Driver/Controller Development Assistance Package For IDEX Health & Science TitanHT™ Driver Board

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Driver/Controller Development Assistance Package for IDEX Health & Science TitanHT™ Motorized Valves Proprietary Letter

This Driver/Controller Development Assistance Information Package (“Information”) consists of the following documents for the TitanHT series of fluidic assemblies:

1. IDEX Health & Science TitanHT Driver Board Description
2. IDEX Health & Science TitanHT Dimensional Drawing

This Information is proprietary to IDEX Health & Science, L.L.C., and is provided by IDEX Health & Science as a service to assist IDEX Health & Science OEM customers in the development of drive and control circuitry to be used in conjunction with IDEX Health & Science motorized valves. By requesting and accepting this Information, the recipient agrees to make no other use of this Information, and not to disclose this Information to persons not involved in the development of such control circuitry.

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Introduction

This document includes driver specifications related to Rheodyne's TitanHT™ driver board PN 8382101, to assist OEM users interface with the platform. Please contact IDEX Health & Science, 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.

1.0 Driver Specifications for TitanHT Driver Board

The following Stepper Motor Driver Specifications pertain only to the hardware and firmware that is provided by IDEX Health & Science. Please refer to IDEX Health & Science document TBD if you want to develop your own version of firmware to drive the TitanHT. Please refer to Figure 1 in Section 2 for component locations.

1.1 Connectors/Pin-Outs

Stepper Motor Driver/Controller Board (PN 8382101) Headers

- **J1: 12-pin header for digital logic control**
- **J2: 10-pin header for serial communication and programming**
- **J3: 2-pin header for power input**
- **J4: 10-pin header for interface with TitanEX/HP valves**
- **J5: 8-pin header for interface with TitanHT valve motor**
- **J6: 6-pin header for interface with TitanHT valve sensor board**
- **J7: 13-pin header for for digital logic control, power, and I2C**

The connector pin call-outs for Rheodyne's TitanHT Driver Board (PN 8382101) are defined below.

J1: 12-pin header for digital logic control

Molex part number: 87831-1242
Use Molex part number 51110-1260 to interface with this header.

Pin	Color*	BCD mode	Level logic mode	Dual-pulse mode	Pulse mode
J1-1	Orange	BCD FB0			
J1-2	Violet	BCD FB1			
J1-3	White	BCD FB2			
J1-4	Grey	BCD FB3			
J1-5	Pink	Error FB	Error FB	Error FB	Error FB
J1-6	Tan	reserved	reserved	reserved	reserved
J1-7	Brown	Done FB	Done FB	Done FB	Done FB
J1-8	Green	BCD CMD3	Level Logic Input	Pulse A Input	
J1-9	Black	GND	GND	GND	GND
J1-10	Blue	BCD CMD2		Pulse B Input	Pulse Logic Input
J1-11	Yellow	BCD CMD1	Position B FB	Position B FB	Position B FB
J1-12	Red	BCD CMD0	Position A FB	Position A FB	Position A FB

*Color Designation is for Titan Control Cable (P/N 7770-051).

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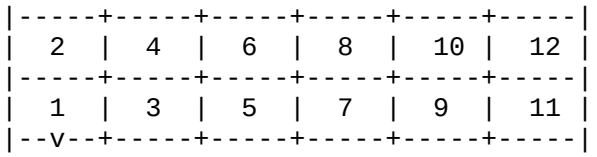
Layout of the J1 header:



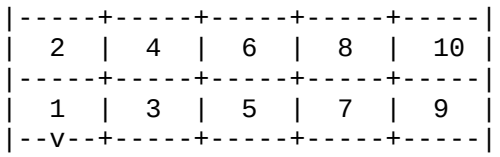
J2: 10-pin header for serial communication and programming

Molex part number: 87831-1042
Use Molex part number 51110-1060 to interface with this header.

Pin	Color*	Description
J3-1	Orange	I2C SDA
J3-2	Violet	I2C SCL
J3-3	NA	+5 VDC
J3-4	Black	GND
J3-5	Green	AUX1
J3-6	Grey	AUX2
J3-7	NA	Vpp (programming voltage)
J3-8	NA	reserved
J3-9	Blue	UART TXD
J3-10	White	UART RXD

*Color Designation is for Titan Control Cable (P/N 8381-303). Layout of

the J2 header:

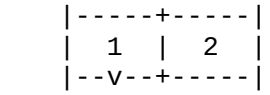


J3: 2-pin header for power input

Molex part number: 70543-0001
Use Molex part number 50-57-9402 to interface with this header.

Pin	Description
J3-1	GND
J3-2	+24 VDC

Layout of the J3 header:



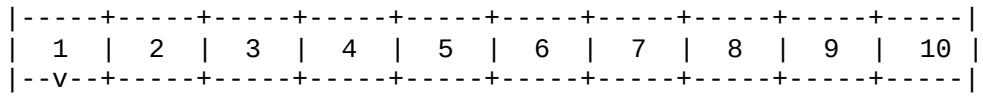
J4: 10-pin header for interface with TitanEX™/TitanHP™ valves

Molex part number: 70543-0009
Use Molex part number 50-57-9410 to interface with this header.

Pin	Color*	Description
J4-1	Red	Motor Red
J4-2	Grey	Motor Grey
J4-3	Black	Motor Black
J4-4	Yellow	Motor Yellow
J4-5	Red	GND
J4-6	Yellow	Sensor 3
J4-7	Black	Sensor 2
J4-8	Orange	Sensor 1
J4-9	White	Sensor 0
J4-10	Brown	Sensor power (5VDC)

*Color designation is for motor/sensor cable of TitanEX/TitanHP valves.

Layout of the J4 header:

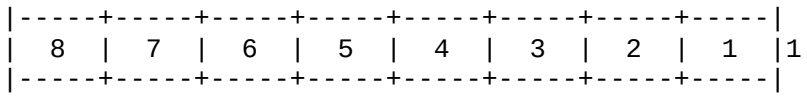


J5: 8-pin header for interface with TitanHT™ valve motor

Molex part number: 22-23-2081
Use Molex part number 22-01-2085 to interface with this header.

Pin	Color*	Description
J5-1	Orange	Motor A+
J5-2	Black/White	Motor A+
J5-3	Red	Motor B+
J5-4	Yellow/White	Motor B+
J5-5	Black	Motor A-
J5-6	Orange/White	Motor A-
J5-7	Yellow	Motor B-
J5-8	Red/White	Motor B-

*Color designation is for motor cable of TitanHT valves. Layout of the J5 header:



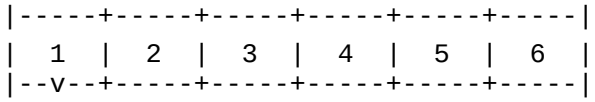
J6: 6-pin header for interface with TitanHT™ valve sensor board

Molex part number: 70543-0005
Use Molex part number 50-57-9406 to interface with this header.

Pin	Color*	Description
J6-1	Purple	Sensor power (5VDC)
J6-2	White	Sensor 0
J6-3	Orange	Sensor 1
J6-4	Black	Sensor 2
J6-5	Yellow	Sensor 3
J6-6	Red	GND

*Color designation is for sensor cable of TitanHT valves.

Layout of the J6 header:



J7: 13-pin header for digital logic control, power, and I2C

Molex part number: 70543-0012
Use Molex part number 50-57-9413 to interface with this header.

Pin	Color*	BCD mode	Level logic mode	Dual-pulse mode	Pulse mode
J7-1	NA	GND	GND	GND	GND
J7-2	NA	+24V	+24V	+24V	+24V
J7-3	NA	+5V	+5V	+5V	+5V
J7-4	Black	GND	GND	GND	GND
J7-5	Brown	DoneFB	DoneFB	DoneFB	DoneFB
J7-6	Pink	ErrorFB	ErrorFB	ErrorFB	ErrorFB
J7-7	Green	BCD CMD3	Level Logic Input	Pulse A Input	
J7-8	Blue	BCD CMD2		Pulse B Input	Pulse Logic Input
J7-9	Yellow	BCD CMD1	Position B FB	Position B FB	Position B FB
J7-10	Red	BCD CMD0	Position A FB	Position A FB	Position A FB
J7-11	Orange	I2C SDA	I2C SDA	I2C SDA	I2C SDA
J7-12	Violet	I2C SCL	I2C SCL	I2C SCL	I2C SCL

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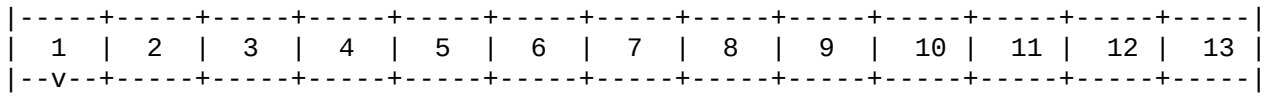
J7-13	NA	reserved	reserved	reserved	reserved

*Color Designation is for Titan Control Cable (P/N 8381-301). Layout of

the J7 header:



1.2 Command Modes

TitanHT™ driver board 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™ (I2C) serial communication
- UART serial communication

1.3 BCD Control, Status, and Feedback

1.3.1 4-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 J1 pins 8, 10, 11, and 12. The pin-out for this command mode is as follows:

Pin #	Control Pins
J1-8	BCD CMD3
J1-10	BCD CMD2

J1-11	BCD CMD1
J1-12	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.

	Pin #			
Position	**J1-8**	**J1-10**	**J1-11**	**J1-12**
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

1.3.2 4-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	**J1-8**	**J1-10**	**J1-11**	**J1-12**
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

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1.3.3 Status Lines in BCD Control Mode

There are two lines of status feedback; an Error feedback line (J1-5) and a Done feedback line (J1-7).

Pin	Status Feedback	Description
J1-7, J1-5	DoneFB=1, ErrorFB=0	Valve has completed last motion. No error detected during last motion process.
J1-7, J1-5	DoneFB=1, ErrorFB=1	Valve has completed last motion. Error detected during last motion process.
J1-7, J1-5	DoneFB=0, ErrorFB=X	Valve is busy. Error feedback line NOT valid.

1.3.4 Position Feedback Lines in BCD Control Mode

There are four lines providing position feedback: BCD FB0, FB1, FB2, and FB3 (pins J1-1, J1-2, J1-3, and J1-4 respectively. The position feedback is updated after the valve has completed the last move.

1.3.5 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.

1.4 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 connector J1.

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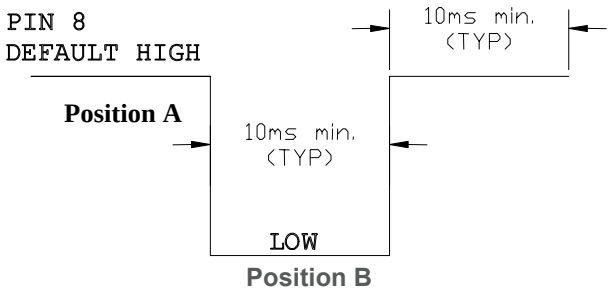
1.4.1 Level Logic Control

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 J1-8 will cause the valve to move to position B and a “high” (+5V or OPEN) on pin J1-8 will cause the valve to move to position A. The change in state of pin J1-8 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 8 Input State

1.4.2 Status and Position Feedback

Done Feedback line (pin J1-7) provides the valve status feedback. There are two lines providing position feedback: Position A Feedback (pin J1-12), and Position B Feedback (pin J1-11). 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

1.4.4 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:

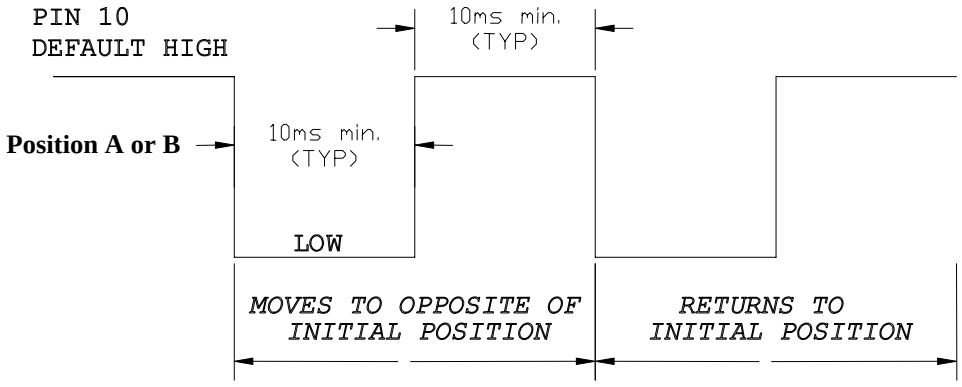
1. **Clear the Done feedback line to indicate the unit is busy and will not accept any new commands.**
2. **Move the valve to the appropriate position using a preset motion profile.**
3. **Check for errors:**
    a. **Only one feedback line will be asserted to indicate that the valve has reached its 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.**

1.5 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 J1.

1.5.1 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 J1-10 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 J1-7 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.



Pulse Logic – Position vs. Pin 10 Input State

1.5.2 Status and Position Feedback

Done Feedback line (pin J1-7) provides the valve status feedback. There are two lines providing position feedback: Position A Feedback (pin J1-12), and Position B Feedback (pin J1-11). 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

1.5.3 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.

1.6 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 J1.

1.6.1 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

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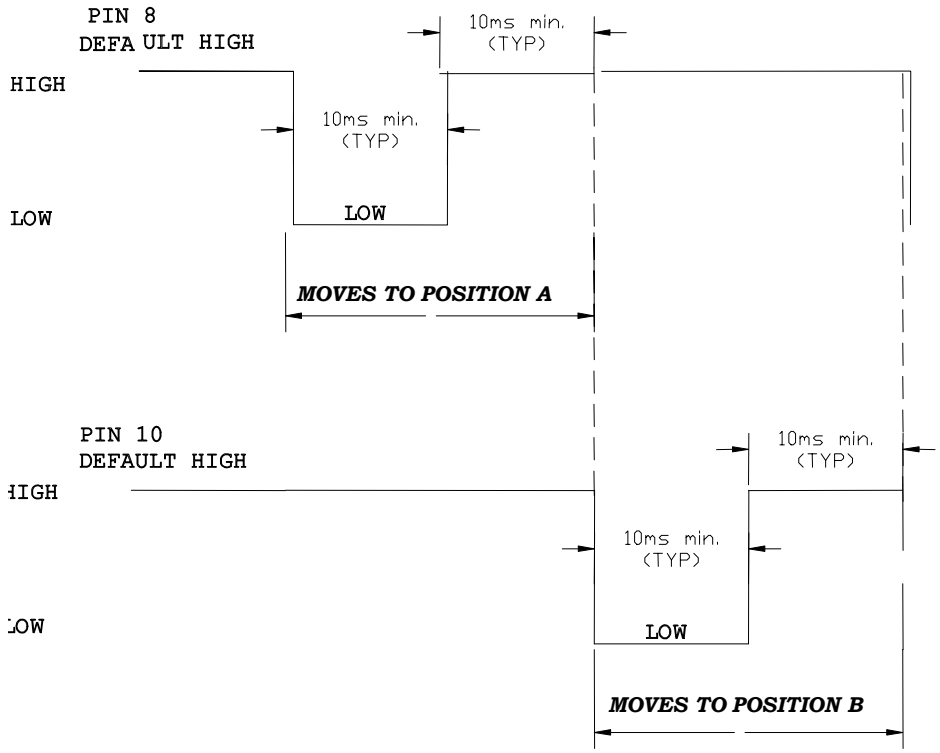
then home to position A. A “low” (pulse of 0VDC or GND) on pin J1-8 will cause the valve to go to position A, and a “low” (pulse of 0VDC or GND) on pin J1-10 moves the valve to position B. The pulse width must be for a minimum of 20 milliseconds (10 milliseconds min. low & 10 milliseconds min. high). See illustration below.



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

1.6.2 Status and Position Feedback

Done Feedback line (pin J1-7) provides the valve status feedback. There are two lines providing position feedback: Position A Feedback (pin J1-12), and Position B Feedback (pin J1-11). 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

1.6.3 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.

1.7 Serial Communications

1.7.1 RheoLink™ (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 IDEX Health & Science 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 IDEX Health & Science document “RheoLink Communication Protocol for TitanEX™ and TitanHT™ Driver Boards” for the implementation details.

1.7.2 UART Communication Control, Status, and Feedback

UART communication protocol allows the user to control a single valve using only three wires (RXD, TXD and ground). The board accepts TTL or CMOS voltage levels (0-5V), but can interface with USB, RS-232, RS-422 or RS-485 ports using external adapters. UART communication protocol implements basic command, status, and feedback commands, as well as advanced commands for board configuration and status.
Please refer to IDEX Health & Science document “UART Communication Protocol for TitanEX and TitanHT Driver Boards” for implementation details.

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1.7.3 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.

1.8 Operational Mode Selection for Valves with Universal Encoders

This paragraph pertains only to valves with a universal position encoder. “Universal” means that the same set of encoder wheels can be used for positioning valves with 60° port layout as well as valves with 36° port layout. This allows for easy change of the valve liquid end without the need to change the actuator.
Input lines AUX1 (J2-5) and AUX2 (J2-6) control the operational mode. These lines are internally pulled up, so they will both be read as “high” if no external signal is attached. The lines are sampled only upon board power-up and any input changes after the power-up will be ignored.

AUX1 logic level	AUX2 logic level	Operational mode
1	1	Default operational mode, as programmed by firmware
0	1	Forces 60°mode
1	0	Forces 36°mode
0	0	Default operational mode, as programmed by firmware

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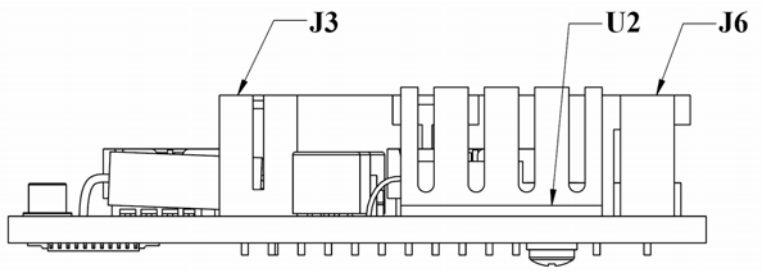
2.0 TitanHT^{TM} Driver Board Information 2.1 Power Requirements

Input voltage: 24 VDC +5/-10%
Input current: Quiescent: 20 mA

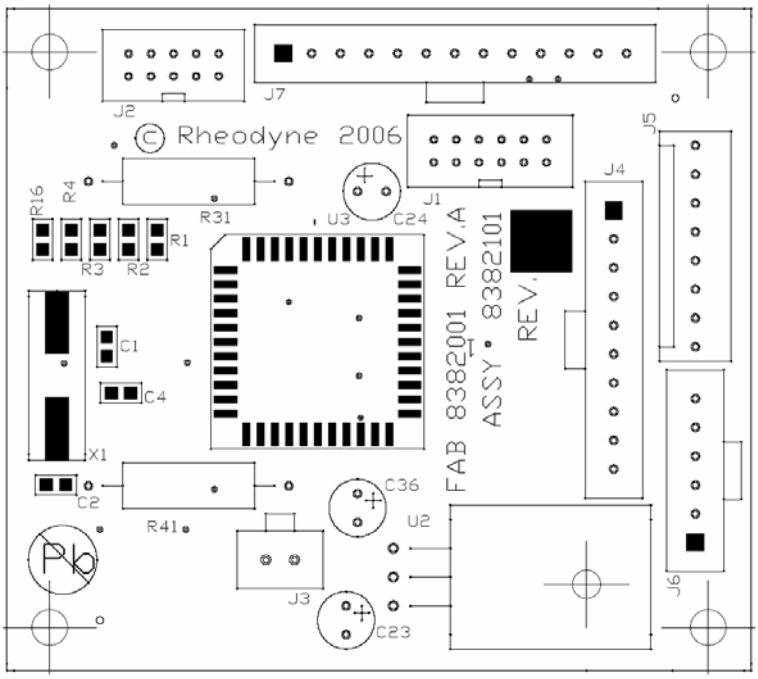
Peak: 3.7 A
RMS: 1.3 A
Average: 0.8 A

Board Dimensions: 2.6 in. x 2.3 in.
Maximum Operating temperature: 70°C

2.2 Board Layout and Ground Plane Details

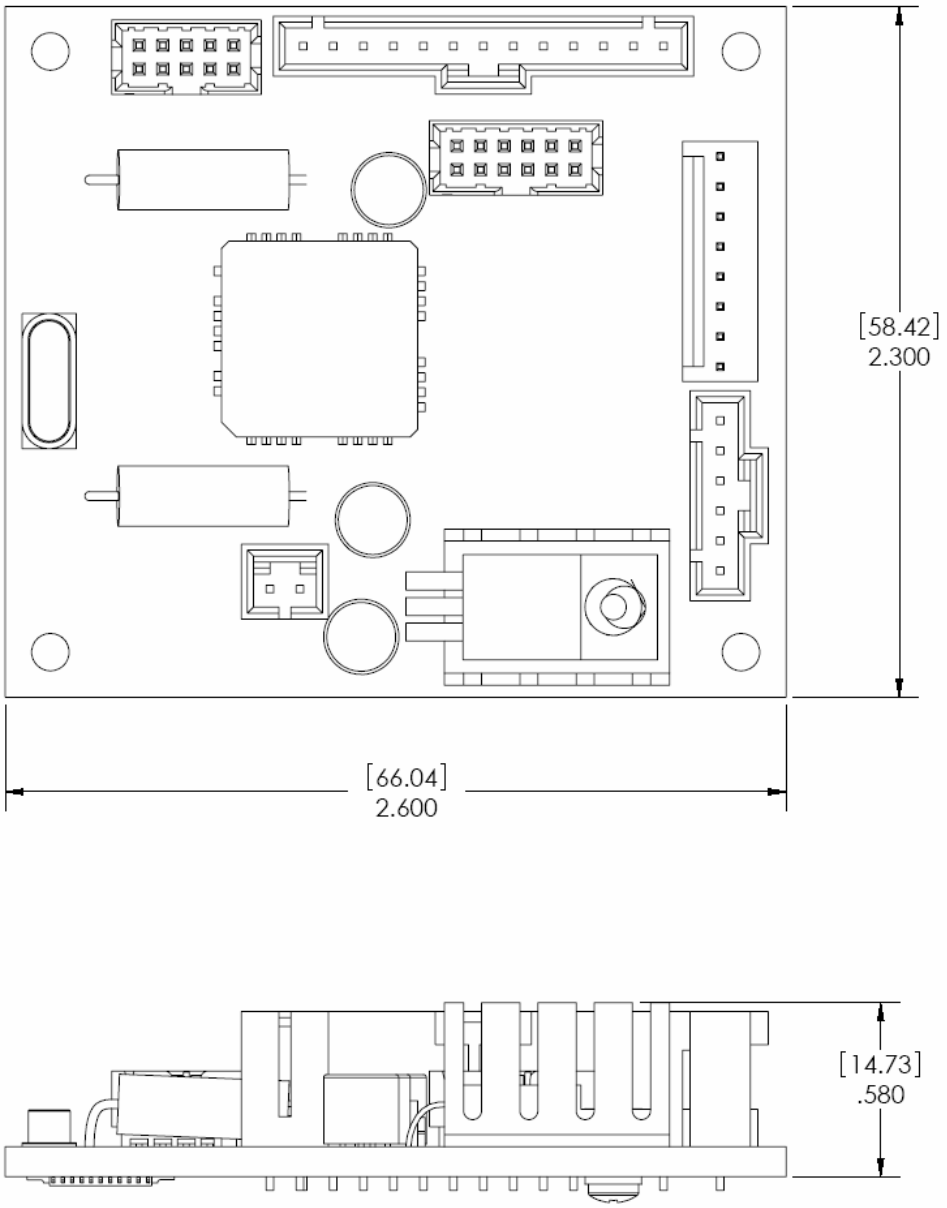


PROFILE VIEW WITH HEATSINK



TOP VIEW

2.3 Titan Driver Board Dimensional Drawings ([mm]/inches)



3.0 Demonstration Kit

IDEX Health & Science, L.L.C. offers a Demonstration Kit (P/N 7770-052) as a convenience to assist OEM customers in development. This Kit contains all necessary components to drive the valve including:

1. Universal Power Supply - input is 100-240VAC, 50-60 Hz, output is 24VDC, 1.7A.
2. Power Line Cord
3. Power Supply Adapter Cable (P/N 7900-901)
4. Control Cable for connector J4 (P/N 7770-051)
5. Control Cable for connector J5 (P/N 8381-301)

Please contact IDEX Health & Science, L.L.C for additional information on this Kit.

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