

Automated Window Shade

Using a Programmable Logic Controller

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Summary

Abstract

Automated window shade system controlled by a PLC to regulate indoor light and temperature environments. For simulation, the potentiometers are used to provide the variables for the temperature and lighting inputs. The blind is mounted on a custom-made wooden frame and controlled by 2 stepper motors, one for tilt and the other for height. Reed switches will be used for calibration points with LEDs used for confirming triggers. A small fan is mounted and simulate an extractor fan to aid in temperature management. The system was tested using the action research methodology, refining control logic for responsiveness.

Aim

To develop an automated window shade system controlled by a PLC and HMI

Objectives:

- Simulate environmental sensor (Brightness, indoor/outdoor UV and temperature) input using potentiometers
- Program Motor response logic use a PLC
- User interface with an HMI screen

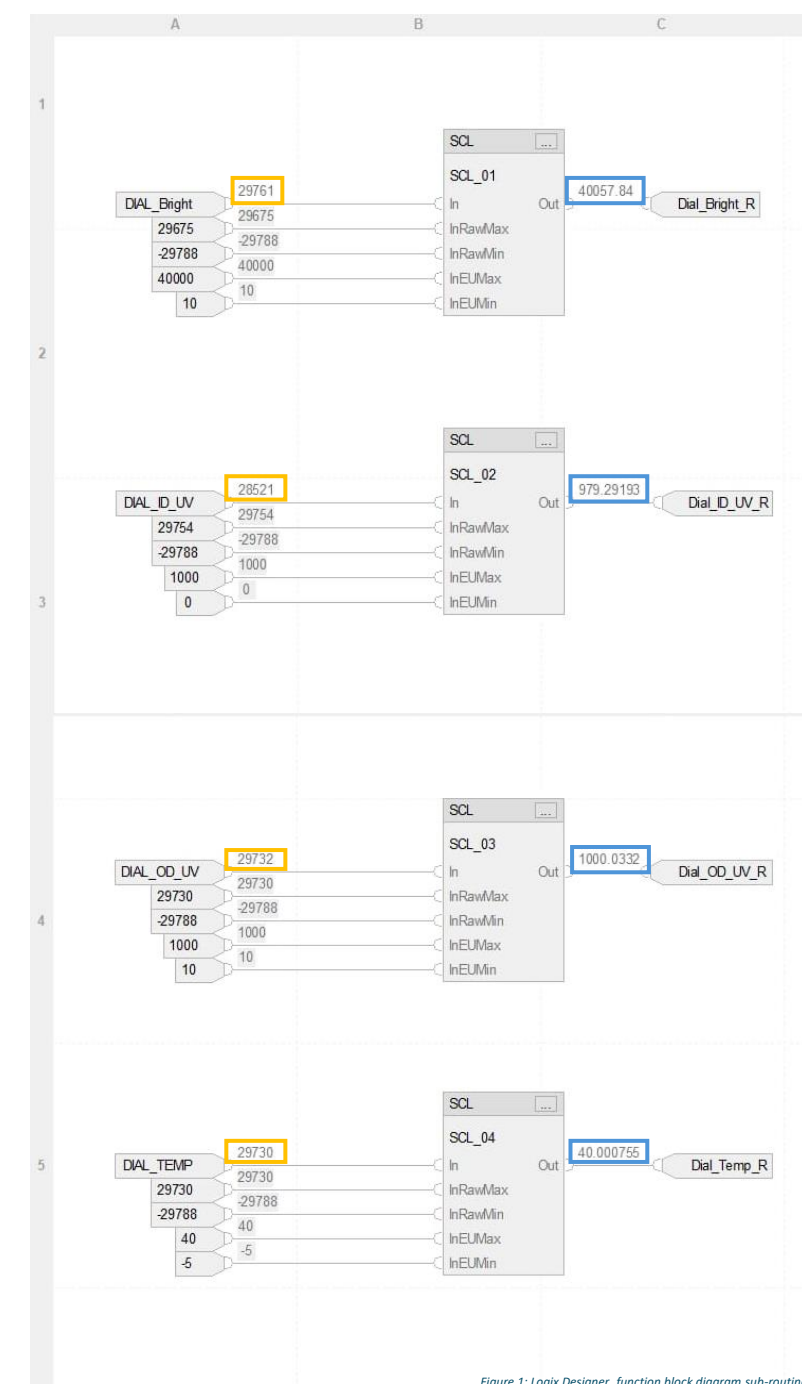
Components and Hardware:

- PLC (Allen Bradley)
- Analog Input Module
- HMI (Red Lion)
- Blinds
- Frame for the Blinds
- 4 Potentiometers
- 2 Stepper Motors (Nema17)
- 2 Stepper Motor Drives (DM542)
- Peli Case
- Cables and connector blocks

Method

Potentiometers

1. Scaling Voltage Input

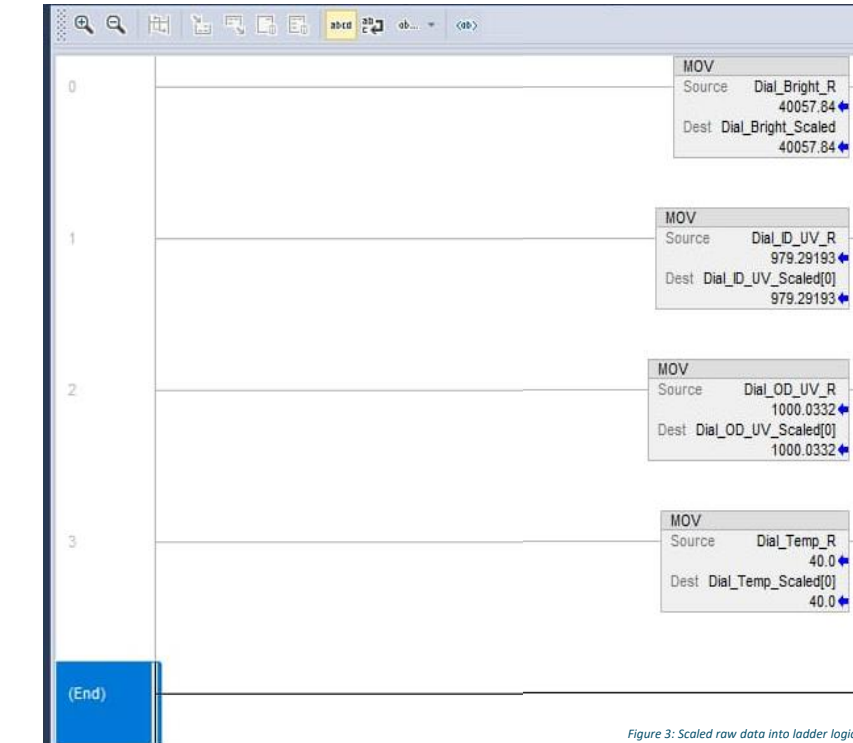


The Voltage Analogue Module 1769-IF8 (Expansion I/O) reads the potentiometers voltage input of 0-10V into Raw Data format, unique to Allen Bradley controllers as shown below in fig.2 highlighted in orange.

Table 3.17 Valid Input Data					
1769-IF8 Normal Operating Range	Full Range (Includes over and under Normal Operating Range)	RawPotentiometer Data	Engineering Units	Scaled-for-PID	Percent
-10V to +10V dc	+10.5V to -10.5V	-32767 to +32767	-10000 to +10000	-410 to 10783	-100.00 to +100.00%
0V to 5V dc	0.0V to 5.25V	-32767 to +32767	0 to 5250	0 to 17002	0 to 100.00%
0V to 10V dc	0.0V to 10.5V	-32767 to +32767	0 to 10000	0 to 10000	0 to 100.00%
4 mA to 20 mA	3.2 mA to 21 mA	-32767 to +32767	3200 to 21000	-819 to +17401	-5.00 to +100.00%
1.0V to 5V dc	0.5V to 5.25V	-32767 to +32767	500 to 5250	-2046 to +17807	-12.50 to +100.00%
0 mA to 20 mA	0 mA to 21 mA	-32767 to +32767	0 to 21000	0 to 17002	0.00 to 100.00%

The instruction SCL shown in fig.1 scales the raw data (-29788 to +32767) into an easier range e.g. 0-100 which is then used in to interact with the stepper motor control ladder logic shown in fig.3.

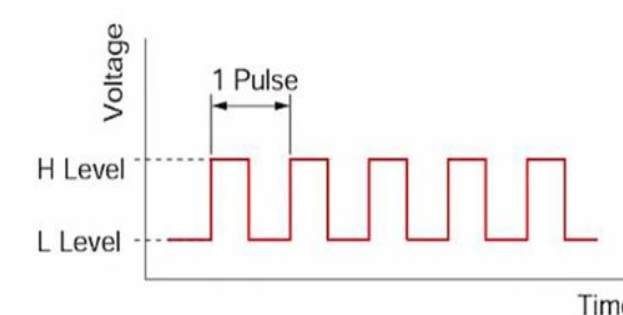
2. Scaled Voltage Input



Stepper Motor Control

Stepper Motor Pulse needed:

To create movement for the stepper motors we need to have even pulses shown like the graph below (fig.4)

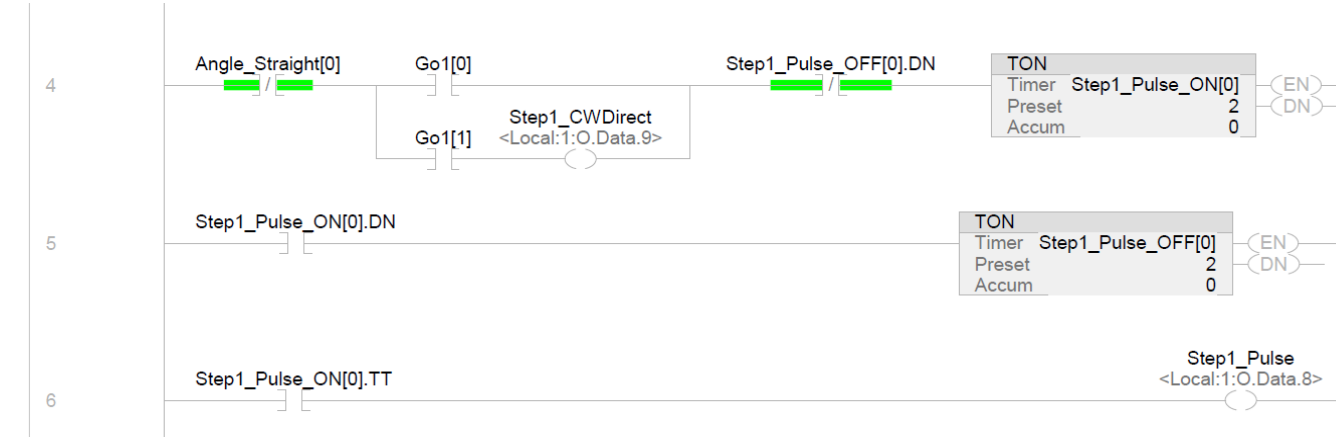


Use of Reed-switches:

Reed switches are used for the motors to calibrate the blind adjustment limits when switching on.

Stepper Motor Pulse Logic:

Using digital output from the PLC, the TON (timers) are used to switch the voltage ON and OFF 2ms apart, creating pulses



The direction of the motors (which default is CCW) can be changed by giving or taking away a constant feed to the direction control input on the stepper motor drive DM542.

Results

Stepper Motor Setup

Stepper Motor 1



Figure 6: Stepper Motor 1, controlling blind angles

Stepper Motor 2



Figure 7: Stepper Motor 2, controlling blind height

Stepper Motor 2 string management



Figure 8: Stepper Motor 2 excess string management

The reed-switches are connected to LEDs to indicate when triggered for fault and confirmation purposes. Shown circled in yellow in fig.6.

Custom Wooden Frame for the blind control and movement simulation



Figure 9: Custom Wooden Frame

HMI Screen for Users

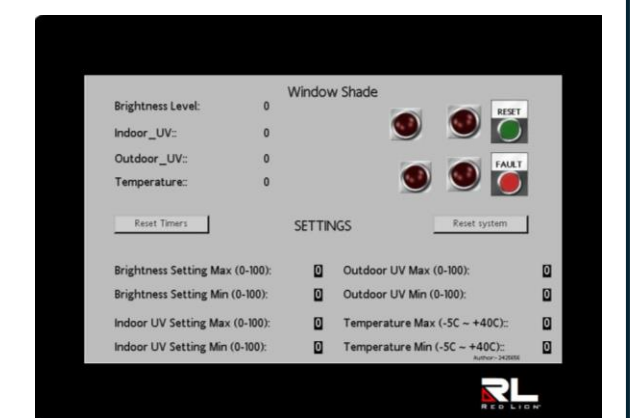


Figure 10: HMI Screen

Peli Case showing Buttons, LEDs and HMI Screen



Figure 11: Peli Case showing Buttons, LEDs and HMI Screen

Have the Objectives been achieved?

- The potentiometer output have been successfully scaled to simulate different sensor input.
- The Stepper Motors can be controlled by the PLC logic, but the logic can be refined for more reactive control.
- An interactive HMI screen has been created for the user to be able to sensor input response setting.