PRODUCT FAMILY: Sure Servo   **Number:** AN-SERV-003

**Subject:** Sureservo rotary cutter example   **Date issued:** Oct-16-2006

Revision: Rev A, March-17

In this example,we will control the rotary cutter shown on the diagram below to get a cut on labels for bags with a synchronized speed with the web, on a system to manufacture bags. We will control the system with a servomotor, a PLC DL06 and a panel EA1-S3ML-N.

We will determine in this document the kinematics and the dynamics of the movement and discuss some design considerations, including the servomotor sizing and then we will wire the servo drive to the PLC DL06. We will show the wiring of the drive, the program of the PLC and the programming of the servo drive.

See the following diagram to explain the concept.
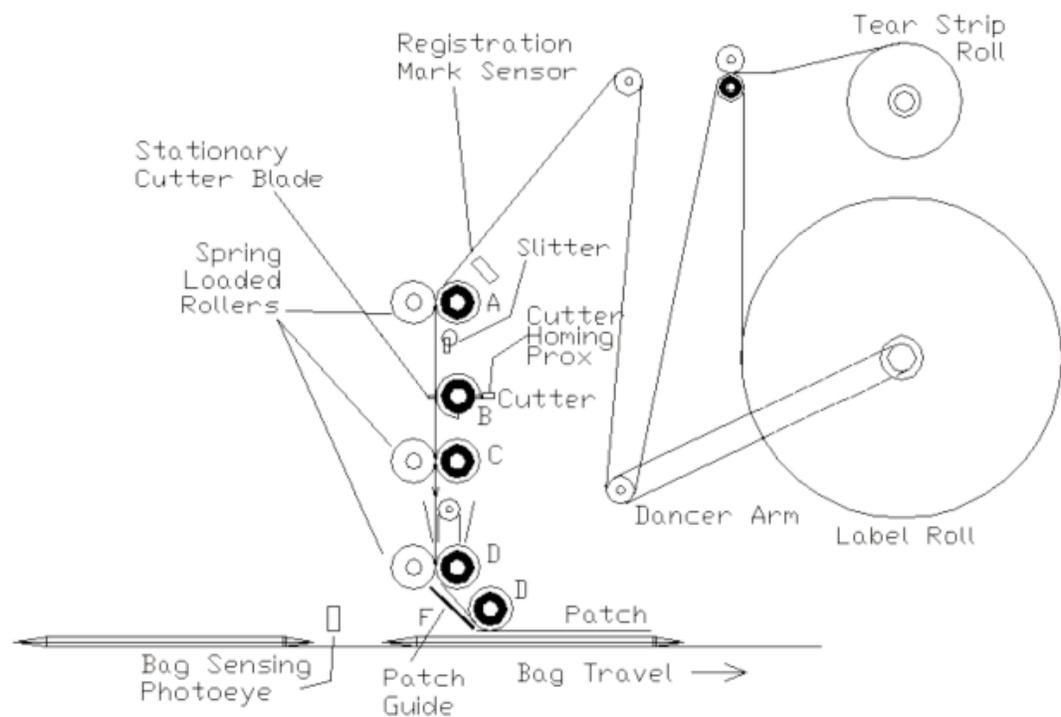
The web will be moving at a maximum set speed of 1 m/s. The cutter B has a diameter of 180 mm with a blade that cuts the web at a synchronized speed. The speed is read with an encoder on the roller A, with a diameter of 180 mm. The web has a registration mark that allows to sense when the cutter has to start to get the cutter blade at the proper position to cut the web at certain distance of the registration mark. The blade will cut the web and after that, the roller will increase the speed such that it allows to come back to the original starting position. The cutting of the web should be 13 inches or 22 inches. See more details on the following diagram.

The technical data for the cutter roller are:

Roller diameter   180 mm
Roller inertia   0.55 Kg-m^2
Gear head ratio: to be selected
Blade length   10 mm

The technical data for the encoder roller are:

Roller diameter   180 mm
Pulses per revolutions   2000 ppr
Encoder selected   TRD-N2000-RZVWD

The distance from the registration mark up to the cutting position is 900 mm.

The servomotor should accelerate from the initial position to the cutting position in such a way that the speed of the cutter roller is the same at the web at the time the cut is done.

Let us see the conditions:

Since the web speed is 1 m/s at the most, the tangential speed of the roller is determined with the formula

w [rad/s]=v [m/s]/r [m]

since v = 1 and r is 0.1 [m], the rotational speed is 10 radians/second; that is, 1.5915 cycles per second or 95.49 rpm.

280 mm

220 mm

400 mm

Encoder

Cutter

Blade @ 180

The registration mark is detected with a photoelectric sensor, called **mark sensor**, that is connected to an input of a PLC DL06.

The cutting at 22 inches corresponds to cut the web every 558.8 mm.

The cutting at 13 inches corresponds to cut the web every 330.2 mm.

The distance to be cut has to be controlled by a precise speed control of the web.

Obviously, the mark should be separated by the proper distance. It will be necessary to work with specific marks on each web, with different marks spacing, one every 558.8 mm and the other every 330.2 mm.

The total time to complete a revolution of the blade roller should be less than 556 ms with 22 inches patch, since the web is running at 1 [m/s] or 330 mm in the case of a patch of 13 inches.

The concept for the operation is to use 2 roller speeds, one that corresponds to the web speed for 22 inches and the other arbitrarily at about double the speed.

If we define the start position (Home) is at 45 degrees from the cutting point, first we will command the servo to go to the low speed, **at the synchronized speed**, and when the PLC detect the signal from the proximity sensor called **blade sensor**, the speed should change to the maximum speed, to compensate for the lost time on the first movement. On a third point, there a a third sensor, called c**utting homing sensor**, to tell the servo to stop. To further explain the concept, please see the next diagram.

Cutter roller

Starting point at 45 degrees
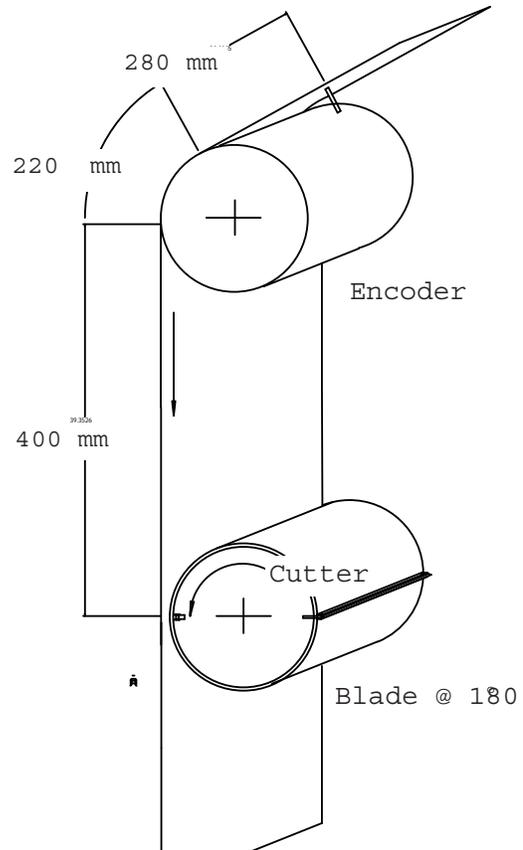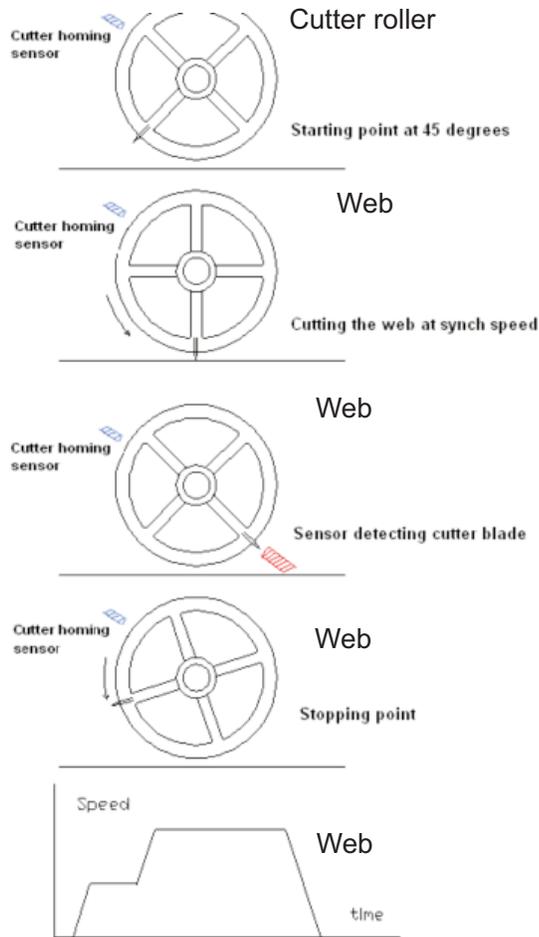
1) Starting time of displacement at low speed.This is activated with the signal of the **mark sensor**.

Web

Cutting the web at synch speed

2) Cut time during displacement at synchronized speed.

Web

Sensor detecting cutter blade

3) Starting time of displacement at double the synchronized speed. This is activated with signal of the **blade sensor**.

Web

Stopping point

4) Stopping time of displacement to position B.This is activated with the signal of the **cutter homing sensor**. This sensor should be position adjustable, to determine the proper stop point

Web

Expected speed profile of the blade roller. The blade roller will be syncronized with the speed readings of the encoder.

Kinematics

Let us assume that the **mark sensor** input takes 10 [ms] to react on the PLC and give to the servo drive the trigger pulse to go to the proper speed. We have assumed arbitrarily that the servo has been stopped at 45 degrees from the cutting point and it has to accelerate to the maximum speed in 50 [ms].

The blade roller has to go to an eight of a turn (12.5%) to get the point where the blade will be cutting the web. On the first 25 [ms] of the displacement the speed will change from 0 to 1.5915 [rev/s] on the cutter roller; then the acceleration will be 1.5915 [rev/s]/0.025 = 63.66 [rev/s^2].

The % of revolutions will be $s=1/2*(v_1 - v_0)*t$ = 1/2*1.5915*0.025= 0.01989 or 1.989% of a revolution.

The time to get the cutting point is determined by the time it travels at constant speed to displace 0.125 - 0.01989 revolutions = 0.123011 [rev]; the additional time above the 25 [ms] will be calculated with the formula v=s/t; since s and v are known, then

$t= s/v$ => 0.123011 [rev]/ 1.5915 [rev/s] = 0.0771228 [s] or about 77 [ms].

On the time 112 [ms], the cutter blade had reached the point when the **blade sensor** pulse is detected, and had cut the web at sync speed. When the mark input has been positively energized, the PLC can generate other speed reference. Let us say that the PLC takes another 10 ms to react to the pulse. Since the speed is constant at 1.5915 for 10 ms, the movement is s=v*t = 1.5915X0.01 = 0.0015915 [revolution].

At the time 122 [ms] the servo system should accelerate to get to the final speed to move one revolution. That is, it should displace the rest of the blade roller to complete a revolution and then stop when the **cutter homing sensor** is reached..

Then, the time for taking the servo from 1.5915 rps to 3.183 rps is another 25 ms, since the ramp in this case has been designed for 50 [ms] and the ramp is a 50% of the total ramp. Again, the displacement will be calculated with the formula

 $s=1/2*(v_1 - v_0)*t$ = 1/2*(3.183-1.5915)*0.025= 0.019893 revolutions. The cutter roller have moved in total 0.123011+0.0015915+0.019893 = 0.144496 [rev], that is 14.4496 % of a revolution. The rest is 1.0 - 0.40915 = about 85.55%. Then we have to move faster to avoid that the mark pulse reach us while still not completing a revolution.

The time to move the rest of the displacement at a constant speed of 3.183 rev/s will be t= s/v = 0.8555/3.183 seconds= 0.26877 s or about 26.9 ms.

Obviouly the time will be larger because some aditional time will be used during the deceleration (50 [ms])

The rotation during the deceleration is 1/2*3.183*0.05 = 0.07957 [rev] or about 7.96 %; then, the time to move to the rest of the revolution is calculated by first determining the displacement on the rest of the revolution:

85.55- 7.96% = 77.54% at a constant speed of 3.183 [rev/s] or 0.2436 [s] or about 243.6 [ms]. Theoretically the time will be 10+ 25+77+10+25+243.6+50 = 440.6 [ms].

See that this time is enough for the case of cutting at 550 ms (22 inches, but not for the case of 13 inches). Other faster speed will be necessary for the case of 12 inches) or a slower web speed is necesary. Since the servo can only go to 3000 rpm, the only option is to decrease the web speed.

The result is shown on the diagram below:
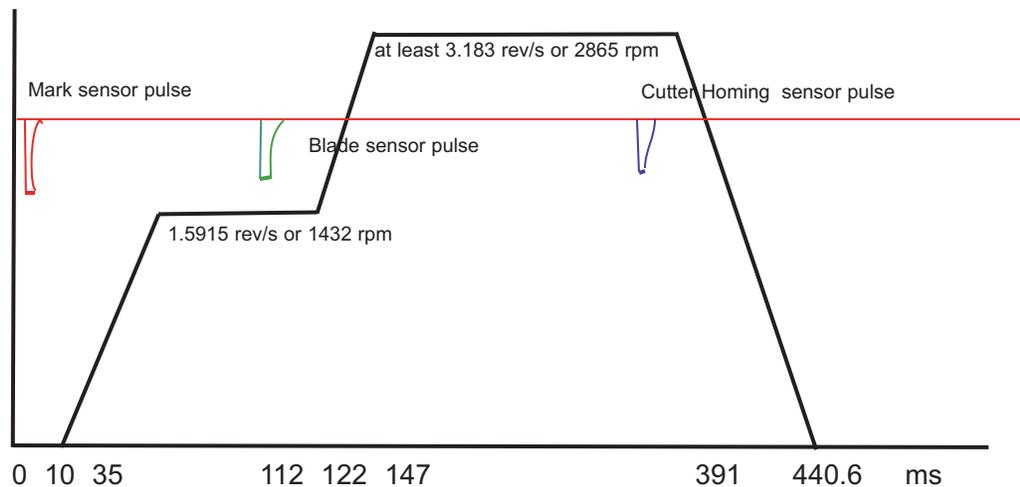
Dynamics

Two components will intervene here to determine the resistive torque. One is the friction torque and the other is the dynamic torque.

The friction torque is the opposing resistive torque given by the bearings, the selected gear reducer and the servo friction. Since we do not know these values, let us guess a conservative friction torque of 5 [N-m]. This determination may requiere measurements.

The dynamic torque will be **Tdyn{N-m}= J[Kg-m2]*dw [rad/s]/dt [s]**

being **J** the total inertia, **dw** is the speed change (acceleration) in radians/second and **dt** the time to change speed at constant acceleration.

When moving to the first position, the drive should use the velocity of the web.

The inertia of the roller is 0.55 [Kg-m^2]; we do not know the reducer and servo inertia and for this reason we will assume those insignificant at this time; on a second trial we will consider the final values after selecting one reducer and one servo motor.

During the acceleration between 10 to 35 [ms] and 122 to 147 [ms]

$T_{dyn\{N-m\}}$= 0.55[Kg-m^2]* 10 [rad/s]/ 0.025 [s] = 220 [N-m]

During deceleration:

$T_{dyn\{N-m\}}$= 0.55[Kg-m^2]* 20 [rad/s]/(441-391) [ms] = -220 [N-m]

The torque on acceleration is 225 [N-m] and on the deceleration is -215 [N-m].

The curves obtained are:

From here we can see that the need of a reducer is important, since we have to deliver a relatively big torque of about 220 [N-m].
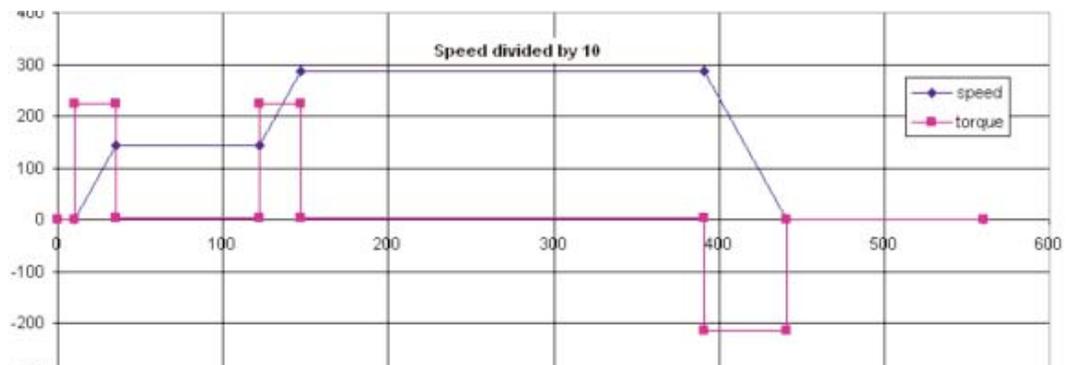
Let us do a table to see what would be the proper reducer selection:

Ratio	Servo torque [N-m]	Speed [rev/min]
Direct	225	95.49 rpm
5:1	45	477.45 rpm
8:1	28.1	763.92 rpm
15:1	**15.0**	**1432.35rpm. It seems the selected one.**

The dynamic torque on the second ramp acceleration period is the same, because the acceleration time, the speed change and the inertia are the same.

The motor SVM-220 will deliver the torque of up to 15.7 [N-m] in the intermitent range. Since the time is short , this could be the selected servomotor.

However, we have to remake the calculations to check that the reducer and the motor inertias are considered on the dynamic torque calculations.

The total inertia now is the addition of the roller, the reducer and the servo motor:

Let us select a SHIMPO reducer type ABLE VRAFE0902000035000, frame E, with an inertia of 3.75 Kg-cm^2 These are the inertia values

Cutter roller : 0.55[Kg-m^2] referred to the load

Gear reducer 0.000375 [Kg-m^2] or 0.084375 [Kg-m^2] referred to the load

Servomotor 0.00158 [Kg-m^2]or 0.3555 [Kg-m^2] referred to the load (for next size)

Total inertia is 0.989875 [Kg-m^2] referred to the load

We referred the inertia to the load side by transfering the inertia using the square of the reducer ratio.

During the acceleration between 10 to 35 ms:

$T_{dyn\{N-m\}}$= 0.989875[Kg-m^2]* 10 [rad/s]/ 0.025 [s] = 395.95 [N-m]

During deceleration:

$T_{dyn\{N-m\}}$= 0.989875[Kg-m^2]* 20 [rad/s]/0.05 [ms] = -395.95 [N-m]

Torque on acceleration is 400.9 [N-m] and on deceleration is -390.9 [N-m].

The curves obtained are:
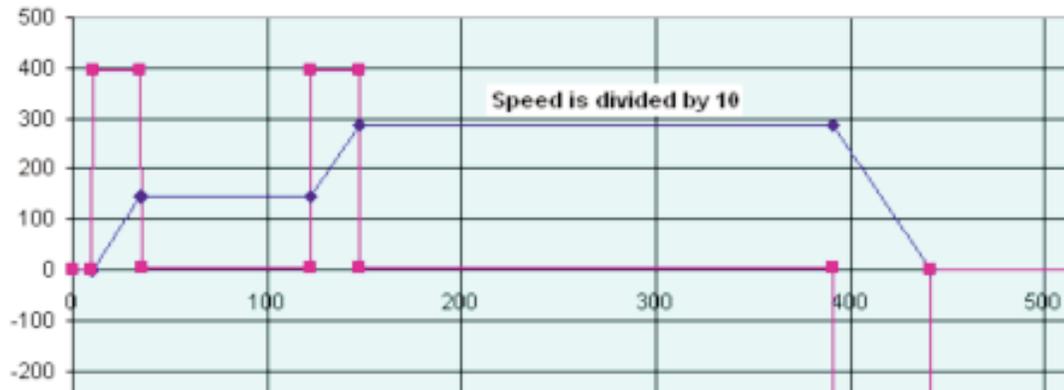
Let us do a table to see what would be the proper reducer selection:

Ratio	Servo torque [N-m]	Speed [rev/min]	Max speed is 3000 rpm
Direct	400.95	95.49	
5:1	80.19	477.75	No servo torque capability
8:1	50.11	763.92	No servo torque capability
15:1	26.73	1432.35	This is the correct one.

The motor SVM-220 is short on the torque in the intermittent range by 12% and then the acceleration has to be decreased. Let us increase the time to 60 ms (20%) and this will satisfy the needs and also more than the double speed is required on the second movement to satisfy the time before other mark pulse comes. Inertia ratio is 0.989875/0.355 = 2.78. Excellent ratio.

Considerations on how to control the drive with the PLC

Then, the system could be starting aproximately every 558 ms when the speed is 1 m/s. Obviously, the period of the cycle will be different if the web speed is smaller. The speed will be given by a following action based on the reading of the encoder.

The encoder reading will be done with a H0-CTRIO2 module. The encoder feedback is transformed directly in servo rpm by the H0-CTRIO2 and transferred to the PLC; the result of the calculation will be contained in a register. The acceleration and deceleration are not dependent on the current speed, but will be defined for the maximum speed. Recall that the slope of the acceleration will be given by the parameter P1-55. The criteria of control makes independent the slope with the current web speed. The servo drive will receive data from the PLC thru a MODBUS communication done with a D0-DCM.

Then, let us consider the following steps to generate the servo drive control:

a) The servo will have the DI1 input defined as **Servo Enable**. The corresponding PLC output is Y1. The servo shaft will rotate 15 revolutions by every roller revolution. The start will corresponds to about 45 degrees before the cutting position, but will be set on the start up. For that, the servomotor will have a position that has certain relationship with the blade on the cutting position. This will be studied later.

b) The Servo drive is configured as Vz mode, with the parameter P1-01 as 104.

c) The registration **mark sensor** will generate a pulse to report to the PLC to start the movement of the roller. Let us say that the sensor input is X0.

d) The speed of the blade roller should correspond to the encoder rpm, which is 95.49 rpm in this case; that is, the PLC will copy the calculated speed from the encoder (finally the web speed) to the proper register that is the preset velocity 0. The servo required speed is 15 times higher, that is, 1432 rpm. The corresponding parameter will be P1-09.

e) The PLC generates an output Y11 to set DI2 as ON to force the servo to run at the preset speed in P1-09 when the conditions are met.

f) The servo will go to the defined speed, at the acceleration defined on parameter P1-34. We intend that the acceleration be 60 ms to go to 191 rpm on the cutter. The servo required speed is 15 times higher, that is, 2865 rpm. If we define the maximum speed at 3000 rpm on parameter P1-55, the value that we have to define in P1-34 maintains the same slope. The same is valid for the deceleration.

g) At certain point, the blade will cut the web. Theoretically, this would be at 112 [ms] from the **mark sensor** pulse, that is, exactly at 12.5% of a revolution. This might change slightly and this should be defined during the commissioning of the machine.

h) The point of changing to the high speed is defined with a second sensor, the **blade sensor**; The servo required speed is about double than the previous one, that is, about 2865 rpm. If we define the maximum speed at 3000 rpm on parameter P1-55, the value that we have to define in P1-34 maintains the same slope. The same is valid for the deceleration.

i) The point of stopping is defined with a third sensor, the **cutter homing sensor**; to indicate that the servo has to stop, to keep a consistent stop position. The Stop command should be given after detecting this sensor and the servo will decelerate at a rate of 50 ms.

i) The position of the cutter homing sensor may have to be found on the commissioning of the drive. The ideal position should be about 95 degrees before the cutting point, but it is not necessary such precision.

h) The servo will stop and keep waiting for the next command from the **mark sensor** to go to the low speed. If the speed changed in the meantime, the program will take care automatically for the necessary adjustment. This algorithm is not dependent on the web speed up to a certain extent.

i) The speed is read by the encoder. In this note we only show the concept for the web speed of 1 [m/s], but the concept can be applied for any speed below 1 [m/s]. The D0-DCM transmits at a rate of about 46 writings per second or 22 [ms] and it is expected that the web moves at a constant speed. The encoder roller has a diameter of 180 mm, and for this reason, when the web is moving at 1 [m/s], the roller is rotating at **w** [rad/s]=v [m/s]/r [m], or 1/0.09 = 11.1111 [rad/s]; this translates into 1.76838 cycles per second, or 106.10 rpm. On the other side of the gear head the speed is 15 times faster, or 1591.54 [rpm]. for an encoder of 2000 pulses per revolution, the pulses per second are 3536.77 pulses, rounded to 3536 pulses. Small error that may affect the accuracy!

MODBUS communications

The servo drive may communicate thru serial communication at a maximum speed of 115.2 kBaud. For this practical application, we elected to use a D0-DCM module in the slot 3 of the PLC DL06.

The cabling between the port 2 of the D0-DCM has been implemented with a cable SVC-485HD15-CBL-2 connected with the wiring as follows:

The changes of speed and the condition that the parameter P2-30 should be 5 to disable the writing into EEPROM will be handled by MODBUS communications.
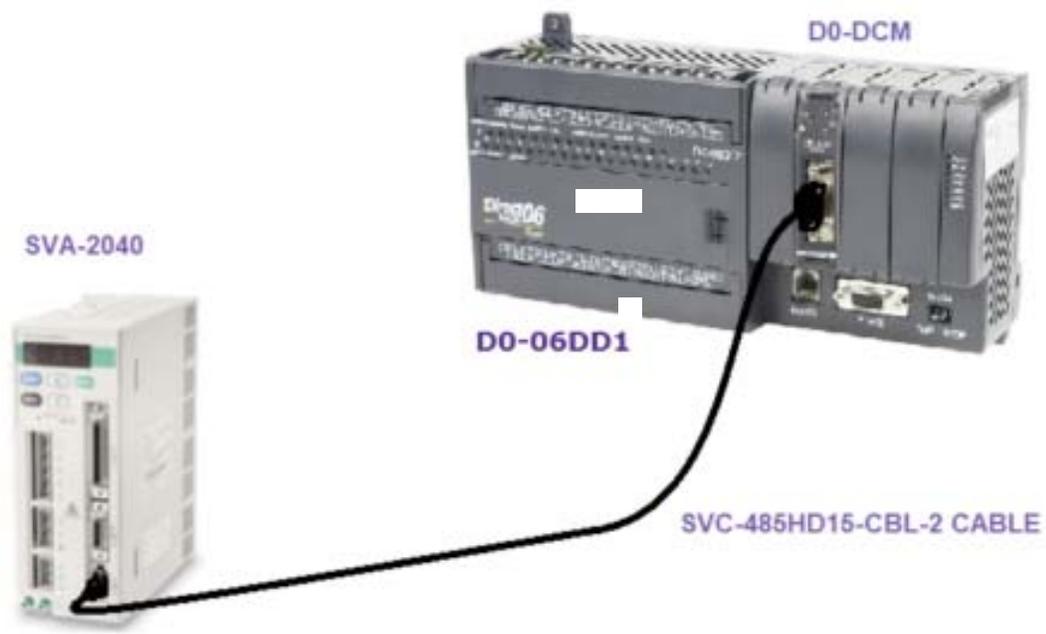
The only task of the MODBUS communication is to trasmitt the web speed for synchronization. We have selected the velocity mode Vz, to ensure a 0 speed when the cuttler roller has to stop. Other possible option would be to use analog signal for speed control, but there is the problem of zero speed offset.

The matter of the communication programming is shown in detail on the explanations of the ladder diagram and and it is presented here for a wide variety of other practical applications.

Control with an operator panel.

The C-more micro operator panel will have the following functions on the application note.

- A button to enable the servo (F2)

- A button to start the motion (F4)

- A button to reset the counter for the number of bags (F5)

- A numeric display of the current cuts.

- Status of the servo.

The reader can add functions, specially if the serial communication is implemented.

The following figure shows the screen of the panel, as done on the prototype system to test the concept.

The buttons F2 and F4 are toggle type.The button F5 is momentary On.
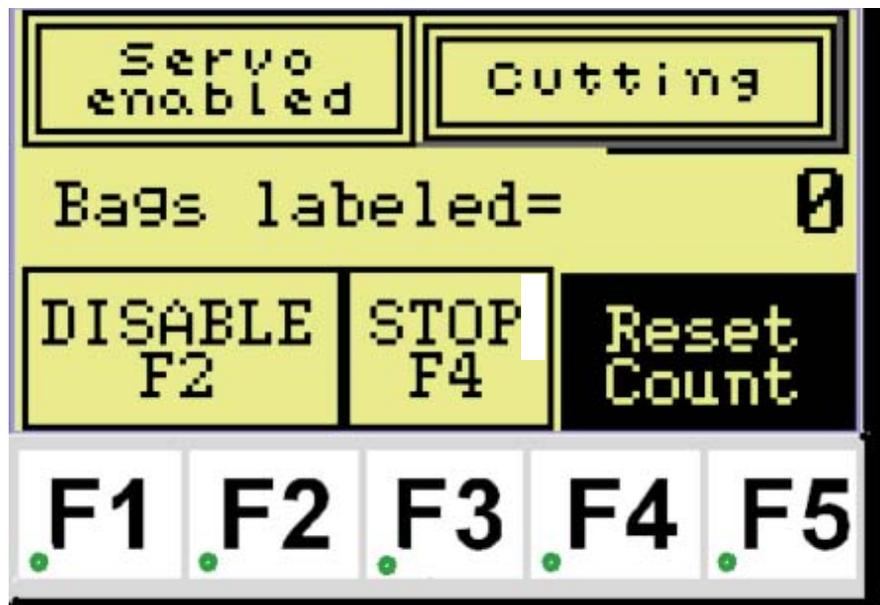
W iring between PLC and servo drive

On the PLC we will select the following functions and the corresponding output:

C100 is the **Enable** command (F2), coming from the operator panel, C101 is the Cut command (F4) to initiate the movement. X1 is the **Sensor to detect the registration mark**. X1 is the **cut sensor**. X2 is the **cutter homing sensor**.

Y10 will be the **Servo Enable**. Y11 will be the signal select velocity 0 preset. Y12 will be the signal select velocity 1 preset**.**

In the diagram below are shown the control connections necessary to make the system work as required.
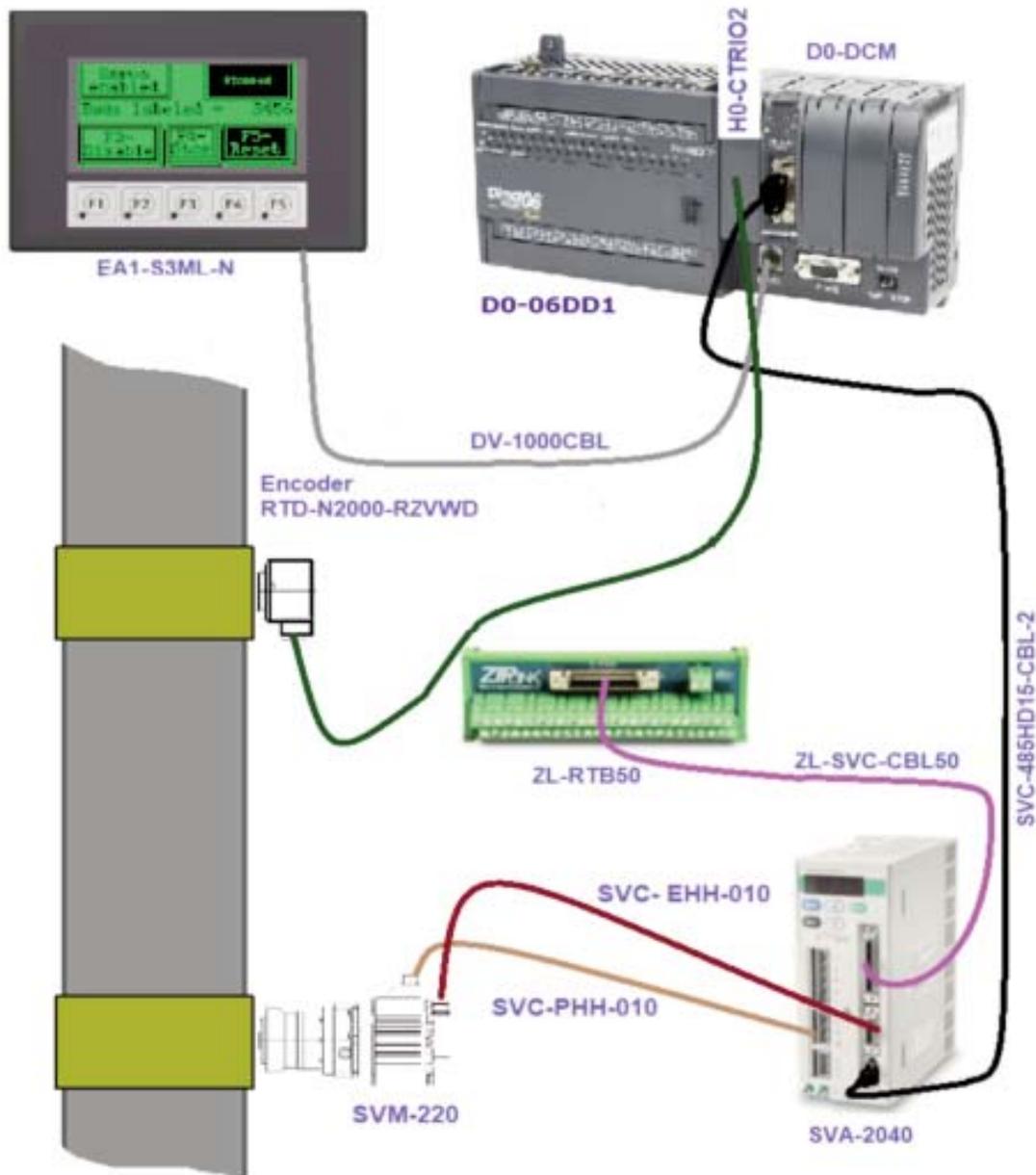
PLC ladder diagram

On the following pages it is shown the code to make this work. At the right side of the diagram are explained the details of each rung.

There are also some additional explanation on the rung comments or on the left side of an specific instruction , to highlight the importance of the code.

Rung to define X0 and X1 as pulse catch inputs

1
_FirstScan
SP0

LD	K50
OUT	V7633
LD	K5
OUT	V7634
LD	K106
OUT	V7636
OUT	V7637

The PLC DL06 can capture short time pulses and extend the pulse for one scan. We use this feature for this program and this rung is the configuration for the mode 50, pulse capture. See more details elsewhere on the DL06 manual

Rung to configure the module D0-DCM and various constants

2
_FirstScan
SP0

LD	KE0
OUT	V712
LD	K1601
OUT	V713
LD	K0
OUT	V716
LD	KAA
OUT	V717

This rung defines the functions of the port 2 on the communication module D0-DCM.
The module is located on slot 2 and it will use MODBUS RTU, as RS-485 with a baud rate of 115.2 kbps, parity ODD and 1 stop bit.

A "0" to define a value of V3100 different from "5" on the first scan.
A "5" to define a value of "5" on the parameter P2-30.

LD	K0
OUT	V3100
LD	K5
OUT	V3102

Beginning here we define some constants to be used during the program execution.

Constants to be used to calculate the current speed, based on the pulses coming from the encoder TRD

LD	K1432
OUTD	Web base speed V3030
LD	K3536
OUTD	counts/1432 rpm V3040

3
V3100 ─┤≠├─ K5 ──────────────(C200 SET)

C200 is true if the content of V31000 is not "5"

4

C200 ——| |—— SP124 ——|/|—— 1-30readcomplete C0 ——|/|——

```
LD
     K302
```
```
LD
     K2
```
```
LDA
     O3100
```
```
RX
     CTA36
```

1-30readcomplete
C0
—(SET)

If C200 is true on this rung, we read the value on V3100 on the initial operation. It will be "0". we set the bit C0 as ON and then, after being executed the next rung, on the next scan it will read a "5" as content of the memory V3100.

5

C200 ——| |—— SP124 ——|/|—— 1-30readcomplete C0 ——| |——

```
LD
     K302
```
```
LD
     K2
```
```
LDA
     O3102
```
```
WX
     TA12
```

1-30readcomplete
C0
—(RST)

If C200 is true on this rung, when the reading transaction is done, we write a "5" into the parameter P2-30 with the help of the block transfer parameters.
V3100 has a 5 now.

C0 is reset.

6

C200 ——| |—— 1-30readcomplete C0 ——|/|—— C200 —(RST)

If C200 is true on this rung AND the bit C0 is OFF, we reset C200. C200 will not be ON for the rest of the time the PLC is powered ON.

7

V3100 —[=]— K5 —— HMI ENABLE C100 ——| |—— Servo Enable Y10 —(OUT)

When the drive is with P2-30 with a value of 5, we can enable the servo with the help of the panel

8

Sync speed C10 ——| |—— speed select 0 Y11 —(OUT)

C10 and C11 will activate the outputs Y11 and Y12, to define the preset speed bits 0 and 1.

9

High speed C11 ——| |—— Speed select 1 Y12 —(OUT)

10

HMI CUT C101 ——|↑↓|——

Sync speed C10 C11 —(RST)

C30 —(RST)

When the cutting operation is stopped, the preset speed bits are reset and this causes the servomotor to stop (In reality keeps speed 0 rpm, with holding torque).

Rung that activates the cuts

11

HMI CUT C101 ——| |——

K1 —(MLS)

C101 is activated from the panel when the web is at constant speed.

```
            Mark sensor                                    Sync speed
            SP100                                          C10
   12       ─┤ ├──────────────────────────────────────────( SET )

            Blade sensor

                                                           Sync speed
            X3                                             C10
   13       ─┤ ├────────────────────────────────────┬─────( RST )

                                                           High speed
                                                           C11
                                                    └─────( SET )


            STOP sensor                                    High speed
            X2                                             C11
   14       ─┤ ├──────────────────────────────────────────( RST )


            SP124     C20                            ┌──────────────┐
   15       ─┤/├──────┤/├──────────────────────────┤ LD           │
                                                    │         K302 │
                                                    ├──────────────┤
                                                    │ LD           │
                                                    │          K2  │
                                                    ├──────────────┤
                                                    │ LDA          │
                                                    │        O4000 │
                                                    ├──────────────┤
                                                    │ RX           │
                                                    │         TA6  │
                                                    └──────────────┘
                                                           C20
                                                    └─────( SET )


            SP124     C20                            ┌──────────────┐
   16       ─┤/├──────┤ ├──────────────────────────┤ LD           │
                                                    │         K302 │
                                                    ├──────────────┤
                                                    │ LD           │
                                                    │          K2  │
                                                    ├──────────────┤
                                                    │ LDA          │
                                                    │        O3000 │
                                                    ├──────────────┤
                                                    │ WX           │
                                                    │              │
                                                    │  Param P0-10 │
                                                    │         V411 │
                                                    └──────────────┘
                                                           C20
                                                    └─────( RST )


                                                           K0
   17       ─┬────────────────────────────────────────────( MLR )

            │
   18       ─┼────────────────────────────────────────────( NOP )

            │ Bag counter that counts a web cut at a time
            │
            │   High speed                           ┌──────────────┐
            │   C11                                  │ CNT          │
   19       ─┴──┤↑├──┬───────────────────────────────│              │
                     │                                │       CT10   │
                HMI count reset                       │              │
                C102 │                                │      K9999   │
                ─┤ ├─┘                                └──────────────┘
```
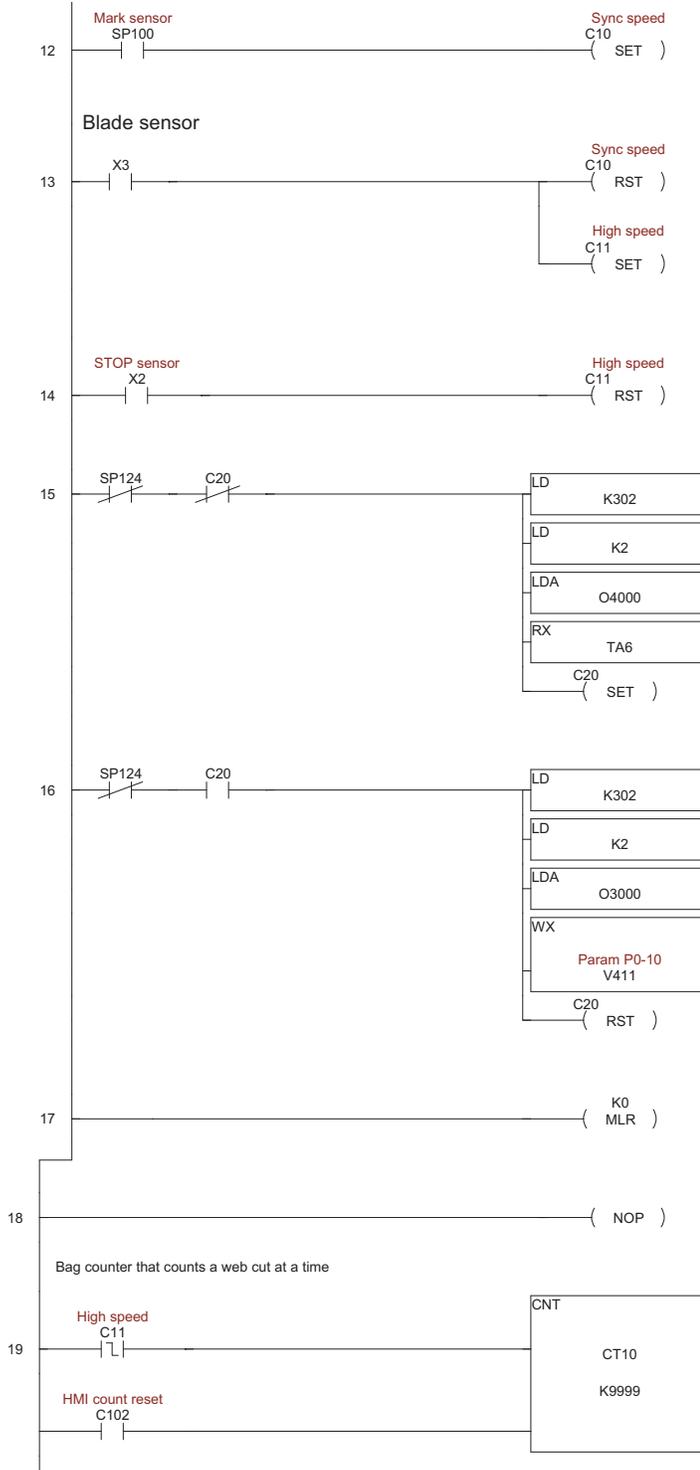
The mark sensor activates the C10 bit. This activates Y11, preset speed bit 0.

The blade sensor activates the C11 bit and resets C10. This activates Y12, preset speed bit 1.

The cutter homing sensor resets the C11 bit.

These rungs do continuous reading and writing of data using the module D0-DCM.

The most important is the writing of the current speed.

The current spped is contained in V3000. V300 is populated with the speed value calculated by the module H0-CTRIO2, when reading encoder pulses.

The accumulated count of the labels cut would be usefull for the operation. This rung counts the cuts done.

Page 3

```
 _1Second                                    clock 1 s
   SP4                                          C2
  ──┤├──┤├───────────────────────────────────────( PD )

 clock 1 s                            ┌──────────────┐
   C2                                 │LDD           │
  ──┤├──┤├─────────────────────────── │ Encoder counts│
                                      │    V10000    │
                                      ├──────────────┤
                                      │SUBBD         │
                                      │       V3010  │
                                      ├──────────────┤
                                      │OUTD          │
                                      │       V3020  │
                                      ├──────────────┤
                                      │BCD           │
                                      │              │
                                      ├──────────────┤
                                      │MULD          │
                                      │ Web base speed│
                                      │    V3030     │
                                      ├──────────────┤
                                      │DIVD          │
                                      │ counts/1432 rpm│
                                      │    V3040     │
                                      ├──────────────┤
                                      │BIN           │
                                      │              │
                                      ├──────────────┤
                                      │OUTD          │
                                      │ Servo SP speed│
                                      │    V3000     │
                                      └──────────────┘

 clock 1 s                            ┌──────────────┐
   C2                                 │LDD           │
  ──┤├──┤├─────────────────────────── │ Encoder counts│
                                      │    V10000    │
                                      ├──────────────┤
                                      │OUTD          │
                                      │       V3010  │
                                      └──────────────┘

  ──────────────────────────────────────────────( END )

  ──────────────────────────────────────────────( NOP )
```
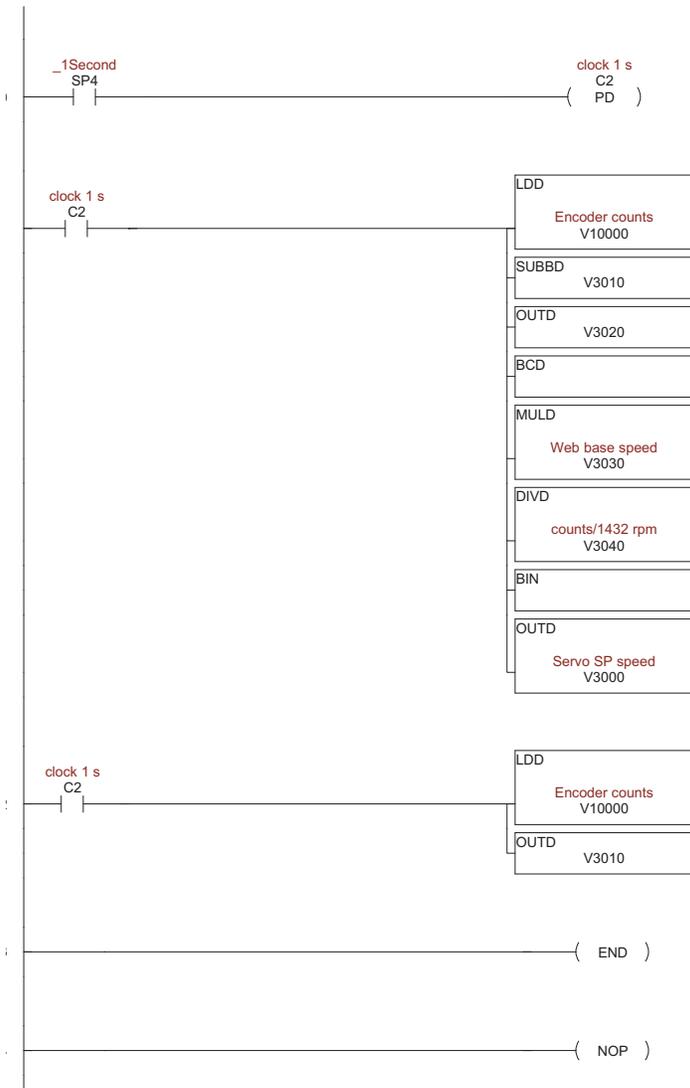
These 2 next rungs makes calculations of the current speed based on the counts supplied by the encoder pulses being read by the module H0-CTRIO2.

Here are used the constants defined on the first scan, to correct the value of speed
Iti s important to correct the speed value to assure a synchronous speed activated with the output Y11.

Tuning.

Before the system goes into operation, it could be necessary to tune the servo drive to the mechanical system; otherwise you would get oscillations when the system is put into operation.

The tuning can be done with the help of the SureServo Pro software. The standard white cable SVC-PCCFG-CBL is used to connect the PC with the servo.

Create a new configuration, give a name, reset the parameters to default, setting 10 on parameter P2-08, and use the parameters defined earlier:

For this action, go to the menu **Utilities>Current config>Print current config.**

The tuning done on the prototype for this app note was a manual tuning for velocity.

Set the scope by going into the menu **Utilities>Scope** and set the capture as "Triggered single capture" with the condition "Starts when the speed is greater than 5 rpm" and set a time range of 6 seconds, for example.

The tuning parameters P2-04 and P2-06 will be different than the real application, and every application has a different set of values.

The procedure adopted here was the following, using the keypad of the drive:

- Disable the servo drive and set P2-32 to 0 and then re-enable the servo drive.

- Set the value 0f P2-06 to 0 (this is the integral gain of the velocity loop)

- Next the value of P2-04 has to be adjusted. Let us start with 5000.

- Use the parameter P4-05 to define a JOG speed of let us say 1000 rpm, and then create forward and reverse pulses aproximately every second. See if the curve is not oscillating. In the prototype for the application note the following figure shows the the curve obtained. So far so good!.
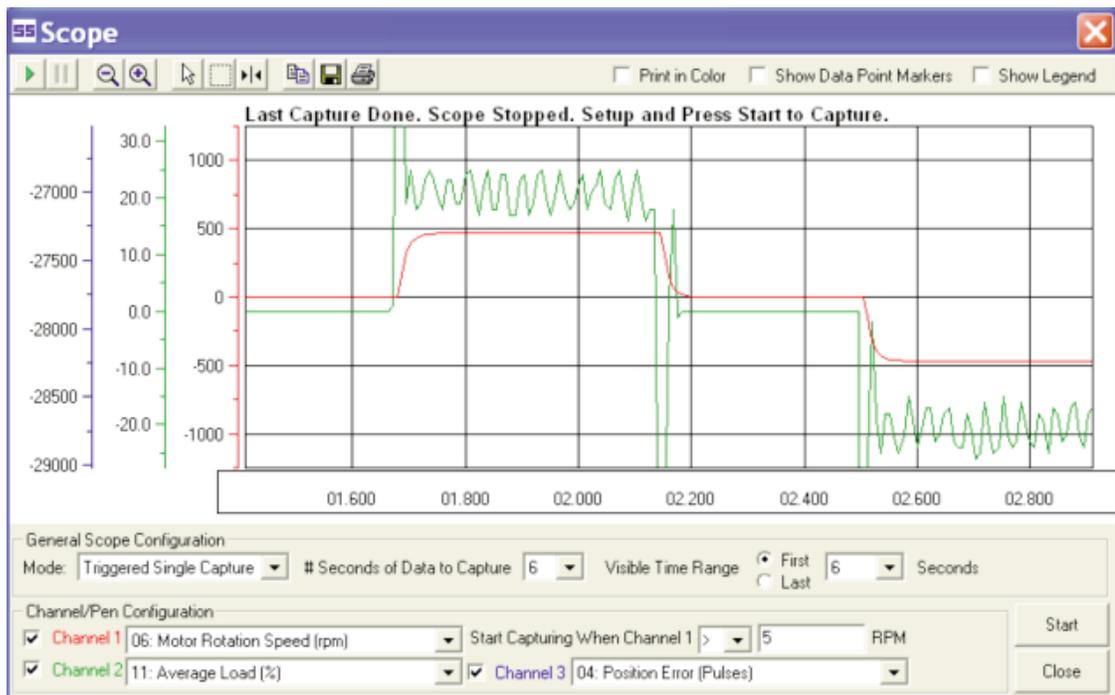
First trial P2-04 = 5000

The curve indicates us that the P2-04 can be increased. We selected P2-04 as 9000; In the prototype the following figure shows the the curve obtained. It is oscillating.
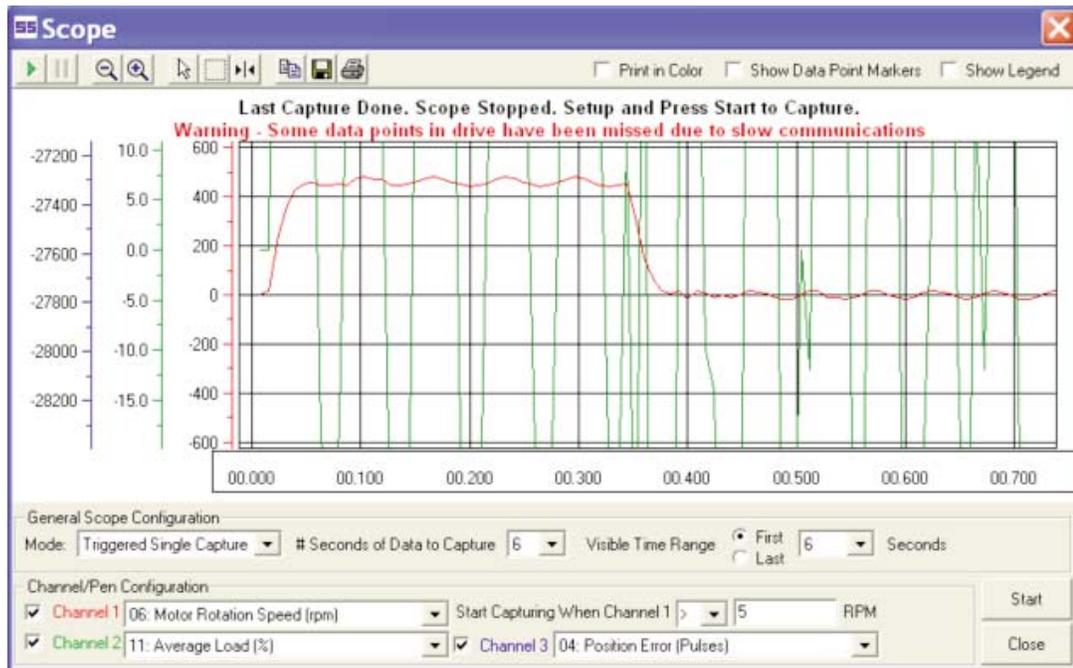
second trial P2-04=9000

By several trial and errors, the best value was a value of P2-04 as 6000 and P4-06 as 1.

This exercise shows the importance of using the Servo Pro utility and the Scope capability, as well as the form of observing that the servo is really tuned. You may select a higher or lower jog speed based on your particular maximum speed. This is other picture obtained during the tuning, changing acceleration times .
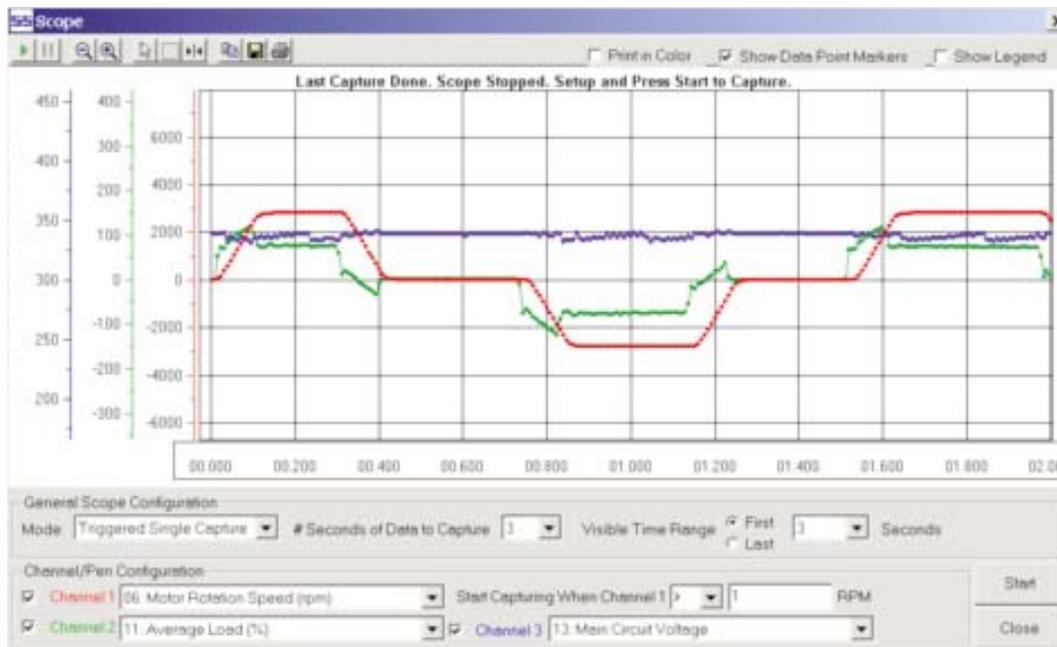
Sureservo parameters for the prototype

The next list the the set of parameters we obtained for an operation with the prototype to simulate the operation. The motor was smaller, the
reducer was a planetary reducer from NEUGARTUSA
with other reduction, the load inertia and and the load are different than the real operation, but we can obtain the roller to stop always on the same point (at least in a range of about 20 positions on 10,000 positions of the revolution of the servo shaft).

Automation Direct **SureServo PRO Drives Configuration**

ReportConfig Name: ejemplo 3.ssc

Motor Code: 11

```
 Parameter
 ---------
  P0.00 - Software Version
  P0.01 - Drive Fault Code
  P0.02 - Drive Status (Front panel display)
  P0.03 - Analog Monitor Outputs
 P0.04 - Status Monitor 1
 P0.05 - Status Monitor 2
 P0.06 - Status Monitor 3
 P0.07 - Status Monitor 4
 P0.08 - Status Monitor 5
 P1.00 - External Pulse Input Type
 P1.01 - Control Mode and Output Direction
 P1.02 - Speed and Torque Limit
 P1.03 - Output Polarity Setting
 P1.04 - Analog Monitor Output Scaling 1 (CH1)
 P1.05 - Analog Monitor Output Scaling 2 (CH2)
   P1.06 - Analog Velocity Command Low-pass Filter
   P1.07 - Analog Torque Command Low-pass Filter
   P1.08 - Position Command Low-pass Filter
  P1.09 - Preset Velocity Command / Limit 1
  P1.10 - Preset Velocity Command / Limit 2
  P1.11 - Preset Velocity Command / Limit 3
  P1.12 - Preset Torque Command / Limit 1
  P1.13 - Preset Torque Command / Limit 2
  P1.14 - Preset Torque Command / Limit 3
  P1.15 - Position 1 Command (Revolutions)
```

Parameter	Value
P1.16 - Position 1 Command (Counts)	1000
P1.17 - Position 2 Command (Revolutions)	20
P1.18 - Position 2 Command (Counts)	2000
P1.19 - Position 3 Command (Revolutions)	30
P1.20 - Position 3 Command (Counts)	3000
P1.21 - Position 4 Command (Revolutions)	40

P1.22 - Position 4 Command (Counts)	0
P1.23 - Position 5 Command (Revolutions)	0
P1.24 - Position 5 Command (Counts)	0
P1.25 - Position 6 Command (Revolutions)	0
P1.26 - Position 6 Command (Counts)	0
P1.27 - Position 7 Command (Revolutions)	0
P1.28 - Position 7 Command (Counts)	0
P1.29 - Position 8 Command (Revolutions)	0
P1.30 - Position 8 Command (Counts)	0
P1.31 - Motor Code	11
P1.32 - Motor Stop Mode Selection	0
P1.33 - Position Control Mode (Internal Indexer)	0
P1.34 - Acceleration Time (Internal Indexer)	60
P1.35 - Deceleration Time (Internal Indexer)	50
P1.36 - Accel / Decel S-Curve	2
P1.37 - Inertia Mismatch Ratio	280
P1.38 - Zero Speed Output Threshold	10
P1.39 - Target Speed Output Threshold	3000
P1.40 - Max Analog Velocity Cmd or Velocity Limit	3000
P1.41 - Max Analog Torque Cmd or Torque Limit	100
P1.42 - On Delay Time of Electromagnetic Brake	20
P1.43 - Off Delay Time of Electromagnetic Brake	20
P1.44 - Electronic Gear Numerator 1	1
P1.45 - Electronic Gear Denominator	1
P1.46 - Encoder Output Scaling Factor	1
P1.47 - Homing Mode	1222
P1.48 - Homing Speed 1 Fast Search Speed	1000
P1.49 - Homing Speed 2 Creep Speed	24
P1.50 - Home Position Offset (Revolutions)	5
P1.51 - Home Position Offset (Counts)	0
P1.52 - Regenerative Resistor Value	40
P1.53 - Regenerative Resistor Capacity	60
P1.54 - In Position Window	100
P1.55 - Maximum Speed Limit	3000
P2.00 - Proportional Position Loop Gain (KPP)	45
P2.01 - Position Loop Gain Boost	100
P2.02 - Position Feed Forward Gain (KFF)	5000
P2.03 - Smoothing Constant of Position Feed Forward Gain	5

P2.04 - Velocity Loop Proportional Gain (KVP)	6000
P2.05 - Velocity Loop Gain Boost	100
P2.06 - Velocity Loop Integral Compensation (KVI)	1
P2.07 - Velocity Feed Forward Gain (KVF)	0
P2.08 - Factory Defaults and Security	0
P2.09 - Bounce Filter	2
P2.10 - Digital Input Terminal 1 (DI1)	101
P2.11 - Digital Input Terminal 2 (DI2)	114
P2.12 - Digital Input Terminal 3 (DI3)	115
P2.13 - Digital Input Terminal 4 (DI4)	0
P2.14 - Digital Input Terminal 5 (DI5)	0
P2.15 - Digital Input Terminal 6 (DI6)	102
P2.16 - Digital Input Terminal 7 (DI7)	0
P2.17 - Digital Input Terminal 8 (DI8)	0
P2.18 - Digital Output Terminal 1 (DO1)	109
P2.19 - Digital Output Terminal 2 (DO2)	105
P2.20 - Digital Output Terminal 3 (DO3)	0
P2.21 - Digital Output Terminal 4 (DO4)	0
P2.22 - Digital Output Terminal 5 (DO5)	0
P2.23 - Notch Filter (Resonance Suppression)	1000
P2.24 - Notch Filter Attenuation (Resonance Suppression)	0
P2.25 - Low-pass Filter (Resonance Suppression)	5
P2.26 - External Anti-Interference Gain	0
P2.27 - Gain Boost Control	0
P2.28 - Gain Boost Switching Time	10
P2.29 - Gain Boost Switching Condition	10000
P2.30 - Auxiliary Function	0
P2.31 - Auto and Easy Tuning Mode Response Level	68
P2.32 - Tuning Mode	0
P2.33 - Reserved	0
P2.34 - Overspeed Fault Threshold	5000
P2.35 - Position Deviation Fault Window	30000
P2.36 - Position 1 Velocity	2000
P2.37 - Position 2 Velocity	1000
P2.38 - Position 3 Velocity	1000
P2.39 - Position 4 Velocity	1000
P2.40 - Position 5 Velocity	1000
P2.41 - Position 6 Velocity	1000
P2.42 - Position 7 Velocity	1000

P2.43 - Position 8 Velocity	1000
P2.44 - Digital Output Mode	0
P2.45 - Index Mode Output Signal Delay Time	1
P2.46 - Index Mode Stations	6
P2.47 - Position Deviation Clear Delay Time	0
P2.48 - Backlash Compensation (Index Mode)	0
P2.49 - Jitter Suppression	0
P2.50 - Clear Position Mode	0
P2.51 - Servo Enable Command	0
P2.52 - Dwell Time 1 - Auto Index Mode	0
P2.53 - Dwell Time 2 - Auto Index Mode	0
P2.54 - Dwell Time 3 - Auto Index Mode	0
P2.55 - Dwell Time 4 - Auto Index Mode	0
P2.56 - Dwell Time 5 - Auto Index Mode	0
P2.57 - Dwell Time 6 - Auto Index Mode	0
P2.58 - Dwell Time 7 - Auto Index Mode	0
P2.59 - Dwell Time 8 - Auto Index Mode	0
P2.60 - Electronic Gear Numerator 2	1
P2.61 - Electronic Gear Numerator 3	1
P2.62 - Electronic Gear Numerator 4	1
P2.63 - Velocity and Position Deviation Scaling Factor	0
P3.00 - Communication Address	2
P3.01 - Transmission Speed	5
P3.02 - Communication Protocol	8
P3.03 - Communication Fault Action	0
P3.04 - Communication Watchdog Time Out	0
P3.05 - Communication Selection	0
P3.06 - Reserved	0
P3.07 - Communication Response Delay Time	0
P3.08 - Digital input software control mask.	0
P4.00 - Fault Record - Most recent (N)	6
P4.01 - Fault Record (N-1)	11
P4.02 - Fault Record (N-2)	11
P4.03 - Fault Record (N-3)	11
P4.04 - Fault Record (N-4)	11
P4.05 - JOG Function	480
P4.06 - Force Outputs Command	0
P4.07 - Input Status	0
P4.08 - Reserved	8

P4.09 - Output Status   0

P4.22 - Analog Velocity Input Offset   11

P4.23 - Analog Torque Input Offset   0

Start up and operation

The start up on the prototype began with slow speeds and after everything was working we increment the speed as needed. There is certain speed where the scan time of the PLC cannot keep up with the needed response.

The operation does not have vibration or oscillations, the motor responds well to the commands given by the PLC.

Please observe the figures below, that show the magnified trends. The theoretical curve was almost reached. The purpose of the control was achieved!