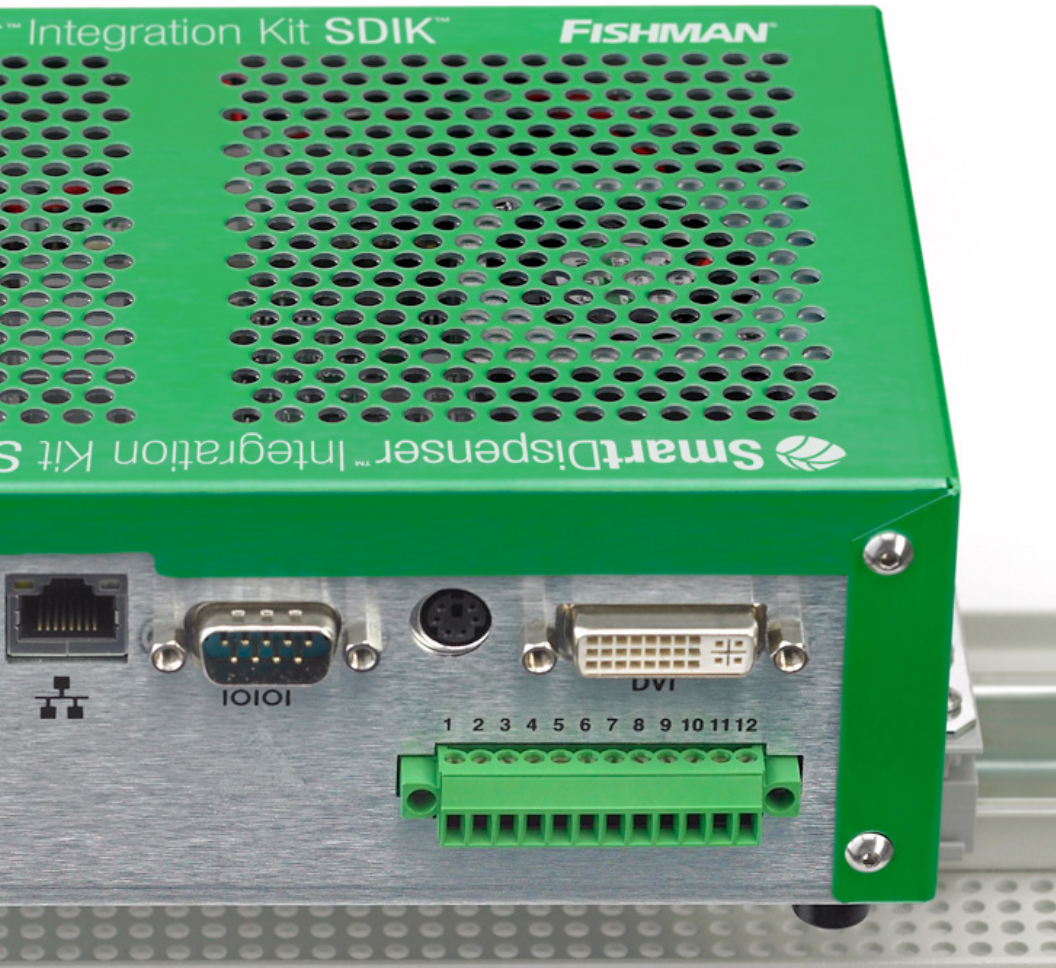
INTEGRATOR MANUAL

Programmable Logic Controller Setup Guide

PLC



FISHMAN®
Dispensing Innovation®

Thank you for purchasing the SmartDispenser®

THE FUTURE OF FLUID DISPENSING.

This setup guide is designed to help Integrators setup the SmartDispenser® system via programmable logic controller.

If you are unsure of any step or have questions about integration, contact your Fishman distributor, or call us at one of the numbers below.

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SmartDispenser®

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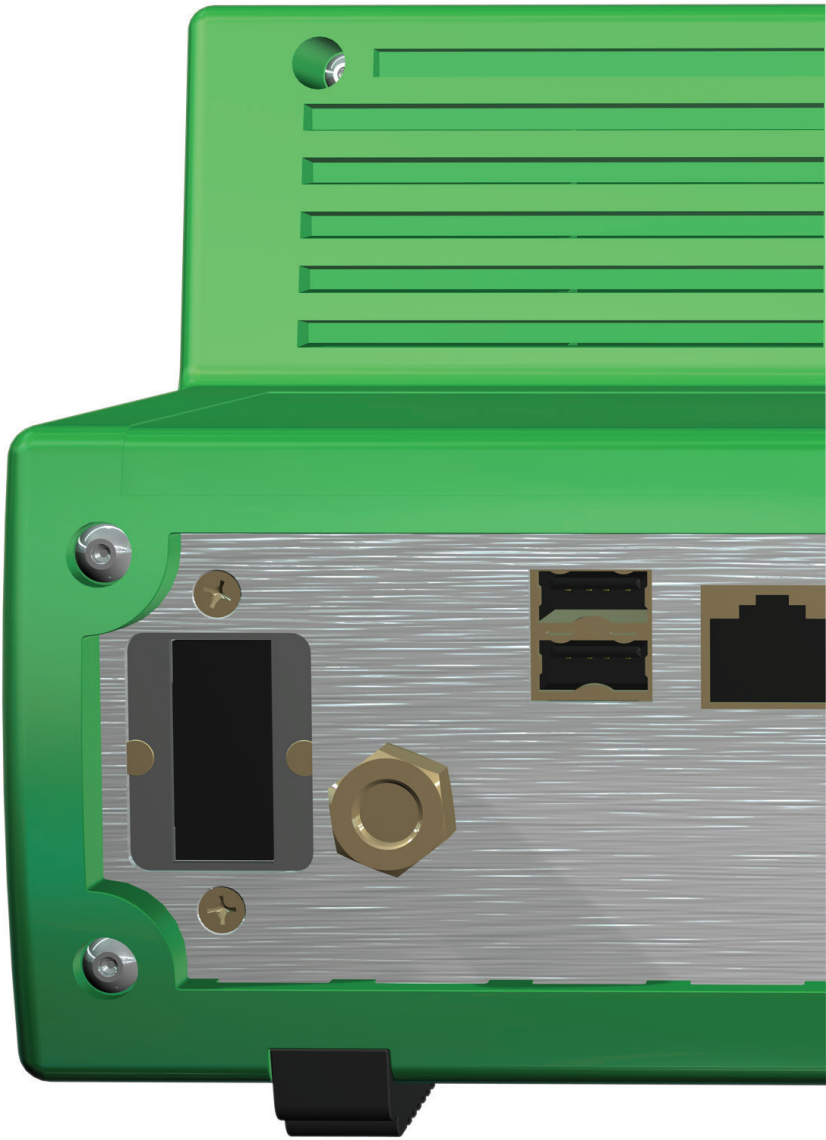
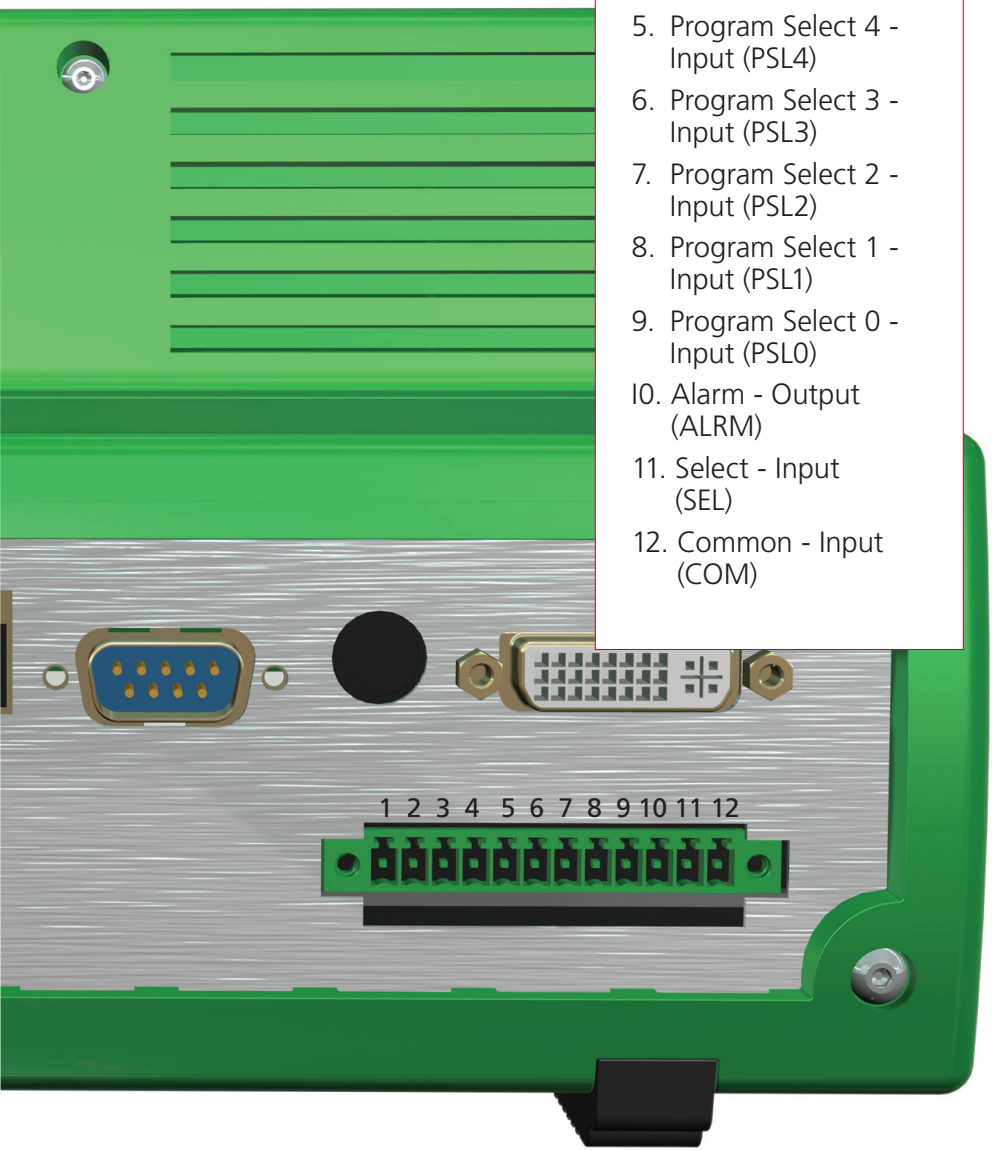
1.0 12 Pin I/O Terminal

1.1 The SmartDispenser® is equipped with a twelve pin, I/O terminal connector which is located on the back of the unit.





Twelve Pin Key

1. Power - Input (PWR)
2. Empty - Output (EMPY)
3. Ready - Output (RDY)
4. Dispense - Input (DIS)
5. Program Select 4 - Input (PSL4)
6. Program Select 3 - Input (PSL3)
7. Program Select 2 - Input (PSL2)
8. Program Select 1 - Input (PSL1)
9. Program Select 0 - Input (PSL0)
10. Alarm - Output (ALRM)
11. Select - Input (SEL)
12. Common - Input (COM)

2.0 SmartDispenser® I/O Pin Descriptions

2.1 I/O Terminal Connector

All SmartDispenser® inputs and outputs are Active(LOW). In this section, I/O pin numbers and there descriptions.

I/O Description Table

SIGNAL	PIN #	DIR	DESCRIPTION
Power (PWR)	1	SD Input	User supplied 5-24VDC Power
Common (COM)	12	SD Input	User supplied 5-24VDC Common
Select (SEL)	11	SD Input	The SELECT signal is used to detect the presence of a PLC and select a program.

The controller detects the presence of a PLC when the SEL line (pin 11) goes high. Conversely, the PLC is considered disconnected when the SEL line goes low. This logic coincides with a PLC disconnect when the PLC is physically disconnected from the SmartDispenser® (i.e. the PLC connector is removed) or when it is turned off.

The controller waits 50ms after detecting a state change on this line before making the determination of a PLC connect or disconnect. This is required because the SEL pin is also used to select a program. Program selection occurs when the SEL pin is pulsed. The maximum pulse width is 50ms and the minimum pulse width is 2ms **(25ms is recommended)** If the SEL line state changes for more than 50ms then it is assumed that the PLCconnection status has changed, accordingly.

I/O Description Table (Continued)

Prog Select Bits 0-4			The PROG SELECT bus (5 bits wide) is used to select pre-saved programs with in the SmartDispenser®
PLS0	9	SD Input	
PLS1	8	SD Input	
PLS2	7	SD Input	
PLS3	6	SD Input	
PLS4	5	SD Input	

Dispenser must be in AUTO mode to accept program commands

A program is selected by setting all of the Prog Select Bits pins appropriately and then pulsing the Select (SEL) pin. A valid pulse width is in the range of 2 to 50ms **(25ms pulse is recommended)**. The Prog Select Bits pins are mapped to PC2 operation or to traditional mode programs according to the following table.

I/O Description Table (Continued)

Dispense (DIS)	4	SD Input	The DISPENSE signal is used to initiate a dispense cycle. The SmartDispenser® must be in the proper mode in order for this signal to be initiated. (For example, no dispense will be performed if the dispenser is empty or READY[low] is not asserted.) A DISPENSE will result in READY(low) signal going INACTIVE(high) while the dispense is taking place then back to READY(low) when the dispense is completed. An EMPTY signal will be returned from the SmartDispenser® when a dispense operation is completed and there is not sufficient fluid available for the next dispense operation.

	5	4	3	2	1
PROGRAM	PLS4	PLS3	PLS2	PLS1	PLS0
PC2	HIGH	HIGH	HIGH	HIGH	HIGH
TRAD PROG 1	HIGH	HIGH	HIGH	HIGH	LOW
TRAD PROG 2	HIGH	HIGH	HIGH	LOW	HIGH
TRAD PROG 3	HIGH	HIGH	HIGH	LOW	LOW
TRAD PROG 4	HIGH	HIGH	LOW	HIGH	HIGH
TRAD PROG 5	HIGH	HIGH	LOW	HIGH	LOW
TRAD PROG 6	HIGH	HIGH	LOW	LOW	HIGH
TRAD PROG 7	HIGH	HIGH	LOW	LOW	LOW
TRAD PROG 8	HIGH	LOW	HIGH	HIGH	HIGH
TRAD PROG 9	HIGH	LOW	HIGH	HIGH	LOW
TRAD PROG 10	HIGH	LOW	HIGH	LOW	HIGH
TRAD PROG 11	HIGH	LOW	HIGH	LOW	LOW
TRAD PROG 12	HIGH	LOW	LOW	HIGH	HIGH
TRAD PROG 13	HIGH	LOW	LOW	HIGH	LOW
TRAD PROG 14	HIGH	LOW	LOW	LOW	HIGH
TRAD PROG 15	HIGH	LOW	LOW	LOW	LOW
TRAD PROG 16	LOW	HIGH	HIGH	HIGH	HIGH
TRAD PROG 17	LOW	HIGH	HIGH	HIGH	LOW
TRAD PROG 18	LOW	HIGH	HIGH	LOW	HIGH
TRAD PROG 19	LOW	HIGH	HIGH	LOW	LOW
TRAD PROG 20	LOW	HIGH	LOW	HIGH	HIGH
TRAD PROG 21	LOW	HIGH	LOW	HIGH	LOW
TRAD PROG 22	LOW	HIGH	LOW	LOW	HIGH
TRAD PROG 23	LOW	HIGH	LOW	LOW	LOW
TRAD PROG 24	LOW	LOW	HIGH	HIGH	HIGH
TRAD PROG 25	LOW	LOW	HIGH	HIGH	LOW
TRAD PROG 26	LOW	LOW	HIGH	LOW	HIGH
TRAD PROG 27	LOW	LOW	HIGH	LOW	LOW
TRAD PROG 28	LOW	LOW	LOW	HIGH	HIGH
TRAD PROG 29	LOW	LOW	LOW	HIGH	LOW
TRAD PROG 30	LOW	LOW	LOW	LOW	HIGH
TRAD PROG 31	LOW	LOW	LOW	LOW	LOW

High= 24v Low = 0v

I/O Description Table (Continued)

SIGNAL	PIN #	DIR	DESCRIPTION
Ready (RDY)	3	SD Output	The READY signal is an indicator from the SmartDispenser®. It indicates that the SD is READY to accept a command. During system initialization, the READY signal is inactive(HIGH). When the system is ready to accept commands such as selecting a program or dispensing, READY is active(LOW). Following a SELECT command, the READY signal will be temporarily inactive (HIGH) while the command is processed by the SmartDispenser®. Following a DISPENSE command, the READY line will be inactive(HIGH) during the entire dispense cycle, and will return to an active(LOW) state when the dispense is completed.

I/O Description Table (Continued)

SIGNAL	PIN #	DIR	DESCRIPTION
Alarm (ALRM)	10	SD Output	The ALARM signal is an indication of an alarm condition which requires attention. For example, when operating with a scale, the ALARM would indicate that the scale did not read a value within the expected range. The system will not respond to SELECT or DISPENSE signals when in the ALARM state. The output is active(LOW) as long as the condition persists.
Empty (EMPY)	2	SD Output	The EMPTY signal is an indication from the SmartDispenser® that the dispenser syringe does not have enough material left to perform another of the programmed DISPENSE operations. When this signal occurs following a DISPENSE, the preceding DISPENSE operation has completed. The system will not respond to SELECT or DISPENSE signals when in the EMPTY state. This output is active(LOW) as long as the condition persists.

3.0 Detailed PLC Information

System Overview The SmartDispenser® system, as shown in Figure 1, is comprised of two distinct components: a Single Board Computer (SBC)

running the SmartDispenser® application and a custom controller board running custom firmware. The system is designed for standalone operation with various responsibilities distributed between the two components.

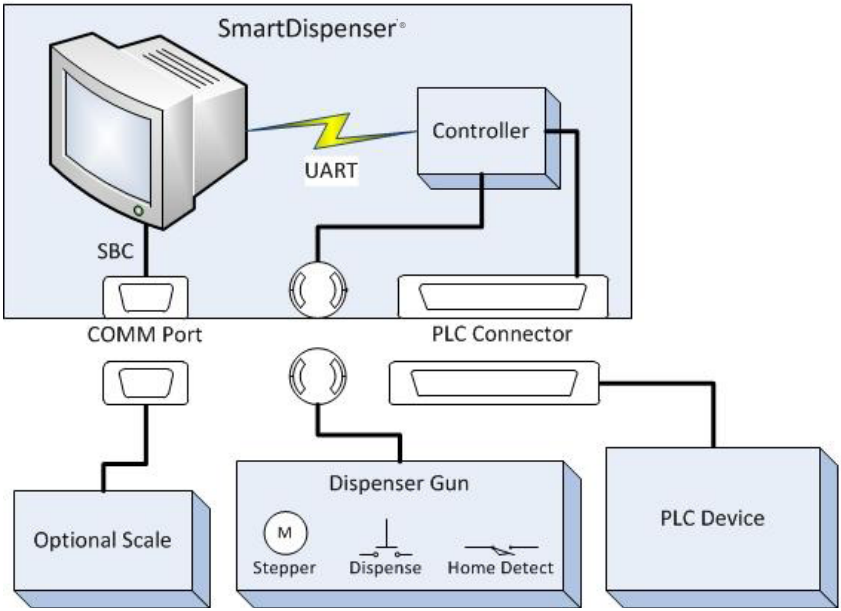


Figure 1: SmartDispenser® System

The controller takes care of all real time operations associated with driving the dispenser gun motor, detecting dispenses and interacting with the optional PLC. The SBC may also send commands to trigger dispenses, but the controller controls the dispense cycle, once initiated. The controller also disables dispensing in certain contexts (e.g. whenever the gun motor is moving). Note that the optional foot switch is ignored here for simplicity sake, but is identical in behavior to the hand switch (Dispense) on the gun.

The controller has no non-volatile storage. It cannot store any program information. All program data is stored on the hard drive of the SBC. It also is a very simple device that does not perform any of the complicated calculations involved in determining dispense parameters. Rather, the SBC supports a GUI with which a user enters all program data. Calculations are performed to convert all user data into step count format that can be used to directly drive the gun motor. Each program is then sent to the controller in this step format. Any change to program parameters results in an update of the controller in the step format. Furthermore, the only way to update the step data stored in the controller is via the SBC GUI.

With no scale connected, the controller is responsible for the entire dispense cycle. Status is provided to the SBC so that the GUI can be updated to reflect the syringe status, but the SBC is not involved in the actual dispense cycle.

The scale is connected to the SBC; not the controller. For this reason, the SBC is involved in the dispense cycle when the scale is connected. In this case, the SBC detects when the status from the controller indicates the completion of a dispense cycle (up to the completion of the optional backoff phase). The SBC then communicates with the scale to determine if the dispense weight is within tolerance. A pass/fail signal is provided to the controller, which then generates the appropriate signals to the PLC and prevents any further dispenses, in the case of a failure.

The controller is also responsible for detecting an empty syringe (based on the step count). This condition is reported to the SBC, which then manages the process of replacing the syringe. Note that the gun includes a limit switch to detect the home position when retracting. When the user indicates that the syringe has been replaced and primed, the SBC signals the controller, which signals the PLC, and dispensing can resume.

Connecting a PLC Device

The controller is responsible for detecting the presence of a PLC device. It reports this to the SBC. The PLC is then in control of setting which program is active and initiating dispenses of that program. The SBC is largely disabled while the PLC is in control of dispensing. The GUI is only used to reflect the status of the system. The controller detects the presence of a PLC when the SEL line (pin 11) goes high. Conversely, the PLC is considered disconnected when the SEL line goes low. This logic coincides with a PLC disconnect when the PLC is physically disconnected from the SmartDispenser® (i.e. the PLC connector is removed) or when it is turned off.

The controller waits 50ms after detecting a state change on this line before making the determination of a PLC connect

or disconnect. This is required because the SEL pin is also used to select a program. Program selection occurs when the SEL pin is pulsed. The maximum pulse width is 50ms and the minimum is 2ms **(25ms is recommended)**.

If the SEL line state changes for more than 50ms then it is assumed that the PLC connection status has changed, accordingly.

Figure 2 shows the timing of PLC signals when a PLC device is connected. The diagram assumes power has already been applied to pin 1 of the PLC connector, which would typically drive the RDY line high because the default state is not ready. In theory, a user could power on a PLC device and drive the SEL line and the PWR line high simultaneously, but the controller always drives the RDY line high when the SEL line is low.

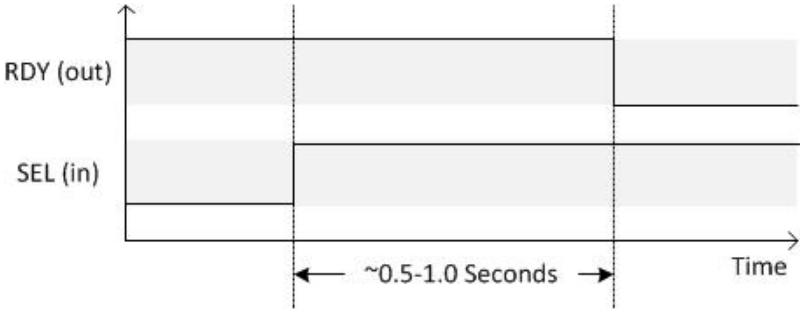


Figure 2: Timing of RDY line after connecting PLC device

In this example, the SEL line is driven high by the PLC device, indicating that the PLC device is connected and will be controlling the SmartDispenser®. The controller changes to the PLC mode of operation after 50ms. This state change is detected by the SBC via a status update. The SBC software disables its GUI and sends a command back to the controller. The controller then drives the RDY line low to indicate it is ready to accept input signals from the PLC device.

There are too many variables involved to determine exactly how long it takes for the exchange between the controller and the SBC, but it is typically in the range of half a second to a second. Note that this process also occurs when the software is launched and the user logs in, if the PLC is already connected. In general, we recommend that the application be launched with the PLC disconnected (or off). Ensure the configuration is set properly for the first syringe and then connect (turn on) the PLC device. This is not strictly necessary; the PLC can be connected and on. However, the GUI will be disabled on startup, which may be cumbersome if the unit is not configured exactly as desired.

Figure 3 shows the effect of driving the SEL line low in order to indicate that the PLC has been disconnected. The diagram assumes the PLC device has not been physically disconnected or powered down. Although the controller sets the state of the output lines regardless of whether a PLC device is connected, the output lines can not be driven high without power being connected to the PWR line.

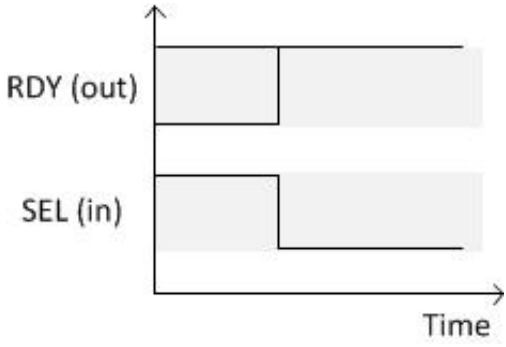


Figure 3: Timing of RDY line after disconnecting PLC device

The initial state of the RDY line is irrelevant; it will always be driven High (Inactive) when the SEL line is driven low. The RDY line changes state immediately, but the controller waits 50ms before making the determination that the PLC device has been disconnected. The PLC status is provided to the SBC, which then enables the GUI so that the SmartDispenser® may be used interactively.

Upon detecting the PLC disconnect, the SBC software begins sending commands to the controller to configure it for interactive use. These commands are illegal while the controller is in PLC mode. Sending these commands to the controller, while in PLC mode, results in the PLCCONN error response. If the PLC is truly being disconnected then no error will be generated. However, if the SEL line is being driven low and then high for the purpose of resetting the PLC interface then the SEL line should be held low for enough time for the SBC to complete its transition.

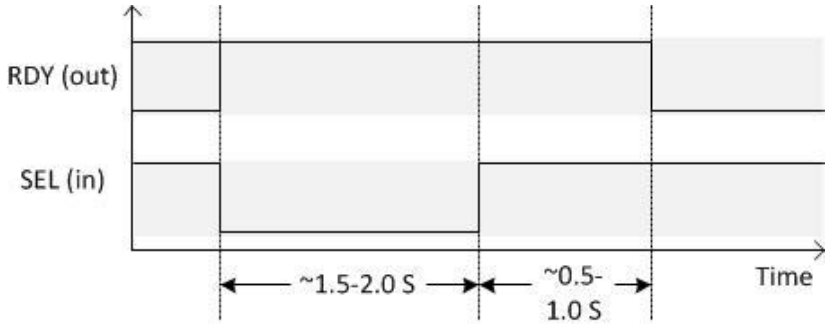


Figure 4: Timing of RDY line after PLC reset

There are too many variables involved in communicating with the SBC to provide exact timing. The SEL line must be held low for approximately 1.5 to 2.0 seconds, as there is no feedback to know when the SBC has completely transitioned. After the SEL line is driven high, the RDY line will indicate that the PLC has been completely reset.

NOTE: **Whenever the PLC transitions from being disconnected to being connected, the PLC device should perform a program selection. Otherwise, there is no guarantee that the correct program will be selected when dispensing begins.**

Program Selection

There are no means of setting program parameters via the PLC interface. All program parameters must be set via the SBC using its GUI. The PLC only provides a mechanism for selecting one of the programs that has been preset via the SBC. The PLC has the option to select a PC2 operation by selecting program 0 or it may select up to 8 preset tradition programs by selecting programs 1-8.

A program is indicated by setting the levels of the Program Select lines (PS0-PS4). Collectively, these lines form a binary encoded value in the range of 0-31 with PS0 representing the least significant bit. The values 9-31 are reserved for future expansion, but this is merely by convention. This limit is not enforced by the controller. Note that a bit value of zero is represented by a high pin level and a bit value of one is represented by a low pin level.

The SEL line performs the dual functions of indicating that a PLC is present and changing the current program. This ambiguity is resolved by using a pulse for the latter function. Program

selection occurs when the SEL line is pulsed low. There is a maximum pulse width beyond which we assume the SEL line is changing state (i.e. it is not a pulse). The timing of the pulse is shown in Figure 5.

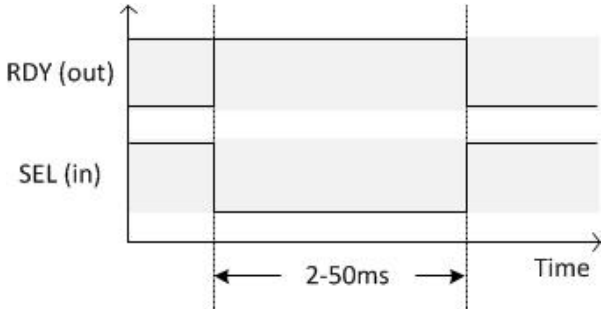


Figure 5: Timing of RDY line after program selection

The value of the program selection is latched at the start of the pulse, so the states of the PSx lines must be set at or before that time. The program selection does not occur until the end of the pulse.

The RDY line is set high immediately upon the start of the pulse. If the pulse width is less than 2ms then it is invalid. Program selection does not occur and the RDY line will not be set low. If the pulse width is greater than 50ms then it is assumed to be a PLC disconnect and the RDY will not be set low. The RDY line is only driven low if the pulse width is within range. Any pulse width within this range is acceptable.
(A 25ms pulse is ideal)

NOTE: Whenever the PLC transitions from being disconnected to being connected, the PLC device should perform a program selection. Otherwise, there is no guarantee that the correct program will be selected when dispensing begins.

Dispensing

Dispensing is initiated by driving the DISP line active low, as shown in Figure 6. The RDY line is immediately driven inactive high. The PLC device must not attempt another dispense until the RDY line is active low again. Any attempt will be ignored and the PLC will not receive any feedback that the attempt failed. The duration of the RDY line inactive state corresponds to the duration of the dispense cycle.

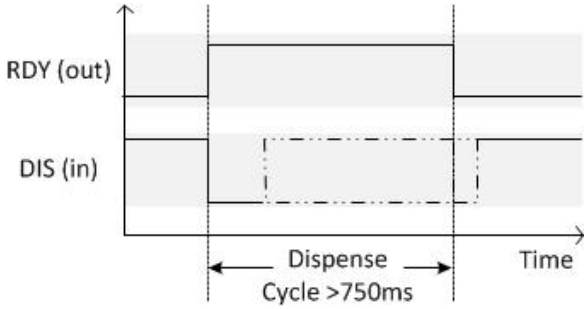


Figure 6: Timing of RDY line after dispense

The dispense is triggered on the falling edge only, which implies that the line must be driven inactive high before another dispense can occur. There are two options for handling the DIS line after initiating the dispense.

The most straightforward approach is to treat the signal as a pulse. It is reasonable to make the pulse width shorter than the dispense cycle time. The duration of the dispense cycle is complex, but it will never be shorter than 750ms. Any pulse width shorter than this is best, although there is no inherent reason why the width can not be longer.

The second approach would be to return the DIS line to its inactive high state in response to the RDY line transition at the end of the dispense cycle. In this scenario, it might make sense to add a small delay before the next dispense to allow any state transitions to propagate through the system, but this is a PLC implementation detail. The PLC device must not initiate a dispense unless the RDY line is Active (Low), the ALRM line is inactive high and the EMPTY line is Inactive (High). These latter two requirements are exception cases described in Managing Exceptions.

Managing Exceptions

There are two circumstances in which the SBC GUI is enabled and the PLC is temporarily restricted from dispensing: when an empty syringe is detected or when an alarm condition occurs. During either of these circumstances, the GUI is enabled; allowing a user to take the necessary steps to address the situation so that the PLC device can resume dispensing.

The controller determines that a syringe is empty when there is not enough fluid left in the syringe to satisfy another dispense, according to the parameters of the active program. The state of the RDY line is driven inactive high at the start of the last complete dispense, as shown in Figure 7.

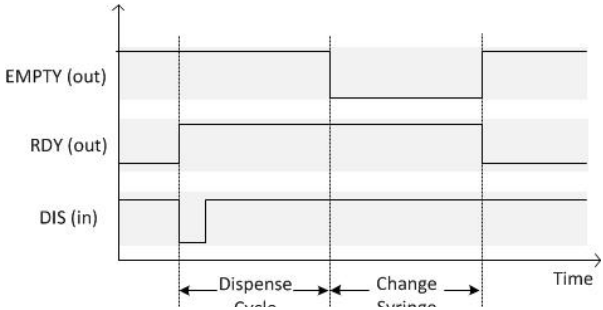


Figure 7: Timing of output lines after last dispense

When the dispense cycle is complete, the RDY line does not return to the active state. Rather, the EMPTY line is driven active low, indicating the empty syringe. The user must then follow the appropriate process to replace and prime the syringe. The exact steps of that process are determined by the configuration of the software, but the software sends a command to the controller when the process is complete. This has the effect of driving the EMPTY signal to inactive high and the RDY line to active low, enabling the PLC device to dispense again.

It may be the case that the syringe is not completely empty when the controller determines that the syringe is empty. The controller is detecting when the syringe does not have enough fluid for the next dispense. It is not possible to change to a different program with a smaller dispense after the EMPTY condition. The only choice is for the user to replace the syringe.

The ALRM line is used to indicate any other exceptional conditions. At this time, there are two such conditions defined. The first occurs when using the optional scale. After a dispense, a scale reading takes place. If the dispense weight is out of tolerance then an exception is indicated.

Exceptions are indicated by driving the ALRM line Active (Low), as shown in Figure 8.

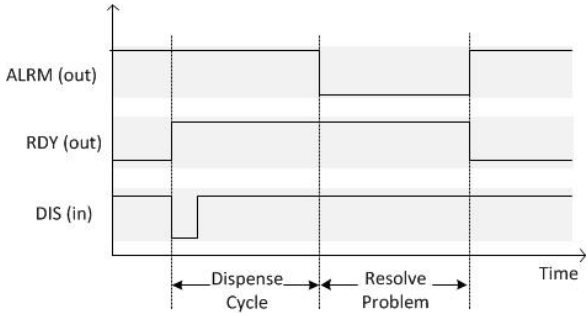


Figure 8: Timing of output lines after exception

Similar to the empty condition, the RDY line does not return to the active state. Rather, the ALRM line is driven active low, indicating the exception. The user must then follow the appropriate process to clear the condition and the software sends a command to the controller when the process is complete. This has the effect of driving the ALRM signal to inactive high and the RDY line to active low, enabling the PLC device to dispense again.

NOTE:
This section refers to the HT GUN ONLY.

The other exception occurs when a gun connected to the SmartDispenser® does not match the software configuration. This condition is detected asynchronously. Any time a gun mismatch exists, the exception is indicated by driving the ALRM line active low. The state of the RDY line remains unchanged, so it should not be involved in the PLC logic when detecting this condition. Typically, this condition would exist before any dispense occurs; most likely, immediately after connecting the PLC device. If this exception were to occur during a dispense then the implication is that the gun has been disconnected while the dispense was occurring.

To clear this condition, simply connect a gun that matches the configuration or change the configuration to match the gun.

NOTES

NOTES

SmartDispenser®

Meets applicable CE requirements.

Integrator Manual
Programmable Logic Controller Setup Guide | Version 4

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