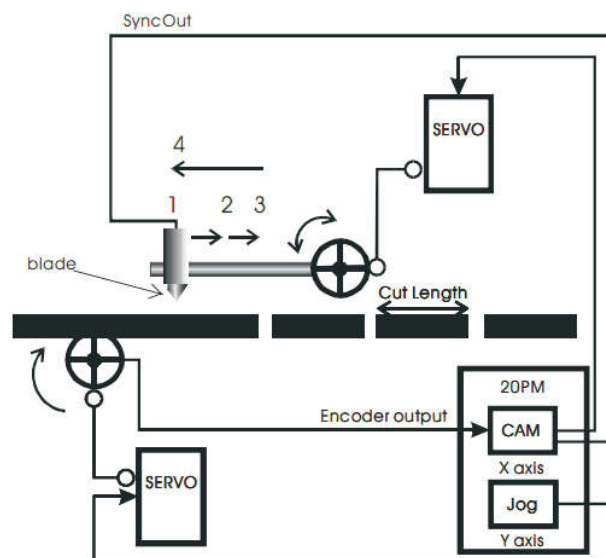
1.Fly saw is applied to equipments which need to move with processed objects, e.g. a tube cutter. The processing axis (slave axis) used accelerates at first so that it can catch up with a processed object. After the processing axis moves to the synchronization area designed, the speed of the processing axis will be the same as the speed of the processed object. After the processing axis leaves the synchronization area, it will return to its original position. The feeding axis (master axis) used always feed materials at a uniform speed.

2.The movement of fly saw has two phases: following phase and return phase shear. Distances of these phases should be equal. In terms of the speed the fly saw, the positive area in which the fly saw moves is equal to the negative area.

3.During the cutter axis processing an object, the feeding axis does not stop. The speed of the cutter axis must be the same as the speed of the feeding axis. The time is enough for the cutter axis to return back the safety position.

4.The time length of synchronization is also the time for processing of the cutter axis, Synchronization area could be considered from this point, the longer of synchronized area, the shorter time for acceleration and deceleration, which maybe be damage for step motors, blade and framework, and it will cause the step servo overflow, and products could not work properly.

speed override of
master slave axis

Synchronization zone

The slave axis
begins to
operate.

The slave axis stops to
move in the negative
direction.

The slave axis returns to
its original position.

Positive area

Position of the master axis

Zone in which the
slave axis waits

Negative area

Processing signal
sent by the slave axis

The slave axis
begins to process
an object.

The slave axis finishes
processing an object.

Position of the master axis

2.2 Fly saw parameters

<table>
<tr><td colspan="6" align="center">Fly saw parameters settings</td></tr>
<tr><td>Parameter</td><td>Offset</td><td>Data</td><td>Format</td><td>Explanation</td><td>Default</td></tr>
<tr><td rowspan="2">P1</td><td>NO.0</td><td>Length of Master</td><td rowspan="2">32-bit Integer</td><td rowspan="2">Length of the material feeding axis. Unit: pulse</td><td rowspan="2">3000</td></tr>
<tr><td>NO.1</td><td>Length of Slave</td></tr>
<tr><td rowspan="2">P2</td><td>NO.2</td><td rowspan="2">Length of Slave/ Sync start position</td><td rowspan="2">32-bit Integer</td><td rowspan="2">Length of the cutting axis (cutter length included). Unit: pulse.
When sync function is enabled, the register sets up the sync start position.</td><td rowspan="2">1000</td></tr>
<tr><td>NO.3</td></tr>
<tr><td rowspan="2">P3</td><td>NO.4</td><td rowspan="2">Length of Slave/ Sync end position</td><td rowspan="2">32-bit Integer</td><td rowspan="2">Length of sync area. Unit: pulse
When sync function is enabled, the register sets up the sync end position</td><td rowspan="2">300</td></tr>
<tr><td>NO.5</td></tr>
<tr><td rowspan="2">P4</td><td>NO.6</td><td rowspan="2">Magnification ratio</td><td rowspan="2">Floating</td><td rowspan="2">The speed of master and slave is synchronized in sync area.
Calculation method of magnification ratio
$$V_1 = V_2 \Rightarrow \frac{F_1 \times 3.14 \times D_1}{R_1} = \frac{F_2 \times 3.14 \times D_2}{R_2} \Rightarrow \frac{F_2}{F_1} = \frac{R_2/D_2}{R_1/D_1}$$
V1(V2)=Master(Slave)speed (mm/sec);
F1(F2)=Master(Slave) frequency (Hz);
D1(D2)=Master(Slave) diameter;
R1(R2)=Master(Slave)pulses of single round</td><td rowspan="2">5/3</td></tr>
<tr><td>NO.7</td></tr>
<tr><td rowspan="2">P5</td><td>NO.8</td><td rowspan="2">Max magnification ratio</td><td rowspan="2">Floating</td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td>NO.9</td></tr>
<tr><td rowspan="2">P6</td><td>NO.10</td><td>Acceleration curve</td><td>Integer</td><td>Electronic cam acceleration setting:
0: Uniform curve
1: Uniform acceleration curve
2: B type curve</td><td></td></tr>
<tr><td>NO.11</td><td>Cam curve</td><td>Integer</td><td>Cam curve selection for different sections in sync area, e.g. start, end:
0: leftCAM: Sync area is on the left side of cam curve</td><td></td></tr>
<tr><td>P7</td><td>NO.12</td><td>Resolution</td><td>Integer</td><td></td><td></td></tr>
<tr><td>P8</td><td>NO.13~ NO.19</td><td>Reserved</td><td>Reserved</td><td>Reserved</td><td></td></tr>
</table>

2.3 Demo for Fly saw
(1) Control parameters
  ①. Servo parameter is 1000 pulse/rev.
  ②. Other Parameters:
     Length of master: 660 mm.
     Circumference of master: 60π mm.
     Length of slave : 40mm.
     Circumference of slave axis: 20 mm.
     Speed of master axis: 1,000 Hz.

2.3.1 creating fly saw
(1).The parameters for creating fly saw
MasterLength (WorkLength):
Suppose Master servo parameters is 1,000 pulse / rev, and agencies parameters 60π mm / rev, so 1 pulse= 0.188 mm. →660mm=3501pulse.

SlaveLength (Work axis length):
Suppose Master servo parameters is 1,000 pulse / rev, and agencies parameters 20mm / rev, so 1 pulse= 0.01 mm. →40mm=2000Pulse.

The position of sync area:
The low threshold of sync area is triggered by START0, the slave axis accelerates from 0 to the speed of master axis, the position is 200, the high threshold of sync area is ended at position 500.

Velocity ratio in sync area:
The velocity ratio between master and slave

Velocity ratio between Master and Slave when returning:
Total length – following length = returning length, and then because following length = returning length, so the Velocity ratio is 3.

(2).Creating datasheet for fly saw automatically
①. Creating Chart for Positive Square
   Parameter 1: Input MasterLength, 660*1000/60Pi=3,501 pulses, because slave axis need to return back to the zero point,   so MasterPulse: 3501 / 2 = 1750 pulse.
   Parameter 2: SlaveLength 40mm, →40 * 1000 / 20 = 2000 pulse
   Parameter 3: Sync length of Slave axis : it is about 1/3 of Slave circumference (pulse): 2000/3=667 pulse
   Parameter 4: Synchronization rate= Slave pulse for 1mm/ Master pulse for 1mm
         = (1000/20)/(1000/60π) =3π (Floating)
   Parameter 5: Highest synchronization rate: 10 (Floating)
   Parameter 6: Low word: H0: Uniform acceleration
         High word: H0: LEFTCAM mode.

②. Creating Chart for Negative Square
   Parameter 1: Input MasterLength, 660*1000/60Pi=3,501 pulse, because Slave axis need to backto original, so MasterPulse: 3501/2=1750 pulse.
   Parameter 2: The opposite direction is -2000 pulse.
   Parameter 3: Same
   Parameter 4: Same
   Parameter 5: Same
   Parameter 6: Low word: H0: Uniform acceleration
         High word: H1000: LEFTCAM mode.

(3).Creating Chart by Instruction
   Parameter 1: Input MasterLength, 600*1000/60Pi=3,501 pulse, because Slave axis need to back to original, so MasterPulse: 3501/2=1750 pulse.
   Parameter 2: SlaveLength 40mm, →40 * 1000 / 20 = 2000 pulse
   Parameter 3: Sync length of Slave axis: it is about 1/3 of Slave circumference (pulse):
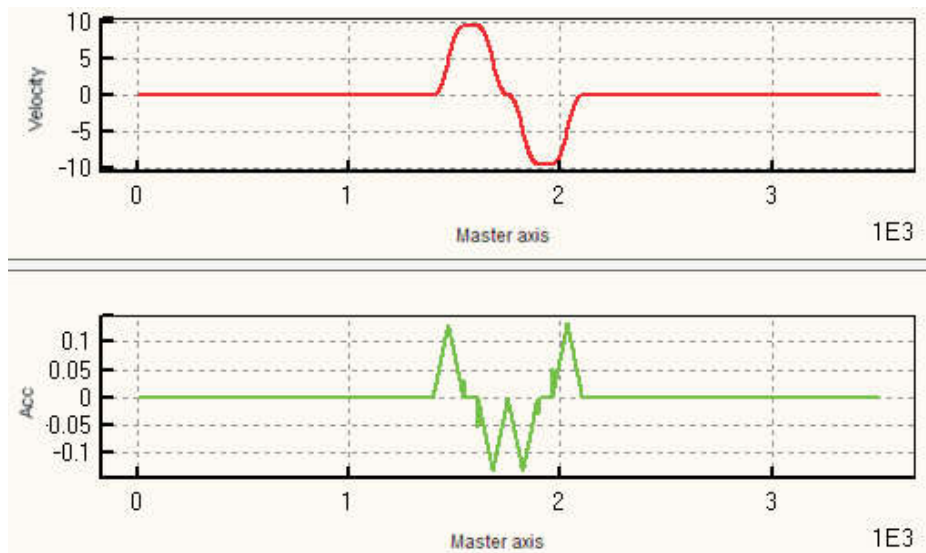   2000/3=667 pulse
   Parameter 4: Synchronization rate= Slave pulse for 1mm/ Master pulse for
         1mm = (1000/20)/(1000/60π) = 3π (Floating)
   Parameter 5: Highest synchronization rate: 10 (Floating)
   Parameter 6: Low word: H1: Uniform acceleration
         High word: H0: can't work.

ECAMTBX Instruction
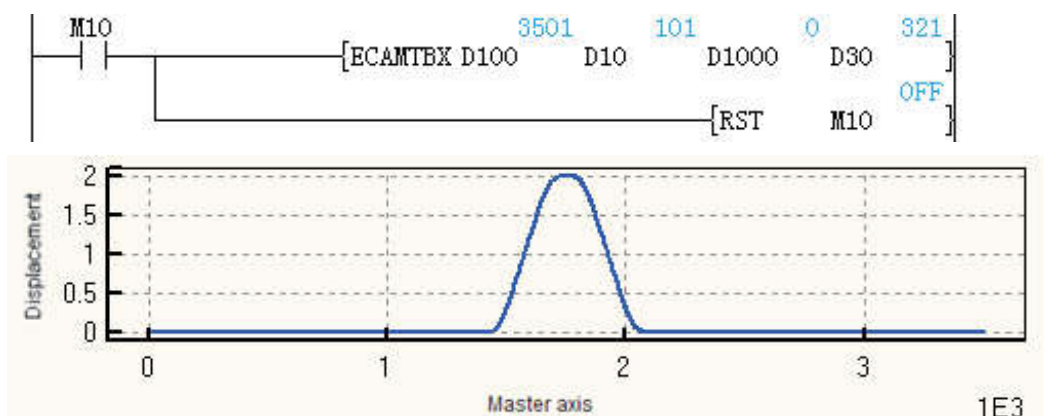
3 S-type acceleration& deceleration curve

Datasheet of S-type acceleration& deceleration is generated under the following conditions: give time of acceleration and deceleration and given top speed.

3.1 S type acceleration/deceleration speed parameters

| Parameters	Offset	Explanation	Format	Unit	Range
		S type acceleration/deceleration speed parameters settings			
P1	NO.0	Length of the material feeding axis.	32-bit Integer	Pulse	
	NO.1				
P2	NO.2	Max speed	32-bit Integer	Hz	0-150000
	NO.3				
P3	NO.4	Reserved	Reserved		
	NO.5				
P4	NO.6	Acceleration time	16-bit Integer	ms	0-32767
P5	NO.7	Deceleration time	16-bit Integer	ms	0-32767
P6	NO.8	Resolution	16-bit Integer	ms	51-512
P7	NO.9	Reserved			
P8	NO.10	Master axis pulse in last section	32-bit Integer	Pulse	
	NO.11				
P9	NO.12	Slave axis pulse in last section	32-bit Integer	Pulse	
	NO.13				
P10	NO.14	Uniform time	32-bit Integer	Pulse	Generated by internal
	NO.15				
P11	NO.16	The max speed in Chart result	32-bit Integer	Hz	
	NO.17				
P12	NO.18	Reserved			
P13	NO.19	Results of Chart generation			

3.2 Calculation Cas

1. Control parameters

Total number of pulses (length): 10000 pulses;
Acceleration time: 100ms;
Deceleration time: 100ms;
Resolution: 200;

2. Other Parameters:

Parameter 1: total number of output pulses: 10000;

Parameter 2: top speed: 50000;

Parameter 3: 0;

Parameter 6: acceleration time: 100ms;

Parameter 7: deceleration time: 100ms;

Parameter 8: resolution: 200;
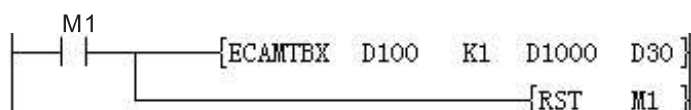
Datasheet of this case is as following shows,
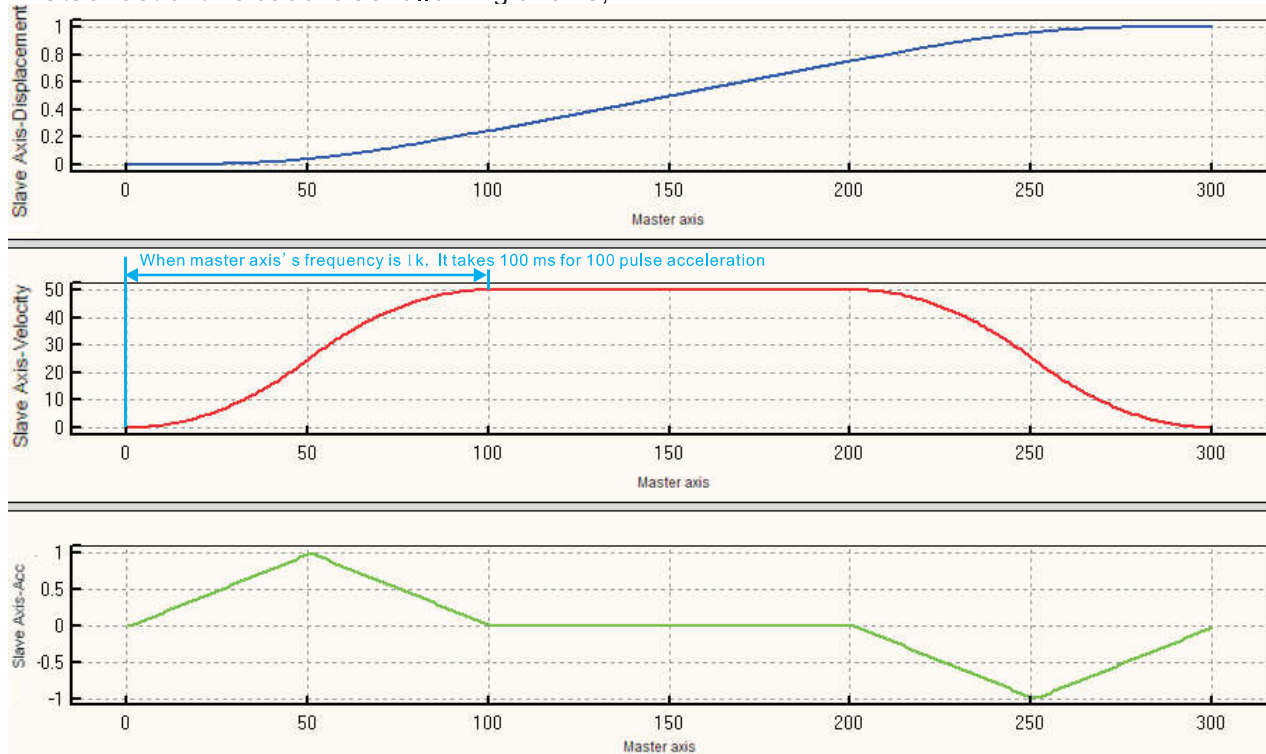
4. Special address

D8141 (high byte), D8140 (low byte): The number of output pulse in Y000. It will reduce when reversal(32-bit);

D8143 (high byte), D8142(low byte): The number of output pulse in Y001. It will reduce when reversal(32-bit);

D8151 (high byte), D8150(low byte): The number of output pulse in Y002. It will reduce when reversal(32-bit);

D8153 (high byte), D8152(low byte): The number of output pulse in Y003. It will reduce when reversal(32-bit);

M8145: Stop output pulse in Y000 (stop immediately);
M8146: Stop output pulse in Y001 (stop immediately);
M8152: Stop output pulse in Y002 (stop immediately);
M8153: Stop output pulse in Y003 (stop immediately);

M8147: Monitoring the output pulse in Y000 (BUSY/READY);
M8148: Monitoring the output pulse in Y001 (BUSY/READY);
M8149: Monitoring the output pulse in Y002 (BUSY/READY);
M8150: Monitoring the output pulse in Y003 (BUSY/READY).