PRODUCT FAMILY: *Sure*Servo

Subject: *Sure*servo linear displacement

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This example demonstrates how to use a *Sure*servo to control a linear movement by selecting parts available from AutomationDirect. After that it is shown how to program a PLC, the servo drive and a 6 inch C-more micro operator interface. The machine is shown in the figure below:

This is a device that moves a saw horizontally installed over a movable table to any of four desired positions entered by an operator with the help of a rack and pinion mechanism through a maximum distance of 134 inches from the Home position. The servomotor is mounted over the table.

The mechanical department has defined that the table will move 0.6284 inches when the servomotor rotates 1 revolution. The acceleration and deceleration time is 0.6 s.

Typically the operator will set the desired target position with one of the 4 buttons on the operator interface, and he will need to move it on the range of 0 to 134 inches from the Home position possibly with precision of 1 thousandth of an inch.

At the start of the job, when the servo system is enabled, the machine shall go to the Home position, located at some inches from the one of the sides. The Home is determined by a proximity sensor. There are also overtravel limit switches.

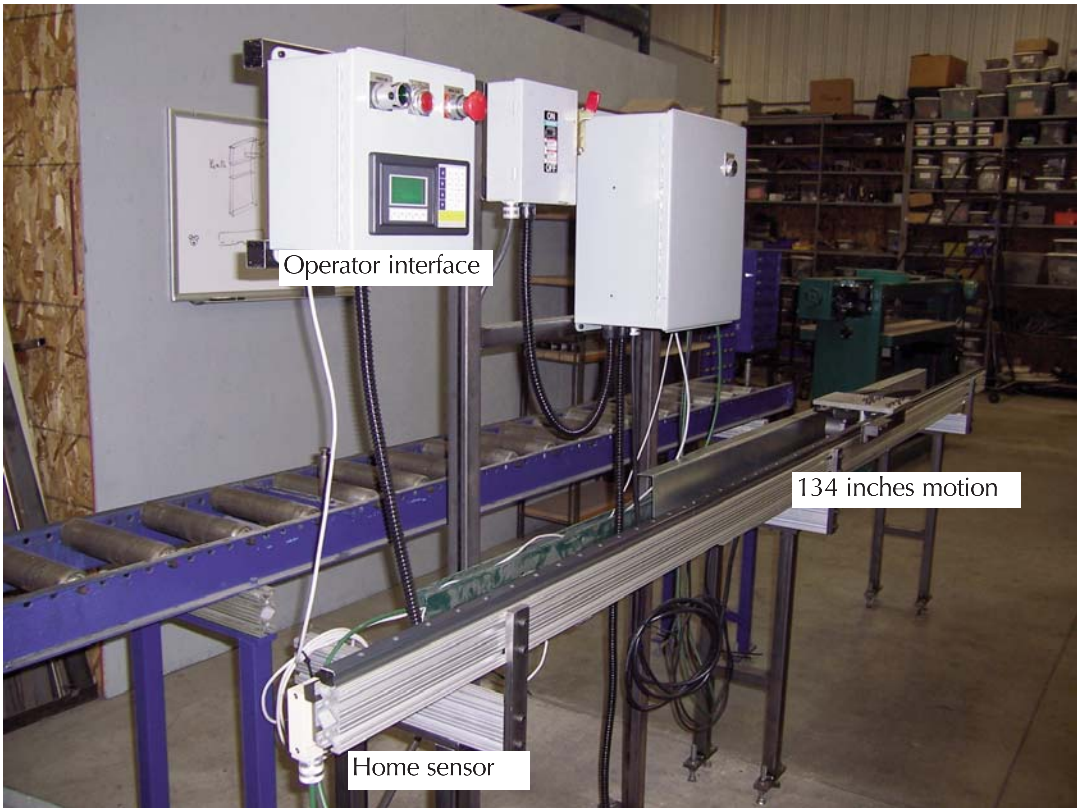
The operator panel will show the current position on screen 1 and will have buttons to trigger the motion to any of the 4 given targets. The second screen will allow the entering of the targets and use Jog forward and reverse, as well as enable and disable the servo.

We have selected to use a PLC D0-05DD and an operator interface EA1-S6ML to control the positions of the saw. The figure below shows the same arrangement with a C-more micro of 3.1 inches, instead of the 6 inch operator interface panel.

Control concept

This application note details some of the actions for designing the control system.

In this example we will need to run the motor with 4 target positions, given by the operator, with a value given directly in thousand of an inch in the range of 0 to 134 inches, variable values defined every day by the operator at the beginning of the shift and entered in the operator interface.



The transfer of target values and the writing of digital inputs is done though MODBUS RTU, from the port 2 of the PLC DL05. This is possible only if the servo drive has a firmware version 2.105 or later.

The operator will see in the operator panel where the saw is located at any given time. The acceleration, maximum speed and deceleration are fixed values.

The home search is done every time the servo is enabled if the home has not been found. The operator can enable or disable the servo from the operator interface.

There is no brake in this system but one output is to be programmed to release a brake, when the servo is enabled.

In this case the motion is ideally suited to be absolute motion with internal registers.

The servo is defined arbitrarily as slave 2 for the PLC. The operator panel is the master for the PLC. They are located in different networks.

The Home sensor as well as the overtravel limit switches and external fault have been left directly wired to the servo drive.

Steps for the execution of the control

This is the sequence of operations that shall be followed in this example to get the system up and running:

- Define the control hardware to be used including the wiring
- Create the wiring diagram
- Select and set the communication parameters.
- Read the status of the servo though MODBUS, using the RX instruction.
- Measure the communication speed in transactions per second.
- Write data to servo (Set it to write data in RAM memory only.
- Make the details of the block transfer parameters.
- Make the code for reading an writing interlocks
- Define the block transfer parameters
- Define the values of P0-04 to P0-11 and the value of P3-08.
- Define the main parameters on the servo.
- Factor of revolutions versus displacement for targets defined
- Current position math defined
- Some C-more micro programming concepts defined
- Add the revolutions and counts of displacement and scale it to show the current displacement.
- Read servo output data (To be used the status data in P4-09 to create logic for the operation)
- Digital inputs to be used for commanding the servo defined.
- Reading the servo status from PLC.
- Operator code to write the desired target positions and send to the PLC.
- Additional code to make the operation automatic.
- Code to use the output status on PLC and operator panel.
- Test the program together with the servo and the operator panel.
- Program the operator interface
- Test the program and correct any errors. May be you need to tune the servo.
- Prepare a copy of the ladder and the servo parameters in this document.
- Prepare documentation to describe the operator what it is necessary to do to operate the machine. May be leave as screen text data on the Operator panel.

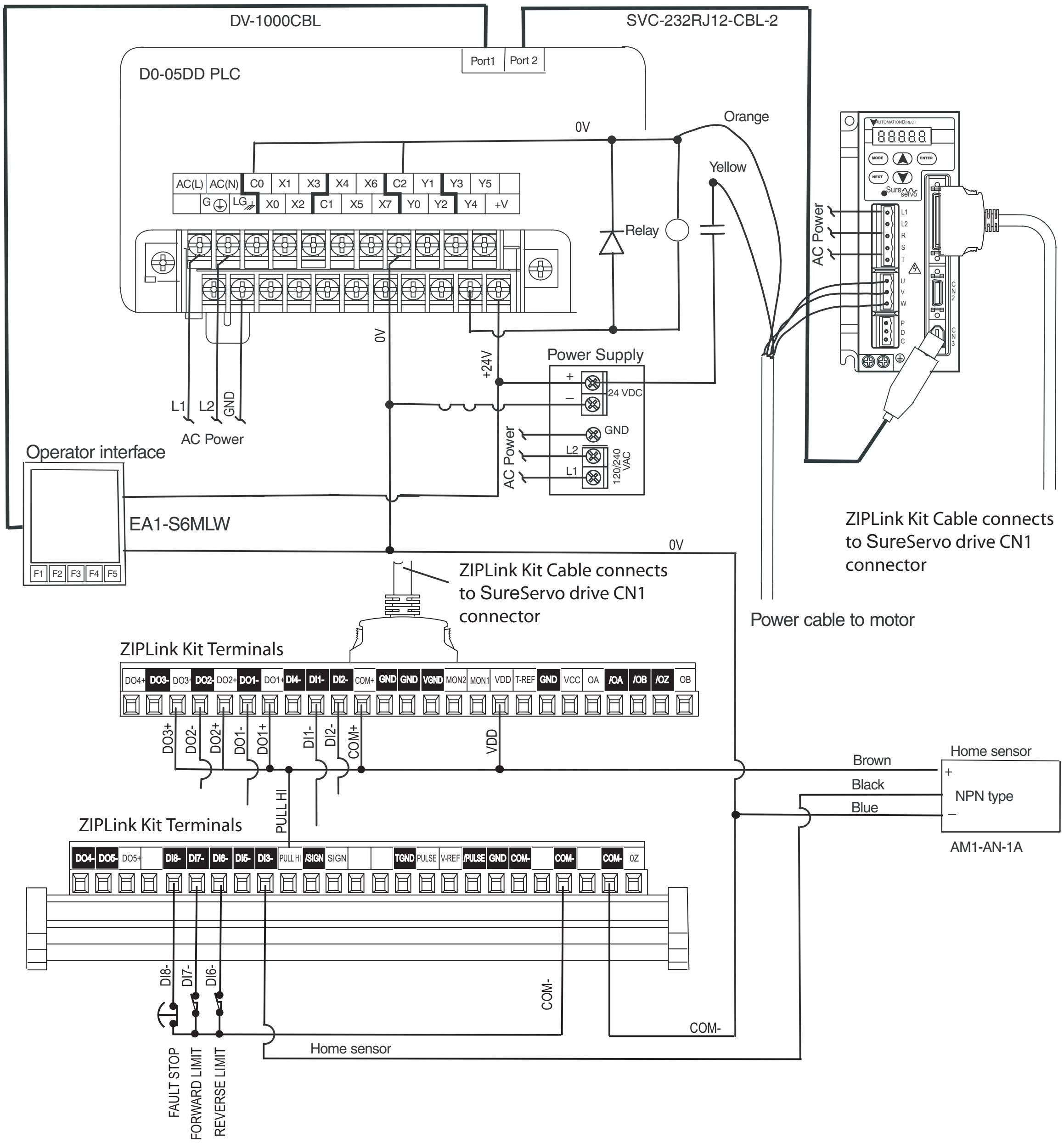
Definition of the control hardware

The different hardware parts of the control system are:

- Servo motor SVL-204B
- Servo drive SVA-2040, firmware 2.105
- Power cable SVC-PFL-020
- Encoder cable SVC-EFL-020
- Terminal block board ZL-RTB50
- ZipLink cable ZL-SVC-CBL50
- Cable to link PLC to servo SVC-232RJ12-CBL-2
- PLC D0-05DD
- Programming cable (for panel and PLC) EA-MG-PGM-CBL
- Power supply PS24-075D
- Proximity sensor AM1-AN-1A
- Operator panel EA1-S6MLW
- Relay 782-2C-24D
- Socket 782-2C-SKT
- Surge suppresor ASD-BSDM-250
- Fuses and wiring as well as an enclosure for mount the control system.

Definition of wiring diagram

See below the initial wiring diagram



Select and set the communication parameters for servo

The servo drive, the slave in the network, has registers or internal memory locations with parameters whose content causes the servo work the way that the designer of the control system wants it to work.

These registers have addresses you specify, shown in chapter 6 of the user manual of the servo drive.

For example, if you want to read if the servo is with or without fault or read the type of fault, in case there is an alarm, you can read the the register 40002, that corresponds to the P0-02 parameter.

You can easily create a control system with a servo using a serial MODBUS network.

The servo communication configuration is done with the keypad of the servo drive.

Set P3-00 parameter to the desired slave address. In this case we will use the value 2, that is to say, servo drive slave 2.

Then set a value 3 in P3-01, that defines the transmission rate as 38,4 kBaud. This value also must be set in the configuration of PLC port 2.

P3-02 defines the protocol and the configuration of the same one. In this case, let us select 8.

Finally, we set the P3-05 value according to the system of communication RS-232, with a value of 0.

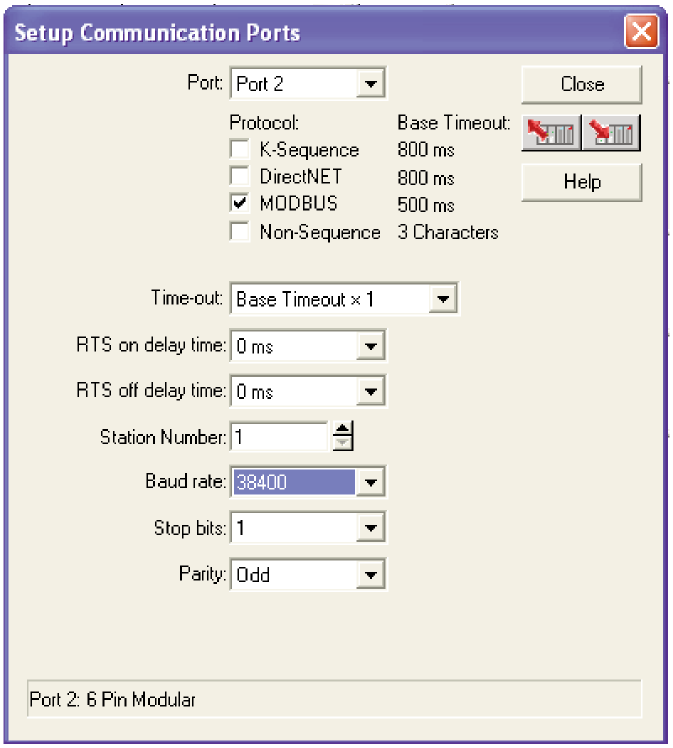
Communication parameters for PLC.

The communication parameters in PLC DL05 are configured with the software *Direct*SOFT5 and we show the adopted values in the adjacent figure.

The configuration on the Port 2 is saved in RAM Memory. That is, it is possible that the port set up be lost after the PLC has a period of 4 days without power.

In this case we can also do the port set up with ladder code, which is retained in Flash memory and in this case there is no need of power to keep the set up stored.

See the set up on the DL05 user manual or in one of the application notes on the web site of AutomationDirect. Let us leave the other values as default values.



Setup Communication Ports

Port: Port 2

Protocol:	Base Timeout:
☐ K-Sequence	800 ms
☐ DirectNET	800 ms
☑ MODBUS	500 ms
☐ Non-Sequence	3 Characters

Time-out: Base Timeout × 1

RTS on delay time: 0 ms

RTS off delay time: 0 ms

Station Number: 1

Baud rate: 38400

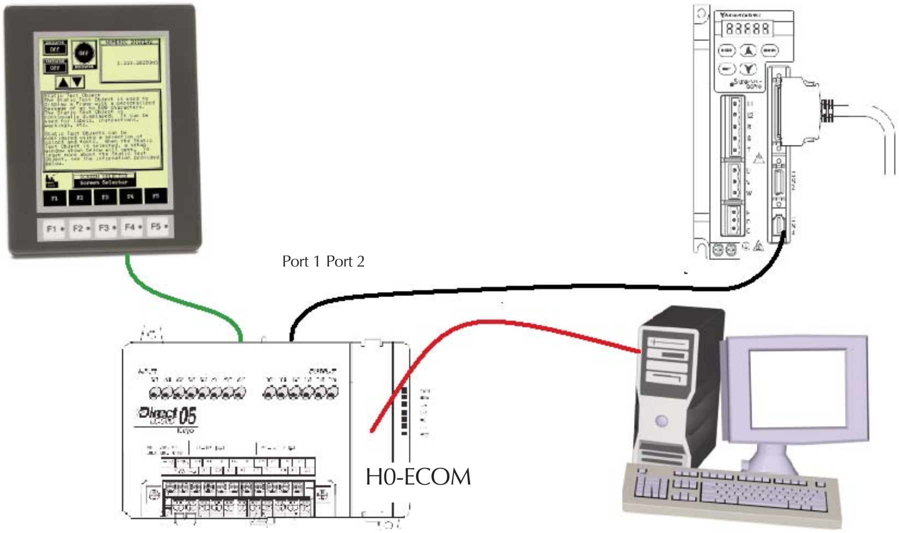
Stop bits: 1

Parity: Odd

Port 2: 6 Pin Modular

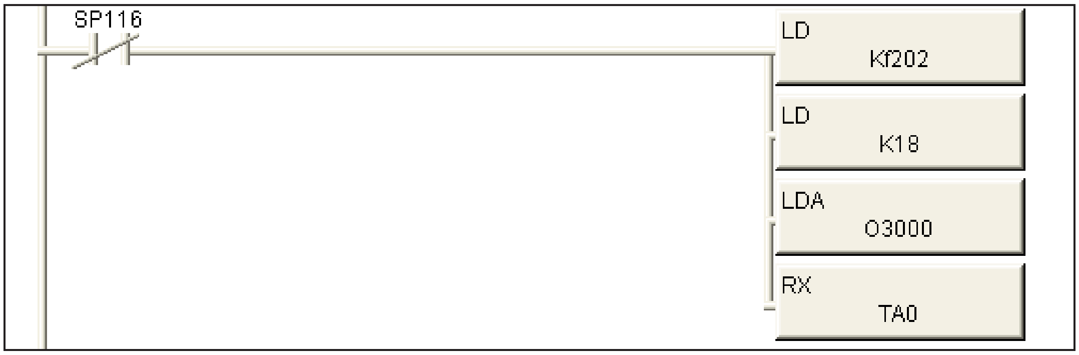
At this time, we are only trying to connect the PLC with the servo. Later, we will connect the C-more micro panel to the port 1of the DL05 PLC. For convenience, we can use a H0-ECOM to allow the connection of the panel to port 1, the servo to port 2 and the laptop with *Direct*SOFT to the H0-ECOM module inserted on the slot available. This is not a must, only a convenience, but for testing purposes this layout becomes very convenient.

Then we must connect the PLC with the servo drive.



Read the status of the servo though MODBUS, with RX instruction

In order to be able to read the data from the servo drive and to check that connections are correct, I suggest to run the program shown in the following diagram.



SP116

LD Kf202

LD K18

LDA O3000

RX TA0

Set a value 10 in the P2-08 parameter with the keyboard to configure all the values of the servo as default values). It will appear errors ALE14, ALE15 and ALE13 on the display, and this is normal.

The fault ALE14 in the servo display indicates that the overtravel limit switch is activated, and this is true, since of P2-15 default (that corresponds to the DI6 input function) it set as 22, P2-16 (that corresponds to the DI7 input function) is set as 23 and P2-17 (that corresponds to the DI8 input function) is set as 21. Same for ALE14 and ALE15.

To make these errors disappear we may set P2-15 to P2-17 to a value 0 to disable the function of each input in DI6, DI7 and DI8 or wire the proper switches there.

In order to clear the faults press the “up and down arrow” keys on the keypad simultaneously, clearing any error can be there, or it is also possible to power cycle the servo drive to get the same function.

Next, be sure that the value of the motor code is set in the P1-32 parameter.

The axis of the motor should turn freely (Do not couple the servo to the machine until the tests of the programs have been done) and the data that is contained in the memories P0-00 up to P0-08 can be read. These memories have MODBUS addresses 40001 up to 40009, as it is in the following table and described in the user manual, in chapter 6.

Parameter	Value	MODBUS address	Description
P0-00	2.105	40001	Software version
P0-01	14	40002	Fault code
P0-02	0	40003	Display code
P0-03	1	40004	Analog monitor
P0-04	1	40005	Status monitor 1
P0-05	0	40006	Status monitor 2
P0-06	0	40007	Status monitor 3
P0-07	0	40008	Status monitor 4
P0-08	0	40009	Status monitor 5

This is the explanation of the operation:

SP116 is a bit in the PLC that turns ON when the communication is happening and itis called “busy”. It indicates when the PLC is transmitting data through the communication in port 2, and turns OFF when the data transmission is completed.

Therefore, in the first scan, the instruction RX is executed if the servo slave is ready to communicate. See more details in the DL05 manual.

Let us say that the PLC scan takes 2 ms; when beginning the transmission the contact of bit SP116 closes and makes the rung true to allow the transmission to be executed. When establishing the transmission, SP116 turns ON; when the transaction completes, SP116 contact is closed again and then another transaction begins and thus it follows continuously. Typically the transmission takes more than the PLC scan time. In this case it is approximately 17 ms.

The values in the selected range go to the memories of the PLC V3000 to V3010, according to the following table:

Parameter	Value	MODBUS address	PLC memory	Description
P0-00	2.105	40001	V3000	Software version
P0-01	14	40002	V3001	Fault code
P0-02	0	40003	V3002	Display code
P0-03	1	40004	V3003	Analog monitor
P0-04	1	40005	V3004	Status monitor 1
P0-05	0	40006	V3005	Status monitor 2
P0-06	0	40007	V3006	Status monitor 3
P0-07	0	40008	V3007	Status monitor 4
P0-08	0	40009	V3010	Status monitor 5

Also, it is necessary to set some function in P0-04 until P0-08 parameters to be able to monitor what it is desired to see in the PLC and later in the operator panel.

We will change the values in the parameters according to the following table:

Parameter	Value	MODBUS address	PLC memory	Description
P0-00	2.10	40001	V3000	Software version
P0-01	14	40002	V3001	Fault code
P0-02	0	40003	V3002	Drive Status
P0-03	1	40004	V3003	Analog monitor
P0-04	1	40005	V3004	Current revolutions
P0-05	0	40006	V3005	Current counts
P0-06	6	40007	V3006	Current rpm
P0-07	11	40008	V3007	Current % torque
P0-08	13	40009	V3010	DC Bus voltage

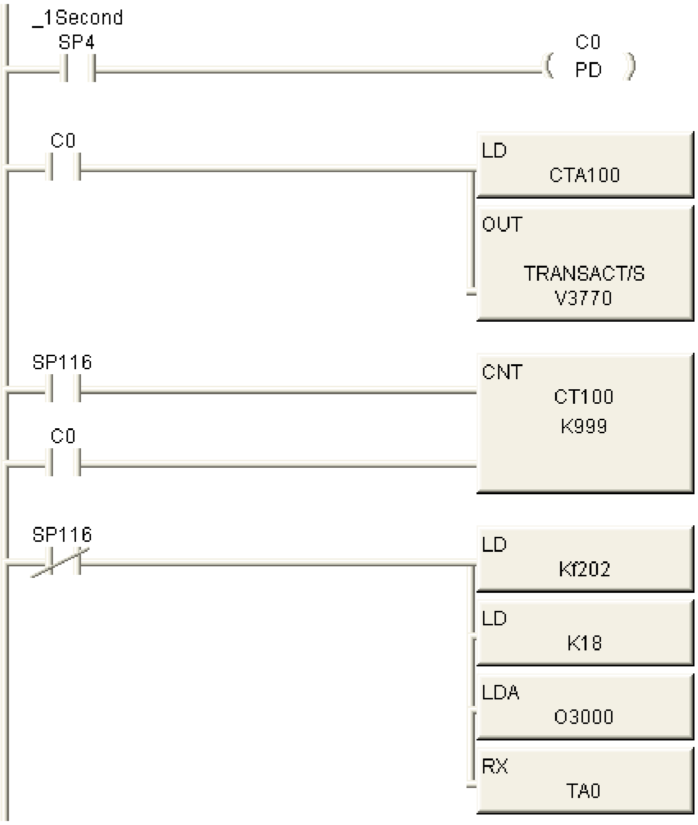
The values in V3000 until V3010 are all signed decimal values.

When the parameter changes have been done, you can move the shaft of the servomotor and it will be possible to observe that the content of V3005 memory shows the same number than the display on the servo when the shaft of the motor moves (parameter P0-02 should be set to 0). This fact allows to check that the communication has been established.

Measure the communication speed in transactions per second

How can we measure the PLC scan time and how many transactions are happening per second? Using Data View in *Direct*SOFT to monitor the V-memory V7775 which is the current scan time. Or use the window of “scan time”.

As we know, when a communication transaction begins, SP116 will turn ON, and then, using this bit, we can count how many times the SP116 contact closes in 1 second, for example with a simple counter. Remember that a counter counts whenever is a transition of the input from OFF to ON. See the diagram of the figure below with the corresponding code ladder and the explanations in each line.



C0 closes one scan every second

Every time C0 closes the current count of CT100 is loaded to the accumulator. The instruction OUT reads what is in the accumulator and copies to V3770

Here the counter CT100 counts every time the bit SP116 turns on. The CT100 counter current value goes to zero every time C0 closes.

Here is the same rung programmed before, used to configure the network

You can read V3770 in Data View, as in the adjacent figure, and can see that the result is 60 counts every second. Since there are 1000 milliseconds in a second, 1000/60 ms is approximately 17 ms.

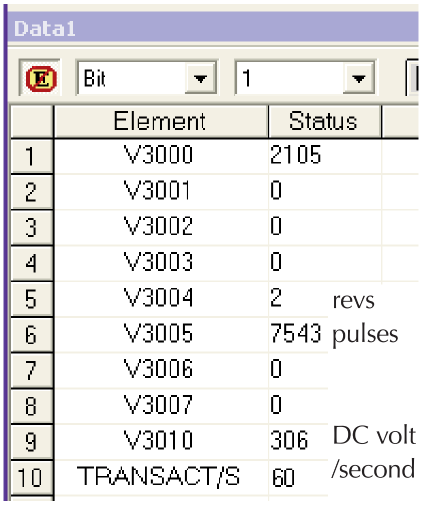
You can also see that the vmemory:

V3000 has the firmware version,

V3004 has the current number of revolutions, V3005 the current number of counts,

V3010 the DC bus voltage of the servo, etc.

This it is a good method to determine the transmission speed.



Data1

Bit | 1

	Element	Status	
1	V3000	2105	
2	V3001	0	
3	V3002	0	
4	V3003	0	
5	V3004	2	revs
6	V3005	7543	pulses
7	V3006	0	
8	V3007	0	
9	V3010	306	DC volt
10	TRANSACT/S	60	/second

Writing to the servo

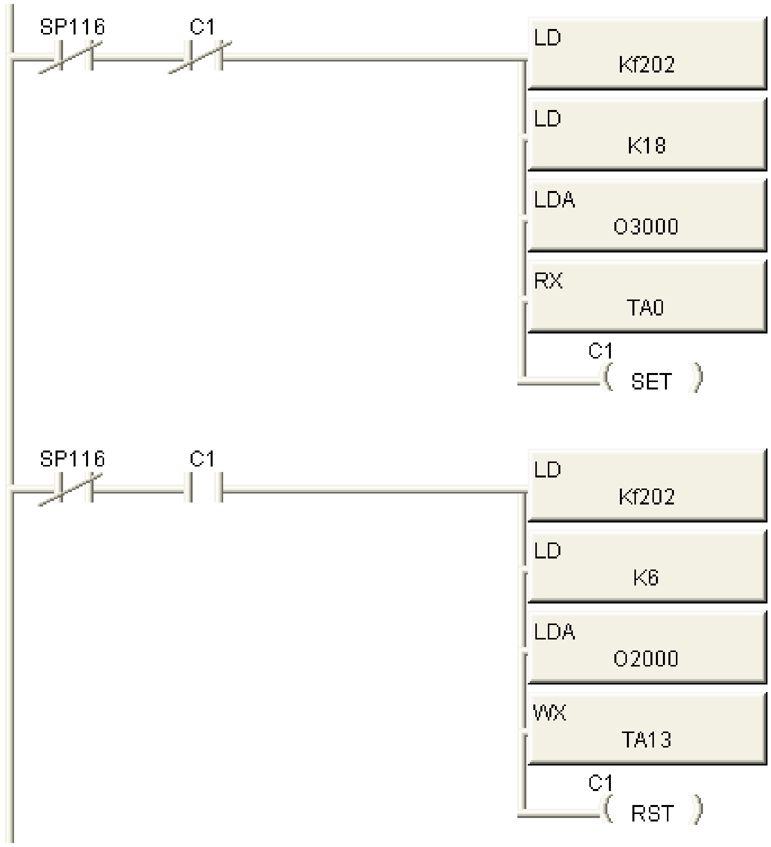
When already proven the communication link between the PLC and the servo, we should see what algorithms to do in the PLC to be able to give the servo the values to be written into it.

Remember that we are still in the stage of creation of the program on the master PLC. Also it is necessary to define how data is written to the servo drive.

We have said previously that we want to write values in the servo.

RX and WX should not execute at the same time otherwise the communication will fail.

A simple way we could do this would be the following:



```
SP116   C1
--|/|---|/|---+-- LD   Kf202
              +-- LD   K18
              +-- LDA  O3000
              +-- RX   TA0
              +-- C1 ( SET )

SP116   C1
--|/|---| |---+-- LD   Kf202
              +-- LD   K6
              +-- LDA  O2000
              +-- WX   TA13
              +-- C1 ( RST )
```

At the beginning, the closed contact SP116 and C1 allow the reading with RX of 9 consecutive registers, but immediately will turn ON C1 with the SET instruction, and waits for SP116 to be turned OFF.

C1 will close but SP116 will be ON (busy).

When the reading transaction is completed, the writing begins with instruction WX; it writes 3 registers;

C1 is turned OFF with the Reset instruction.

The PLC would be reading and writing once at the time in sequence.

Nevertheless, it is necessary to consider the following:

The servo drive has two types of memory, RAM and EEPROM. In RAM memory data can be written at any time but the memory EEPROM can be written a limited number, of the order of 100000 times. The parameters that do not change in time are written typically in EEPROM memory and with this memory it is not necessary to maintain the drive powered. When powering the servo drive, these values will be still stored in the memory.

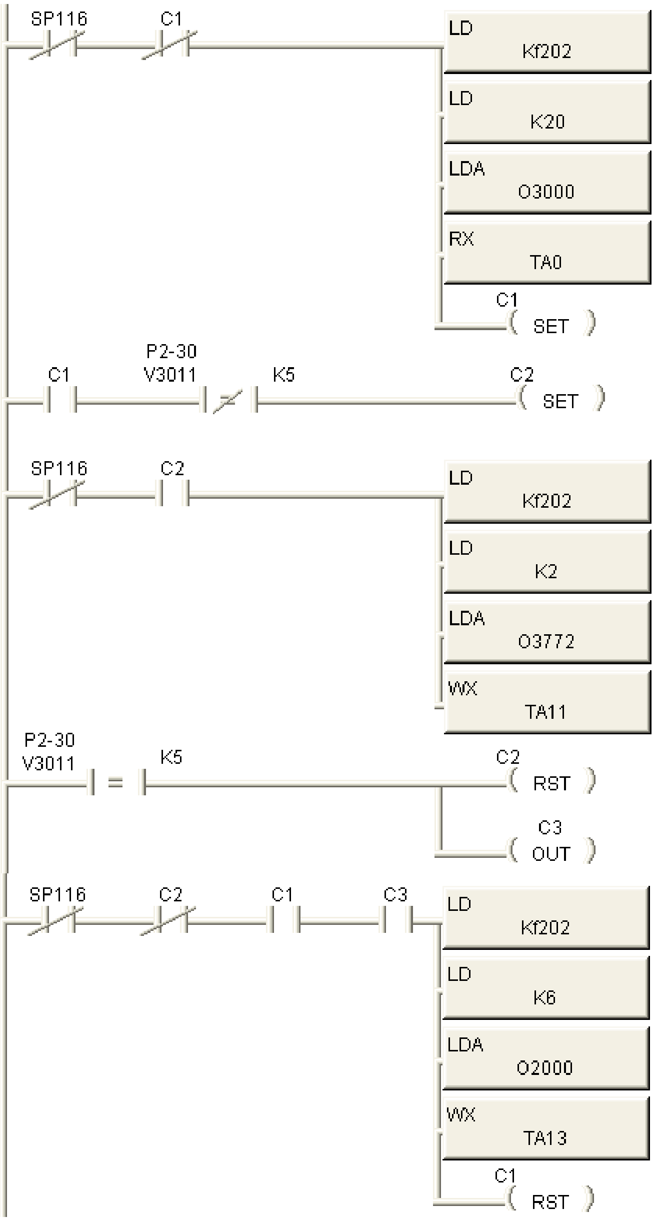
In RAM memory this is not possible and the data only stay stored if the servo drive is powered. If we want to write continuously to the drive RAM memory, we should set the value of P2-30 parameter as 5; but this value is not retained in memory EEPROM.

Clearly it is not possible that the setting of this value be done by the machine operator when the servo powers on. Therefore it is necessary to write a value of 5 to this memory when the drive powers ON or otherwise the servo will reach the limit of writings and the device will not be functional anymore.

One of several ways is to use a comparison function reading the content of P2-30 parameter and on the basis of that value it is executed a writing on that parameter.

That is, if the reading on that parameter shows that the value is not 5, we will set a bit or flag to force a 5 into the same memory.

It can be created an interlock such that it is not executed this function anymore when P2-30 (MODBUS address 40543 [or 21E in hexadecimal format or V1036 in octal]) has a 5 in its content.



Here it is advisable the use of the block transfer parameters P0-09 up to P0-16, that are configurable parameters allowing to read or write data in consecutive servo addresses, which is better than to read data in random addresses (Not consecutive).

For that, we will configure P0-09 (Modbus address 40010) with the keyboard (By default with value 407) as **21E**, that causes that this parameter be defined as P2-30. Then we will increase the reading of 9 registers in RX to 10, to include P0-09.

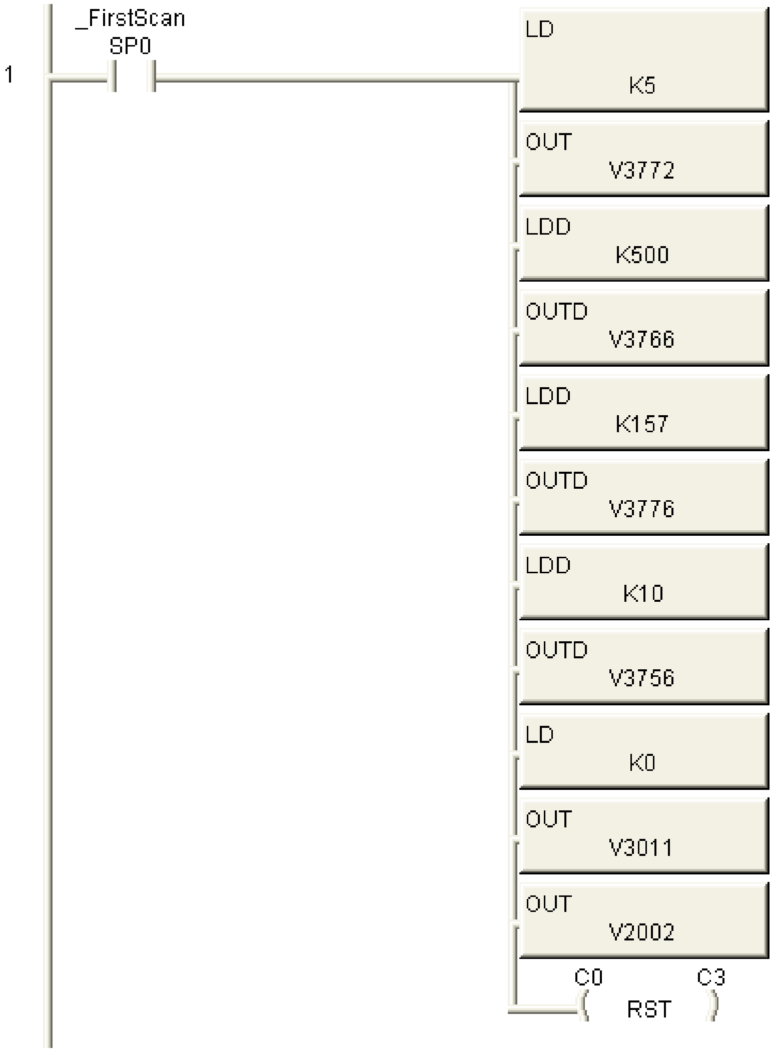
Note that we have to force a value of 5 into the content of the register that corresponds to P2-30. For that, we have to set a V-memory with a constant 5. This is done on a first scan on rung 1 and the memory is V3772. We also create other constants that are necessary for the program. We should also reset the bits C0 to C2.

In order to test this step, turn off the servo and P2-30 will reset to off. Then, when turning the servo on, you can monitor V3011 with Data View to see the value there.

You will observe that the PLC did not took notice that the servo was powered off.

Then, it is necessary to create an interlock in such a way that the PLC resets C0 to C2 when the servo goes from “servo not ready” to “servo ON”. For this we will read the data in P4-09.

We added the rung 1 for constants we will need later. See below.



```
1  _FirstScan
   SP0
   LD    K5
   OUT   V3772
   LDD   K500
   OUTD  V3766
   LDD   K157
   OUTD  V3776
   LDD   K10
   OUTD  V3756
   LD    K0
   OUT   V3011
   OUT   V2002
   C0 RST C3
```

When SP0 closes: Load the constant 5 to the accumulator.

The instruction OUT reads what is in the accumulator and copies the value to V3772

Load the constant 500 to the accumulator.

The instruction OUTD reads what is in the accumulator and copies the value to V3766

Load the constant 157 to the accumulator.

The instruction OUTD reads what is in the accumulator and copies the value to V3776

Load the constant 10 to the accumulator.

The instruction OUTD reads what is in the accumulator and copies the value to V3756.

Load the constant 0 to the accumulator.

The instruction OUTD reads what is in the accumulator and copies the value to V3011.

C0 and C2 are set to OFF

The transactions statistics are in rungs that were explained on page 8.

Test it again to be sure that the code is working as you want.

Notice that, as an option to reduce the transactions per second figure, we can eliminate parameters P0-00 to P0-03 on the reading instruction RX, thus transferring less words and we will add one register for purposes to be seen later.

Now, we have created a code that makes interlocks to allow the writing once when the value in P2-30 is a value of 5; that is, the next instruction WX will be executed any given time if the value in P2-30 be 5.

C3 is the flag that advices that the value in P2-30 is a 5. When C3 is ON, we have permission to write to the servo over RAM memory.

By now we have the MODBUS RTU communication working but we have not set the servo parameters for position operation.

Use of block transfer registers

Let us go back to the discussion on the reading of up to 13 registers in the memories V3004 to V3020. Why this is convenient?

Because the block transfer parameters P0-09 to P0-16 are "configurable parameters", that is, the ones that could be changed to read or write any desired address in the servo drive.

We have done so for P0-09. We can read the 13 registers and configure the data in a convenient way for our specific purpose.

We have the following settings, so far:

Parameter	Value	MODBUS address	PLC memory	Description
P0-04	1	40005	V3004	Current revolutions
P0-05	0	40006	V3005	Current counts
P0-06	6	40007	V3006	Current rpm
P0-07	11	40008	V3007	Current % torque
P0-08	13	40009	V3010	DC Bus voltage
P0-09	21E	40010	V3011	Set not as default, as parameter P2-30
P0-10	10F	40011	V3012	**Default is P1-15 -Target 1 revolutions**
P0-11	110	40012	V3013	**Default is P1-16 -Target 1 counts**
P0-12	224	40013	V3014	**Default is P2-36 -Target 1 velocity**
P0-13	111	40014	V3015	**Default is P1-17 -Target 2 revolutions**
P0-14	112	40015	V3016	**Default is P1-18 -Target 2 counts**
P0-15	225	40016	V3017	**Default is P2-37 -Target 2 velocity**
P0-16	109	40017	V3020	**Default is P1-09 -Velocity command 1**

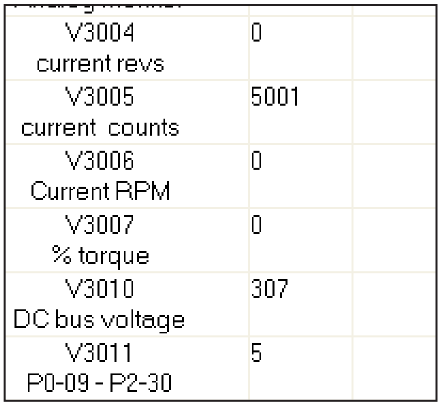
Parameters P0-10 to P0-16 may be changed to our convenience or leave as they are.

We will be using the parameters P0-10 to P0-13 for other functions explained after this section. In this example it is convenient to define P0-10 as P4-09, P0-11 as P1-15, P0-12 as P1-16 and P0-13 as 407. The rest can continue to be the default (Or, if necessary, to configure to read or write other values)

Note that the values there are to be written only by the keypad and this is not reported by the report that *Sure*servo PRO software generates. However, when the values are written there and the servo drive is power cycled, the setting is retained in EEPROM memory.

The final setting is shown on the parameter table at the end of the document.

The adjacent figure shows the content of 8 consecutive memories as seen with Data View in *Direct*SOFT. This is one way to determine that we are really communicating with the servo. C3 could also indicate this action, but this reading of data is an assurance.



V3004 current revs	0	
V3005 current counts	5001	
V3006 Current RPM	0	
V3007 % torque	0	
V3010 DC bus voltage	307	
V3011 P0-09 - P2-30	5	

Definition of P3-08

Let us define the value of parameter P3-08, the input mask.

The values of digital inputs are defined by the content in the P3-08 parameters and the P4-07.

P3-08 is a parameter that allows us to control digital inputs with MODBUS. After setting the input mask word P3-08 to define which bits in P4-07 will act as hardwired inputs or virtual inputs o perform a particular function. P4-07 is a conduit for activating any of the 16 inputs (DI1 to DI16). Turning any particular bit in P4-07 that correspond to each one of the digital inputs of the servo drive, will signal each input to execute the pre-programmed function. Note that P4-07 takes on dual functionality: It still serves as an indicator for the digital input status as seen in the servo drive display an may be used with MODBUS to write to the digital inputs that have been configured as virtual digital inputs.

If any of the eight less significant bits on P3-08 is a 1, digital inputs DI1 until DI8 are used as virtual digital inputs with MODBUS; we call them virtual digital inputs as opposed to real digital inputs. We can imagine each bit of P3-08 as a permissive to use MODBUS for each one of the defined functions.

The 8 most significant bits have preassigned functions.

We will set each one of the P3-08 bits according to the following table:

Bit order	Digital input	Code	Description.	Assigned value	
0	DI1	101	Servo Enable	1	3
1	DI2	104	Clear command	1	
2	DI3	124	Home sensor	0	
3	DI4	0	Disabled	0	
4	DI5	0	Disabled	0	0
5	DI6	22	Reverse overtravel limit switch, opens on overtravel	0	
6	DI7	23	Forward overtravel limit switch, opens on overtravel	0	
7	DI8	21	External fault stop, opens on fault	0	
8	DI9	108	Command Trigger - predefined	1	F
9	DI10	111	PCS0 - Bit de selection 0 de position - predefined	1	
10	DI11	112	PCS1 - Bit de selection 1 de position - predefined	1	
11	DI12	113	PCS2 - Bit de selection 2 de position - predefined	1	
12	DI13	102	Alarm reset- predefined	1	F
13	DI14	127	Home search command - predefined	1	
14	DI15	137	JOG Forward- predefined	1	
15	DI16	138	JOG Reverse - predefined	1	

In this case, we must set P3-08 as FF03. The default value is 0.

Notice that Home sensor, overtravel limit and external fault stop are hardwired. The inputs DI1 and DI2 and DI8 to DI16 are used with MODBUS.

Main parameter setting

- P0-04 Set as 1, current revolutions
- P0-05 Set as 0, current counts.
- P0-06 Set as 6, servo shaft speed.
- P0-07 Set as 11, % torque.
- P0-08 Set as 13, DC bus voltage.
- P0-09 Set as 21E, corresponding to P2-30.
- P0-10 Set as 409, corresponding to P4-09.
- P1-01 Operation mode, that by default is 0, set as 1 (**Pr** mode) 0r 101.
- P1-32 Selection of the stop mode, changed to 1 from value 0.
- P1-33 set as 0, absolute mode
- P1-34 Acceleration time: it was defined as 600 ms.
- P1-35 Deceleration time: 600 ms.
- P1-36 S-curve: set as 30 arbitrarily.
- P1-47 Home search definition : set as 223.
- P1-48 Home search fast speed; set as 600 rpm arbitrarily.
- P1-49 Home search creep speed; set as 60 rpm arbitrarily.
- P1-50, Revolutions offset from home sensor, for example, 9 revolutions.
- P1-51, Count offset from home sensor.
- P1-55, left as 2174 rpm.
- P2-10, DI1, set as 101, that is, servo enable
- P2-11, DI2, set as 104, clear command, to zero the counts after home position.
- P2-12, DI3, set as 124, defined as a home sensor normally open
- P2-13, DI4, set as 0, disabled.
- P2-14, DI5 , set as 0, disabled
- P2-15, DI6, set as 22, as reverse overtravel limit; it is a normally closed contact.
- P2-16, DI7 , set as 23, as forward overtravel limit; it is a normally closed contact.
- P2-17, DI8, set as 21, as external fault stop; it is a normally closed contact.

Note from the table on the previous page that bits 8 to 15 are predefined functions for digital inputs.

- P2-18 , DO1, as 102, that is the output servo OK.
- P2-19 , DO2, as 109, that is the output Home completed.
- P2-20 , DO3, as 105, that is the output At position.
- P2-21 , DO4, as 107, that is the output Active fault.
- P2-22 , DO5, as 101, that is the output servo ready.
- P2-36 Position 1 velocity set to 2174 rpm.
- P2-50 Clear command, set to 1.
- P3-08 Digital input mask, set as FF03.

Note that in order to store the parameter values into the servo drive, parameter P2-30 shall be set as 0 and, when the values have been entered, you should power cycle the servo drive, that is, power OFF and then ON the servo drive.

The concept of absolute position control will be so that, after the operator enables the servo drive with DI1, the servo will make the home search after 3 seconds of servo enable.

When the servo finds the home position, we will zero the position (0 revs and 0 counts) and then after that we can have a reference point to the target position on P1-15 and P1-16. Recall that P4-07 is the value that contains the digital inputs.

The digital inputs could be real inputs or virtual inputs defined with MODBUS.

Repeating the explanation, if any of the eight less significant bits on P3-08 is a 1, digital inputs DI1 until DI8 are used as virtual digital inputs with MODBUS; we call them virtual digital inputs as opposed to real digital inputs.

We have arbitrarily associated to P4-07 the following definitions:

Bit order	Digital input	Code	Description.	Assigned value in P3-08	PLC bit
0	DI1	101	Servo Enable	1	N/A
1	DI2	104	Clear command	1	N/A
2	DI3	124	Home sensor	0	N/A
3	DI4	0	Disabled	0	N/A
4	DI5	0	Disabled	0	N/A
5	DI6	22	Reverse overtravel limit, opens on overtravel	0	N/A
6	DI7	23	Forward overtravel limit, opens on overtravel	0	N/A
7	DI8	21	External fault stop, opens on fault	0	N/A
8	DI9	108	Command Trigger - predefined	1	C100
9	DI10	111	PCS0 - Bit de selection 0 de position - predefined	1	N/A
10	DI11	112	PCS1 - Bit de selection 1 de position - predefined	1	N/A
11	DI12	113	PCS2 - Bit de selection 2 de position - predefined	1	N/A
12	DI13	102	Alarm reset- predefined	1	C101
13	DI14	127	Home search command - predefined	1	C102
14	DI15	137	JOG Forward- predefined	1	C103
15	DI16	138	JOG Reverse - predefined	1	C104

We can define the P0-11 parameters and subsequent in such way than they are the values of position in P1-15 (P0-11), P1-16 (P0-12) and the digital inputs in P4-07 (P0-13). Therefore, the code of line 9 is such that it is written in 3 consecutive registers. The initial associated V memory on the PLC will be the memory V2000.

In this way, we should set the parameters as follows, with the keyboard.

Parameter	Value	MODBUS address	PLC memory	Description
P0-04	1	40005	V3004	Current revolutions
P0-05	0	40006	V3005	Current counts
P0-06	6	40007	V3006	Current rpm
P0-07	11	40008	V3007	Current % torque
P0-08	13	40009	V3010	DC Bus voltage
P0-09	**21E**	40010	V3011	Set not as default, as parameter P2-30
P0-10	**409**	40011	V3012	Set not as default, as parameter P4-09
P0-11	**10F**	40012	V3013	Set as position command 1, revolutions
P0-12	**110**	40013	V3014	Set as position command 1, counts
P0-13	**407**	40014	V3015	Set as input status

P0-11 will be the desired revolutions with the value $10F_{hex}$ equivalent to P1-15. P0-12 will be desired counts with the value 110_{hex} equivalent to P1-16.

P0-13 will be the word with the digital inputs with the value 407_{hex} equivalent to P4-07.

You may select other block transfer parameters, if it is necessary in your application.

Current position math

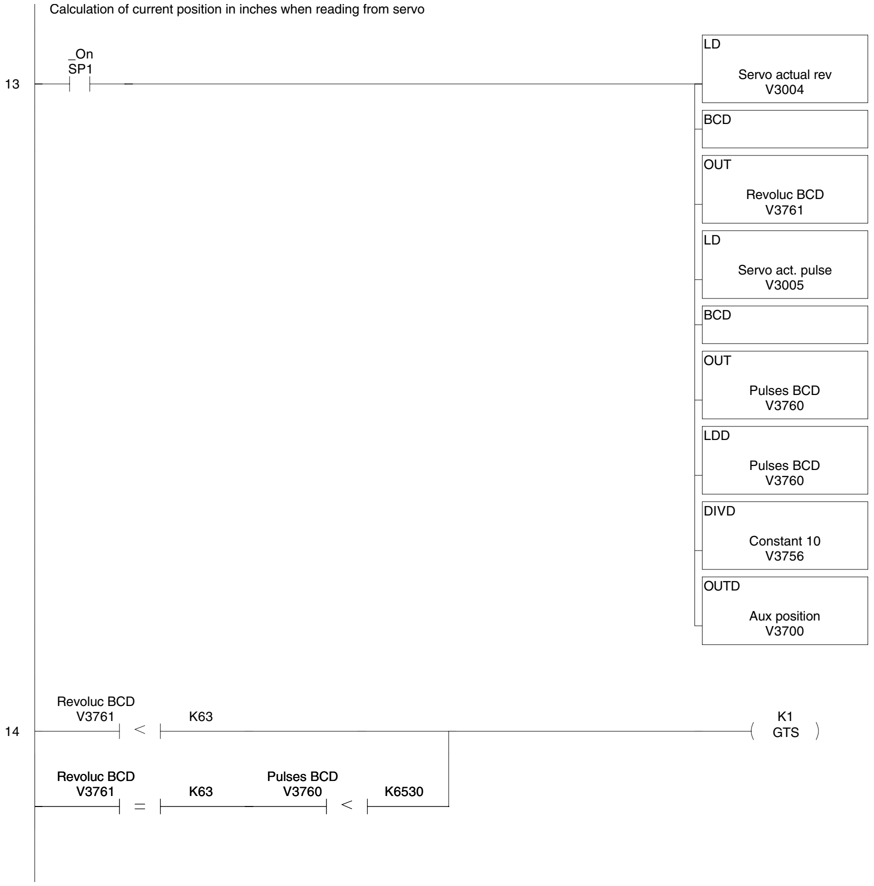
We should calculate the current position in V7362, after reading the revolutions and fractions from the servo drive.

See the ladder code on the figure below to implement this.

- We know that the current revolutions are in V3004 and the current counts in V3005. We can execute a calculation to get the current position expresssed in revolutions to be displayed in thousandths of an inch.

The client may test that the panel communication link is working together with the servo. The way to do that is to force some values, because we have not done all the set up. But is is possible to see the current position by rotating the shaft of the servo.

Notice that it could be a small error due to truncation.



The servo contains the current revs and pulses in parameters P0-04 and P0-05, that are read into v3004 and V3005.

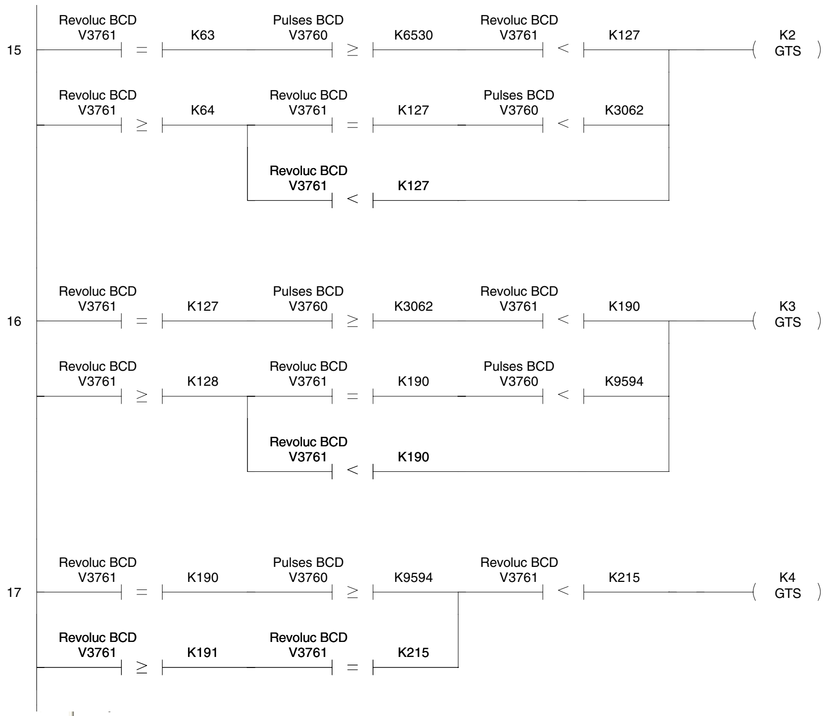
The value is transformed into a value of revolutions in a double word BCD V3760.

In order to do some logic, we divide the value by 10 and put the result into V3700.

Depending on the value of the current value, we have to change the algorithm and for that purpose we use subroutines, Each subroutine will put the result into V7362.

The calculation is done in segments of 40 inches, or the equivalent count in the servo.

See below the development of 2 subroutines. The complete section is shown at the end of this document.

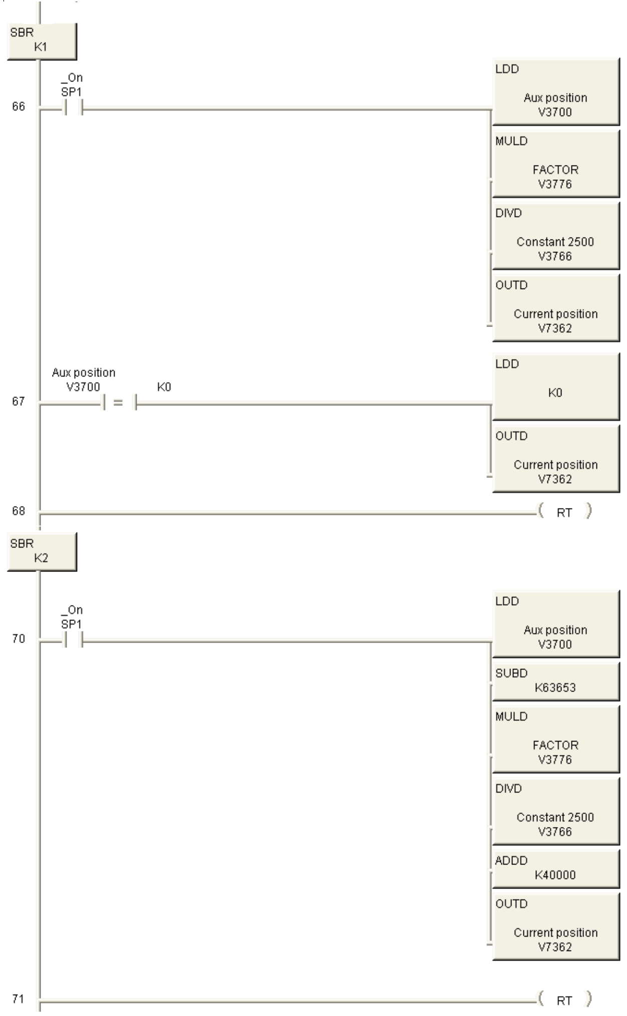


Subroutines 1 and 2

Note that:

- We use the lower and upper words of 16 bits for the value of revolutions and counts and each one is converted to binary format with the instruction BIN.

The complete section is shown at the end of this document.



On the same token, it would be important to the operator to show the current position. The servo will report the revolutions and the counts and this value will have to be scaled.

Factor of revolutions versus displacement

As concept, we will have target positions A, B, C and D, to be defined by 4 entries on the operator panel. By request of the mechanical department, we will have to clamp the numbers in the range between 3inches to 134 inches.

Every time the operator select one target and enters the data, the target value of revolutions on the servo will change accordingly.

We had defined that V2000 is the value of the target revolutions in P1-15, it is logical that we will have the V2001 values as the value of the target counts, that is zero so far, and V2002 will have the bits that go to P4-07.

The PLC will have to do some math to relate the linear distance to revolutions and counts. This is what we will explain now.

Since we know that one revolution of the servo shaft will displace 0.6284 inches, we can create the proper scale. We know that the maximum displacement is 134 inches and the precision shall be close to 2 thousands of an inch.

That is, 134.000 inches entered by the operator should be equivalent to 134/0.6284 or 213.2399 revolutions. This is the math we have to implement on the PLC.

Notice that there are integer revolutions and fractions. The revolution value should go to the parameter P1-15. The counts will go to the parameter P-16.

The operator will only define the inches to be displaced from the Home position in thousand of an inch units.

Now, recall that we have an operator interface that will write 4 numbers, such as 34.250, 56.789, 89.1243 and 102.500 inches in the PLC in double memories V4000 to V4006, arbitrarily defined.

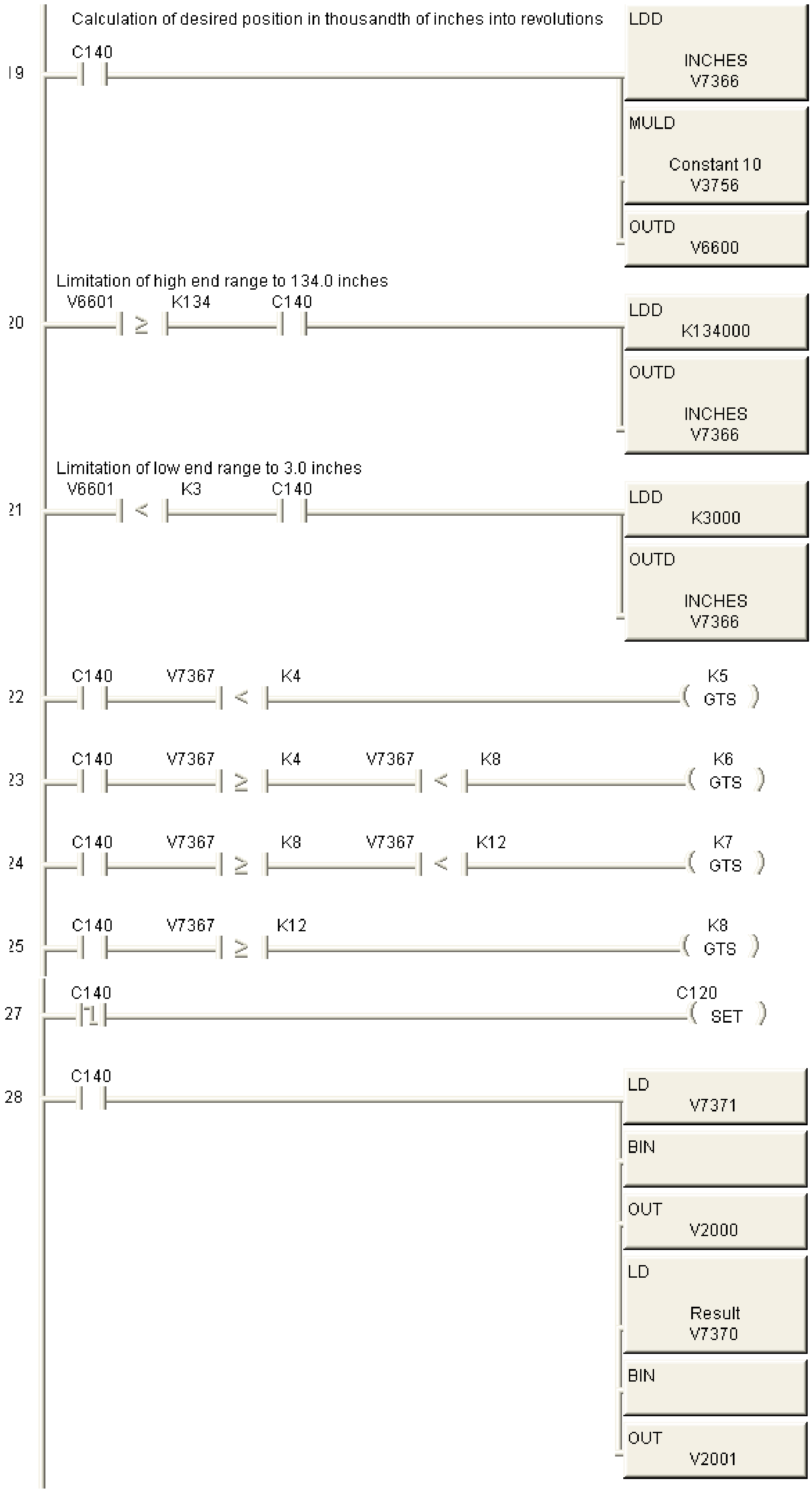
These values will be saved in the PLC and will be transferred to the target in the servo at the proper time.

The selected target value has to be scaled and separated into 2 numbers that are in binary format (Or decimal, as called in *Direct*SOFT software).

We have a small problem, and it is that the PLC calculates only up to 9999,9999 in the accumulator. We will have to split the calculation into sections using subroutines. The value, in thousandth of an inch shall be divided by 0.6284, which is the same as multiplying 10,000/6,284, or 2,500/1,571.

The ladder code on next pages explains how to do this using the unique memory V7366. We will copy the selected target to V7366 in the code. The calculation is done in segments and for that subroutines 5 tyo 8 are used, in the same manner that the ones done for the calcutlaion of the current position scaling.

Remember that the value of target revolutions shall go to V2000 and the target counts into V2001.



19
Calculation of desired position in thousandth of inches into revolutions
C140
LDD INCHES V7366
MULD Constant 10 V3756
OUTD V6600

20
Limitation of high end range to 134.0 inches
V6601 ≥ K134 C140
LDD K134000
OUTD INCHES V7366

21
Limitation of low end range to 3.0 inches
V6601 < K3 C140
LDD K3000
OUTD INCHES V7366

22
C140 V7367 < K4 (K5 GTS)

23
C140 V7367 ≥ K4 V7367 < K8 (K6 GTS)

24
C140 V7367 ≥ K8 V7367 < K12 (K7 GTS)

25
C140 V7367 ≥ K12 (K8 GTS)

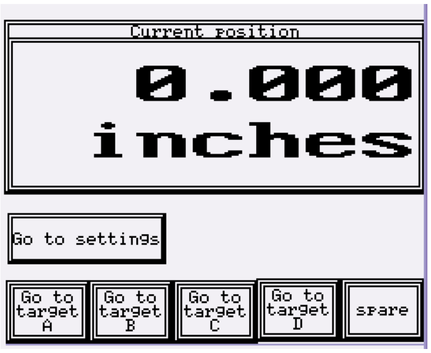
27
C140 ↑ (C120 SET)

28
C140
LD V7371
BIN
OUT V2000
LD Result V7370
BIN
OUT V2001

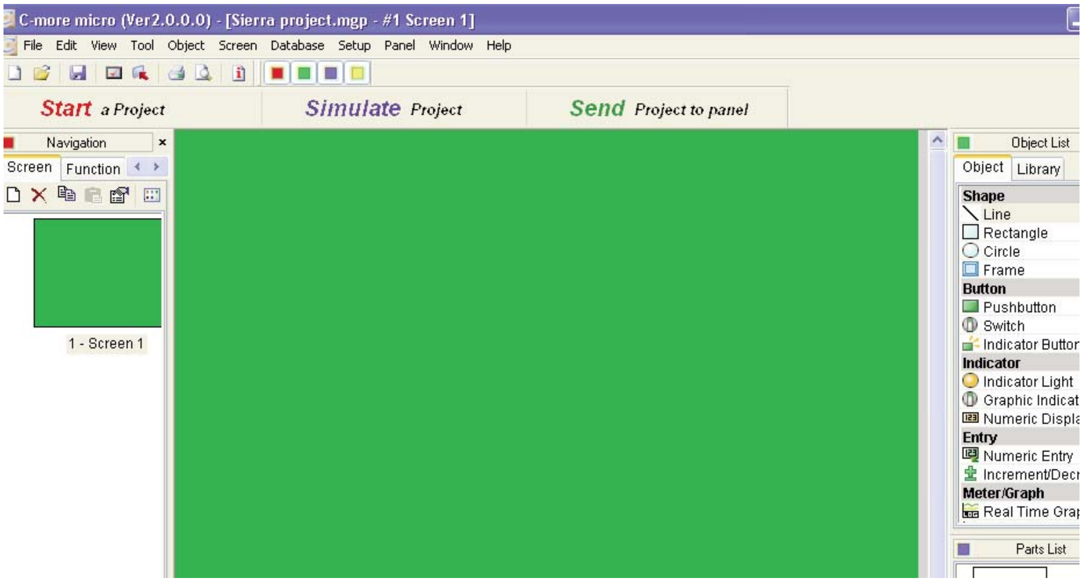
Now, it is the time to do some operator panel programming.

C-more micro programming

We will describe here how to program the objects on the operator interface. Recall that we want a screen 1 with the current position and 4 buttons to command the motion to any of the 4 targets. The second screen will have the settings. See the idea on the adjacent figure.

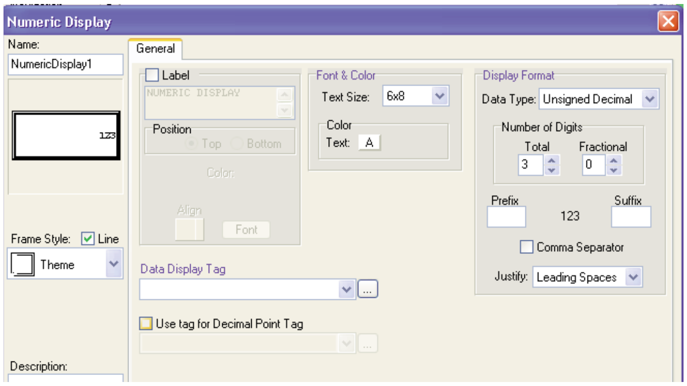


Open the C-more micro program and create a new project by clicking on the button "***Start a project***". Give a project name (for example, **Sierra project**) then select the HMI; the HMI type will be the one you are using. The PLC protocol will be Automation Direct K-sequence and click **OK**. The next screen will show up:



The position is portrait in this example.

Next, we will create a numeric display object to show the current position. Click on the menu **Object** and then select **Indicator** and then **Numeric display** and click on it. The cursor will turn into a cross symbol and then drag it by holding the left mouse button and form a rectangle with it.



Name: NumericDisplay1

Frame Style: ☑ Line

Theme

□ Label

Text Size: 6x8

Text: A

Data Type: Unsigned Decimal

Total: 3

Fractional: 0

Prefix:

Suffix:

□ Comma Separator

Justify: Leading Spaces

□ Use tag for Decimal Point Tag

When you finish the dragging, the numeric display dialog box will show up and then you can fill up the data. See it on the adjacent figure. The main features are explained on next page.

Text Size: Click on the down arrow to select the Text Size of the number to be displayed. In this case we will select 32X32.

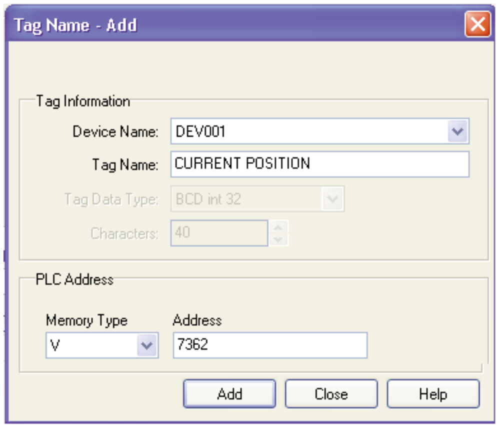
Data Display Tag: Click on the down arrow to select a Tag Name. In this case we will select CURRENT POSITION . Click on the button at the right with 3 dots and other dialog box will show up, as in the adjacent figure. Fill up according to the data on the figure. Tag name Type shall be BCD 32 bit.

Number of Digits: Click on the Up or Down arrows to select the number of Total and Fractional digits to be displayed. set as TOTAL 6 & FRACTIONAL 3.

Suffix: Click on the field to enter a common Suffix value that will always be displayed. In this case we will select inches.

You can get familiar with the object properties.

Other fields are not important at this time. You can read more on the on line help. Click on the button **ADD** to return to the main dialog box and then click OK.



Tag Name - Add

Tag Information

Device Name: DEV001

Tag Name: CURRENT POSITION

Tag Data Type: BCD int 32

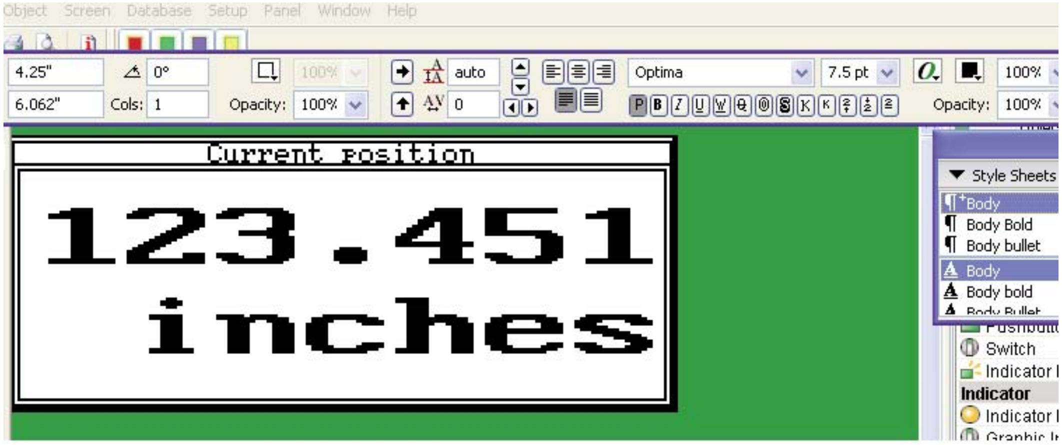
Characters: 40

PLC Address

Memory Type: V

Address: 7362

Note that the object is displayed where you have made the rectangle. Drag it to the top of the screen. You should see an object similar to the following:



Current position

123.451

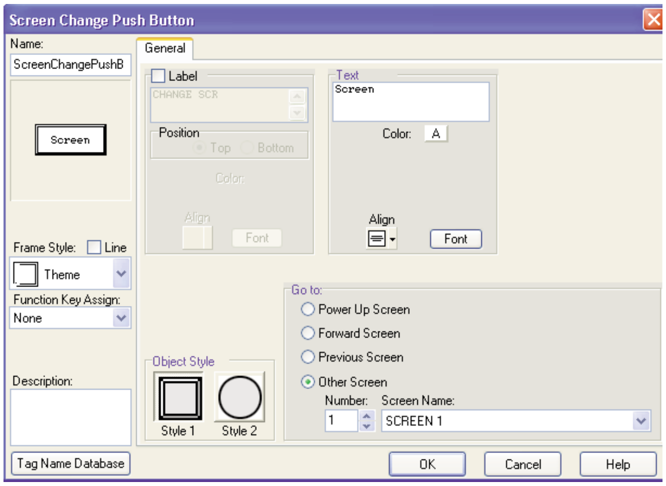
inches

You may drag it to the desired position, if necessary; you can also give other size and shape. then, save to the disk

We will create 2 buttons to jump to other screens, screen 2 and 3, that arbitrarily are defined as settings and instructions. Of course, the client can customize the operator panel as desired. More than 90 screens are possible, even though this is not practical.

In order to to this, please click on Object and then select Control and Screen change pushbutton. Click again and the cursor will turn into a cross.

Drag it forming a rectangle somewhere under the numeric display object. It will pop up a dialog box as follows:



Screen Change Push Button

Name: ScreenChangePushB

☐ Label: CHANGE SCR

Text: Screen

Color: A

Frame Style: ☐ Line — Theme

Function Key Assign: None

Description:

Go to:
○ Power Up Screen
○ Forward Screen
○ Previous Screen
● Other Screen

Number: 1 — Screen Name: SCREEN 1

Change the field Text with the words **Go to settings** and in the field Go to: select other screen and set it as number 2 and you may set other properties here.

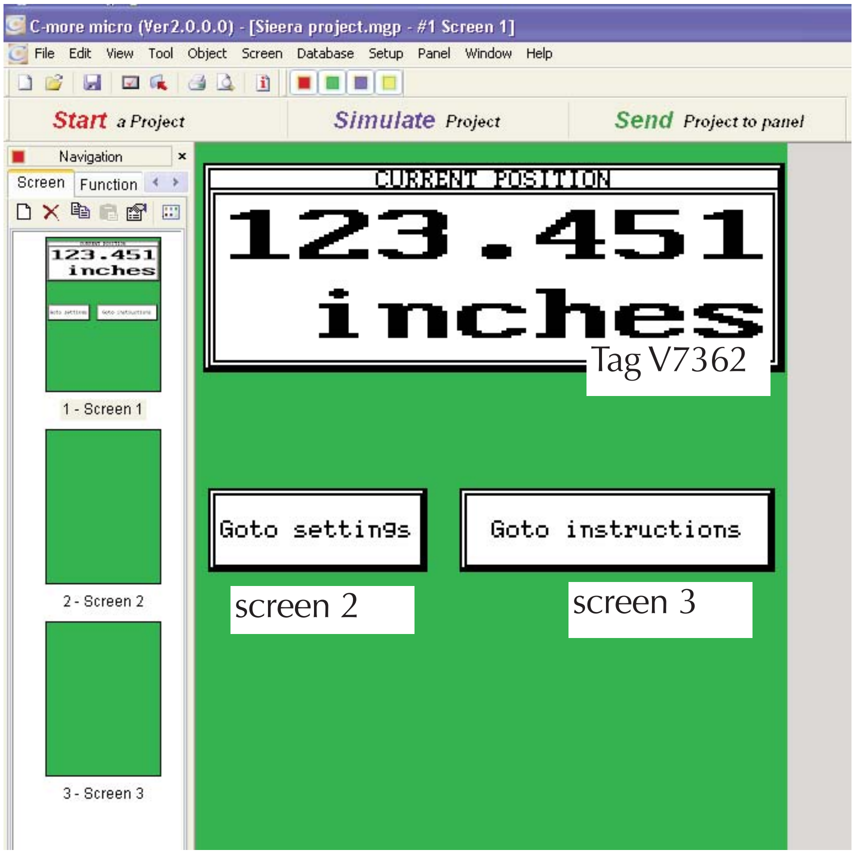
In the same way, set other change screen button to go to screen 3, that will be called **Go to instructions**. You can copy the object and then change the properties. For that, select the change screen button by clicking into it and then go to the menu Edit and hit "copy". Then got other submenu "Paste". A copy will show up over the original set, offset and showing dots on the corners. Drag it to the right of the existing one.

Now we can right-click on the bottom text object and a submenu will show up. Click on the submenu Object Properties and change the necessary fields.

You can relocate the objects to align with the upper ones. You may change the frame to other, to distinguish from the previous one.

On the same way, you may change the properties of the numeric display.

The result and the tags related to each object are shown on the following figure:



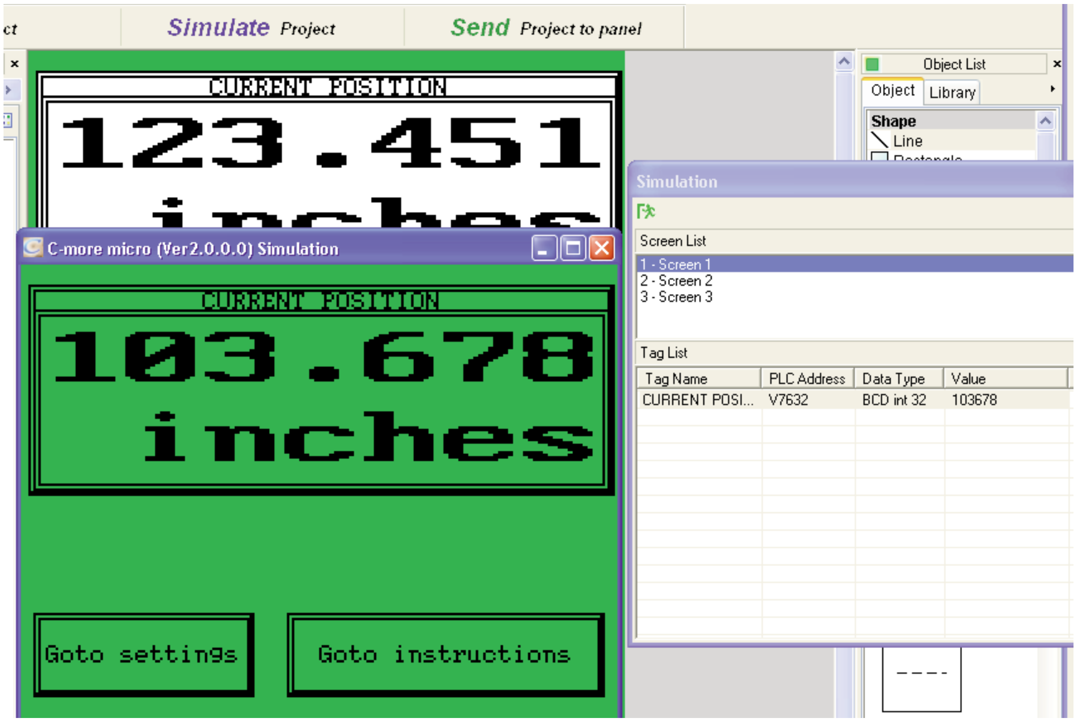
Tag V7362

screen 2

screen 3

This project can be downloaded to the panel for testing purposes by clicking on the button "**Send** Project to Panel". Set the panel to Setup mode.

You can also simulate the behavior of the panel on the PC by clicking the button "**Simulate** panel". This function provides the possibility to show what you will see on the panel. For example, you can click on the numeric entry object and the display will show a keypad that can be clicked to enter a number, as you do on the panel.



Screen List

1 - Screen 1
2 - Screen 2
3 - Screen 3

Tag List

Tag Name	PLC Address	Data Type	Value
CURRENT POSI...	V7632	BCD int 32	103678

More instructions are found on the on line Help of the software.

We will create the functionality for the buttons on the operator panel. We will have defined functions that are different on each screen.

On the screen 1 we will create the following arrangement:

Button 1 - Go to target A

Button 2 - Go to target B

Button 3 - Go to target C

Button 4 - Go to target D

Button 5 - It is spare. We could also create an emergency stop here, if desired by using a servo disable command.

On the screen 2 we will create the following arrangement:

Button 1 - Servo enable

Button 2 - Alarm reset

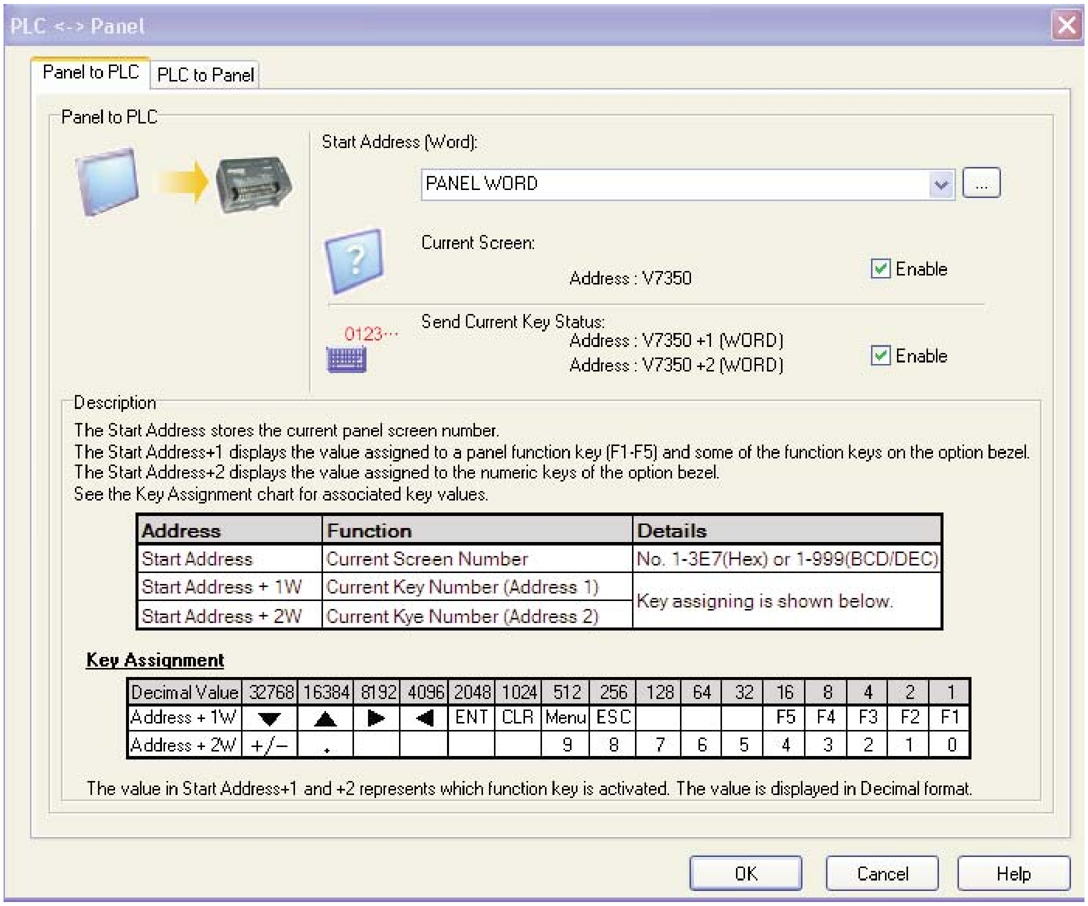
Button 3 - Spare. To be programmed to turn ON Y5 as example

Button 4 - Spare. To be programmed to turn ON C333 as example

Button 5 - Servo disable

The C-more micro panel 5 buttons has associated bits of a word that it is necessary to define. We will go to the menu SETUP and then select PLC <-> Panel.

The following dialog box will show up; we will create a **Start address** in V7350:



Start Address (Word):

PANEL WORD

Current Screen:

Address : V7350 ☑ Enable

Send Current Key Status:

Address : V7350 +1 (WORD)

Address : V7350 +2 (WORD) ☑ Enable

Description

The Start Address stores the current panel screen number.
The Start Address+1 displays the value assigned to a panel function key (F1-F5) and some of the function keys on the option bezel.
The Start Address+2 displays the value assigned to the numeric keys of the option bezel.
See the Key Assignment chart for associated key values.

Address	Function	Details
Start Address	Current Screen Number	No. 1-3E7(Hex) or 1-999(BCD/DEC)
Start Address + 1W	Current Key Number (Address 1)	Key assigning is shown below.
Start Address + 2W	Current Kye Number (Address 2)	

Key Assignment

Decimal Value	32768	16384	8192	4096	2048	1024	512	256	128	64	32	16	8	4	2	1
Address + 1W	▼	▲	▶	◀	ENT	CLR	Menu	ESC				F5	F4	F3	F2	F1
Address + 2W	+/−	.					9	8	7	6	5	4	3	2	1	0

The value in Start Address+1 and +2 represents which function key is activated. The value is displayed in Decimal format.

The explanation of the 3 words related to the panel functions are in the figure above, but for now we are interested on register V7351.

Let us define the functions of the operator interface as follows

F1 => C110 Servo enable; the servo enable shall be set by the operator.

F2 => C100 Command trigger;

F3 => C101 Alarm reset; this should also be commanded by operator

F4 => spare

F5 => C102 Servo disabled; it shall be commanded by the operator.

We will relate the word V7351 value to any of the C bits, as follows:

If the button F1 is pressed, V7351 will change to a 1 BCD.

If the button F2 is pressed, V7351 will change to a 2 BCD.

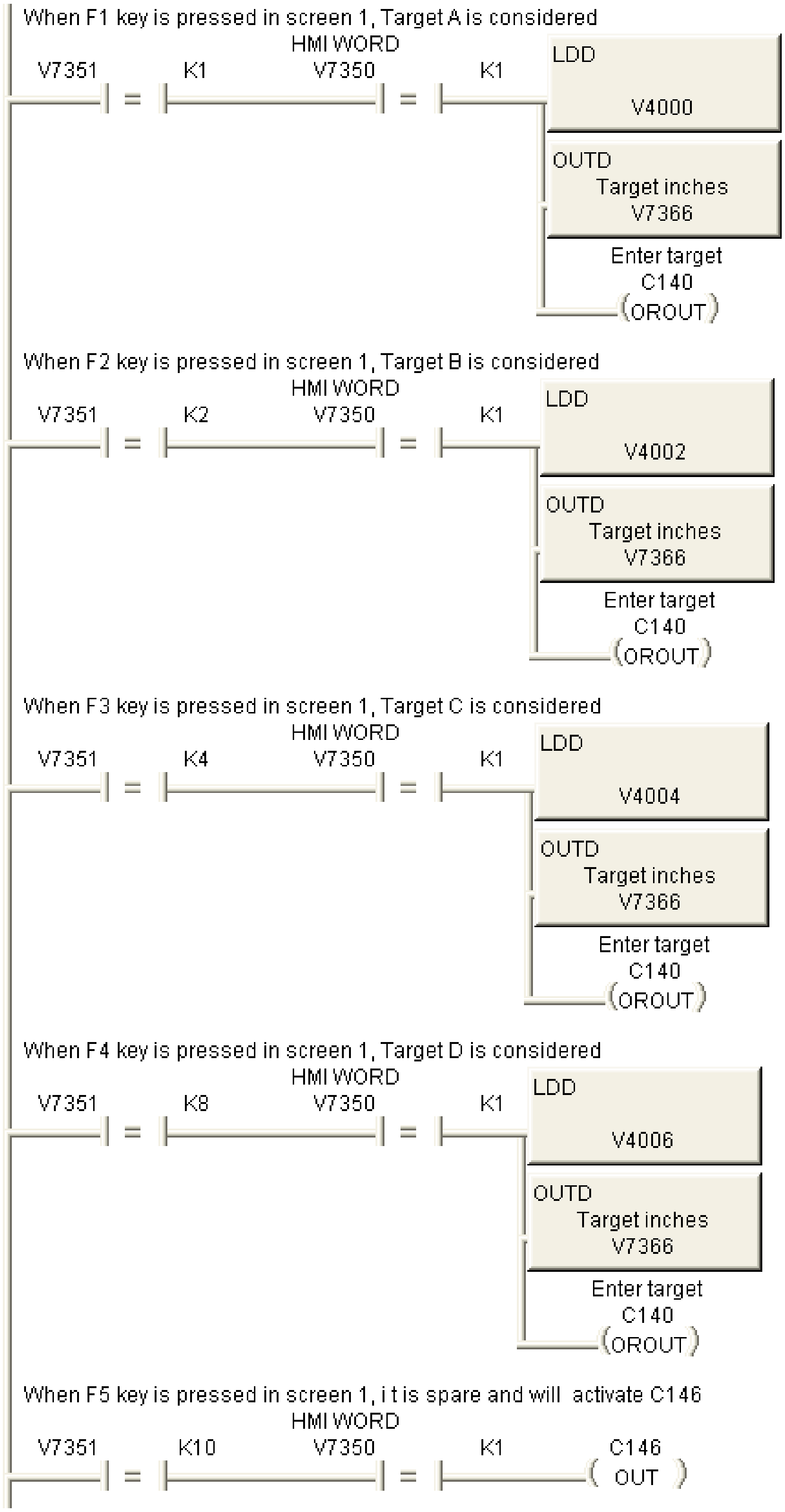
f the button F3 is pressed, V7351 will change to a 4 BCD.

If the button F4 is pressed, V7351 will change to a 8 BCD

If the button F5 is pressed, V7351 will change to a 10 BCD.

Defining the digital inputs to be used for commanding the servo

With these considerations we will implement more ladder code on the PLC.



When F1 key is pressed in screen 1, Target A is considered

When F2 key is pressed in screen 1, Target B is considered

When F3 key is pressed in screen 1, Target C is considered

When F4 key is pressed in screen 1, Target D is considered

When F5 key is pressed in screen 1, i t is spare and will activate C146

Recall that V7351 is the word associated to the panel key. When the content of V7351 is 1 the key F1 has been pressed. C140 is turned on this case.

When the content of V7351 is 2 the key F2 has been pressed. C140 is turned on this case.

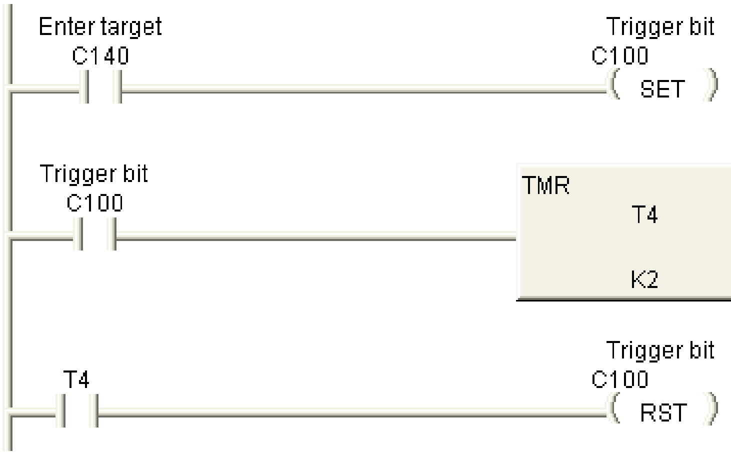
When the content of V7351 is 4 the key F3 has been pressed. C140 is turned on this case.

When the content of V7351 is 8 the key F4 has been pressed. C140 is turned on this this case.

When the content of V7351 is 10 the key F5 has been pressed. C146 is turned on this this case.

In the test at AutomationDirect, we used a H0-ECOM to connect *Direct*SOFT to the PLC; the Port 1 has the Panel and the Port 2 is connected to the servo drive.

In order to create a trigger command after one of the buttons have been pressed, we created the following code:



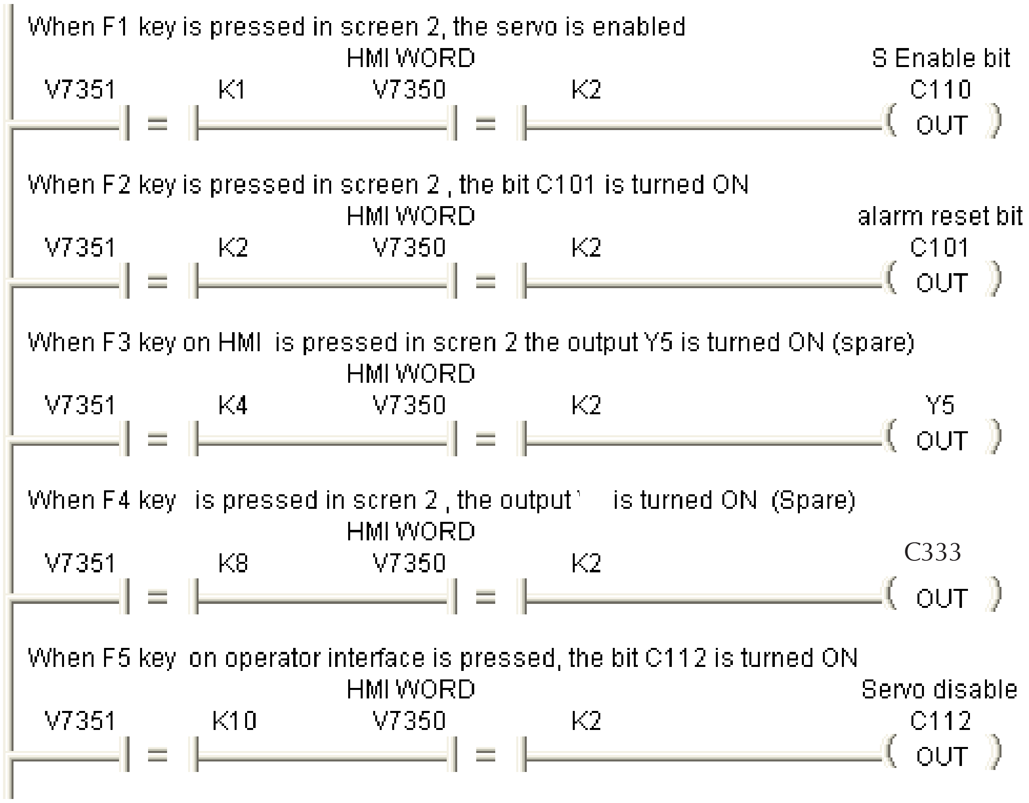
When the bit C140 is activated, the action sets the bit C100, which is the trigger bi

When C100 is On, the timer counts for 200 ms and will turn ON T4 after this time.

When T4 is ON, the bit C100 is reset to OFF.

We will create a static text object with the descriptions of the functions to the operator panel. in order that the operator can identify the proper button. Of course, other possibility is to engrave the function on the empty labels supplied with the panel.

We have other action on the screen 2 buttons. See below:


When F1 key is pressed in screen 2, the servo is enabled

When F2 key is pressed in screen 2 , the bit C101 is turned ON

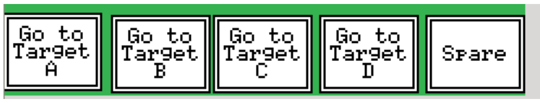
When F3 key on HMI is pressed in scren 2 the output Y5 is turned ON (spare)

When F4 key   is pressed in scren 2 , the output `   is turned ON (Spare)

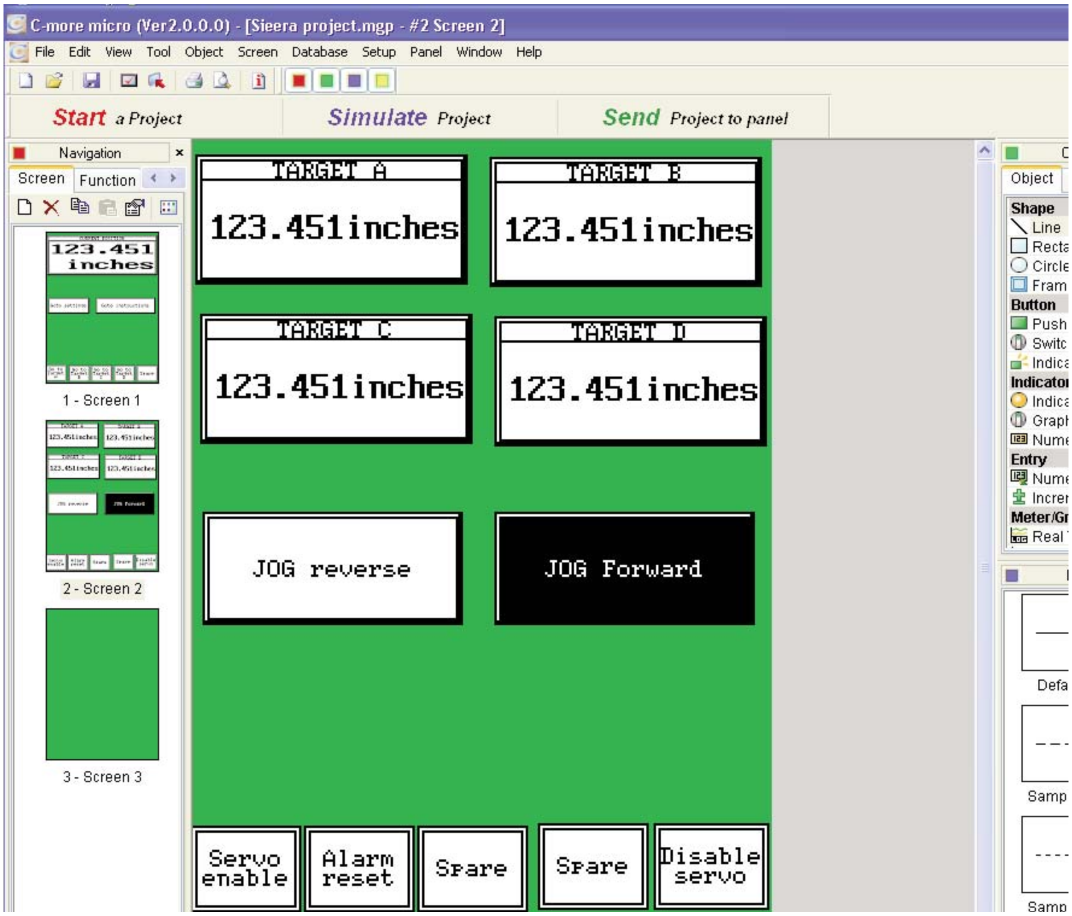
When F5 key on operator interface is pressed, the bit C112 is turned ON

We are ready to create the screen 2 and screen 3.

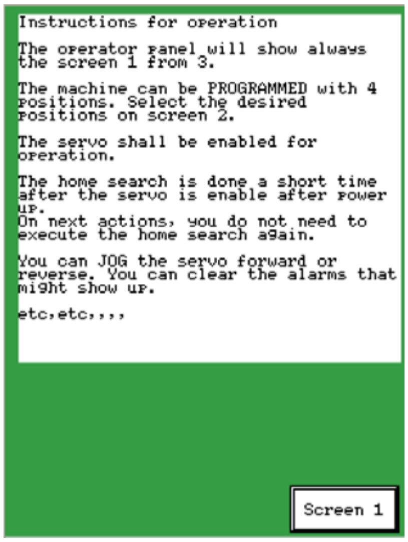
In screen 2 we will set 4 numeric entry objects to define the position targets data to be used. See the adjacent figure about the text created.



We may have to add a JOG forward and a JOG reverse later on this project, for the rare case that the tool get the overtravel limit switch activated or any need to test the motion. This can be set with a touch screen button. Finally, we have to identify the buttons for screen 2. The figure above is the probable result.



Screen 3 can be just text, as shown on the adjacent figure. Of course, the client should set the proper instructions for the specific machine. The instructions can also be several pages with navigation buttons there.



Instructions for operation

The operator panel will show always the screen 1 from 3.

The machine can be PROGRAMMED with 4 positions. Select the desired positions on screen 2.

The servo shall be enabled for operation.

The home search is done a short time after the servo is enable after power up.
On next actions, you do not need to execute the home search again.

You can JOG the servo forward or reverse. You can clear the alarms that might show up.

etc,etc,,,,

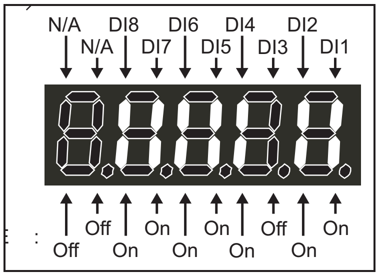
Now is the time to check the connections between the PLC and the servo.

In order to turn the servo outputs ON, we can use the parameter P4-06.

P4-06 shall be set to 1 to force DO1 to ON. When pressed the Enter key, the Display will show OP 01 and the XO LED of the PLC will turn ON. In the same manner, when set to 2, and then pressed the Enter key, the Display will show OP 02 and the X2 LED of the PLC will turn ON.

Now it is the time to turn the PLC outputs ON, when the proper input is turned ON and the effect will be seen on the servo by observing the display when set for the parameter P4-07. See the figure attached for having an idea of how each input that is active is seen.

Having this wiring test done, we are at the moment to test the program as it has been set up.

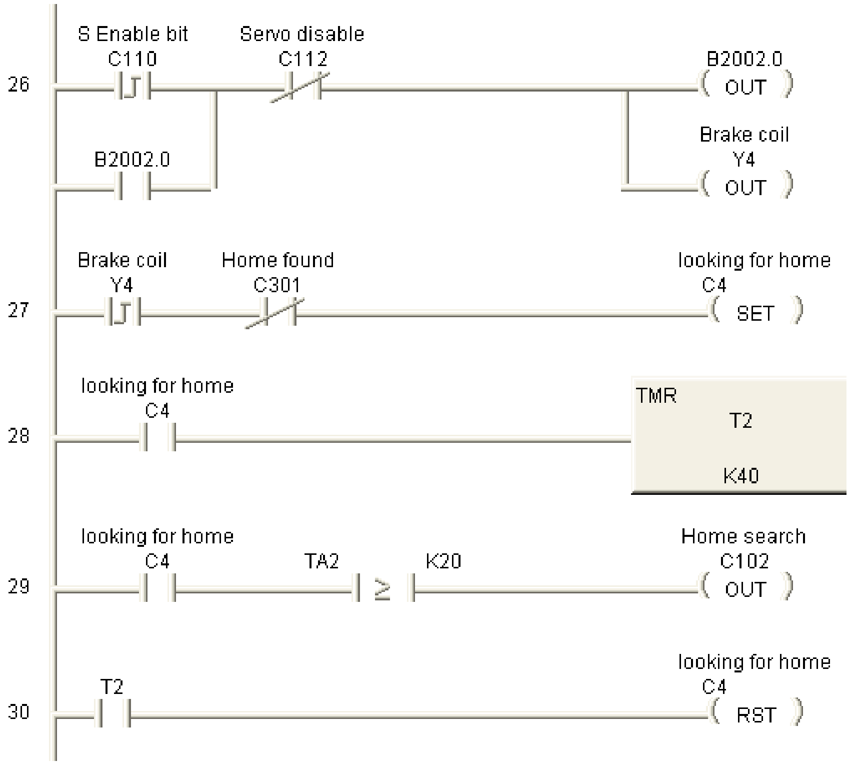


Press F1 on the operator panel. The output Y4 will turn ON. The shaft of the motor shall be locked since now the servo is enabled and you will hear a typical sound of current flowing through the windings of the servomotor

Press F5 on the operator panel. The output Y4 will turn OFF. The shaft of the motor shall not be locked anymore.

The Home search shall begin automatically after the servo is enabled, if there is no signal Home completed (P2-19 shall be set as 109). We have not done this logic.

For now, let us configure the command Home search 2 seconds after the servo is enabled. One way to implement this it is as follows:



C110 enables the servo and turn ON the output Y4

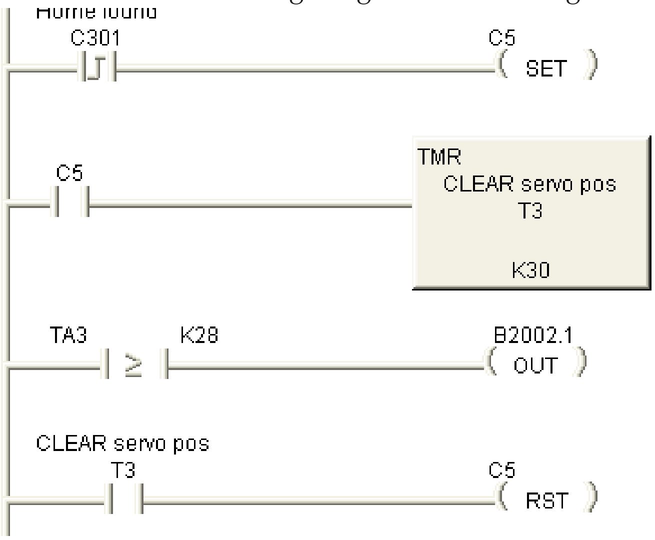
When Y4 is turned ON and Home has not been found , C4 turns ON

The timer T2 begins to count the time up to 4 seconds when C4 is turned ON

When C4 is ON AND the current value of the T2 timer is over 2 s, C102 is turned ON

When The timer reaches 4 seconds, C4 is reset, as well as C102

After the Home is completed, there is no need to do home search again. When the Home is completed, we should clear the current counts (And revolutions) to get the 0 counts at this time and allow a proper indication of the current position. This is shown on the following rungs of the next figure.



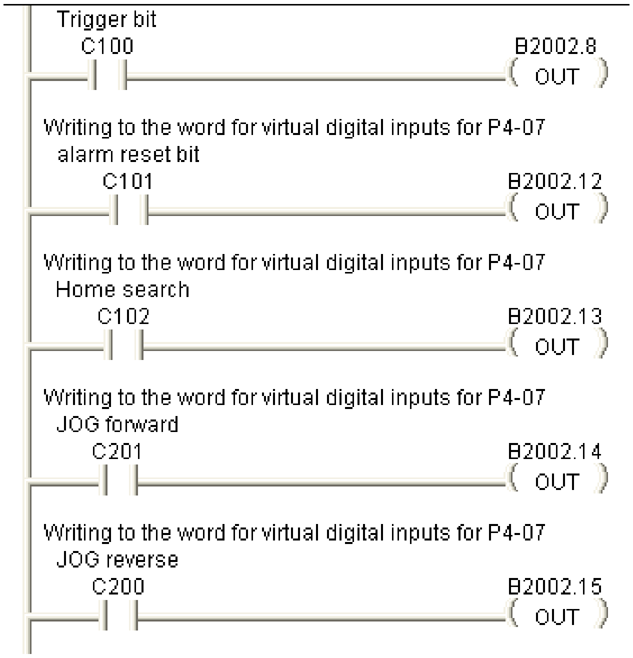
When the Home has been found, the bit C5 is set .

When C5 is ON, the timer T3 begins to count up to 3 seconds.

V2002.1 is turned ON for 200 ms to clear the current position

when the timer T3 completes 3 seconds, the bit C5 is reset.

We should transport the necessary digital input to the servo though MODBUS. This is one way to implement it; C100 has to be turned ON at the proper time:


Trigger bit
C100
B2002.8
OUT
Writing to the word for virtual digital inputs for P4-07
alarm reset bit
C101
B2002.12
OUT
Writing to the word for virtual digital inputs for P4-07
Home search
C102
B2002.13
OUT
Writing to the word for virtual digital inputs for P4-07
JOG forward
C201
B2002.14
OUT
Writing to the word for virtual digital inputs for P4-07
JOG reverse
C200
B2002.15
OUT

When C100 turns ON the eighth bit of the word V2002 is turned ON. This will give the command to move to the servo.

When C101 turns ON the bit 12 of the word V2002 is turned ON. This will clear alarms on the the servo drive.

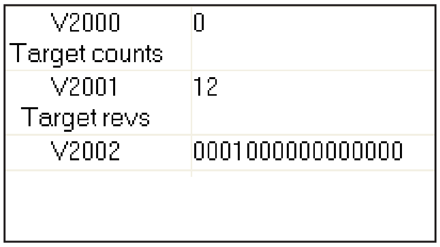
When C102 turns ON the bit 13 of the word V2002 is turned ON. This will give the servo the command to move to search for the home sensor.

When C201 turns ON the bit 14 of the word V2002 is turned ON. This will give the command to JOG forward.

When C200 turns ON the bit 15 of the word V2002 is turned ON. This will give the servo the command to JOG reverse.

At this time we can test again the program.

The data can be seen with Data View using the proper formatting. See the adjacent figure to see how to check that the Alarm reset button C101 has been pressed. Bit 12 turns ON.

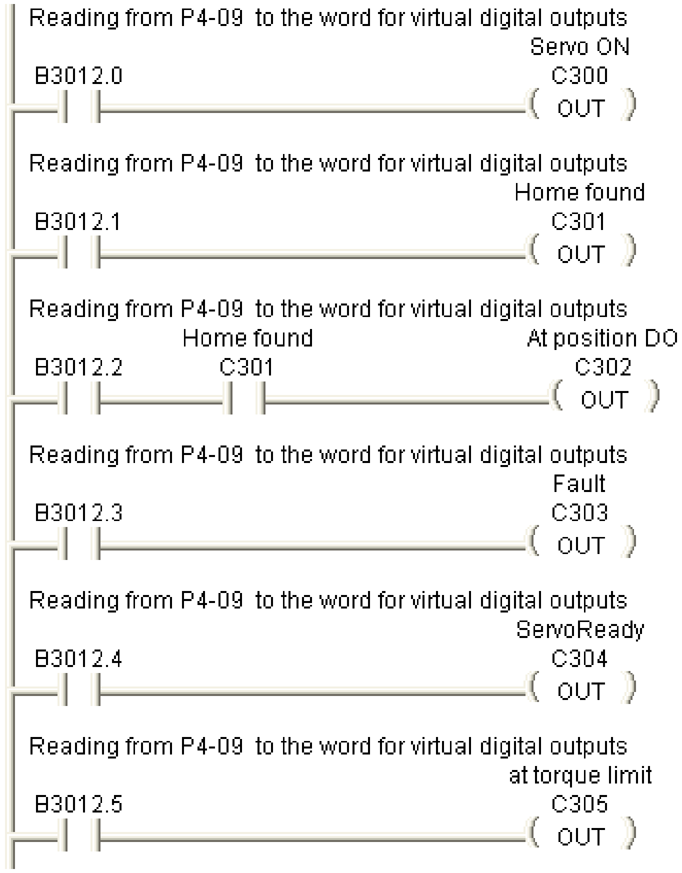


V2000 Target counts	0
V2001 Target revs	12
V2002	0001000000000000

Using the output status data in P4-09

We need the servo digital output data for some actions on the PLC program. We know that we are getting data continuously on the word V3012.

The following part of the ladder program shows how this can be accomplished.



```
Reading from P4-09  to the word for virtual digital outputs
                                                   Servo ON
B3012.0                                              C300
--| |--------------------------------------------( OUT )

Reading from P4-09  to the word for virtual digital outputs
                                                 Home found
B3012.1                                              C301
--| |--------------------------------------------( OUT )

Reading from P4-09  to the word for virtual digital outputs
              Home found                      At position DO
B3012.2         C301                                 C302
--| |-----------| |------------------------------( OUT )

Reading from P4-09  to the word for virtual digital outputs
                                                     Fault
B3012.3                                              C303
--| |--------------------------------------------( OUT )

Reading from P4-09  to the word for virtual digital outputs
                                                 ServoReady
B3012.4                                              C304
--| |--------------------------------------------( OUT )

Reading from P4-09  to the word for virtual digital outputs
                                              at torque limit
B3012.5                                              C305
--| |--------------------------------------------( OUT )
```

When the bit 0 on the register P4-09 is ON, the servo is ON. This turns ON C300.

When the bit 1 on the register P4-09 is ON, the Home search has been completed. This turns ON C301.

When the bit 2 on the register P4-09 is ON and home is completed, the servo is at position. This turns ON C302.

When the bit 3 on the register P4-09 is ON, the servo is at fault. This turns ON C303.

When the bit 4 on the register P4-09 is ON, the servo is ready. This turns ON C304.

When the bit 5 on the register P4-09 is ON, the servo is at torque limit. This turns ON C305.

The bit C300 can be used for resetting the logic on rung 1, to avoid that the servo communications is not well established.

All the bits that show the status of the servo can be used for other purposes on the ladder code. For example, to show the status on the screen 1 of the operator panel.

Testing the program

You may want to be sure that the hardwired inputs are working properly. Also that the speeds are the ones you want.

The next step is to turn on the servo and the PLC and the operator panel. The current position should be 0 inches, even though it might not be there. The **Home not found** banner will be on the top. Also, the servo is **Disabled** and **Ready.**

The **transactions/s** should be about 25 to 48 Transactions/s.

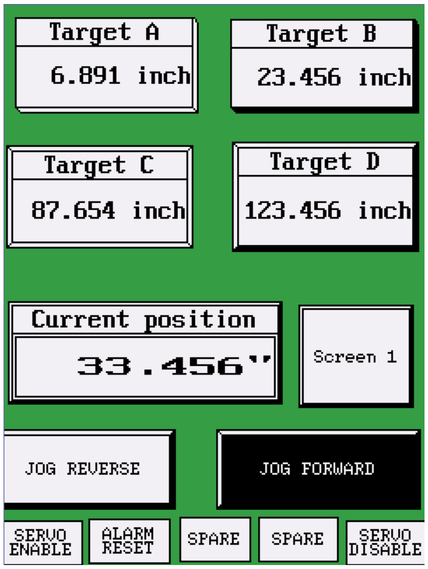
If significant lower than from a value close to this, please troubleshoot the problem.

You should press the **Goto Settings** button to go to screen 2 to load target values and test that the servo is moving to the corresponding position.

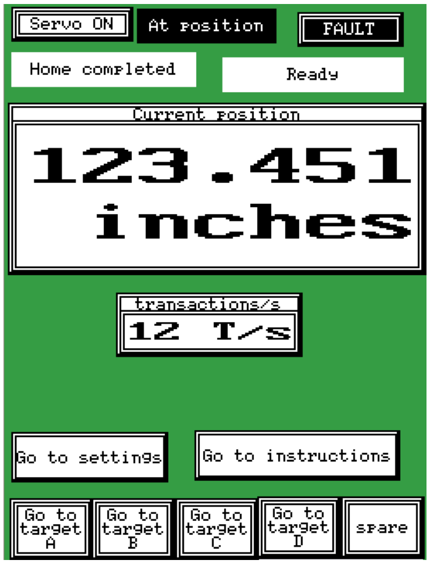
Before proceeding with this, it is possible to rearrange and add more functionality to the operator interface panel.

We have added the transactions per second on screen 1 as well as the status indicators. Notice that the transaction counts per second has decreased. See the adjacent figures for one possible option.

Screen 2



Screen 1



Write targets in the "numeric entries" by touching the object. The numeric keypad will show up. Clear the number that is there by touching the key "CLR".

Press the button F1, **Servo enable** and the servo will move to find the Home sensor. When this is done, the servo will stop moving and after a short period, the Current position will go back to zero (0.000 inches).

Press the Screen1 button to go back to the screen 1.

The banner at the top has changed to **Home completed**.

It is checked that the number is not greater than 130 inches. If greater or equal than 130 inches, it clamps the value and forces a 130 inches on the target. But this has not been transferred to the servo. For that to happen, we should press one of the buttons F1 to F4 on the screen 1.

When this is done, the logic on the PLC triggers the motion. The servo will move to the corresponding number of revolutions and counts.

To come back to other position, we can repeat the action, that is, after at position, press other button. It will move to the selected target.

This is the operation. If everything works as described, the project has been done.

If the motion has some oscillations, you may need to execute some tuning. Tuning is not covered in this technical note.

But you should document the operation for the operator to have a description of what the machine will do, how to troubleshoot, How to reset alarms if any, etc.

This concludes the programming of the PLC and basic configuration of the servo.

At this time, we have a PLC scan time of 10 ms average, with excursion to 14 ms and 8 ms.

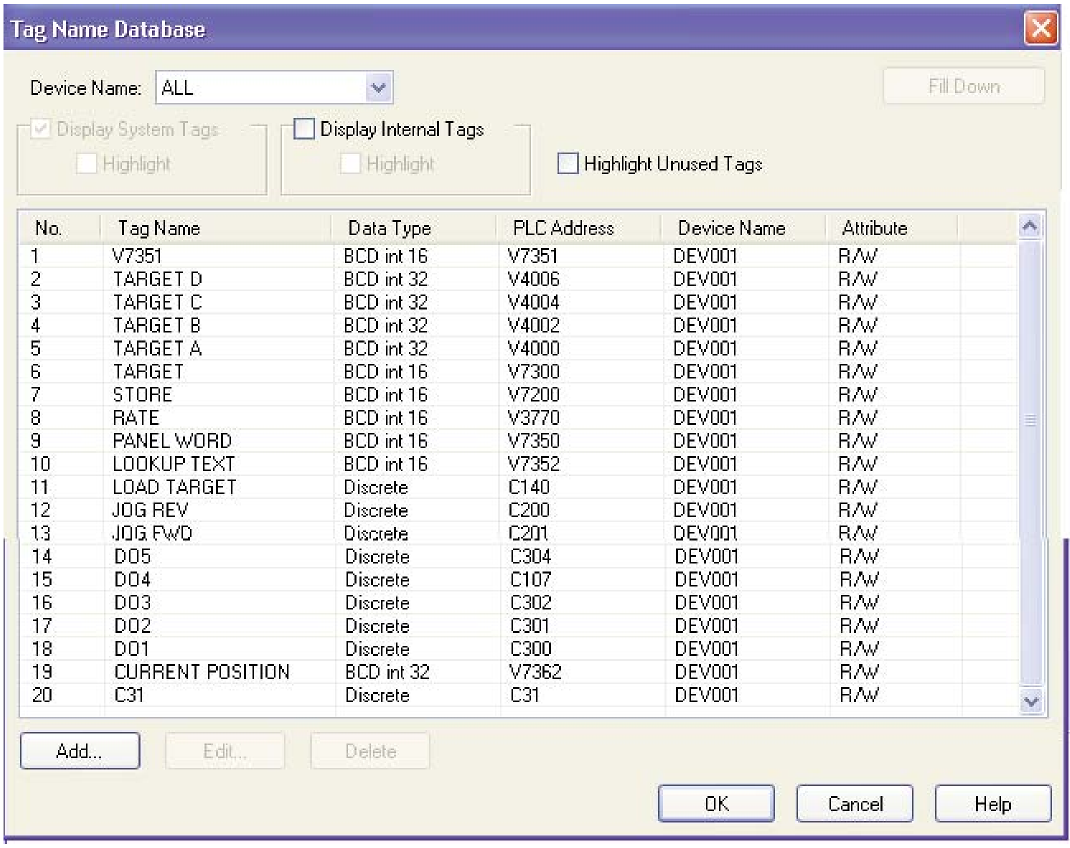
The transaction/second are about 42 or 43 T/s , that is, the reading occurs every 47.6 ms. This is, 1000[ms]/42 [transactions is 23.8 ms. since for every reading there is a writing, we multiply that value by 2=> 23.8x2 = 47.6 ms.

What to do if we need more updates per second?

A - We can reduce the number of points to be read and written.

B- If we use a faster master, such as the D0-DCM or the F0-CP128 on the DL05, or other PLC with more Baud rate, such as the Click PLC, the reading can occur faster.

On next pages are shown the tag database on the operator panel, The ladder code and the parameters selected on the servo.



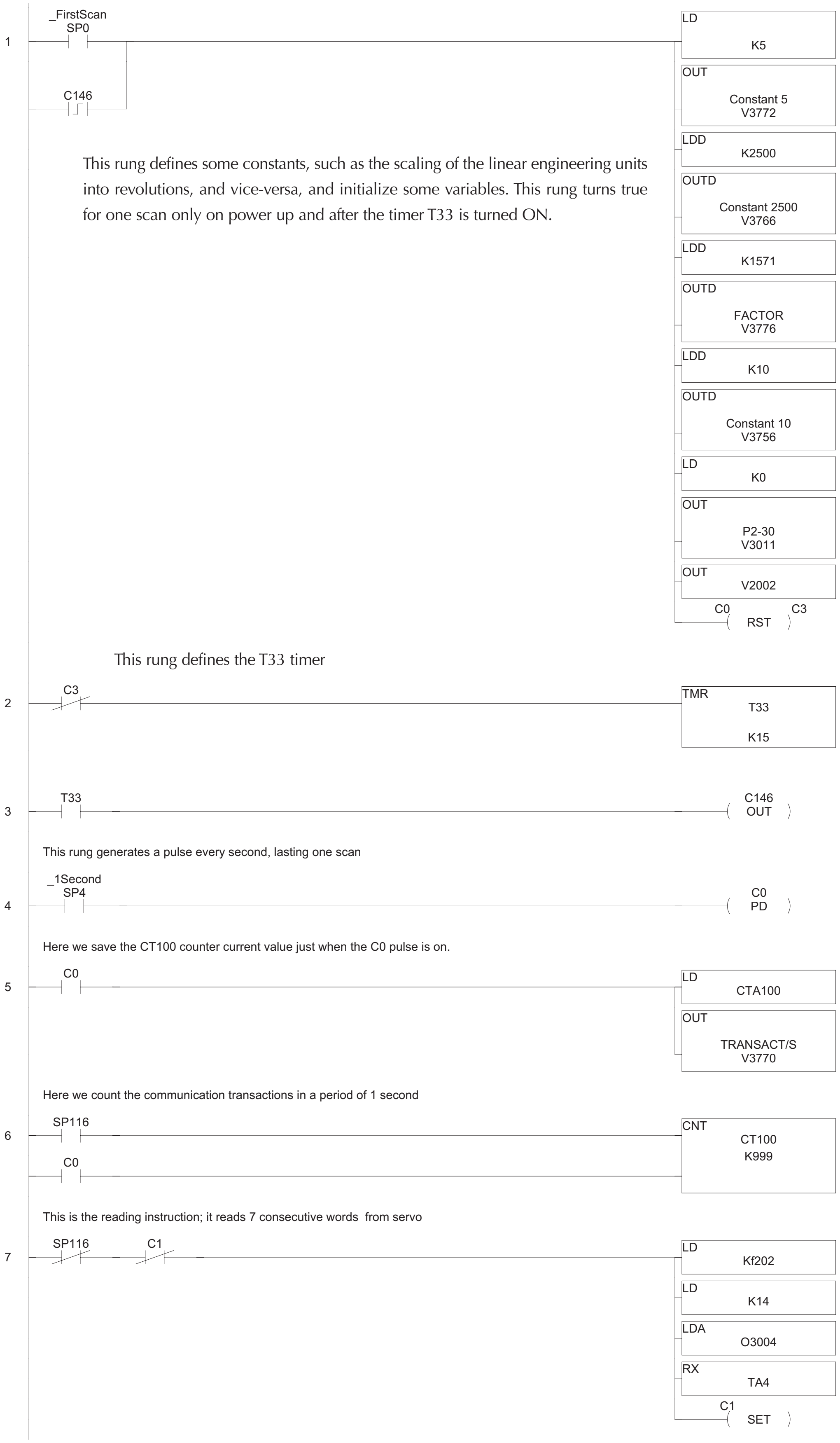
Device Name: ALL

☑ Display System Tags □ Highlight

□ Display Internal Tags □ Highlight

□ Highlight Unused Tags

No.	Tag Name	Data Type	PLC Address	Device Name	Attribute
1	V7351	BCD int 16	V7351	DEV001	R/W
2	TARGET D	BCD int 32	V4006	DEV001	R/W
3	TARGET C	BCD int 32	V4004	DEV001	R/W
4	TARGET B	BCD int 32	V4002	DEV001	R/W
5	TARGET A	BCD int 32	V4000	DEV001	R/W
6	TARGET	BCD int 16	V7300	DEV001	R/W
7	STORE	BCD int 16	V7200	DEV001	R/W
8	RATE	BCD int 16	V3770	DEV001	R/W
9	PANEL WORD	BCD int 16	V7350	DEV001	R/W
10	LOOKUP TEXT	BCD int 16	V7352	DEV001	R/W
11	LOAD TARGET	Discrete	C140	DEV001	R/W
12	JOG REV	Discrete	C200	DEV001	R/W
13	JOG FWD	Discrete	C201	DEV001	R/W
14	DO5	Discrete	C304	DEV001	R/W
15	DO4	Discrete	C107	DEV001	R/W
16	DO3	Discrete	C302	DEV001	R/W
17	DO2	Discrete	C301	DEV001	R/W
18	DO1	Discrete	C300	DEV001	R/W
19	CURRENT POSITION	BCD int 32	V7362	DEV001	R/W
20	C31	Discrete	C31	DEV001	R/W



1

_FirstScan SP0

C146

LD K5

OUT Constant 5 V3772

LDD K2500

OUTD Constant 2500 V3766

LDD K1571

OUTD FACTOR V3776

LDD K10

OUTD Constant 10 V3756

LD K0

OUT P2-30 V3011

OUT V2002

C0 C3 RST

This rung defines some constants, such as the scaling of the linear engineering units into revolutions, and vice-versa, and initialize some variables. This rung turns true for one scan only on power up and after the timer T33 is turned ON.

This rung defines the T33 timer

2

C3

TMR T33 K15

3

T33

C146 OUT

This rung generates a pulse every second, lasting one scan

4

_1Second SP4

C0 PD

Here we save the CT100 counter current value just when the C0 pulse is on.

5

C0

LD CTA100

OUT TRANSACT/S V3770

Here we count the communication transactions in a period of 1 second

6

SP116

C0

CNT CT100 K999

This is the reading instruction; it reads 7 consecutive words from servo

7

SP116 C1

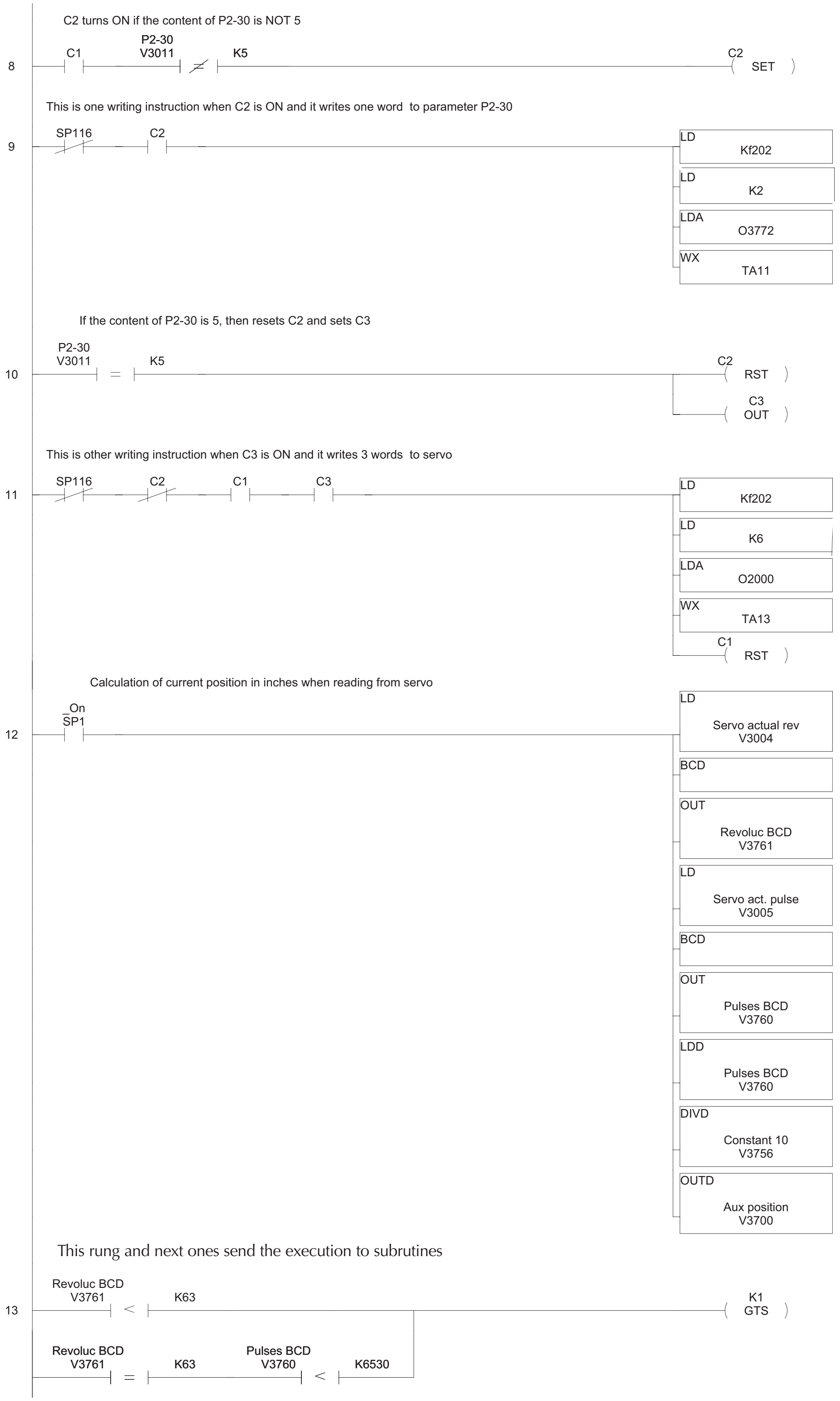
LD Kf202

LD K14

LDA O3004

RX TA4

C1 SET



C2 turns ON if the content of P2-30 is NOT 5

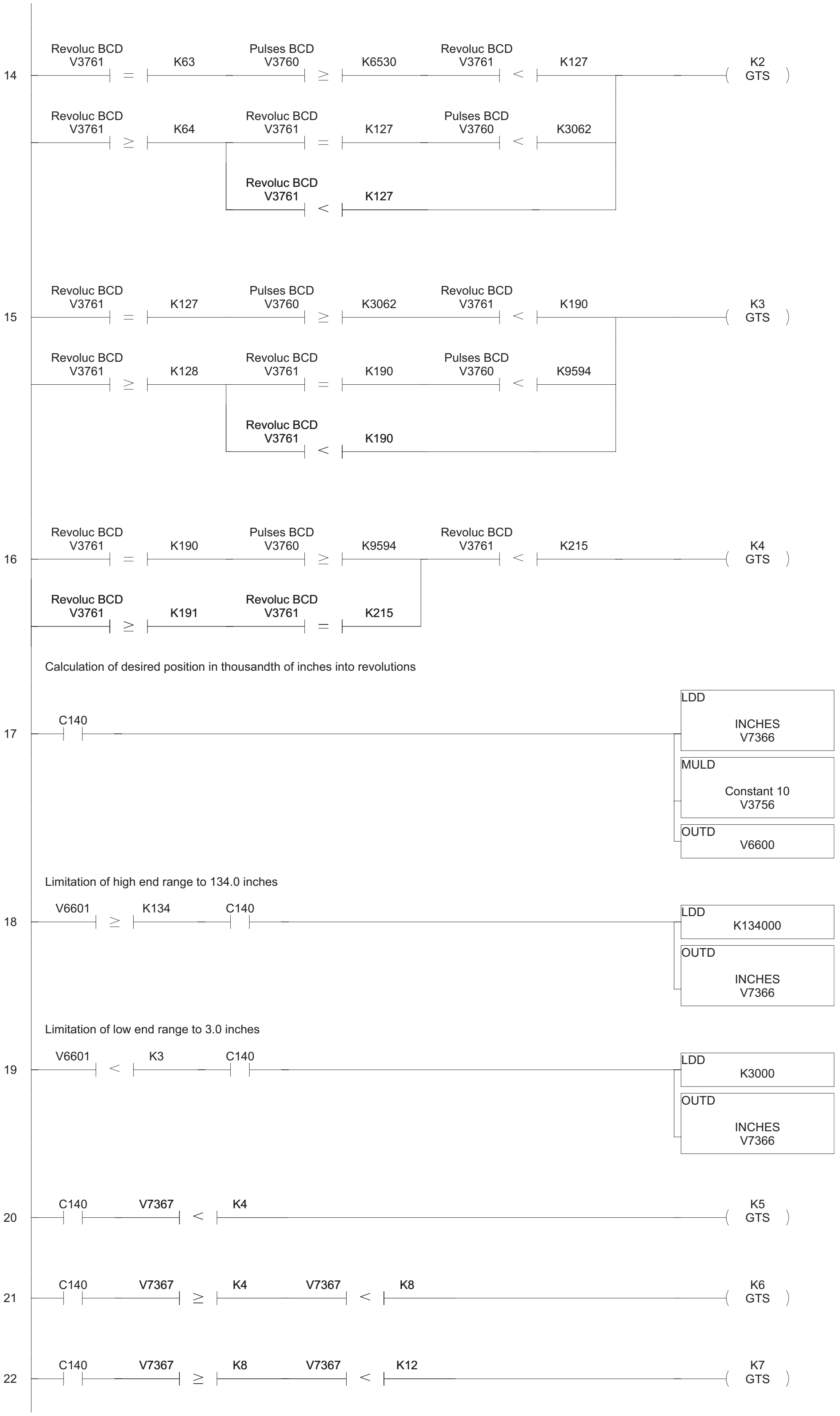
This is one writing instruction when C2 is ON and it writes one word to parameter P2-30

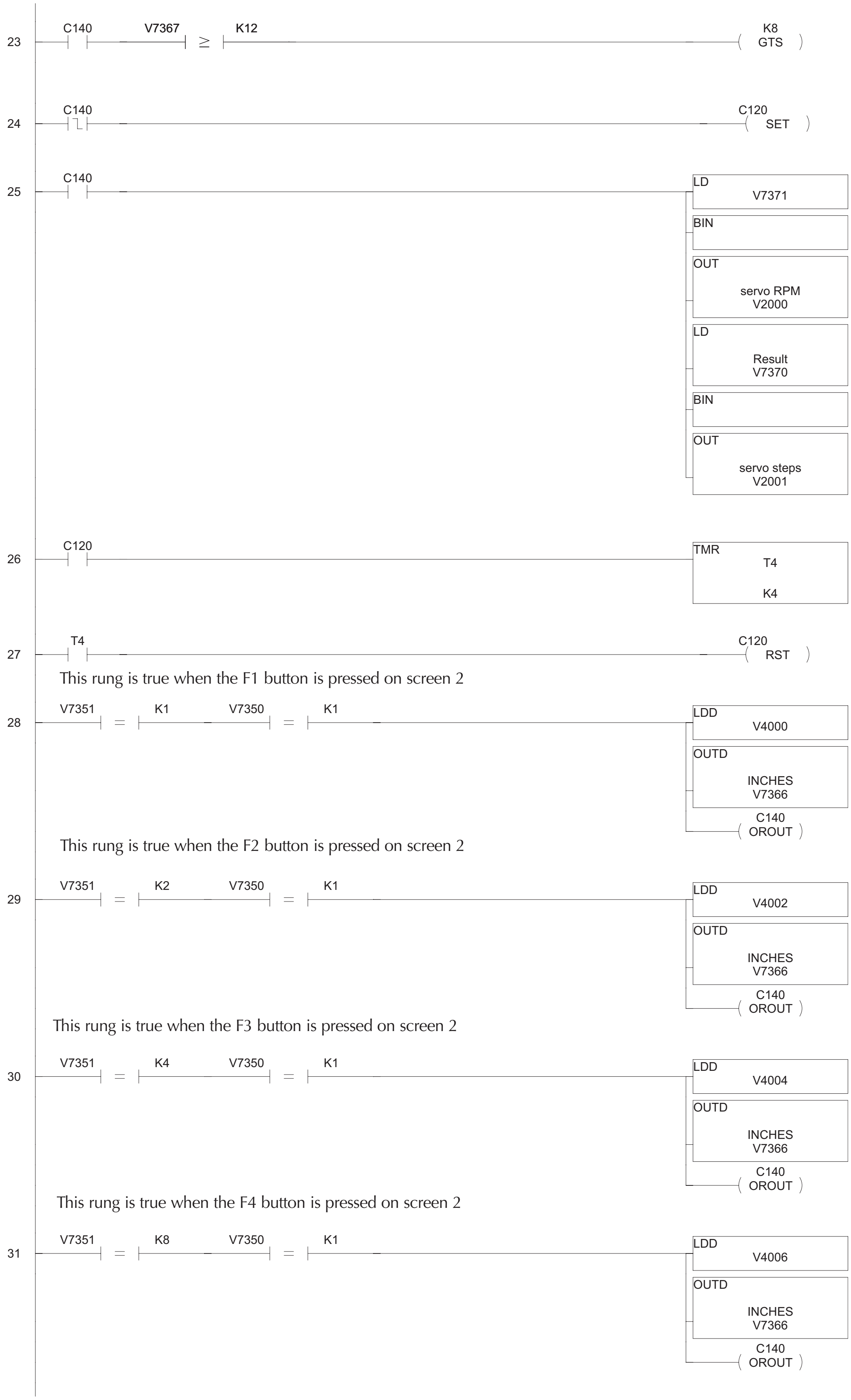
If the content of P2-30 is 5, then resets C2 and sets C3

This is other writing instruction when C3 is ON and it writes 3 words to servo

Calculation of current position in inches when reading from servo

This rung and next ones send the execution to subrutines


14
Revoluc BCD V3761 = K63
Pulses BCD V3760 ≥ K6530
Revoluc BCD V3761 < K127
K2 GTS
Revoluc BCD V3761 ≥ K64
Revoluc BCD V3761 = K127
Pulses BCD V3760 < K3062
Revoluc BCD V3761 < K127
15
Revoluc BCD V3761 = K127
Pulses BCD V3760 ≥ K3062
Revoluc BCD V3761 < K190
K3 GTS
Revoluc BCD V3761 ≥ K128
Revoluc BCD V3761 = K190
Pulses BCD V3760 < K9594
Revoluc BCD V3761 < K190
16
Revoluc BCD V3761 = K190
Pulses BCD V3760 ≥ K9594
Revoluc BCD V3761 < K215
K4 GTS
Revoluc BCD V3761 ≥ K191
Revoluc BCD V3761 = K215
Calculation of desired position in thousandth of inches into revolutions
17
C140
LDD INCHES V7366
MULD Constant 10 V3756
OUTD V6600
Limitation of high end range to 134.0 inches
18
V6601 ≥ K134
C140
LDD K134000
OUTD INCHES V7366
Limitation of low end range to 3.0 inches
19
V6601 < K3
C140
LDD K3000
OUTD INCHES V7366
20
C140
V7367 < K4
K5 GTS
21
C140
V7367 ≥ K4
V7367 < K8
K6 GTS
22
C140
V7367 ≥ K8
V7367 < K12
K7 GTS

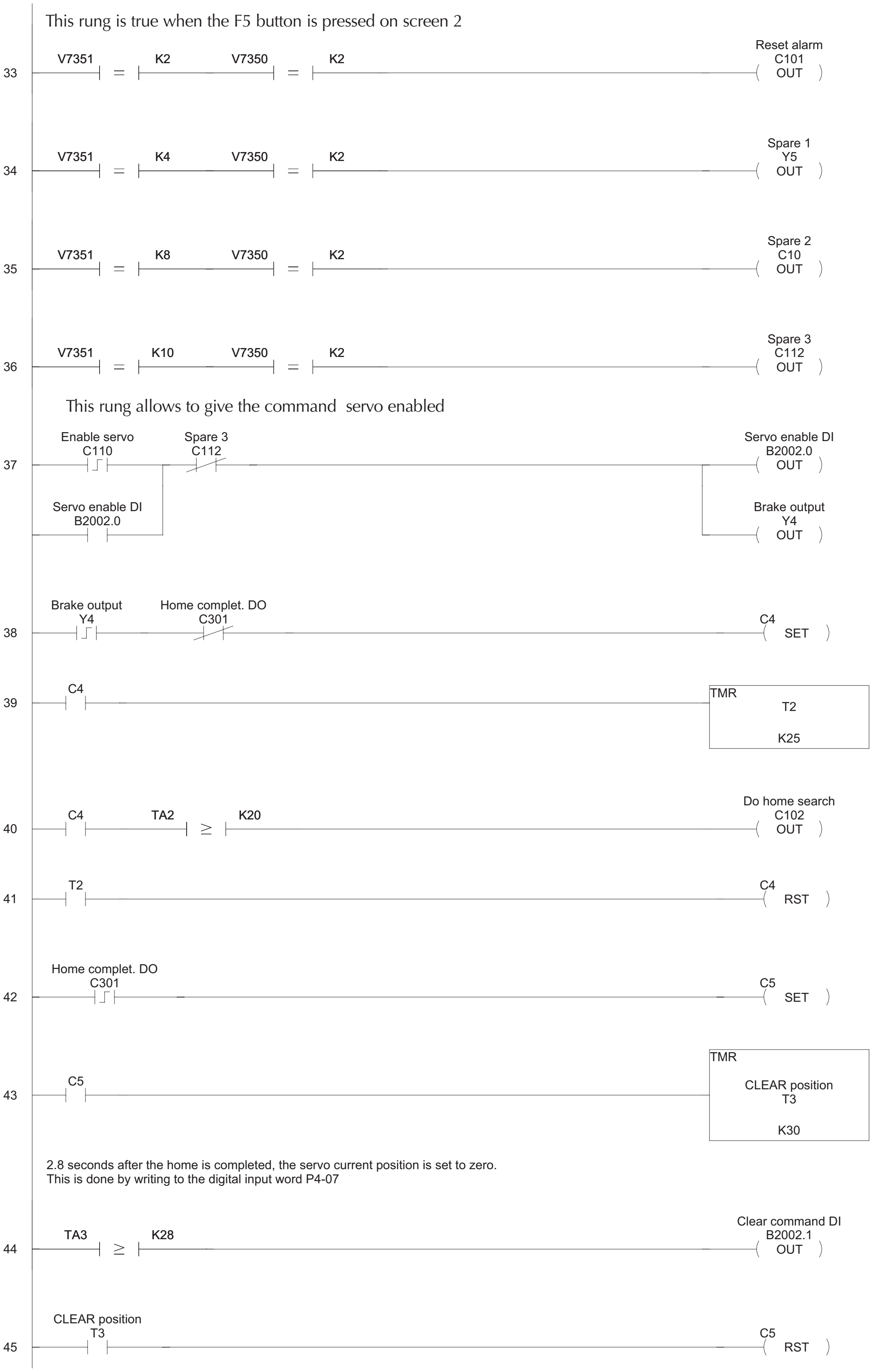


This rung is true when the F1 button is pressed on screen 2

This rung is true when the F2 button is pressed on screen 2

This rung is true when the F3 button is pressed on screen 2

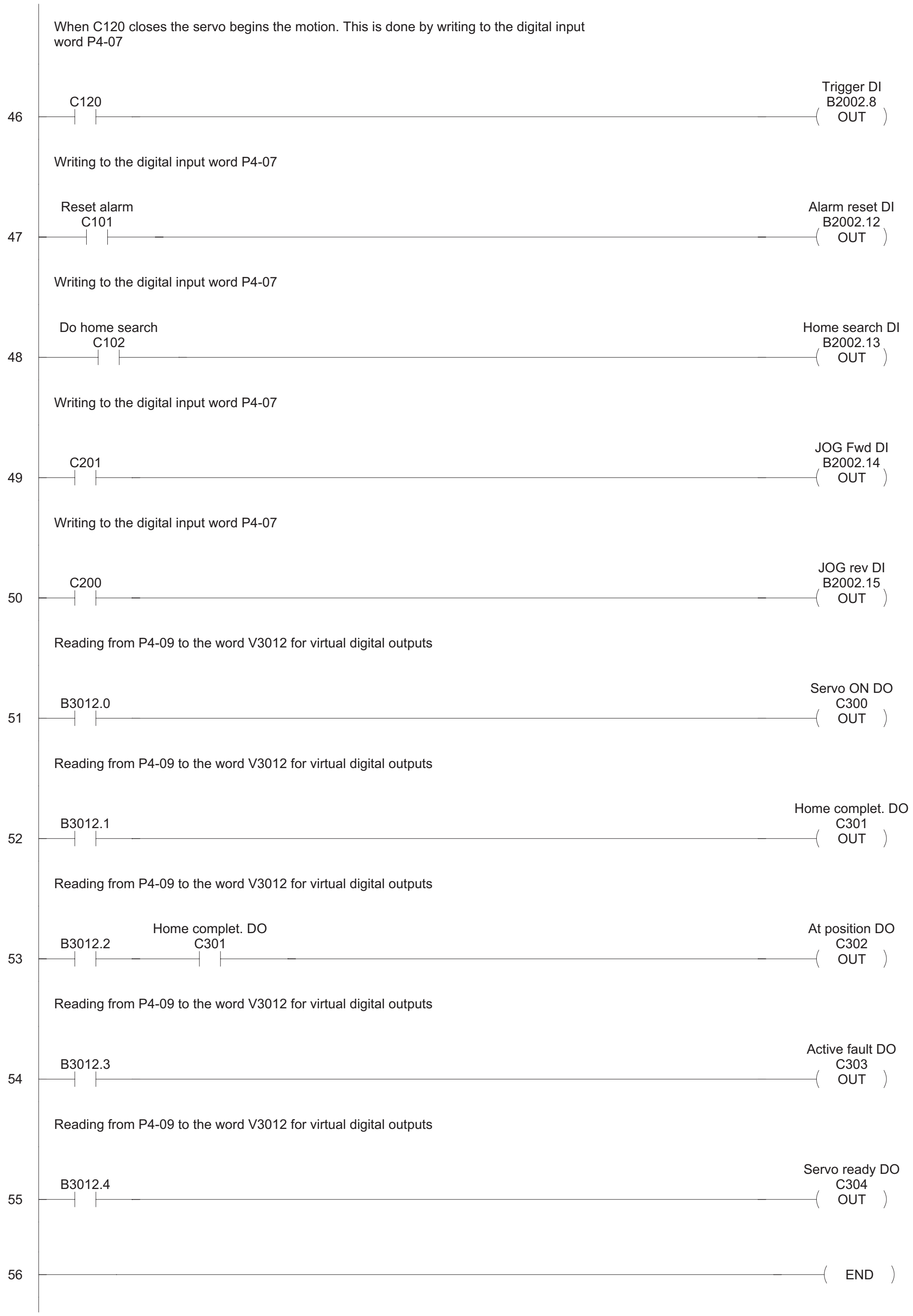
This rung is true when the F4 button is pressed on screen 2



This rung is true when the F5 button is pressed on screen 2

This rung allows to give the command servo enabled

2.8 seconds after the home is completed, the servo current position is set to zero.
This is done by writing to the digital input word P4-07



When C120 closes the servo begins the motion. This is done by writing to the digital input word P4-07

46 C120 — Trigger DI B2002.8 OUT

Writing to the digital input word P4-07

47 Reset alarm C101 — Alarm reset DI B2002.12 OUT

Writing to the digital input word P4-07

48 Do home search C102 — Home search DI B2002.13 OUT

Writing to the digital input word P4-07

49 C201 — JOG Fwd DI B2002.14 OUT

Writing to the digital input word P4-07

50 C200 — JOG rev DI B2002.15 OUT

Reading from P4-09 to the word V3012 for virtual digital outputs

51 B3012.0 — Servo ON DO C300 OUT

Reading from P4-09 to the word V3012 for virtual digital outputs

52 B3012.1 — Home complet. DO C301 OUT

Reading from P4-09 to the word V3012 for virtual digital outputs

53 B3012.2 — Home complet. DO C301 — At position DO C302 OUT

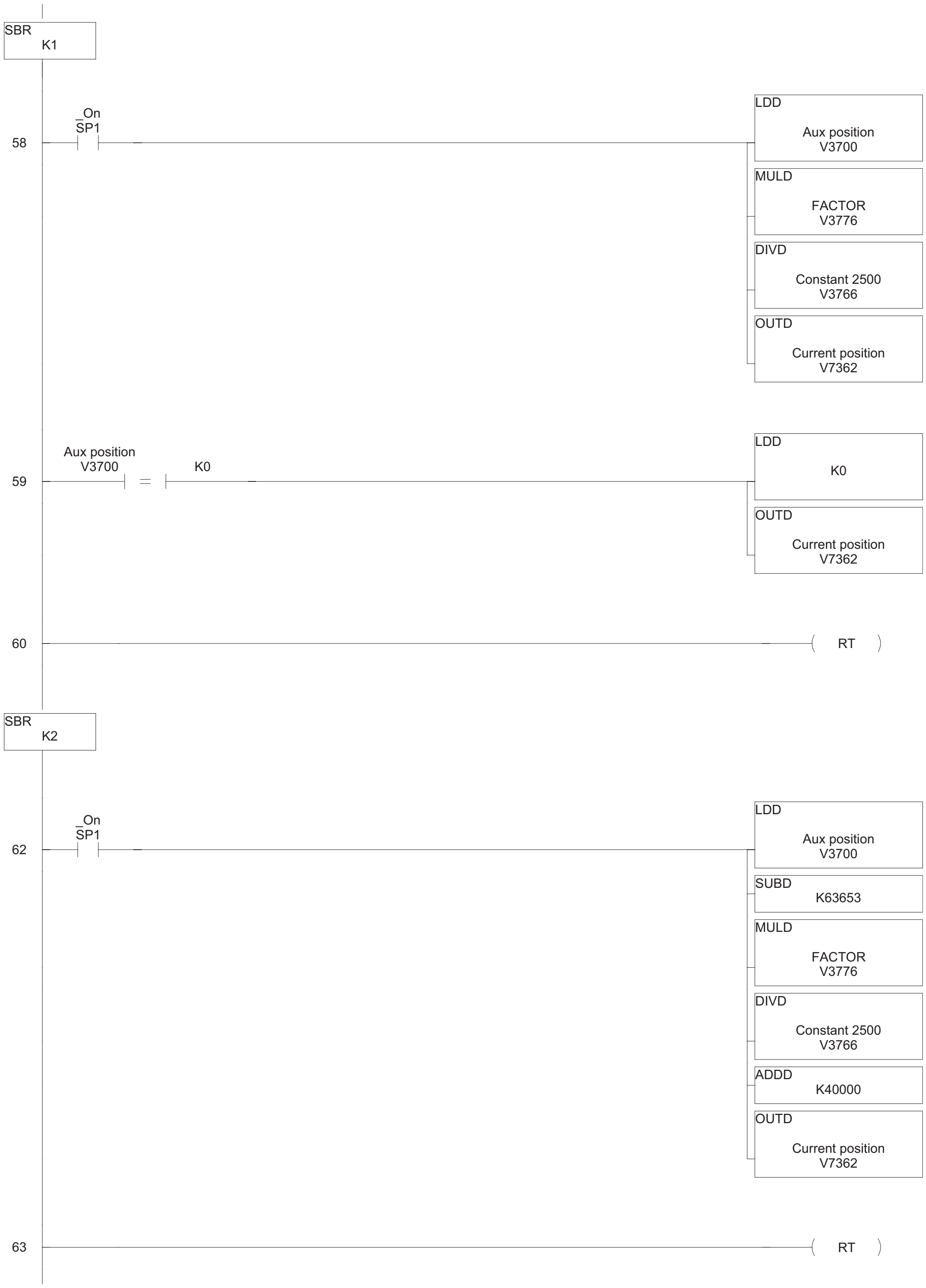
Reading from P4-09 to the word V3012 for virtual digital outputs

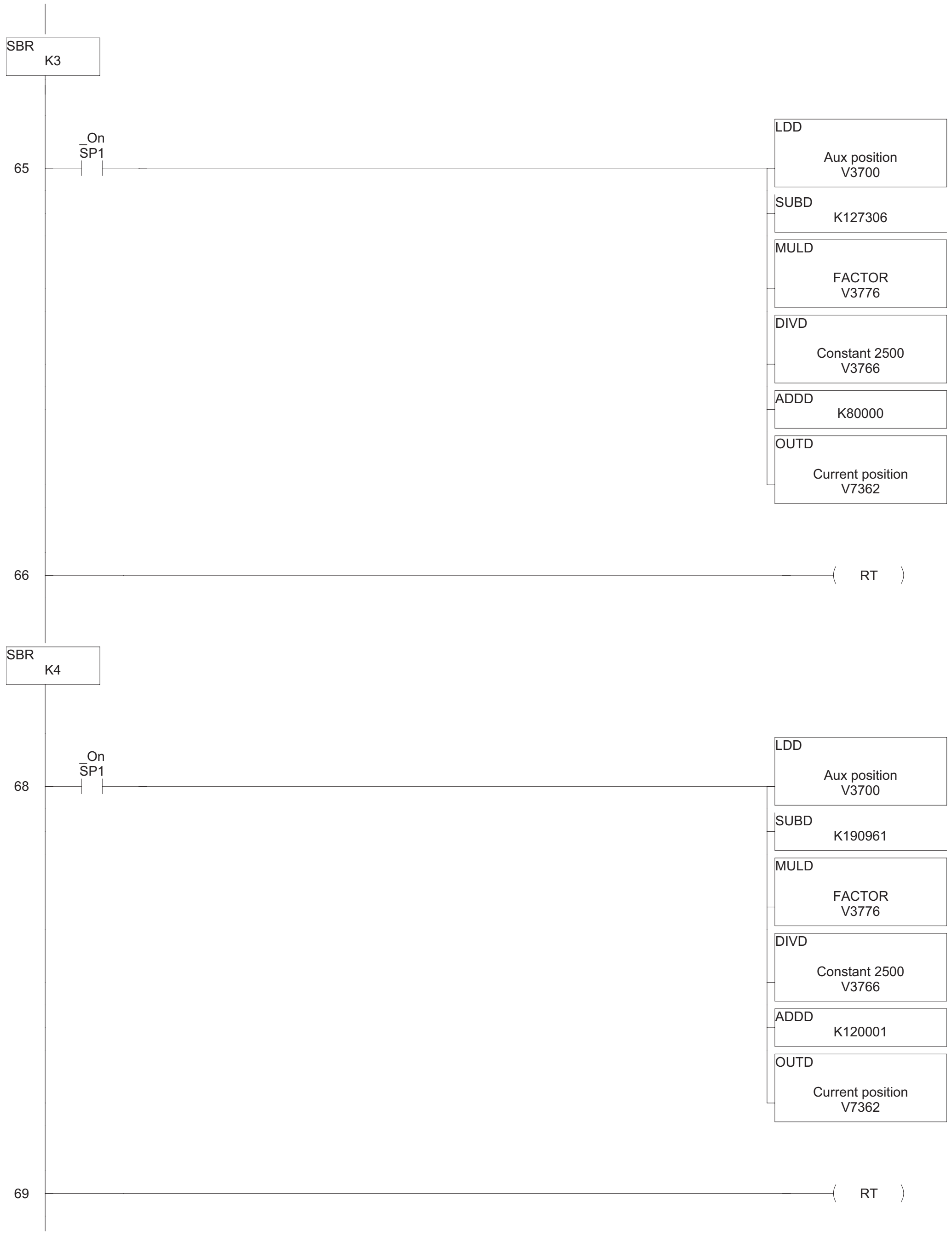
54 B3012.3 — Active fault DO C303 OUT

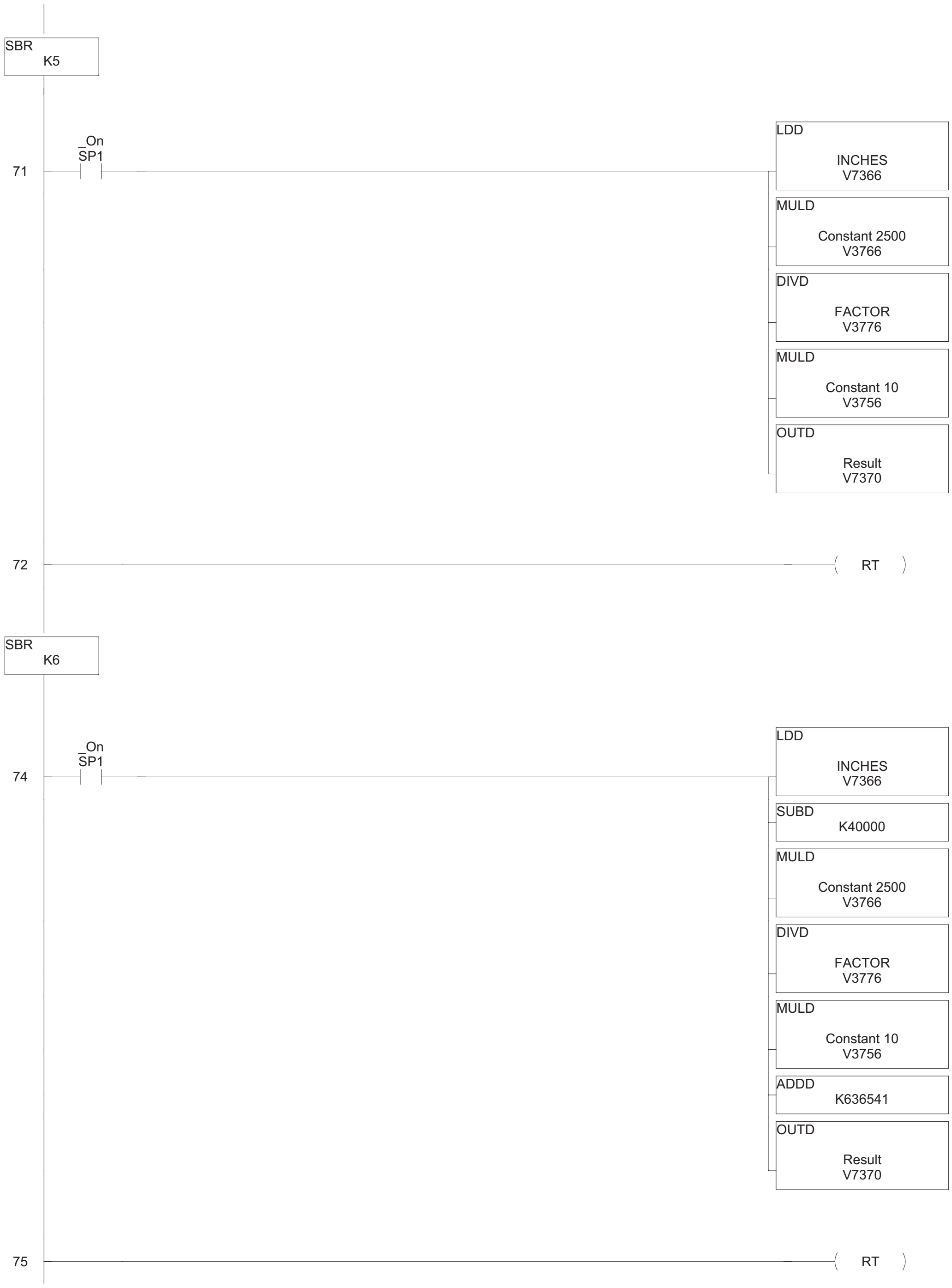
Reading from P4-09 to the word V3012 for virtual digital outputs

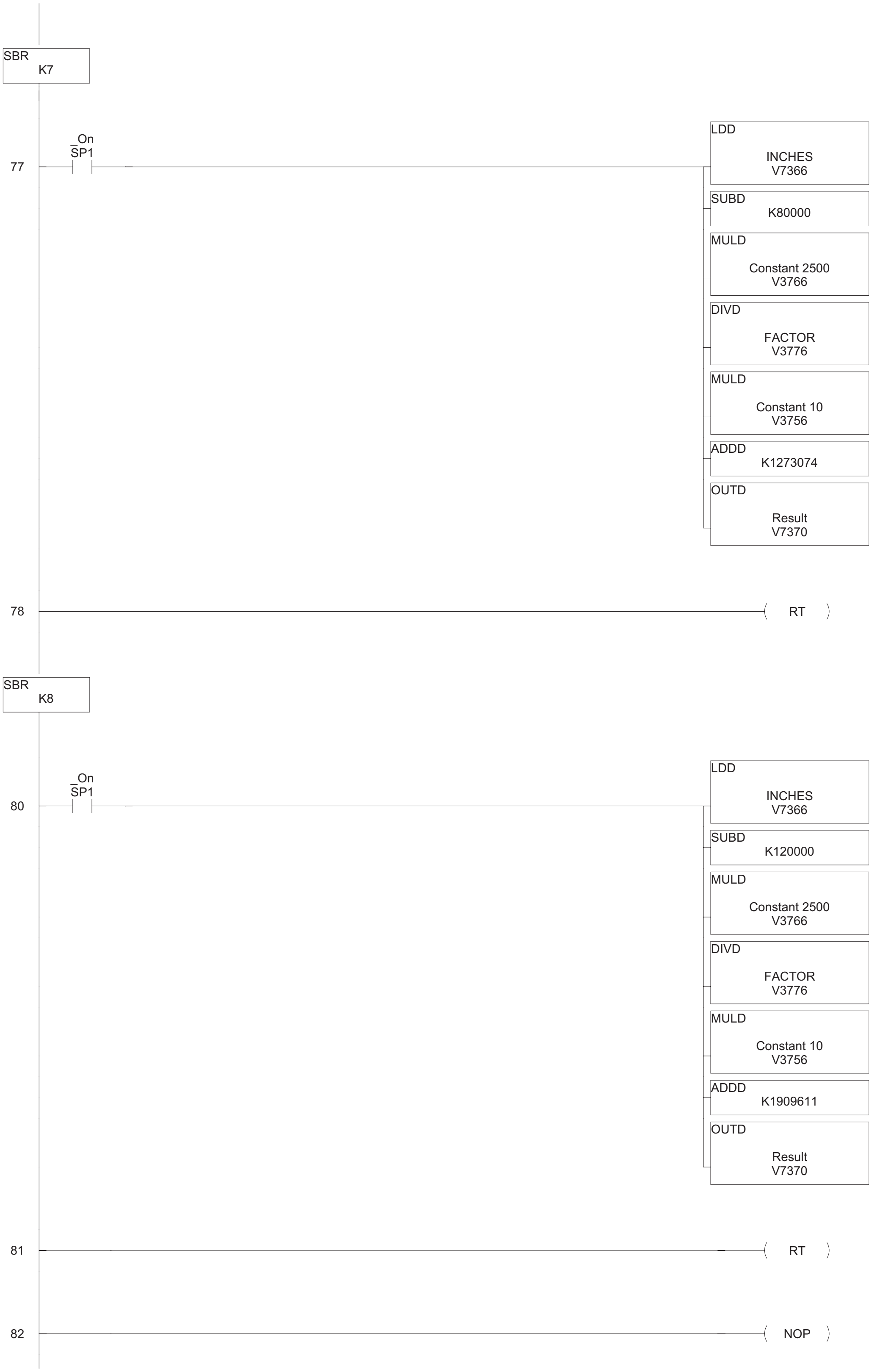
55 B3012.4 — Servo ready DO C304 OUT

56 END


SBR
K1
58
_On
SP1
LDD
Aux position
V3700
MULD
FACTOR
V3776
DIVD
Constant 2500
V3766
OUTD
Current position
V7362
59
Aux position
V3700
=
K0
LDD
K0
OUTD
Current position
V7362
60
RT
SBR
K2
62
_On
SP1
LDD
Aux position
V3700
SUBD
K63653
MULD
FACTOR
V3776
DIVD
Constant 2500
V3766
ADDD
K40000
OUTD
Current position
V7362
63
RT


SBR
K3
_On
SP1
65
LDD
Aux position
V3700
SUBD
K127306
MULD
FACTOR
V3776
DIVD
Constant 2500
V3766
ADDD
K80000
OUTD
Current position
V7362
66
RT
SBR
K4
_On
SP1
68
LDD
Aux position
V3700
SUBD
K190961
MULD
FACTOR
V3776
DIVD
Constant 2500
V3766
ADDD
K120001
OUTD
Current position
V7362
69
RT


SBR
K5
71
_On
SP1
LDD
INCHES
V7366
MULD
Constant 2500
V3766
DIVD
FACTOR
V3776
MULD
Constant 10
V3756
OUTD
Result
V7370
72
RT
SBR
K6
74
_On
SP1
LDD
INCHES
V7366
SUBD
K40000
MULD
Constant 2500
V3766
DIVD
FACTOR
V3776
MULD
Constant 10
V3756
ADDD
K636541
OUTD
Result
V7370
75
RT


SBR
K7
77
_On
SP1
LDD
INCHES
V7366
SUBD
K80000
MULD
Constant 2500
V3766
DIVD
FACTOR
V3776
MULD
Constant 10
V3756
ADDD
K1273074
OUTD
Result
V7370
78
RT
SBR
K8
80
_On
SP1
LDD
INCHES
V7366
SUBD
K120000
MULD
Constant 2500
V3766
DIVD
FACTOR
V3776
MULD
Constant 10
V3756
ADDD
K1909611
OUTD
Result
V7370
81
RT
82
NOP

List of parameters on the servo drive

Parameter	Value
P0.00 - Software Version	2.105
P0.01 - Drive Fault Code	0
P0.02 - Drive Status (Front panel display)	0
P0.03 - Analog Monitor Outputs	1
P0.04 - Status Monitor 1	1 (Current revolutions)
P0.05 - Status Monitor 2	0 (Current counts)
P0.06 - Status Monitor 3	6 (Current speed in rpm)
P0.07 - Status Monitor 4	11 (Current % torque)
P0.08 - Status Monitor 5	13 (Current DC bus voltage)
P0.09 - Block transfer parameter 1	21E (Set as P2-30)
P0.10 - Block transfer parameter 2	409 (Set as P3-08)
P0.11 - Block transfer parameter 3	10F (Set as Pos cmd 1 revs)
P0.12 - Block transfer parameter 4	110 (Set as Pos cmd 1 counts)
P0.13 - Block transfer parameter 5	407 (Set as Input status)
P0.14 - Block transfer parameter 6	112 (As default)
P0.15 - Block transfer parameter 7	225 (As default)
P0.16 - Block transfer parameter 8	109 (As default)
P0.17 - Output function status	0
P1.00 - External Pulse Input Type	2
P1.01 - Control Mode and Output Direction	101
P1.02 - Velocity and Torque Limit	0
P1.03 - Output Polarity Setting	0
P1.04 - Analog Monitor Output Scaling 1 (CH1)	100
P1.05 - Analog Monitor Output Scaling 2 (CH2)	100
P1.06 - Analog Velocity Command Low-pass Filter	0
P1.07 - Analog Torque Command Low-pass Filter	0
P1.08 - Position Command Low-pass Filter	0
P1.09 - Preset Velocity Command / Limit 1	100
P1.10 - Preset Velocity Command / Limit 2	200
P1.11 - Preset Velocity Command / Limit 3	300
P1.12 - Preset Torque Command / Limit 1	100
P1.13 - Preset Torque Command / Limit 2	100
P1.14 - Preset Torque Command / Limit 3	100

P1.15 - Position 1 Command (Revolutions)	1
P1.16 - Position 1 Command (Counts)	8280
P1.17 - Position 2 Command (Revolutions)	0
P1.18 - Position 2 Command (Counts)	0
P1.19 - Position 3 Command (Revolutions)	0
P1.20 - Position 3 Command (Counts)	0
P1.21 - Position 4 Command (Revolutions)	0
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	12 (400 Watt for our test)
P1.32 - Motor Stop Mode Selection	1
P1.33 - Position Control Mode	0
P1.34 - Acceleration Time (Internal Indexer)	600
P1.35 - Deceleration Time (Internal Indexer)	600
P1.36 - Accel / Decel S-Curve	20
P1.37 - Inertia Mismatch Ratio	5
P1.38 - Zero Velocity Output Threshold	10
P1.39 - Target Velocity 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	223
P1.48 - Homing Velocity 1 - Fast Search Velocity	600
P1.49 - Homing Velocity 2 - Creep Velocity	60
P1.50 - Home Position Offset (Revolutions)	2
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	2174
P1.56 - Output Overload Warning Threshold	120
P2.00 - Position Loop Proportional Gain (KPP)	35
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)	500
P2.05 - Velocity Loop Gain Boost	100
P2.06 - Velocity Loop Integral Compensation (KVI)	100
P2.07 - Velocity Feed Forward Gain (KVF)	0
P2.08 - Factory Defaults and Password	0
P2.09 - Debounce Filter	2
P2.10 - Digital Input Terminal 1 (DI1)	101 Servo enable
P2.11 - Digital Input Terminal 2 (DI2)	104 Clear command
P2.12 - Digital Input Terminal 3 (DI3)	124 Home sensor
P2.13 - Digital Input Terminal 4 (DI4)	0
P2.14 - Digital Input Terminal 5 (DI5)	0
P2.15 - Digital Input Terminal 6 (DI6)	22 Overtravel limit
P2.16 - Digital Input Terminal 7 (DI7)	23 Overtravel limit
P2.17 - Digital Input Terminal 8 (DI8)	21 External fault
P2.18 - Digital Output Terminal 1 (DO1)	102 Servo ON
P2.19 - Digital Output Terminal 2 (DO2)	109 Home completed
P2.20 - Digital Output Terminal 3 (DO3)	105 At position
P2.21 - Digital Output Terminal 4 (DO4)	107 Active fault
P2.22 - Digital Output Terminal 5 (DO5)	101 Servo ready
P2.23 - Notch Filter (Resonance Suppression)	1000
P2.24 - Notch Filter Attenuation (Resonance Suppression)	0
P2.25 - Low-pass Filter (Resonance Suppression)	2
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	HEX 44
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	2174
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	1
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
P2.64 - Advanced Torque Limit Mixed Mode	0
P2.65 - Special Input Functions	HEX 0

P3.00 - Communication Address	2
P3.01 - Transmission Speed	3
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	FF03
P4.00 - Fault Record - Most recent (N)	13
P4.01 - Fault Record (N-1)	15
P4.02 - Fault Record (N-2)	14
P4.03 - Fault Record (N-3)	14
P4.04 - Fault Record (N-4)	14
P4.05 - JOG Function	120
P4.06 - Force Outputs Command	0
P4.07 - Input Status	0
P4.08 - Reserved	4
P4.09 - Output Status	20
P4.22 - Analog Velocity Input Offset	0
P4.23 - Analog Torque Input Offset	0

This document shows the concept of operation.

We clearly state that this is not necessarily the best programming or that the program is perfect.

Other actions necessary are the tuning of the system and possibly to study and fix the reset condition in case there is a power failure during the operation.

These actions are left for the control designer.