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A Solution to Study Different Homing Methods Using a PLC

In a positioning control with stepper motors it is very important to know zero location. For this purpose it is necessary a homing command. This paper presents a solution that allows the study of different methods implemented to find a home position (also called: zero point) and to observe the differences between these methods.

1. Introduction

The basic purpose of control systems is to keep system behavior on the desired value [1]. In industry are used two common classes of control systems:
- open loop control systems (the output is generated based on inputs)
- closed loop control systems (the output is maintained at a level so that there is no difference between the process variable and the setpoint).

In low-cost open-loop industrial applications for positioning control systems in many cases are used stepper motors. Usually stepper motors were designed to provide precise positioning control within an integer number of steps. They have stable open loop operation to any step position and consequently no feedback is needed to control them. In positioning control systems with or without feedback it is necessary to identifier what is the zero position (home position), which is a unique location somewhere over the course of travel. The stage will accurately go to this position when commanded to "home." Upon reaching the home position, the position counter on the controller resets to zero (actually, the counter resets to the HomePreset value taken from the stages.ini file, which has a default value of 0). This position is taken as the reference point for all subsequent movements. This could be in the middle of travel, the positive or negative limit (end of travel), or the stage's current position. The motor's position can then be commanded to move and hold at one of these steps without any feedback sensor (an open-loop controller), as long as the motor is carefully sized to the application. [2]

2. Proposed solution

The proposed solution (illustrated in Figure 1) is recommended to be used by students at laboratory work to study and analyze various homing methods. [3] This equipment helps to understand which of homing methods studied is better and why. This solution use an old scanner, a PLC and a HMI.
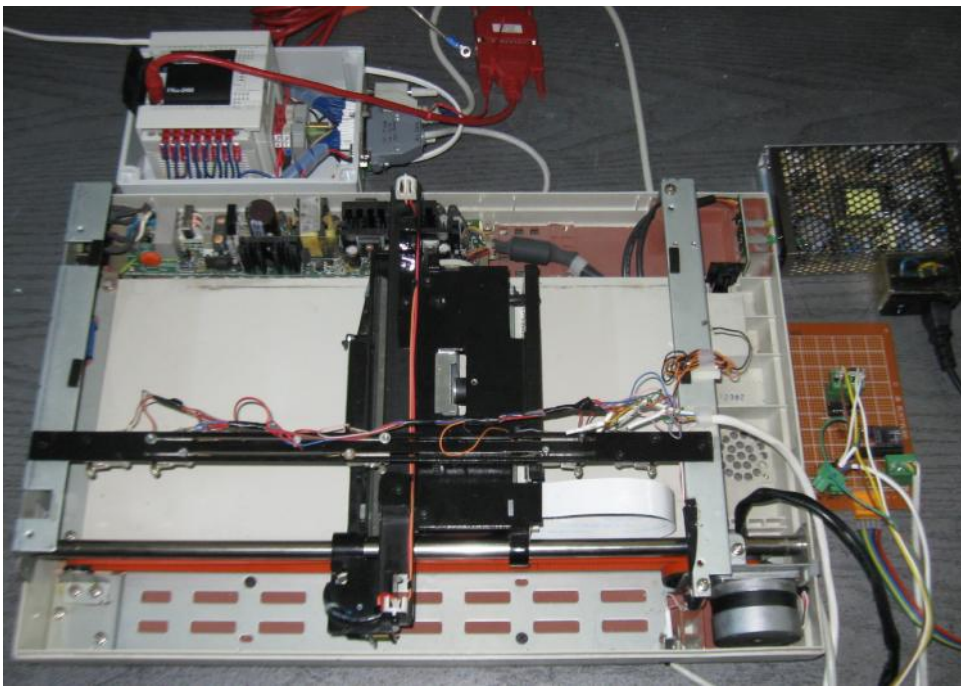

Figure 1. The proposed solution

The scanner use a stepper motor to move optical equipment. The conversion rotational motion of stepper motor to linear motion of optical equipment is made using a toothed drive belt – pulley system. On scanner are mounted five switches for this studies as is presented in figure 2 and are used as follow:

- LHSS (Left Hard Stop Switch) and RHSS (Right Hard Stop Switch) are used for protection of equipment. If one of these switches is activated the motor is immediately stopped because is disabled the stepper motor driver;
- LLS (Left Limit Switch) and RLS (Right Limit Switch) that are used in different homing methods;
- HS (Home Switch) used in for home command.

To drive and control the stepper motor we are using the DRV8825 motor driver carrier, which is a breakout board for TI's DRV8825 microstepping bipolar

stepper motor driver. The DRV8825 features are: adjustable current limiting, over-current and overtemperature protection, and six microstep resolutions (down to 1/32-step). It operates from 8.2 – 45 V and can deliver up to approximately 1.5 A per phase without a heat sink or forced air flow. [4], [5]
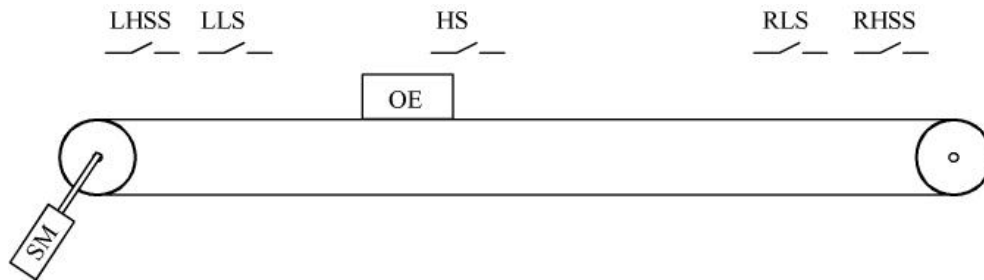

Figure 2. The placement of the five switches on the scanner

Different homing methods are realized using a PLC model FX3G-24M from Mitsubishi Electric. [6] We choose this PLC because can be easily used in positioning control applications due to two reasons:

- hardware reason - the PLC has two high speed outputs Y000 and Y001 (up to 100 kHz), which using pulses can be output simultaneously to 2 axes;
- software reason - for programing the PLC is used GX Developer software, which offer various positioning instructions (i.e. DSZR – for mechanical zero return instruction with DOG search function, DRVI - positioning (relative positioning) to specify the movement from the current position, DRVA - positioning (absolute positioning) to specify the target position based on the current value 0, PLSV - instruction to change the pulse train output frequency).

In addition the PLC has two communication ports an USB port and a serial port. The USB port can be used for communication with PC and online to visualized the stage of variables. The serial port is used for communication with HMI.

For choose one of homing method, to parameterize by setting different parameters such as: speed, acceleration, deceleration and others we use a HMI (Human Machine Interfaces). The HMI used is XV-102-D6-70TWRC, from Eaton, that has also PLC function, but in this application we use only the HMI function.

The solution presented is proper for practical applications with students because they can make software application for any homing method. In the follow is presented some methods for homing command. [7]

3. Experimental results

The HMI starts with main mask presented in figure 3, when this is powered. In this mask the students can choose one of six examples. If they choose example 1.a is open mask presented in figure 4.
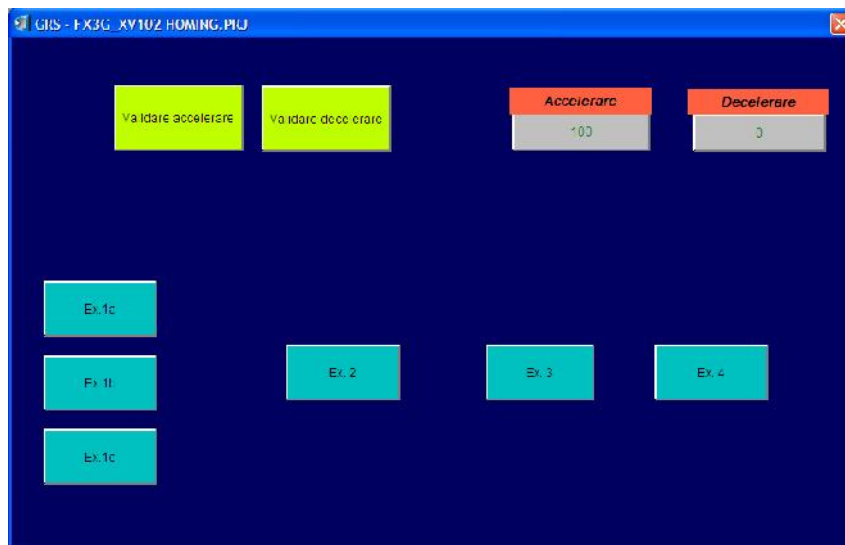

Figure 3. The Start-mask on HMI

Figure 4. The HMI mask for Example 1.a

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The sequence program used for example 1.a, realized in GX Developer, which is programed the PLC is illustrated in figure 4. It can observe how easy is to realize this sequence if it is used the dedicated instruction ZRN_M.
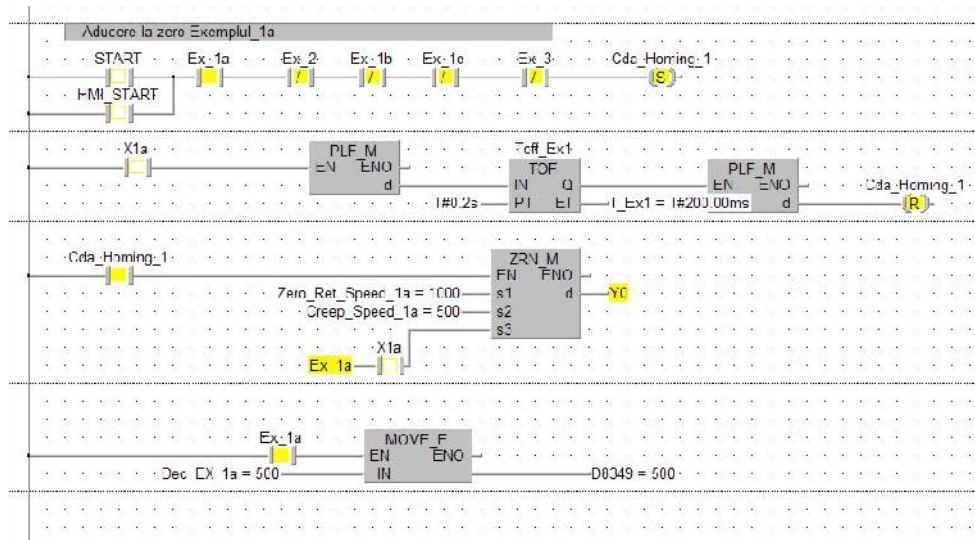

Figure 5. The software application for Example 1.a

The students can put in HMI different values for ZRS (Zero_Return_Speed), Creep_Speed (CS) and Deceleration_Time, as it is shown in figure 3 and observe how these changes influence the system work. The time diagram and detailed drawing of path for Example 1.a is presented in Figure 6. When they give the start command for homing (1) the optical equipment of the scanner (that is, in fact, an axis of positioning) start to move in right (positive) direction with speed set in ZRS parameter looking for falling edge of Home switch (HS). On rising edge of HS (2) the axis decelerates from ZRS to CS and stop motion of the axis (3) with falling edge of HS is realized from low speed and not ZRS, which is high speed. This method improves precision for homing command compared with method prezented in Figure 6.b, when the Zero_Return_Speed = Creep_Speed and Deceleration_Time equal with zero, the time diagram resulted is presented in figure 5.b.

In conclusion using this example the studenst can study what influence has these parameters (Zero_Return_Speed, Creep_Speed and Deceleration_Time) on obtain a shorter time for scanner to execute homing command, to improve the precision of positioning and to reduce the electromechanic shock during the stop of the axis.
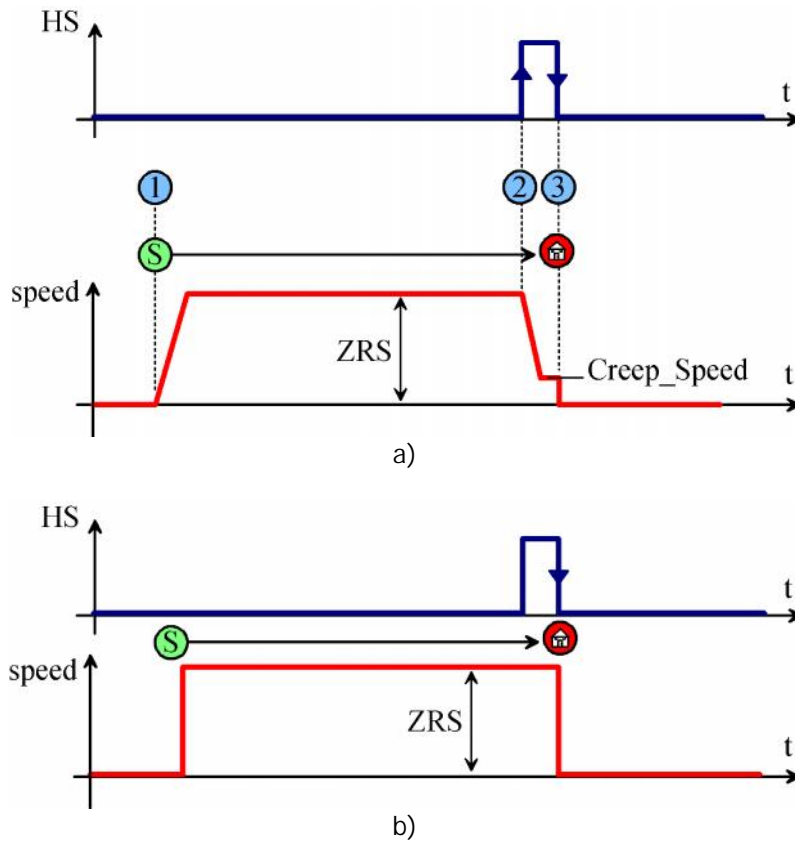
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Figure 6. The time diagram for Example 1.a

Another method for homing command has presented the time diagram and detailed drawing of path in Figure 7. In this case the PLC commands axis to stop only if the axis is moving in left (negative) direction. This method is to eliminate the errors caused of backlash of mechanical transmission of axis. The backlash is the error in motion that occurs when the axis change direction. It exists because there is always some gap between the trailing face of the driving tooth and the leading face of the tooth behind it on the driven gear, and that gap must be closed before force can be transferred in the new direction. In figure 7 are illustrated three cases for homing command depends on the relative position of the scanner optical equipment to the home switch as follows:

- case (a) when the axis is on the left side of the HS and receive homing command (1) in negative direction. During of HS positive edge of the axis will decelerate and is stopped during the falling edge of HS from low speed;

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- in case (b) the axis is on the right side of the HS and receive homing command (1) in positive direction. During of HS positive edge of the axis (2) do nothing because is moving in wrong direction and at falling edge of HS (3) the axis will stop (4). When stopping it has moved some distance away from the HS. Therefore motion is commanded to move axis back to the captured position (falling edge of the Home switch) shown by the Red circle;

- case (c) presents the situation when the axis is on the left side of the HS like in case (a), but receive homing command (1) in positive direction. So, when the axis receive homing command it is moving looking for either falling edge of Home switch (case (a)) or Right Limit switch (case (c)). When axis hits the Right Limit switch, the PLC commands axis to stop. After that change direction of moving and execute homing command as is presented in case (a). The axis is now successfully Homed
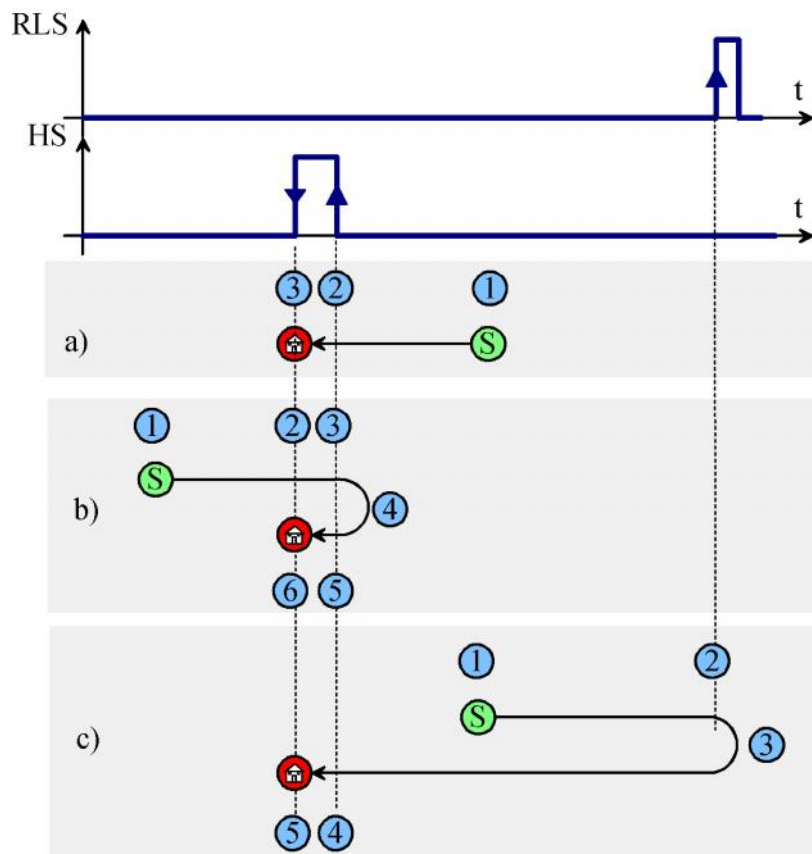

Figure 7. The time diagram for Example 2

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4. Conclusion

A solution to study different homing methods using a PLC has been presented. It uses an old scanner which use a stepper motor to move optical equipment. This solution can be used in laboratory by students where they can working at different practical applications. They can learn about how to programing a PLC for position control of scanner, homing commands and analyze what are differences between these.

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