Driver/Controller
Development Assistance Package
For
Rheodyne MX II

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Driver/Controller Development Assistance Package for Rheodyne MX II^{TM}

Proprietary Letter

This Driver/Controller Development Assistance Information Package ("Information") consists of the following documents for the Matrix II series of fluidic assemblies:

1. Rheodyne MX II Modes of Operation
2. Rheodyne MX II Driver Specification

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This Information is provided as a convenience to Rheodyne OEM customers for the sole purpose of allowing those customers who wish to do so to develop their own electronic circuitry to drive and control Rheodyne motorized valves. This Information is not warranted in any way.

The user of this Information assumes full and complete responsibility for the performance of any circuitry developed by the user.

Rheodyne assumes no obligation to update this Information at any time in the future.

1. Introduction

This document includes driver specifications related to Rheodyne's MX II series solutions, to assist OEM users interface with the platform. Please contact Rheodyne, L.L.C. if additional drawings or firmware information are required. Engineering documents can be sent electronically in the following formats: Pro E, SolidWorks, STEP, IGES, DXF, or DWG, depending on the specific document.

2. MX II Series – Modes of Operation

Rheodyne's MX II Series has two modes of operation – local and remote.

Local Mode
Local mode is to be used if the user wants to manually control the valve position. In order to do so, the Remote key on the front panel must be pressed, turning OFF the LED next to it. Once the Remote LED is OFF the valve position can be controlled via the up and down arrows.

In local mode, the current valve position is always displayed on the LED. If an error occurred in the unit, one of the following messages might be displayed:

"PE" – positioning error
"Ho" – homing
"EE" – error

Pressing both keys while "PE" is displayed causes valve homing and "Ho" to be displayed. If the valve homed successfully the new position will be displayed.
Pressing both keys while "EE" is displayed causes the error code to be displayed. Please refer to Rheodyne Document 2321382 "UART/USB Communication Protocol" for a list of possible errors that can be displayed.

Remote Mode
The unit can also be controlled remotely via USB, I2C and either BCD or inverse BCD (for multi-position valves) or BCD, inverse BCD, level logic, pulse logic, or dual-pulse logic (for two position valves). In order to control the unit remotely, the remote LED must be ON. This is the default mode of communication every time the unit starts up. The connector pin-outs are discussed in the next section.

Please refer to section 3.7.3 that describes possible conflicts between multiple modes of operation being active at the same time.

3. Driver Specifications for MX II Series

3.1 Connectors/Pin-Outs
The following is a list of the connectors available on the back of each MX II unit

USB

Standard USB "B" socket, mates with a USB B side Male socket. The cable length should not exceed 3 meters.

DB-9

Standard DB-9, Female socket, mates with standard DB-9 plug. It is recommended to keep the cables as short as possible in order to avoid signal noise.

Pin Number	Color on Rheodyne Control Cable (PN 2710005)	BCD Mode	Dual Pulse Mode	Pulse Mode	Level Logic Mode
1	Brown	Ground	Ground	Ground	Ground
2	Red	I2C Clock (SCL)	I2C Clock (SCL)	I2C Clock (SCL)	I2C Clock (SCL)
3	Orange	I2C Data (SDA)	I2C Data (SDA)	I2C Data (SDA)	I2C Data (SDA)
4	Yellow	Error FB	Error FB	Error FB	Error FB
5	Green	Done FB	Done FB	Done FB	Done FB
6	Blue	BCD CMD3	Pulse A		Level Control
7	Purple	BCD CMD2	Pulse B	Pulse Control	
8	Grey	BCM CMD1	POS B Feedback	POS B Feedback	POS B Feedback
9	Black	BCD CMD0	POS A Feedback	POS A Feedback	POS A Feedback

Power

Rheodyne MX II Series should be used with the power supply included with the unit. Please refer to section 4.1.

3.2   Remote Command Modes

MX II^{TM} series allows the user to control the valve using either digital logic or serial communications.

The following command modes are available for digital logic control:

- 4-line BCD

- 4-line inverted BCD
- Level logic (two-position valves only)
- Pulse logic (two-position valves only)
- Dual-pulse logic (two-position valves only)

All inputs associated with digital logic (BCD, inverted BCD, level, pulse and dual-pulse) have 10K pull-up resistors on board. They can be controlled using TTL or CMOS logic (0-5V), or by using simple contact closure to ground. All digital logic signals must be stable for at least 10 milliseconds after change of state in order to be accepted as valid.

Serial communication options include:

- RheoLink^{TM} (I2C) serial communication
- USB serial communication

3.3   BCD Control and Status

3.3.1   Line BCD Control
This command mode enables the user to actuate the valve to any position available. A 4-bit parallel binary signal is applied to DB-9 pins 6, 7, 8 and 9. The pin-out for this command mode is as follows:

DB-9 Pin #	Control Pins
6	BCD CMD3
7	BCD CMD2
8	BCD CMD1
9	BCD CMD0

The logic is based on a non-inverted or "active high" binary format as listed below. Zero in the table means logic "low", contact closure to ground, or zero volts. One means logic "high", open contact, or +5 VDC. All four bits must be properly set.

BCD inputs must be stable for 10 ms in order to be recognized as valid. Once the input is recognized as valid, DoneFB line is set low and no new input commands will be accepted until the valve is moved to the new position and the DoneFB line is set high again.

Position	Pin #			
	6	7	8	9
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0

5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
10	1	0	1	0

3.3.2 Four-Line Inverted BCD Control

This control mode is essentially the same as the 4-line BCD control mode, except it uses inverted (active low) binary logic.

	Pin #			
Position	6	7	8	9
1	1	1	1	0
2	1	1	0	1
3	1	1	0	0
4	1	0	1	1
5	1	0	1	0
6	1	0	0	1
7	1	0	0	0
8	0	1	1	1
9	0	1	1	0
10	0	1	0	1

3.3.3 Status Lines in BCD Control Mode

There are two lines of status feedback; an Error feedback line (DB-9, Pin 4) and a Done feedback line (DB-9 Pin 5).

Pin	Status Feedback	Description
DB-9 Pin 5, DB-9 Pin 4	DoneFB=1, ErrorFB=0	Valve has completed last motion. No error detected during last motion process.
DB-9 Pin 5, DB-9 Pin 4	DoneFB=1, ErrorFB=1	Valve has completed last motion. Error detected during last motion process.
DB-9 Pin 5, DB-9 Pin 4	DoneFB=0, ErrorFB=X	Valve is busy. Error feedback line NOT valid.

3.3.4 Logic Flow for BCD Command Mode

On power up, the circuit goes through initialization and configures itself based on the programmed firmware. The startup routine runs next, where the position reading from the sensors is taken and the sensor reading determines the next step of the startup routine. If the

sensor reading is a valid position value, the valve sets the current position to this reading, it does not move at all and it monitors the command lines for a valid position command. If the sensor reading is an invalid value, the valve searches for home, the closest position in the CW direction (decreasing position number rotation), sets the current position to the number of the position found, and then monitors the command lines for a valid position command. Once done with the startup routine, the circuit will set the Done feedback line high. The circuit will then begin monitoring the input lines waiting for a valid position command. If it detects a valid position command, it will then do the following if the valve is not already in the commanded position:

1. Clear the Done feedback line to indicate the unit is busy and will not accept any new commands.
2. Move the valve to the appropriate position using a preset motion profile.
3. Check for errors.
4. When the commanded position is reached, the Done feedback line is set high again to indicate the unit is available for the next command.

3.4   Level Logic Control, Status, and Feedback

Level logic command mode is applicable to two-position valves only. The valve shall be actuated to either the A or B position, per the logic described below, via the DB-9 connector.

3.4.1   Level Logic Control

When operating in level logic mode, the level input has a pull-up resistor that keeps it in "high" state if no other signal is applied. Therefore, on power-up the unit either moves to position A or remains in it if already there. A "low" (0V, CLOSED or GND) on pin 6 of DB-9 connector will cause the valve to move to position B and a "high" (+5V or OPEN) on pin 6 of DB-9 connector will cause the valve to move to position A. The change in state of pin 6 must be for a minimum of 10 milliseconds (see illustration below). This logic control allows the valve to be actuated from the initialized A position (A = HOME) to position B with a simple contact closure to ground. Subsequent opening of the contact will return the valve to position A.
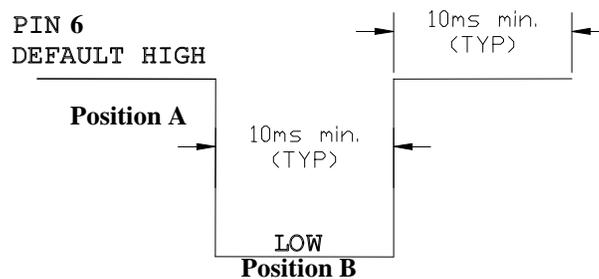
Level Logic – Position vs. Pin 6 Input State

3.4.2 Status and Position Feedback

Done Feedback line (DB-9 pin 5) provides the valve status feedback. There are two lines providing position feedback: Position A Feedback (pin 9, DB-9), and Position B Feedback (pin 8, DB-9). The position feedback lines use inverse logic (active "low") and are updated after the valve has completed the last move.

Done FB	Error FB	Pos_B FB	Pos_A FB	Valve Status
1	0	1	0	Valve in position A, ready for new command
1	0	0	1	Valve in position B, ready for new command
0	0	X	X	Valve is moving (busy)
0	1	1	1	Error

3.4.3 Logic Flow for Level Command Mode

On power up, the circuit goes through initialization and configures itself based on the programmed firmware. The position of the valve is checked, and it is moved to position A (home position) if it is not already there. Once done, the circuit will set the Done feedback line "high". The circuit will then begin monitoring the input line waiting for a new command. If it detects a command, it will then do the following:

1. Clear the Done feedback line to indicate the unit is busy and will not accept any new commands.
2. Move the valve to the appropriate position using a preset motion profile.
3. Check for errors:
   a. Only one feedback line will be asserted to indicate that the valve has reached its desired position.
   b. If the desired position is not reached, the Done feedback line will remain "low" and neither position feedback line will be asserted if the valve is stuck. At this time, Error feedback line will also be set to "high".
4. When the commanded position is reached the Done feedback line is set "high" again to indicate the unit is available for the next command.

3.5 Pulse Logic Control, Status, and Feedback

Pulse logic command mode is applicable to two-position valves only. The valve shall be actuated to either the A or B position, per the logic described below, via connector DB-9.

3.5.1 Pulse Logic Control

When operating in pulse logic mode, the pulse input has a pull-up resistor that keeps it in "high" state if no other signal is applied. Valve position is checked on power-up and the valve is homed to position A if it is not already in position A or B. A "low" (pulse of 0VDC or GND) on pin 7 of

DB-9 will cause the valve to move to the opposite position. The pulse must be for a minimum of 20 milliseconds (10 milliseconds min. low & 10 milliseconds min. high). See illustration below. After a new command is detected but before the valve motion begins, a "done feedback status line" on pin 5 of DB-9 is cleared to indicate that the valve is busy and no further commands will be acted on. After the valve has completed its motion profile, the "done feedback status line" is set to "high" to let the user know that the valve is available for further instructions.

```
PIN 7                          ┌─ 10ms min. ─┐
DEFAULT HIGH ──────┐          │   (TYP)     │      ┌─────────
                   │          │             │      │
Position A or B →  │ 10ms min.│             │      │
                   │  (TYP)   │             │      │
                   └──────────┘             └──────┘
              LOW
              │   MOVES TO OPPOSITE OF  │   RETURNS TO      │
              │     INITIAL POSITION    │ INITIAL POSITION  │
```
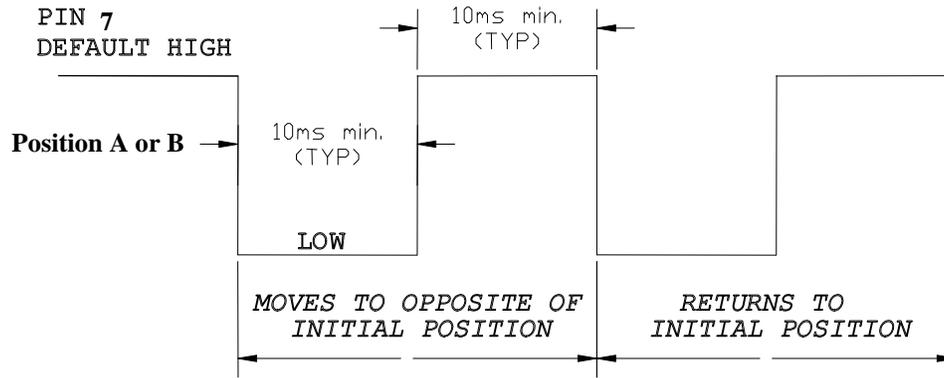
Pulse Logic – Position vs. Pin 7 Input State

3.5.2   Status and Position Feedback

Done Feedback line (pin 5, DB-9) provides the valve status feedback. There are two lines providing position feedback: Position A Feedback (pin 9, DB-9), and Position B Feedback (pin 8, DB-9). The position feedback lines use inverse logic (active "low") and are updated after the valve has completed the last move.

Done FB	Error FB	Pos_B FB	Pos_A FB	Valve Status
1	0	1	0	Valve in position A, ready for new command
1	0	0	1	Valve in position B, ready for new command
0	0	X	X	Valve is moving (busy)
0	1	1	1	Error

3.5.3   Logic Flow for Pulse Command Mode

On power up, the circuit goes through initialization and configures itself based on the programmed firmware. The position of the valve is checked, and it is homed to a valid position if it is not already there. Once done, the circuit will set the Done feedback line "high". The circuit will then begin monitoring the input line waiting for a new command. If it detects a command, it will then do the following:

1. Clear the Done feedback line to indicate the unit is busy and will not accept any new commands.
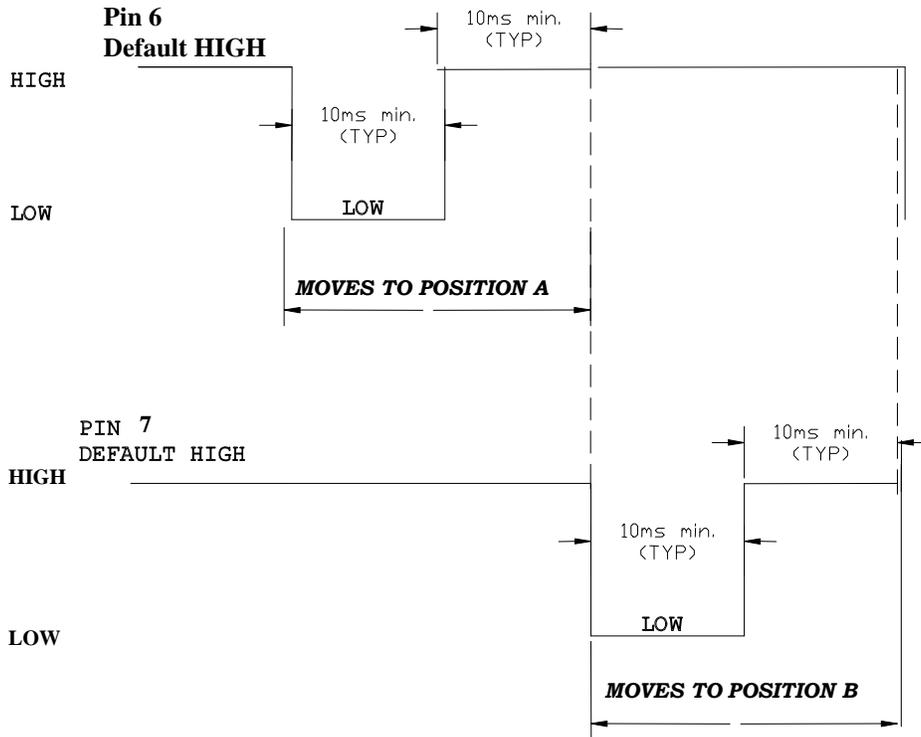
2. Move the valve to the appropriate position using a preset motion profile.
3. Check for errors:
     c. Only one feedback line will be asserted to indicate that the valve has reached its desired position.
     d. If the desired position is not reached, the Done feedback line will remain "low" and neither position feedback line will be asserted if the valve is stuck. At this time, Error feedback line will also be set to "high".
4. When the commanded position is reached the Done feedback line is set "high" again to indicate the unit is available for the next command.

3.6 Dual Pulse Logic Control, Status, and Feedback

Pulse logic command mode is applicable to two-position valves only. The valve shall be actuated to either the A or B position, per the logic described below, via connector DB-9.

3.6.1 Dual Pulse Logic Control

When operating in dual-pulse logic, both inputs have pull-up resistors that keep them in "high" state if no other signal is applied. If the valve is in either position A or B on power-up, it stays in that position until commanded otherwise. If the valve powers up in any other position, it will then home to position A. A "low" (pulse of 0VDC or GND) on pin 6 of DB-9 will cause the valve to go to position A, and a "low" (pulse of 0VDC or GND) on pin 7 of DB-9 moves the valve to position B. The pulse width must be for a minimum of 20 milliseconds (10 milliseconds min. low & 10 milliseconds min. high). See illustration below.

Pin 6
Default HIGH

HIGH

10ms min. (TYP)

10ms min. (TYP)

LOW

LOW

MOVES TO POSITION A

PIN 7
DEFAULT HIGH

HIGH

10ms min. (TYP)

10ms min. (TYP)

LOW

LOW

MOVES TO POSITION B

Dual Pulse Logic – Position vs. Pins 8,10 Input State

3.6.2 Status and Position Feedback
Done Feedback line (DB-9, pin 5) provides the valve status feedback. There are two lines providing position feedback: Position A Feedback (DB-9, pin 9), and Position B Feedback (DB-9, pin 8). The position feedback lines use inverse logic (active "low") and are updated after the valve has completed the last move.

Done FB	Error FB	Pos_B FB	Pos_A FB	Valve Status
1	0	1	0	Valve in position A, ready for new command
1	0	0	1	Valve in position B, ready for new command
0	0	x	x	Valve is moving (busy)
0	1	1	1	Error

3.6.3 Logic Flow for Dual Pulse Command Mode
On power up, the circuit goes through initialization and configures itself based on the programmed firmware. In dual-pulse control mode, the valve's position is checked to see if it is in either position A or position B. If the valve is not in position A or B, the valve is moved to position A. Once done, the circuit will set the "done feedback status line" high. The circuit will

then begin monitoring the input lines waiting for a new command. If it detects a command, it will then do the following:

1. Clear the Done feedback line to indicate the unit is busy and will not accept any new commands
2. Move the valve to the appropriate position using a preset motion profile.
3. Check for errors:
   a. Only one position feedback line will be asserted to indicate that the valve has reached its desired position.
   b. If the desired position is not reached, the Done feedback line will remain clear and neither position feedback line will be asserted if the valve is stuck. At this time, ErrorFB status line will also be set to "high".
4. When the commanded position is reached, the Done feedback line is set "high" again to indicate the unit is available for the next command.

3.7   Serial Communications

3.7.1   RheoLink^{TM} (I2C) Communication Control, Status, and Feedback

RheoLink communication protocol is based on the I2C multi-drop serial communication standard. It allows the user to control multiple valves using only three wires (data, clock and ground). Customer equipment needs to implement the I2C master function, while Rheodyne boards act as I2C slaves. RheoLink implements basic command, status, and feedback commands, as well as advanced commands for board configuration and status.
Please refer to Rheodyne document "RheoLink Communication Protocol for TitanEX^{TM} and TitanHT^{TM} Driver Boards" for the implementation details.

3.7.2   USB Communication Control

MX II uses an FT232R USB UART IC to enable USB communication between the MX II module and control equipment (such as PC). Rheodyne provides a stand-alone GUI that can be used for demonstration purposes of the USB communication. To develop your own control software, utilizing USB communication, please refer to http://www.ftdichip.com/Products/FT232R.htm for driver information as well as code samples. At the time of this publication the user has two options with respect to the choice of drivers. VCP drivers allow the user to control the MX II USB device through a COM port while D2XX allow the user to control the device directly, without using the COM ports.

3.7.3   Serial Communications and Level Logic Interaction

Both serial communications and digital logic control are simultaneously active on a driver board. This can create a conflict if the valve is a two-position one and the command mode is level logic. Level input is internally pulled-up to 5 V and will thus force the valve to a Load position whenever no external signal is applied. If the user utilizes serial communications to command the valve to Inject position, the driver board will first move the valve to Inject. Immediately after

that motion profile is completed, the driver board will check the level input, find it in high state, and as a result, it will immediately move the valve back to Load.

To avoid this conflict, please change the command mode to BCD, Pulse, or Dual-Pulse before using serial communications.

4.0 MX II Operating Conditions

4.1 Power Supply
Manufacturer: Cincon Electronics Co.
Model No: TR45A24-26A03
Using any other power supply is not supported and invalidates CE certification.

4.2 Maximum Temperature
Maximum Operating temperature: 50°C