RheoLink™ Communication Protocol for TitanEX™/ TitanEZ™/TitanHP™, TitanHT™ Driver Boards and MX Series II™ Modules

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Design Specifications

RheoLink™ is a two-wire serial interface based on I2C bus. When exchanging data, one device is the master (controls the clock line), while the other device acts as the slave. In the I2C protocol, each device has a seven-bit address. To initiate a data transfer, the master must first transmit the address of the slave device that it wishes to 'talk' to. All devices on the bus listen, but only the device with the matching address responds. Master and slave are always in opposite modes (transmitter/receiver) of operation during a data transfer, but the master always controls the clock.

IDEX Health & Science devices with RheoLink capability are always configured as slaves. Customer equipment must implement the I2C master function either using a hardware I2C port or using firmware and two bi-directional I/O ports.

Both the SCL and SDA lines must be configured as an open-drain or open-collector bus. The bus can never be driven by an active "high", totem-pole type output. If customer equipment contains a microcontroller with bidirectional digital I/O lines, "high" on the bus is achieved by making the pin an input (by putting the pin in high impedance mode). "Low" on the bus is achieved by making the pin an output and driving it "low".

If bidirectional I/O lines are not available, a solution with two digital inputs and two digital outputs is possible – please refer to Figure 1 for a possible implementation.

The I2C bus pull-up resistors will be located on the I2C master board. The I2C slave interface is capable of sinking 8.5 mA at 0.6 V.

I2C bit rate is 100Kbit/s or less for boards with 20 MHz clock and 50Kbit/s or less for boards with 4 MHz clock. Clock stretching by the slave is allowed but must be minimized. Excessive clock stretching may degrade overall system performance and cause communication timeouts.

General call (I2C address 0x00 and 0x01) is reserved for programming and testing and will not be implemented in normal operation.

References:

The I2C-bus and how to use it – Philips Semiconductor 1995
The I2C-bus specification Version 2.1 – Philips Semiconductor 2000

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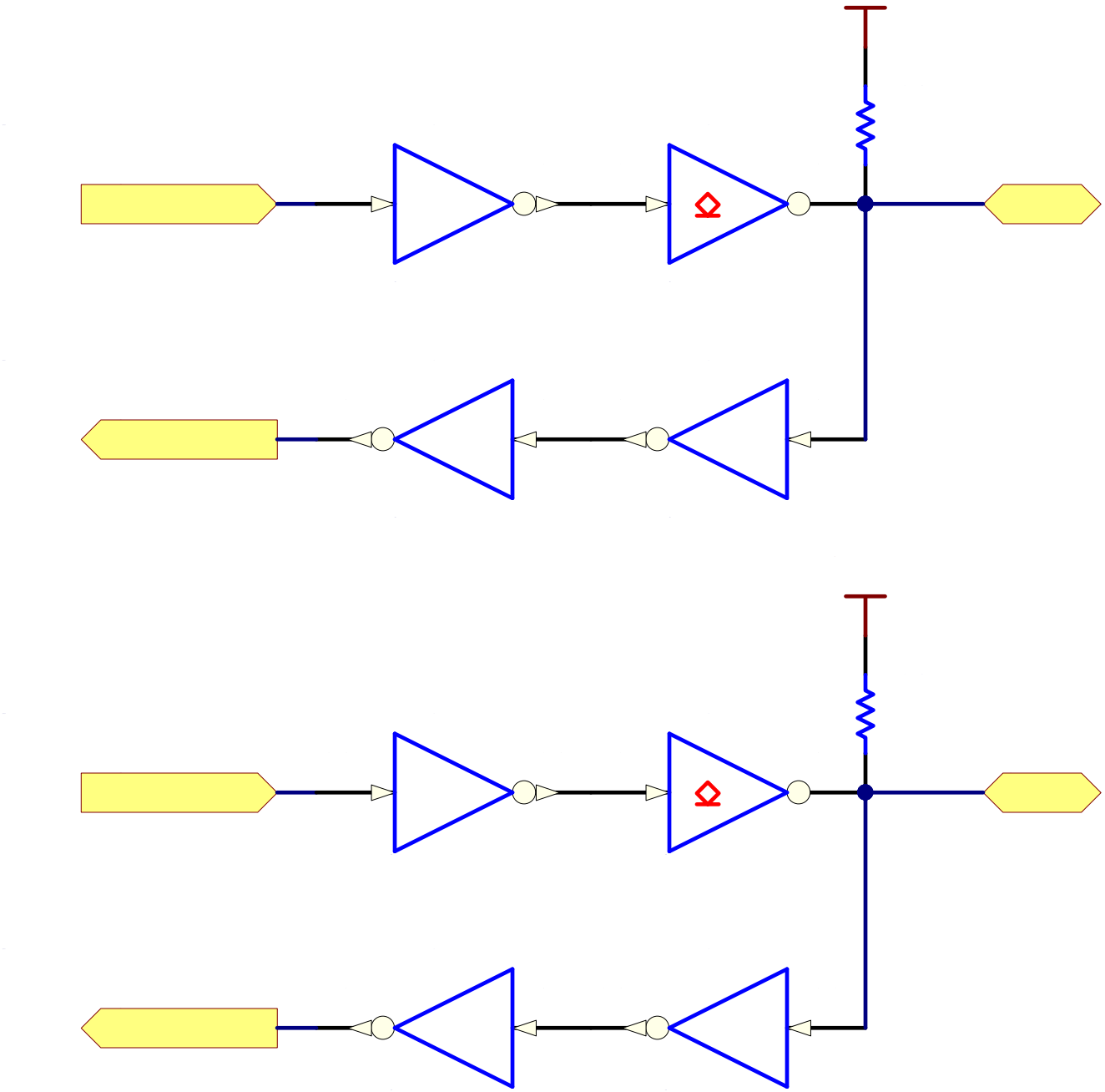

Figure 1. I2C Master Implementation Example

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Master Write Sequence General Format

Start	Address_W	A	Command	A	Data1	A	DataN	A	Csum	A	Stop

Gray Box: From Master to Slave A = Acknowledge
White Box: From Slave to Master ∀ = No Acknowledge

Master Read Sequence General Format

Start	Address_W	A	Command	A	Csum	A	Stop

Start	Address_R	A	Data1	A	DataN	A	Csum	∀	Stop

Gray Box: From Master to Slave A = Acknowledge
White Box: From Slave to Master ∀ = No Acknowledge

Note: Combined format with no Stop bit and with a Repeat Start bit can be used for the Master Read Sequence.

Master Write Sequence Data Exchange General Format

The Master will attempt to write data to the Slave during each Master Write sequence. Data packet will be as indicated in the table below.

Address_W	Device specific	I2C slave write address
Command	Device specific	Command byte
Data1	0x00 – 0xFF	Data byte 1
Data2	0x00 – 0xFF	Data byte 2
…	…	…
DataN	0x00 – 0xFF	Data byte N
Checksum	0x00 – 0xFF	Checksum (XOR of all bytes received including address)

Gray Box: From Master to Slave White Box: From Slave to Master

Master Read Sequence Data Exchange General Format

The Master will attempt to read data from the Slave during each Master Read sequence. Data values will be as indicated in the table below.

Address_W	Device specific	I2C slave write address
Command	Device specific	Command byte
Address_R	Device specific	I2C slave read address
Data1	0x00 – 0xFF	Data byte 1
Data2	0x00 – 0xFF	Data byte 2
…	…	…
DataN	0x00 – 0xFF	Data byte N
Checksum	0x00 – 0xFF	Checksum (XOR of all bytes sent)

Gray Box: From Master to Slave White Box: From Slave to Master

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Communication with TitanEX™/TitanHP™ and TitanHT™ driver boards

Board I2C address

Default device address: 0x0E (AddrW = 0x0E, AddrR = 0x0F)

Note: Each board is shipped with I2C address set to 0x0E. “N” command may be used for changing the device address. Please make sure that the new device address is an even number.

Master Write Sequence

Start | AddrW | Command | Value | Csum | Stop

Master Read Sequence

Start | AddrW | Command | Value | Csum | Stop
Start | AddrR | **Return Value** | **Csum** | Stop **Bold: Data read from the slave**

Busy Status

I2C port will be turned off during the valve motion profile. NACK (no acknowledge) from the valve indicates BUSY state. Master should retry communication until ACK (acknowledge) is received.

Commands

Command: P
Function: commands the valve to a new position
Value: 1 – x, where x depends on the maximum number of positions allowed for the selected mode of operation (2, 3, 4, 6, 8, 10, 12)
Note: Invalid position commands are ignored by the driver board.

Command: + (only implemented for TitanHP and TitanEX, not implemented for TitanHT or MX Series II™) Function: commands the valve to a new position using counter-clock wise motion (CCW)
Value: 1 – x, where x depends on the maximum number of positions allowed for the selected mode of operation (2, 3, 4, 6, 8, 10, 12)
Note: Invalid position commands are ignored by the driver board.

Command: - (only implemented for TitanHP and TitanEX, not implemented for TitanHT or MX Series II)
Function: commands the valve to a new position using clock wise motion (CW)
Value: 1 – x, where x depends on the maximum number of positions allowed for the selected mode of operation (2, 3, 4, 6, 8, 10, 12)
Note: Invalid position commands are ignored by the driver board.

Command: O
Function: sets valve profile
Value: 0x00 - 0xFF
Note: The new operational mode becomes active after driver board reset. Invalid operational mode will cause error 77 (valve configuration error).

Command: N
Function: sets new slave I2C address
Value: 0x0E - 0xFE (even numbers only)
Note: The new I2C address becomes valid after driver board reset.

Command: F
Function: sets valve command mode
Value: 0x01 - 0x05

Level logic = 0x01
Single pulse logic = 0x02
BCD logic = 0x03
Inverted BCD logic = 0x04
Dual pulse logic = 0x05

Note: The new command mode becomes active after driver board reset. Invalid command mode will cause error 77 (command mode error).

Command: X
Function: sets baud rate for UART communication
Value: 0x01 - 0x04

9600 = 0x01
19200 = 0x02
38400 = 0x03
57600 = 0x04

Note: The new baud rate becomes active after driver board reset.

The following commands don't require a specific Value, but the Value byte must still be sent to the slave as part of the Master Write packet:

Command: M
Function: commands the valve to the home position
Value: don't care

The following commands are used in a Master Read sequence:

Command: S
Function: requests valve status
Value: don't care
Return Value:
99 – valve failure (valve can not be homed)
88 – non-volatile memory error
77 – valve configuration error or command mode error
66 – valve positioning error
55 – data integrity error
44 – data CRC error
current valve position (1 to 12) otherwise

Command: Q
Function: reads valve profile
Value: don't care
Return Value: 0x00 - 0xFF

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Command: R
Function: reads firmware revision
Value: don’t care
Return Value: 0x00 - 0xFF

Command: E
Function: reads the latest valve error code
Value: don’t care
Return Value: 0x00 - 0xFF

Command: D
Function: reads the valve command mode
Value: don’t care
Return Value: 0x01 - 0x05

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