



MCR IQ™ 600 assembly
MCR IQ™ 500 assembly
MCR IQ™ 400 board

Theia MCR IQ™ Operator's Manual

Table of Contents

1. Precautions and disclaimers	4
2. Windows Software	4
2.1 Lens home settings	4
2.2 Communication	5
3. Hardware specification	5
3.1. Features:	5
3.2. Ratings and parameters	6
3.2.1 Absolute maximum ratings:	6
3.2.2 Mechanical (board only):	6
3.2.3 Operating parameters:	6
3.3. Connectors	7
3.3.1. USB (J1)	7
3.3.2. I2C (J2)	7
3.3.3. UART (J2)	8
3.3.4. SPI (JP1)	8
3.3.5. Reset (JP1)	9
3.3.6. Factory default reset	9
3.3.7. General Purpose I/O	9
3.3.8. Lens Connectors (J23, J4, J5, J6)	9
3.3.9. Power Supply (J1, JP1, J2)	9
4. Software communication structure	10
4.1. Overview	10
4.2. Different bus behaviors	10
4.2.1 USB bus mode	10
4.2.2 I2C server bus mode	11
4.3. Serial Protocol	11
4.3.1. Move Stepper Motor	12
4.3.1.1. Motion Control for DC motors	12
4.3.2. Read Firmware Version	13
4.3.3. Read Serial Number of the board	13
4.3.4. Read Motor Setup	14
4.3.5. Write Motor Setup	15
4.3.6. Switch active bus	16
4.3.7. Change I2C address	16
Revision history	16

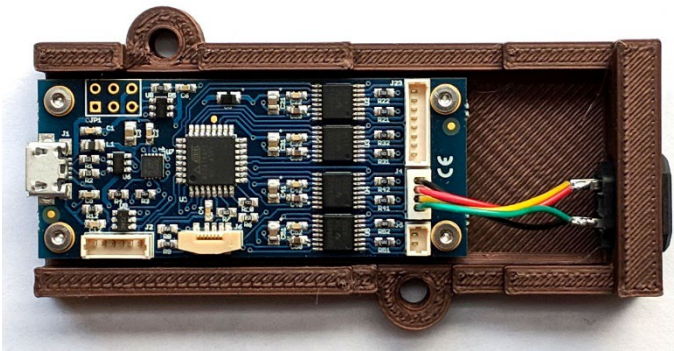
Theia MCR IQ™ Operator's Manual

This motor control board can be used with Theia Technologies® motorized lenses that use a P-iris.

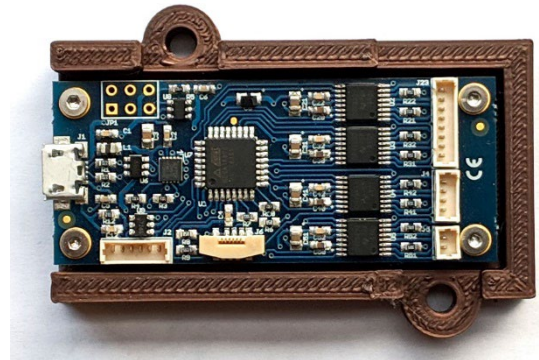
The Theia MCR IQ™ Motor Control Board does not provide for control of Theia's motorized lenses with DC auto iris, but only supports the lens versions with P-iris. The board can be used to control the zoom and focus motors of the DC auto iris lens versions; the iris would need to be controlled separately.

Supported lenses	Motor control board
TL936P R3, TL936P R5	MCR IQ™ 500
TL936P R4, TL936P R6	MCR IQ™ 400 or MCR IQ™ 600
TL1250P R3, TL1250P R5, TL1250P N5	MCR IQ™ 500
TL1250P R4, TL1250P R6, TL1205P N4, TL1250P N6	MCR IQ™ 400 or MCR IQ™ 600
TL410P R3, TL410P R5	MCR IQ™ 500
TL410P R4, TL410P R6	MCR IQ™ 400 or MCR IQ™ 600
ML410P R3, ML410P R5	MCR IQ™ 500
ML410P R4, ML410P R6	MCR IQ™ 400 or MCR IQ™ 600

The motor control board is available in 3 versions. There are 2 assembly versions (MCR IQ™ 500 and MCR IQ™ 600) which come with a plastic base to allow easier handling of the board. The only difference between the two is an adapter cable that allows connection to Theia's -R3/-R5 lenses which use the EYC221 CCTV connector instead of the Molex connector which is built into the board. Theia's -R4/-R6 and -N4/-N6 lenses can be used without this adapter cable.

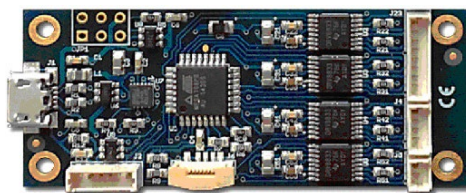


MCR IQ™ 500



MCR IQ™ 600

The third version of the motor control board is the board-only configuration. This version doesn't include the plastic base part and is packaged for higher volume purchases.



MCR IQ™ 400

Theia MCR IQ™ Operator's Manual

1. Precautions and disclaimers

- Do not short circuit any part of the board
- Keep the motor control board dry
- The motor control board contains fuses but proper ESD protection procedures should be followed
- If the motor control board becomes too hot, disconnect it.
- The motor control is not designed for use in life sustaining or lifesaving applications.
- The motor control is not designed for use in applications where their failure may lead to significant loss of property or health of humans or animals.
- The Information given herein is believed to be accurate and reliable. However, users should independently evaluate the suitability of and test each product selected for their own applications.
- The products described herein are intended for integration. Users must get all required certifications and registrations for the resulting assembly including for the products described herein.
- We reserve the right to make changes to the products described herein without notification. A new specification replaces any previous ones. 100% backward compatibility is not guaranteed.
- See [Theia's standard terms and conditions](#) for warranty and other information.

2. Windows Software

Theia provides the MCR IQ™ application – a simple graphical user interface (GUI) and a Python module that can be used to send and receive commands to the board. These applications are created for ease of use. The board integrator may use and modify these programs to suit the needs of the application (following the terms of the open source BSD license [TheiaTech.com/Theia BSD](https://theiatech.com/Theia_BSD)). For more information about the software, download the MCR IQ™ Setup guide.



This guide as well as specification, CAD models, and other information can be downloaded from <https://theiatech.com/mcr>

2.1 Lens home settings

Each lens has a home position. For -R5, -R6, -N5, and -N6 lenses this home position is set by a photo interrupter. For -R3, -R4, -N3, and -N4 lenses, the home position is at the end of the focus and zoom ring rotation but there is no limit switch feedback. When the lens motors are initialized, they find this home position and set the initial step number. This home position could be on the low side or high side of the focus and zoom ring rotations depending on the lens model.

Theia MCR IQ™ Operator's Manual

Lens	Zoom PI	Focus PI
TL410P R5, TL410A R5, TL410P R6, TL410A R6, TL410P N5, TL410P N6	Tele stop	Far stop
TL1250P R5, TL1250A R5, TL1250P R6, TL1250A R6, TL1250P N5, TL1250P N6	Wide stop	Far stop
TL936P R5, TL936P R6, TL936A R6	Wide stop and/or Tele stop	Near stop and/or Far stop
TL410P R3, TL410P R4, TL410A R4	No PI, use either wide or tele end of rotation as home	No PI, use either near or far end of rotation as home
TL1250P R3, TL1250P R4, TL1250A R4	No PI, use either wide or tele end of rotation as home	No PI, use either near or far end of rotation as home
TL936P R3, TL936A R3	No PI, use either wide or tele end of rotation as home	No PI, use either near or far end of rotation as home

2.2 Communication

The board communication protocol can be changed to USB, UART, or I2C. In all cases the command sent to the board should be formatted the same.

3. Hardware specification

3.1. Features:

- supports Theia Technologies® lenses
- controls P-iris, focus, zoom and IR cut filter motors
- reads photo interrupter limit switches for zoom and focus
- supports USB, I2C, and LV-TTL-UART
- small size of only about 2.4" x 1" (60x25 mm²) without base
- over-current protection
- over-temperature protection
- single 5V supply (via USB or pin connector)
- optional base has 2x M4 mounting holes (50mm separation at 45deg to board orientation)

Theia MCR IQ™ Operator's Manual

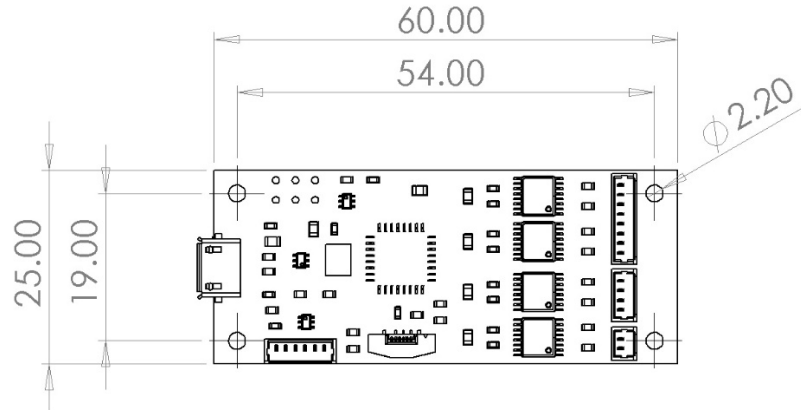
3.2. Ratings and parameters

3.2.1 Absolute maximum ratings:

Maximum Operating Voltage	5.5 V
Maximum current draw	<500mA
Storage Temperature	-40 °C ... 100 °C
Operating Temperature	-35 °C ... 85 °C

3.2.2 Mechanical (board only):

Length	60mm
Width	25mm
Height (without cables)	10mm
Weight	10g
Mounting holes	4x M2



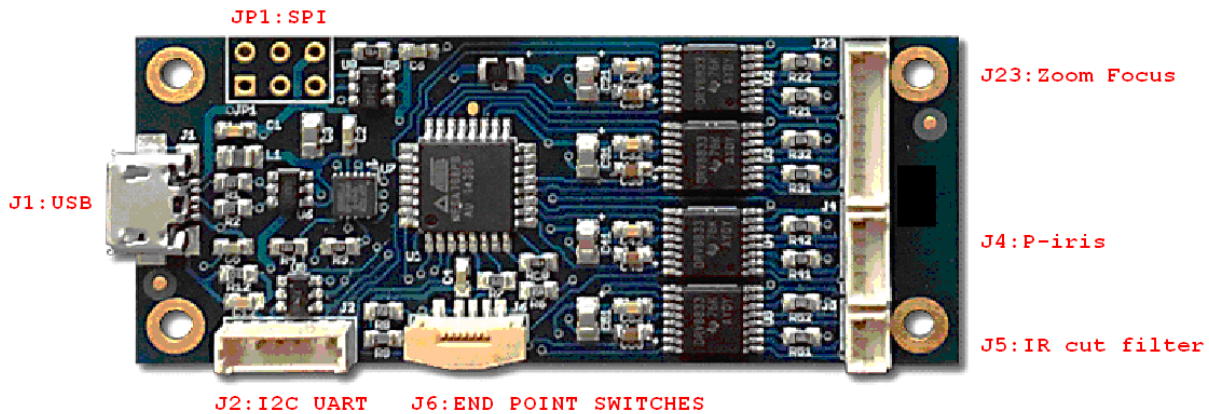
3.2.3 Operating parameters:

Operating Voltage	5.0V ($\pm 0.5V$)
Operating Current (while stepping one motor at a time)	<250mA
Operating Current (while idle)	<50mA
In-rush current protection	1000mA

Note: Power consumption depends on many parameters of the operating mode.

Theia MCR IQ™ Operator's Manual

3.3. Connectors



3.3.1. USB (J1)

Micro USB connector is able to supply and control the board via a single cable. This connector interfaces with a FTDI®* FT200 USB to I2C bridge chip and uses drivers available for that chip. That way this interface appears as a serial port under some major operating systems. General compatibility is USB 2.0 but please refer to the datasheet of that chip to get full information about its features and compatibility.

The I2C side of that bridge chip is also connected to the I2C lines accessible at connector J2. Configuration options accessible through software need to be used to decide which interface (USB or I2C) to use. By default, the USB interface is active.

The USB interface is protected by a Texas Instruments®** TPD3S014-Q1 which limits the supply current and provides ESD protection. Please refer to the datasheet of that chip for the details. Additional protection and filtering comes from passive elements, the FT200 and the controller chip.

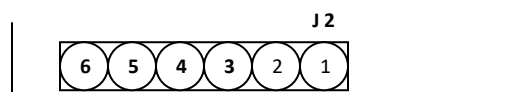
*/ FTDI is a trademark of Future Technology Devices International Ltd, Glasgow, United Kingdom

**/ Texas Instruments is a trademark of Texas Instruments Incorporated, Dallas, Texas, USA

3.3.2. I2C (J2)

J2 is a Molex®* 53047-0610 or compatible connector. The fitting cable connector might be the Molex®* 51021-0600 or compatible.

J2 has a total of 6 circuits (pins) of which the I2C interface uses two for its signals. To function the board would additionally need a ground reference (GND) and a 5V power supply. Both are available on J2 as well.



3 – I2C SCL

4 – I2C SDA

5 – Power GND

6 – Power +5 V

Theia MCR IQ™ Operator's Manual

The I2C signals have 4.7 kOhm pull-up resistors to 5V on board. The board will only interface with 5V I2C bus. If external logic level converter is used it must be I2C-safe. Connecting any electronics that attempt to drive the I2C pins high could result in damage to the motor control board. Speeds up to 400 kBaud are supported. ESD protection is provided to these signals by Littelfuse®** SP724AHTG clamping diode arrays. Please see its datasheet for details.

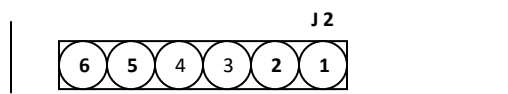
*/ Molex is a trademark of Molex LLC, USA

**/ Littelfuse is a trademark of Littelfuse Inc., USA

3.3.3. UART (J2)

J2 is a Molex®* 53047-0610 or compatible connector. The fitting cable connector might be the Molex®* 51021-0600 or compatible.

J2 has a total of 6 circuits (pins) of which the UART interface uses two for its signals. To function the board would additionally need a ground reference (GND) and a 5V power supply. Both are available on J2 as well.



1 – UART TxD

2 – UART RxD

5 – Power GND

6 – Power +5 V

The UART signals run at (5V CMOS) TTL levels at 19200 Baud and are 8N1 encoded. Please ask if you need that to be changed to something else. Similar boards with RS232 signal levels are available.

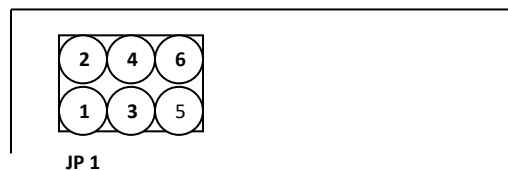
ESD protection is provided to these signals by Littelfuse®** SP724AHTG clamping diode arrays. Please see its datasheet for details.

*/ Molex is a trademark of Molex LLC, USA

**/ Littelfuse is a trademark of Littelfuse Inc., USA

3.3.4. SPI (JP1)

JP1 is 3x2 pin header with 2.54 mm (0.1”) spacing. This header is normally used for the initial firmware upload to the motor control board but is not available for normal communication with the board. If communication by SPI is required, contact us to discuss a custom firmware update.



1 – SPI MISO

2 – Power +5 V

3 – SPI SCK

4 – SPI MOSI

5 – Reset

6 – Power GND

Theia MCR IQ™ Operator's Manual

ESD protection is provided to these signals by Littelfuse®* SP724AHTG clamping diode arrays. Please see its datasheet for details.

3.3.5. Reset (JP1)

Pin 5 of JP1 (see above) is an active-low reset input to the board. It has a pull-up resistor of 4.7 kOhm. ESD protection is provided to it by a Littelfuse®* SP724AHTG clamping diode array. Please see its datasheet for details.

*/ Littelfuse is a trademark of Littelfuse Inc., USA

3.3.6 Factory default reset

The board can be reset to its factory default in case of lost communication. This will reset all EEPROM data (speeds and steps), reset the communication to be USB/I2C client, and reset the I2C address to the 0x10 default.

Steps for doing the factory default:

1. Disconnect USB and serial cables from the board. Only motor cables may be connected.
2. Set a jumper between Pin 1 and Pin 3 of the SPI connector JP1.
3. Power the board via USB or 5V on the I2C/UART connector J2
4. After 1 minute, power cycle the board
5. EEPROM should now be reset to factory default settings. Reset the board to I2C server mode or UART mode if applicable and restore normal cable connections.

3.3.7. General Purpose I/O

Some Pins on some connectors could be reprogrammed into GPIO if certain interfaces are not needed. They could then be used to drive certain periphery like LEDs or read input. Please ask if such special features are needed.

3.3.8. Lens Connectors (J23, J4, J5, J6)

These connectors are intended for cables coming from the lens. More details can be found in the lens datasheet.

J23	Zoom and Focus stepper motor coil connections
J4	P-iris stepper motor coil connections
J5	IR filter switcher coil connections
J6	Zoom and Focus end point switches

Those functions work independently from each other and are optional in that leaving any of these connections unpopulated will not affect the communication or behavior with the motor control board. For instance, manual zoom/focus lenses with a P-iris may be controlled without connections for the zoom/focus motors being connected.

The end point switches are optional. The board needs a software setting to work with them – and would fail to work properly with that setting if the switches were missing. See the command description (4.3.4 Read Motor Setup) on checking the board configuration in the demonstration software.

3.3.9. Power Supply (J1, JP1, J2)

As mentioned above in the sections covering the connectors J1, JP1 and J2, there are several ways to supply power to the board. It is important to note that all the power pins of those connectors are directly connected – all three GND pins are connected and all three +5 Volt pins are connected (note that this includes USB).

DO NOT use more than one power supply at the same time because there are always small differences in their voltages and high cross currents would most probably run through the board – leading to energy loss, heat and may even result in overheating and ignition.

Theia MCR IQ™ Operator's Manual

The board is not intended to be used for power distribution. It may be tempting to receive the power via USB and then serve it to periphery connected to one of the connectors mentioned here. However we discourage use of such a topology. The user would be responsible to check the current capability of the connectors and monitor the heat of the PCB traces under worst case conditions in order to verify how much energy can be distributed safely that way. The user would also have to make the correct setting to the register telling the USB bus what the maximum power requirement is – adding the stepper motor current of the lens to that going to the additional periphery. Depending on the device supplying energy to the USB bus, that request may be denied if such a high current could not be supplied. This would disable the stepper motor operation.

The common +5 Volt supply line goes through a Texas Instruments®* TPD3S014-Q1 which limits the supply current to the board – both its maximum level and its rush-in rate on power-up. Please refer to the datasheet of that chip for the details.

*/ Texas Instruments is a trademark of Texas Instruments Incorporated, Dallas, Texas, USA

4. Software communication structure

4.1. Overview

A simple control software GUI is provided for testing and demonstration. That software is given “as is” in order to help with getting started and testing.

The user can further integrate communication with the motor control board into their own program. In addition to basic stepping commands, there are commands which set device parameters by writing values to a permanent memory on the board.

There is the firmware update mechanism. It may be activated during power-up and in that case a new firmware version can be uploaded, verified and saved to the device memory. Please contact us if there are any questions about firmware upgrades.

4.2. Different bus behaviors

With the exception of the SPI bus, the boards have already been used with different serial buses, namely USB, UART and I2C. In all these cases the commands to a board come from an external source and the board executes them and answers. But there are limitations depending on the type of bus used. The board may be unable to answer while a stepping command is being executed, and/or the board may be unable to actually process any new command arriving while currently executing a stepping command. The latter disables the usability of the STOP command which would normally interrupt the execution of a current stepping sequence.

The current firmware supports one serial bus mode at a time. The default mode is USB which is accessed by the motor control board acting as an I2C client. The bus can be switched to I2C server mode or UART mode via serial command. SPI is not currently supported.

4.2.1 USB bus mode

The USB bus as currently handled on the motor control board includes limitations listed: unable to answer or process new commands while executing the current one. Commands arriving at such a time will remain in the 512 byte input buffer until they can be processed. Commands are not removed from the buffer (see section 4.3). The buffer will be overwritten by any response to a new command. That buffer may overflow so we do not recommend sending new commands until execution of the previous command has finished. In the case of an overflow, a partial command will most probably remain in the buffer. To clean this, a byte containing “Carriage Return” (0x0D) needs to be sent.

If commands are being discarded (like a STOP command when no movement is currently executed) the board will not send the related confirmation. Since via USB any arriving command is delayed until the end of any movement,

Theia MCR IQ™ Operator's Manual

this will always happen; so the STOP commands becomes useless and “invisible” via USB. Such behavior may also be seen with other commands.

4.2.2 I2C server bus mode

The 7-bit address of the board in this mode is (hex) 0x10. This is the address for use with I2C libraries. It represents the upper 7 bits of the address. The least significant bit is the read/write flag, so that address byte should be 0x20 (write) or 0x21 (read).

4.3. Serial Protocol

The current protocol is very simple. That makes it suitable for fast commands coming from low-power hardware. Each command starts with its ID and ends with carriage return CR(0x0D). The answers coming from the board also end with carriage return CR(0x0D).

The response buffer is not cleared after reading which may lead to confusion in some situations. When checking the buffer for completed motor movements, it is possible to send a “get firmware version” (0x76) command between movements and check the first byte of the response buffer. This over-writing with a different command is the best way to clear the buffer.

Theia MCR IQ™ Operator's Manual

4.3.1. Move Stepper Motor

Bytes:

Command ID	Motor ID	Steps (MSB)	Steps (LSB)	Start/Stop	Speed (MSB)	Speed (LSB)	CR
Command ID:	0x66	Rotate far/wide		count steps relative to current position			
	0x62	Rotate near/tele		count steps relative to current position			
	0x73	Rotate from PI stop		count steps absolute from the PI end point switch (zero) (only for motors 0x01 and 0x02 when PI switches enabled) (execution always starts with going back to the switch)			
Motor ID:	0x01	Focus					
	0x02	Zoom					
	0x03	Iris					
	0x04	IR-cut filter		not a stepper motor (see explanations below)			
Steps:	###	Number of steps to do:		(256 * MSB) + LSB For motors of type 0x01 this parameter works differently. Please see the explanations below.			
Start / Stop:	0x01	Start					
	0x00	Stop		set the number of steps to zero (Stop will not work on USB – no parsing while moving)			
Speed:	###	Steps per second:		(256 * MSB) + LSB Must be between min./max. speed of the motor setup. For DC motors this parameter works differently. Please see the explanation in section 4.3.1.1 Motion Control for DC motors.			
CR:	0x0D	End of Command marker					

Answer after the command was executed successfully:

Bytes:

Answer ID	Status	CR
Answer ID:	0x74	End of Rotation
Status:	0x00	Success
CR:	0x0D	End of Answer marker

Note: The step count and speed parameters work differently for motors configured as DC motors. Please read the details in sections 4.3.4 and 4.3.5. Motor number 0x04 (IR filter switcher) is set as a DC motor by default.

4.3.1.1. Motion Control for DC motors

There is a command to write the setup of each motor (see below). There are stepper and DC motors. DC motors are powered for [Number of steps] times of a pulse width. The pulse width is set by 1 / [Steps per second]. Setting [Steps per second] to 500 gives a measuring unit of 2 ms and then setting [Number of steps] to 300 gives a single drive of 600 ms. [Steps per second] **must be between min./max. speed of the motor setup.**

Theia MCR IQ™ Operator's Manual

4.3.2. Read Firmware Version

Bytes:

Command ID	CR
------------	----

Command ID: 0x76 Read Firmware Version

CR: 0x0D End of Command marker

Answer after the command was executed successfully:

Bytes:

Answer ID	Version 1	Version 2	Version 3	Version 4	Version 5	CR
-----------	-----------	-----------	-----------	-----------	-----------	----

Answer ID: 0x76 Firmware Version

Version [1..5]: ### Values identifying the installed firmware version

CR: 0x0D End of Answer marker

4.3.3. Read Serial Number of the board

Bytes:

Command ID	CR
------------	----

Command ID: 0x79 Read Serial Number

CR: 0x0D End of Command marker

Answer after the command was executed successfully:

Bytes:

Answer ID	SN 1	SN 2	SN 3	SN 4	SN 5	SN 6	CR
-----------	------	------	------	------	------	------	----

Answer ID: 0x79 Serial Number

SN [1..6]: ### Values identifying the serial number of the board

CR: 0x0D End of Answer marker

Theia MCR IQ™ Operator's Manual

4.3.4. Read Motor Setup

Bytes:

Command ID	Motor ID	CR
------------	----------	----

Command ID: 0x67 Read Motor Setup

Motor ID: 0x01 Focus
 0x02 Zoom
 0x03 Iris
 0x04 IR-cut filter

CR: 0x0D End of Command marker

Answer after the command was executed successfully:

Bytes:

Answer ID	Motor ID	Motor type	Use left stop	Use right stop	Steps (MSB)	Steps (LSB)	Min speed (MSB)	Min speed (LSB)	Max speed (MSB)	Max speed (LSB)	CR
-----------	----------	------------	---------------	----------------	-------------	-------------	-----------------	-----------------	-----------------	-----------------	----

Answer ID: 0x67 Motor Setup

Motor ID: 0x01 Focus
 0x02 Zoom
 0x03 Iris
 0x04 IR-cut filter

Motor Type: 0x00 Stepper motor
 0x01 DC motor

Use left stop: 0x00 No
 0x01 Yes wide/far stops

Use right stop: 0x00 No
 0x01 Yes tele/near stops

Steps: ### Max. number of steps: (256 * MSB) + LSB
 (The board does NOT keep track of the position)

Min. Speed: ### Min. steps per second: (256 * MSB) + LSB

Max. Speed: ### Max. steps per second: (256 * MSB) + LSB

CR: 0x0D End of Answer marker

Note: For an invalid motor ID the return will be:

0x67 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0x0D

Theia MCR IQ™ Operator's Manual

4.3.5. Write Motor Setup

Bytes:

Command ID	Motor ID	Motor type	Use left stop	Use right stop	Steps (MSB)	Steps (LSB)	Min speed (MSB)	Min speed (LSB)	Max speed (MSB)	Max speed (LSB)	CR
------------	----------	------------	---------------	----------------	-------------	-------------	-----------------	-----------------	-----------------	-----------------	----

Command ID: 0x63 Write Motor Setup

Motor ID: 0x01 Focus
 0x02 Zoom
 0x03 Iris
 0x04 IR-cut filter

Motor Type: 0x00 Stepper motor use this for motors 1, 2 and 3 (Focus, Zoom, Iris)
 0x01 DC motor use this for motor number 4 (IR filter switcher)

Use left stop: 0x00 No
 0x01 Yes wide/far stops

Use right stop: 0x00 No
 0x01 Yes tele/near stops

Steps: ### Max. number of steps: (256 * MSB) + LSB
 (The board does NOT keep track of the position)

Min. Speed: ### Min. steps per second: (256 * MSB) + LSB

Max. Speed: ### Max. steps per second: (256 * MSB) + LSB

CR: 0x0D End of Command marker

Answer after the command was executed successfully:

Bytes:

Answer ID	Status	CR
-----------	--------	----

Answer ID: 0x63 Motor Setup Written

Status: 0x00 Success
 0x01 Wrong Motor ID

CR: 0x0D End of Answer marker

Theia MCR IQ™ Operator's Manual

4.3.6: Switch active bus

Bytes:

Command ID	New bus ID	CR
Command ID:	0x6B	Change active bus
New bus ID:	0x00	I2C server
	0x01	USB (I2C client) factory default
	0x02	UART
CR:	0x0D	End of Command marker

The command will not return any answer but will write the new bus type to EEPROM (semi-permanently) and then execute a motor control board reboot. Any communication after reboot will need to occur over the new bus type.

4.3.7: Change I2C address

Bytes:

Command ID	I2C address	CR
Command ID:	0x41	Change I2C address
I2C address:	0x##	New I2C address range 0x01~0x7F (1~127)
CR:	0x0D	End of Command marker

The command will not return any answer but will write the new address to EEPROM (semi-permanently). The new address will be active after a reboot of the motor control board. It is possible to issue a 0x68 command (switch active bus) with the currently active bus to reboot the motor control board.

Note: I2C uses the upper 7 bits of a byte for the address and inserts a Read/Write flag into the lowest bit. This may lead to confusion of the address sometimes. The address being programmed is the 7-bit value. For example, executing a <0x41 0x10 0x0D> command will set the I2C address to 0x10. Behind the scenes, an I2C library will issue a 0x20 command for reading and 0x21 command for reading.

Revision history

Revision	Changes	Reason
191107	Added Factory reset and I2C address change, added TOC	
200212	Added firmware update instructions	
200226	Corrected bus change address	
200723	Updated PI sides (near/far, tele/zoom) and test software instructions	
201116	Added MCR400 board only version	
201216	Updated for right stop support in I2C commands	
210225	Switched left/right stop definitions to be correct	
210303	Corrected stop positions in 0x63 and 0x67 commands	
220127	Clarified PI stop locations wording (p.8)	
221122	Removed FW update option, changed I2C slave/master terminology to server/client	
230706	Added TL1250 -N4 and -N6 lenses	
240118	Removed supplier GUI references, changed to -IQ versions	
240215	Added trademark to product name	
240221	Formatting	Clarity, legibility