Fortiq42

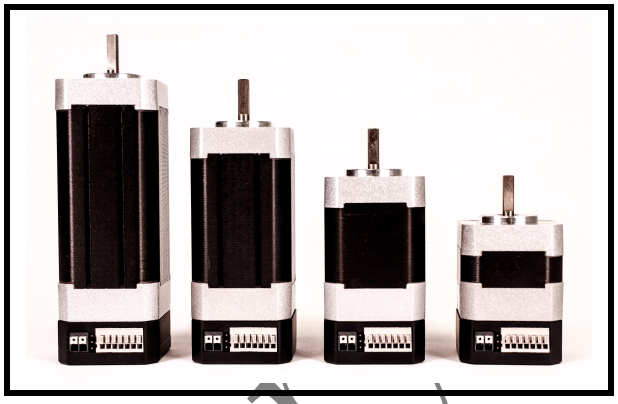
Fully Integrated Servo Motor Module

1 Features

- Closed-loop position control
- Closed-loop velocity control
- Open-loop position, voltage, pwm control
- Anticogging
- Encoder Linearization
- Field Estimated Control
- Industry-leading response times
- Built-in minimum jerk trajectory generator
- Built-in linear motion translator
- Silent operation
- Sinusoidal commutation
- CAN (CANopen)
- Serial TTL UART
- Step/direction input
- 1-2ms PWM, OneShot, MultiShot, DShot
- Standard and custom telemetry
- Over-current protection
- Cver-voltage protection from regen
- Controller-motor integration
- Embedded position sensor (changable 9-14 bit)
- 3 GPIOs
- 1 analog input
- 1 high current output

2 Applications

- 3D Printers
- CNC Machines
- Conveyors
- Fans
- Wheeled vehicles
- Robotics
- Gimbals
- DIY



3 Description

The Fortiq42 is an integrated motor and controller with a wide range of position and velocity based applications. It has an open and closed loop position controller designed primarily to drive high speed loads. Its performance is comparable to or better than other 42mm frame sized motors and can operate at any speed between -4000 and +4000 RPM thanks to its sensored control. The motor can be driven with the integrated PID position or velocity controller. This sits on top of a voltage controller, which compensates for varying input voltages such as battery charge levels or unstable power supplies. Finally, the core is a raw PWM controller. Any of the above controllers can be used by the user.

The Fortiq42 has a wide range of IOs and communication options. IQ's full featured TTL UART protocol allows access to a large number of commands, parameters, and feedback. CANopen provides industry standard access to core functionality. Simple PWM based protocols can be mapped to a wide range of commands. The built-in GPIOs, analog input, and high-power output give the user the ability to read limit switches, potentiometers, thermistors, as well as drive LEDs and heating elements.

4 Motor Specifications

4.1 M42BLS-60

Description	Symbol	Value	Unit	Notes
Phases		3		
Poles		8		
Torque/EMF Constant	K_t	0.035	$\mathrm{N\,m\,A^{-1}}$	
Resistance	R	1.76	Ω	Motor only, 25°C
Inductance	L	2161	µH	10 kHz
Rated Current	I_R	1.80	A	
Rated Torque	τ_R	0.063	N m	
Rated Speed	ω_R	419 (4000)	$\mathrm{rad\,s^{-1}}$ (RPM)	
Rated Power	P_R	26	W	
No Load Speed	ω_0	643 (6140)	$\mathrm{rad\,s^{-1}}$ (RPM)	@V_{CC} = 24 V
No Load Current	I_0	0.125	A	@V_{CC} = 24 V
Mass	m	280	g	Without wires/accessories

4.2 M42BLS-80

Description	Symbol	Value	Unit	Notes
Phases		3		
Poles		8		
Torque/EMF Constant	K_t	0.037	$\mathrm{N\,m\,A^{-1}}$	
Resistance	R	0.76	Ω	Motor only, 25°C
Inductance	L	1162	µH	10 kHz
Rated Current	I_R	3.40	A	
Rated Torque	τ_R	0.125	N m	
Rated Speed	ω_R	419 (4000)	$\mathrm{rad\,s^{-1}}$ (RPM)	
Rated Power	P_R	52.5	W	
No Load Speed	ω_0	590 (5634)	$\mathrm{rad\,s^{-1}}$ (RPM)	@V_{CC} = 24 V
No Load Current	I_0	0.16	A	@V_{CC} = 24 V
Mass	m	470	g	Without wires/accessories

4.3 M42BLS-100

Description	Symbol	Value	Unit	Notes
Phases		3		
Poles		4		
Torque/EMF Constant	K_t	0.0385	$\mathrm{N\,m\,A^{-1}}$	
Resistance	R	0.763	Ω	Motor only, 25°C
Inductance	L	903	µH	10 kHz
Rated Current	I_R	4.80	A	
Rated Torque	τ_R	0.185	N m	
Rated Speed	ω_R	419 (4000)	$\mathrm{rad\,s^{-1}}$ (RPM)	
Rated Power	P_R	77.5	W	
No Load Speed	ω_0	557 (5319)	$\mathrm{rad\,s^{-1}}$ (RPM)	@V_{CC} = 24 V
No Load Current	I_0	0.23	A	@V_{CC} = 24 V
Mass	m	630	g	Without wires/accessories

4.4 M42BLS-120

Description	Symbol	Value	Unit	Notes
Phases		3		
Poles		4		
Torque/EMF Constant	K_t	0.039	$\mathrm{N\,m\,A^{-1}}$	
Resistance	R	0.514	Ω	Motor only, 25°C
Inductance	L	735	µH	10 kHz
Rated Current	I_R	6.40	A	
Rated Torque	τ_R	0.25	N m	
Rated Speed	ω_R	419 (4000)	$\mathrm{rad\,s^{-1}}$ (RPM)	
Rated Power	P_R	105	W	
No Load Speed	ω_0	531 (5071)	$\mathrm{rad\,s^{-1}}$ (RPM)	@$V_{CC} = 24\,\mathrm{V}$
No Load Current	I_0	0.27	A	@$V_{CC} = 24\,\mathrm{V}$
Mass	m	820	g	Without wires/accessories

5 Electrical Specifications

Table 1: Absolute Maximum Ratings

Description	Symbol	Min	Max	Unit	Notes
Supply Voltage	V_{CC}	-0.3	62	V	Relative to V-
Digital Logic Voltage	V_{IN}	-0.3	7.3	V	3.3 V system, 5 V tolerant. UART and GPIO.
Digital Logic Current	I_{IN}	-25	25	mA	UART and GPIO
Analog Input Voltage	V_{INA}	-0.3	4.0	V	
CAN Voltage	V_{CAN}	-60	60	V	Relative to V-
MCU Temperature	T_{MCU}	-20	105	°C	Controller will self-limit performance when approaching max temperature
High Power Output Current	I_{HP}		17	A	MOSFET thermal limit

Table 2: Recommended Operating Conditions

Description	Symbol	Min	Max	Unit	Notes
Battery Cells	S	4	12	V	Use w/ caution on 12S
Power Supply Voltage	V_{CC}	12	48	V	Ensure motor regen does not exceed voltage limit. Use built in regen limiter or use an external load.
Ambient Temperature	T_A	-10	50	°C	
High Power Output Current	I_{HP}		5	A	Connector UL current rating

6 Electrical Interface

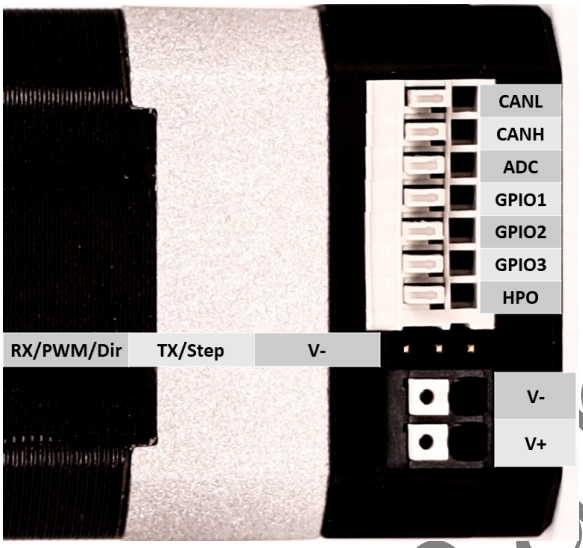


Figure 1: Connector Pin Labels

6.1 Connector Description

6.1.1 IO Terminal

The IO Terminal block is a CUI TBL009-254-07, 7 place connector. This is a screwless terminal block for both solid and stranded wires from 26 to 18 AWG. It has UL safety approval and is IEC 60947-7-4 compliant. You can simply push in solid core wires. Push in the button while inserting stranded wires. Push in the button to release the wire. The top most positions are CAN Low and CAN High respectively. The third position is the ADC input, protected with a 330 ohm resistor in series and an ESD diode in parallel. The forth to sixth positions are GPIOs, all protected with a 330 ohm resistor in series and an ESD diode in parallel. The seventh position is the high-power output, which is an open-drain configuration.

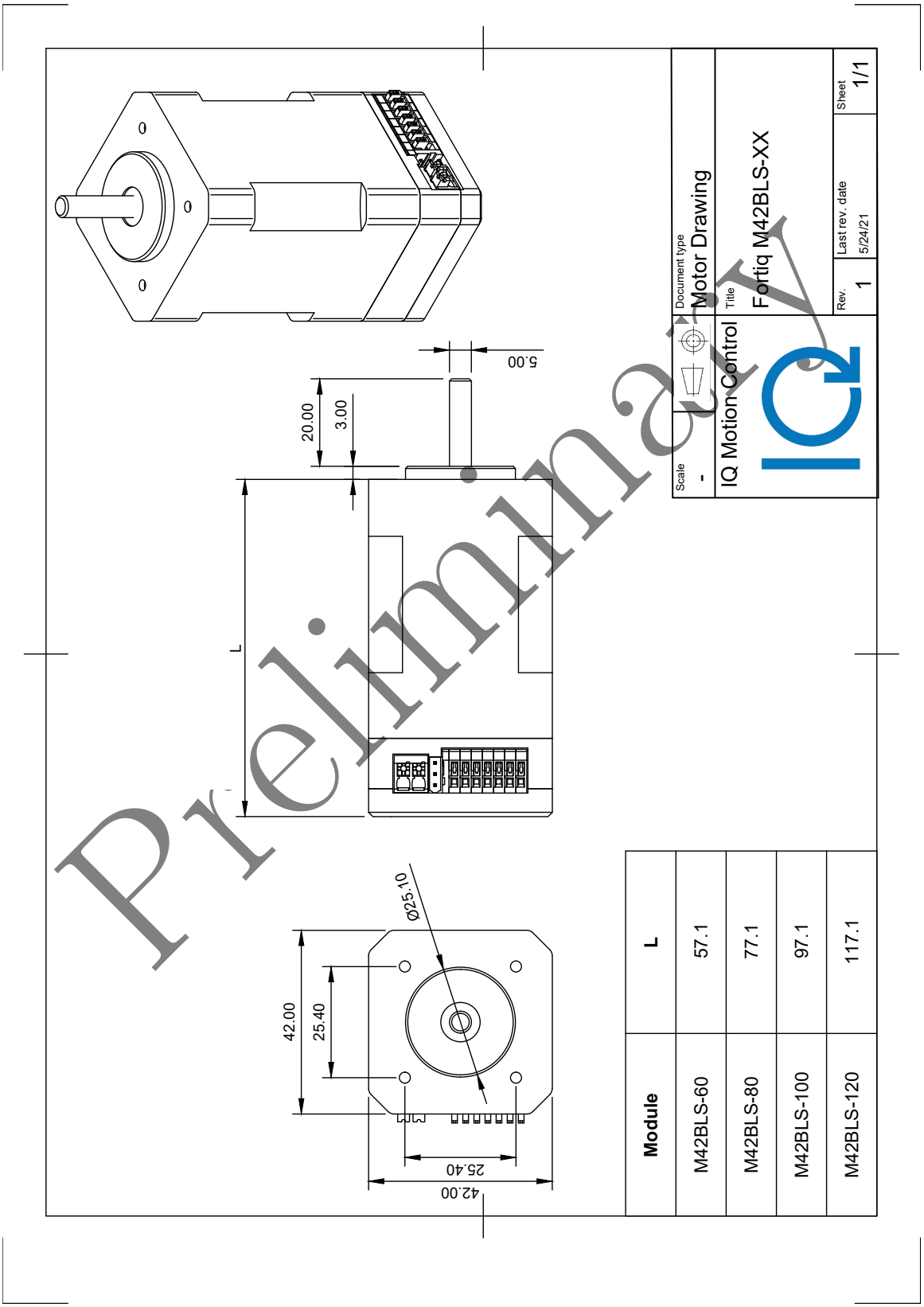
6.1.2 0.1" Header 3 Position

The standard communication connector is a 0.1" (2.54mm) male header, capable of accepting JR type servo connectors, jumper wires, and some female 0.1" sockets. The right pin is the negative terminal. The middle pin is the motor controller TX/host RX, telemetry output, and the step input. The middle pin is a Digital Logic Voltage, V_L. The left pin is the motor controller RX/host TX, PWM input, and direction input. The top pin is a Digital Logic Voltage, V_L. Both logic pins are protected with a 330 ohm resistor in series and an ESD diode in parallel. All interfaces autodetect the communication protocol with the exception of step/direction, which requires dedicated firmware.

6.2 Power Terminal

The power connector is a CUI TBLH10-350-02. This is a screwless terminal block for both solid and stranded wires from 24 to 16 AWG. It has UL safety approval and is IEC 60947-7-4 compliant. You can simply push in solid core wires. Push in the button while inserting stranded wires. Push in the button to release the wire. The top, inboard connection is V-, also call ground. The bottom, outboard connection is V+.

7 Mechanical Interface



Module	L
M42BLS-60	57.1
M42BLS-80	77.1
M42BLS-100	97.1
M42BLS-120	117.1

8 Safety Features

8.1 Over Current Protection

The ESC uses a predictive method for over current protection. The motor controller will not apply a voltage which would put the controller or motor at risk of over current. This is in contrast to a reactive current controller, which only performs limiting once large currents have been detected, and thus already put the hardware at risk.

8.2 Over Temperature Protection

The controller has an onboard temperature sensing circuit. If the temperature sensor detects a temperature that is approaching the controller's maximum temperature limit the controller will begin to derate, resulting in lower speeds and torques than expected. The controller will continue outputting as much power as possible without exceeding its thermal limit. If the temperature drops the controller will automatically exit derate mode and continue normal operation.

Though there is no temperature sensor in the motor's coils, the controller contains a predictive model which estimates the coil temperature. The same derating process as above is applied to the estimated coil temperatures, applying as much power as possible without causing damage. This protection ensures that large loads or stalled conditions do not overheat and damage the motor coils and magnets.

8.3 Over Speed Protection

A soft limiter will reduce the voltage applied to the motor once ω_{max} is exceeded. The farther the speed is above ω_{max} the lower the output voltage of the controller. In extreme overspeed situations the motor acts as a brake, effectively shorting the three phases of the motor together. This will protect the motor from extremely large load changes, poor PID tuning values, and the unlikely chance of a runaway condition. This feature will fight an externally applied load that causes an over speed, but is not able to guarantee the prevention of an over speed condition in this situation.

8.4 Regeneration Voltage Protection

The Fortiq42 is a four quadrant motor-controller, which means it can both motor and generate in both directions. One problem when the motor is generating is the voltage can spike if the connected electronics cannot absorb the energy that is being generated. Power supplies cannot generally absorb energy, while rechargable batteries and capacitors can. This leads to a voltage spike that may destroy the motor and any attached equipment.

The controller prevents these spikes from occurring by limiting the voltage applied to the motor. If an out of allowable range generation occurs, the motor will decrease its own generation, thereby protecting the circuitry. This protection does not prevent the damage from externally applied voltages.

8.5 Command Timeout Protection

A user settable timeout automatically puts the motor in to coast mode if it does not receive a message valid message within a specified amount of time. The normal operation resumes upon receiving a new message.

8.6 Input Connection Protection

All exposed pins are protected with ESD diodes and a small amount of reverse polarity protection. Do not knowingly or intentionally apply reverse polarity or out of limit voltages to the exposed pins.

8.7 Watchdog Protection

In case of an unlikely error in the controller that causes it to freeze, the controller will automatically reboot. While this may allow for a recovery, all normal startup procedures are re-performed and any arming sequence or auxiliary commands must be redone.

9 Revision History

Table 3: Revision History

Version	Date	Changes
0.1.0	2021-05-25	Pre-release