

## 4th Generation 2 x 60A or 1 x 120A Variable Frequency Drive for AC Induction Motors



RoboteQ's FIMG2360T is a features-packed, high-current, dual or single channel drive for AC Induction motors. It is a direct replacement for the company's popular FIM2360T, using a 4th generation processor and implementing many performance, algorithmic, and other qualitative enhancements. The motor can be controlled in Open Loop, Closed Loop Speed, or Torque mode. Advanced control features such as FOC, feedforward control, decoupling control, a 16 kHz current loop, and cascaded control modes ensure precise and efficient motor operation.

The FIMG2360T features several Analog, Pulse and Digital I/Os which can be remapped as command or feedback inputs, limit switches, or many other functions. The FIMG2360T accepts commands received from an RC radio, Analog Joystick, wireless modem, or microcomputer. For mobile robot applications, the drive's two motor channels can either be operated independently or mixed to move and steer a vehicle. Using CAN bus, up to 127 controllers can be networked at up to 1Mbit/s on a single twisted pair.

Numerous safety features are incorporated into the drive, including Safe Torque Off (STO). The drive's operation can be extensively automated and customized using Basic Language scripts. The drive can be configured, monitored and tuned in real-time using a RoboteQ's free PC utility. The drive can also be reprogrammed in the field with the latest features by downloading new operating software from Roboteq.

### Applications

- Automatic Guided Vehicles
- Small Electric Vehicles, Electric Bikes
- Terrestrial and Underwater Robotic Vehicles
- Police and Military Robots
- Hazardous Material Handling Robots
- Animatronics

### Key Features

- USB, Serial, 0-5V Analog, or Pulse (RC radio) command modes
- One RS232 serial port
- CAN bus interface up to 1Mbit/s with multiple protocol support
- RS485 interface
- Auto switch between Serial, USB, CAN, Analog, or Pulse based on user-defined priority
- Built-in dual 3-phase high-power drivers for two AC Induction motors at up to 60A
- Support for NTC temperature sensors through analog inputs (requires an external pull-up resistor)
- Output channels can be paralleled in order to drive a single motor at up to 120A
- Field Oriented Control
- Multiple Motor Operating mode
  - Open Loop Volts per Hertz
  - Fixed Slip Control
  - FOC Torque Mode
  - FOC Speed Mode
- Feedforward control
- Cascaded Torque and Speed PI loops.
- High performance 16KHz current loop
- Support for quadrature encoder
- Full forward & reverse motor control. Four quadrant operation.
- Operates from a single 14V-60V power source
- STO-Safe Torque Off support - Certification pending

- Programmable current limit up to 60A (120A on single channel version) per motor for protecting controller, motor, wiring and battery.
- Accurate speed and Odometry measurement using Encoder data
- Up to 8 Analog Inputs for use as command and/or feed-back
- Up to 8 Pulse Length, Duty Cycle or Frequency Inputs for use as command and/or feedback
- Up to 10 Digital Inputs for use as Deadman Switch, Limit Switch, Emergency stop or user inputs
- Inputs for up to 2 Quadrature Encoders
- 4 general purpose 24V, 1.5A open collector outputs for brake release or accessories
- Selectable min, max, center and dead band in Pulse and Analog modes
- Trigger action if Analog, Pulse or Hall counter capture are outside user selectable range (soft limit switches)
- Built-in Battery Voltage and Temperature sensors
- Optional 14V backup power input for powering safely the drive's logic if the main motor batteries are discharged
- Power Control wire for turning On or Off the controller from external microcomputer or switch
- Regulated 5V output for powering RC radio, RF Modem, sensors or microcomputer
- Separate Programmable acceleration and deceleration for each motor
- Ultra-efficient 2.5 mOhm ON resistance MOSFETs (1.25 mOhm on Single Channel)
- Stall detection and selectable triggered action if Amps is outside user-selected range
- Short circuit protection
- Overvoltage and Undervoltage protection
- Watchdog for automatic motor shutdown in case of command loss
- Overtemperature protection
- I2T protection
- Diagnostic LED
- Efficient heat sinking. Operates without a fan in most applications.
- Dustproof and weather resistant. IP40rating
- Power wiring 0.25" Faston tabs
- 5.5" (139.7mm) L, 5.5" W (139.7mm), 1.0" (25mm) H
- -10° to +70° operating environment
- 1 lbs (500g)
- Easy configuration, tuning and monitory using provided PC utility
- Field upgradeable software for installing latest features via the internet

## Orderable Product References

| Reference          | Number of Channels | Amps/Channel | Volts | Ethernet | STO |
|--------------------|--------------------|--------------|-------|----------|-----|
| <b>FIMG2360T</b>   | 2                  | 60           | 60    | No       | Yes |
| <b>FIMG2360TS</b>  | 1                  | 120          | 60    | No       | Yes |
| <b>FIMG2360TE</b>  | 2                  | 60           | 60    | Yes      | Yes |
| <b>FIMG2360TES</b> | 1                  | 120          | 60    | Yes      | Yes |

## Warning

A dangerous uncontrolled motor runaway condition can occur due to various reasons, including, but not limited to: command or feedback wiring failure, configuration errors, faulty firmware, errors in user scripts or programs, or controller hardware failure.

Users must be aware that such failures can occur and must ensure the safety of their system under all conditions. Roboteq will not be held liable for any damage or injury resulting from product misuse or failure.

## Important Note

All products are not serviceable. If damage is suspected, the item must be replaced rather than repaired.

Attempting to service or repair the product voids any existing warranty and may pose safety risks.

Consult customer support for more information on replacements.

## Power Wires Identifications and Connection

Power connections are made by means of faston tabs located at the back of the controller.

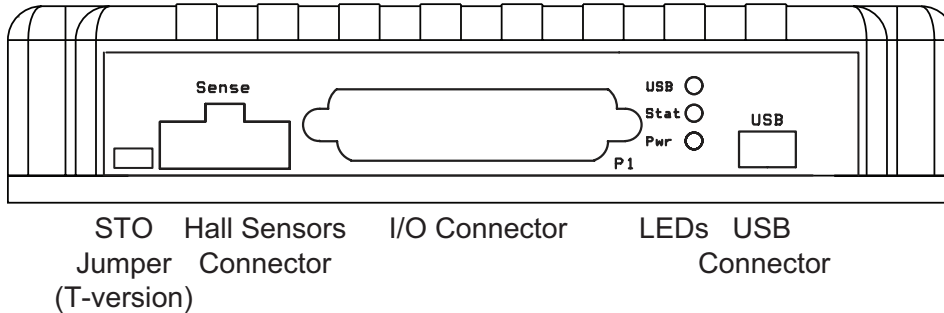


FIGURE 1. FIMG2360T front view

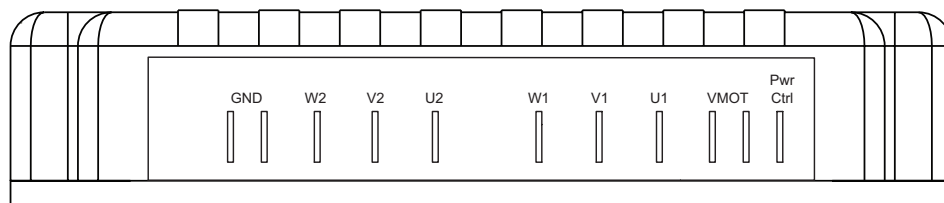


FIGURE 2. FIMG2360T rear view

The diagram below shows how to wire the controller in a dual motor configuration, and how to turn power On and Off.

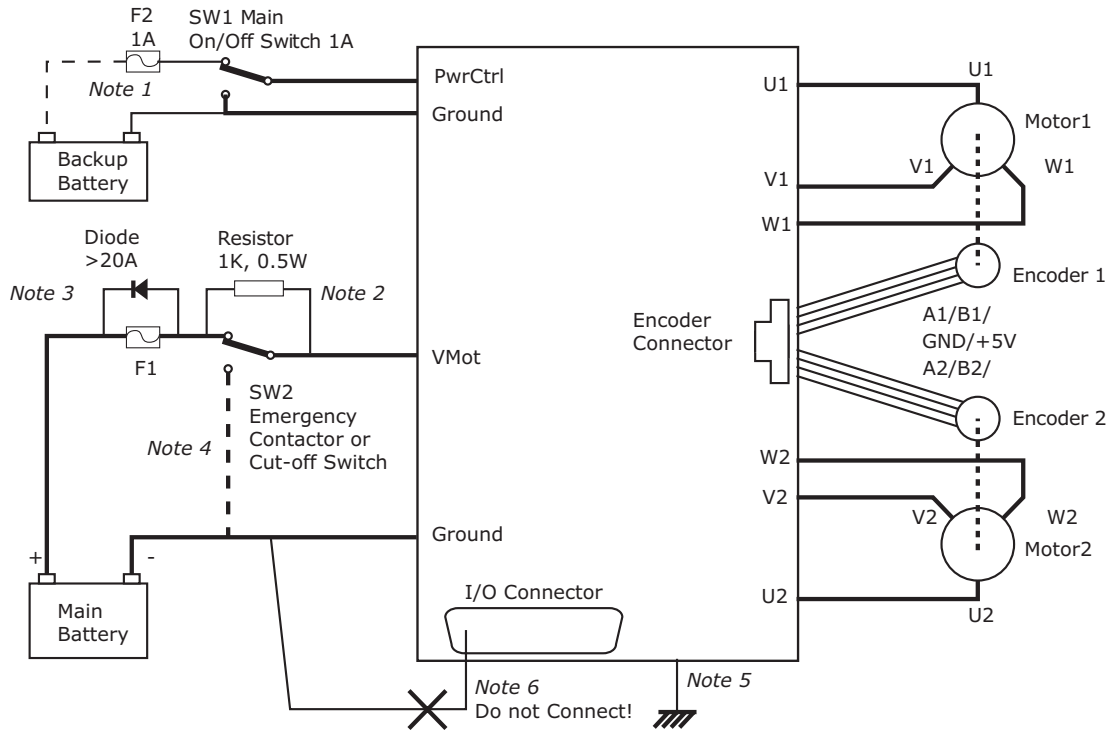


FIGURE 3. Powering the drive. Thick lines identify **MANDATORY** connections

## Caution

**Carefully follow the wiring instructions provided in the Power Connection section of the User Manual. The information on this datasheet is only a summary.**

## Mandatory Connections

It is imperative that the drive is connected as shown Figure 3. All connections shown as thick black lines are mandatory. The controller must be powered On/Off using switch SW1 on the PwrCtrl tab. Use a suitable high-current fuse F1.

## Precharge Resistor

The controller has 2350uF of internal capacitance which will cause a brief yet significant current inrush the moment power is applied.

Note 2: If there is a concern that this current can overload the power supply or the contactor, insert a precharge resistors as shown in figure 3. For precharging to take place, the controller must be turned off by grounding the Power Control pin.

## Enable Safe Torque Off

Note 3: When STO is enabled (STO jumper removed), the motor will be prevented from running until both of its STO inputs are connected to a voltage of 6V or higher. If one or both STO lines are left floating or grounded, the drive will be ON and able to communicate, but the motor will not be driven. For more details, refer to the STO chapter further down in this document and consult the Roboteq Controllers User Manual.

## Regeneration Protection and Braking

During rapid deceleration, the kinetic energy will cause regenerative current to flow out of the motor and back to the power source. When using a battery, this current will recharge the battery and create a dynamic braking effect. When a power supply is used, the current will not be able to flow back to the source. Without a return path, the regenerative current can cause the voltage to rise to a dangerous level for the electronics.

## Connection to Chassis

Note 4: For improved EMI immunity and reduced emissions, it is recommended to connect the controller's bottom plate to the system's chassis. Note that the integrated controller's ground is not DC-electrically connected to the plate. However, there is a capacitor between the controller's ground and the bottom plate, providing AC conductivity.

## Avoid Alternate Ground Paths

Note 5: Be cautious not to create a path between the ground pins on the I/O connector and the battery's negative terminal. An internal connection already exists between the battery's negative pole and the control ground. Avoiding an additional external connection is highly recommended, as this could allow current to circulate in the signal ground, potentially introducing noise into low-power signals. If the main power ground terminal becomes loose or disconnected, very high current from the motor may flow through the signal ground wire, causing damage.

## Precautions When Connecting PC via USB

Note 6: Always use a USB isolator to protect both the drive and the PC against potential electrical damage. When using a portable PC, operate it on battery power to avoid creating an accidental return ground path via the charger.

## Emergency Switch or Contactor

The battery must be connected Permanently to the controller's Vmot tabs via a high-power emergency switch or contactor SW2. The user must be able to deactivate the switch or contactor at any time, independently of the controller state. SW2 should be used only in emergency situations and not for normal operation. Opening SW2 while the motors are rotating can lead to permanent hardware damage.

## Electrostatic Discharge Protection

In accordance with IEC 61000-6-4, Roboteq Motor Controllers are designed to withstand ESD up to 4kV touch and 8kV air gap. This protection is implemented without any additional external connections required.

Some specifications, such as EN12895, require a higher level of protection. To maximize ESD protection, up to 8kV touch and 15kV air gap, connect the metallic heatsink of the controller to the battery's negative terminal.

## EMI/EMC

All cables, including motor, battery, and control cables, should be kept shorter than 3 meters to minimize EMI/EMC issues. Depending on the source of interference and the cable type, the use of external filters or ferrite chokes may be necessary.

## Controller Mounting

The drive should be mounted in such a way that its bottom surface makes direct contact with a metallic surface, such as the system chassis or cabinet. This will assist in dissipating the heat generated during the operation of the controller. It's important to note that the nominal and peak ampere values documented in the datasheet can only be fully achieved with adequate cooling.

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## Single Channel Wiring

For the Single Channel FIMG2360S, connect each motor wire to both output tabs marked with the same letter, as illustrated in the figure below. Use the Encoders of Channel 1 for operation.

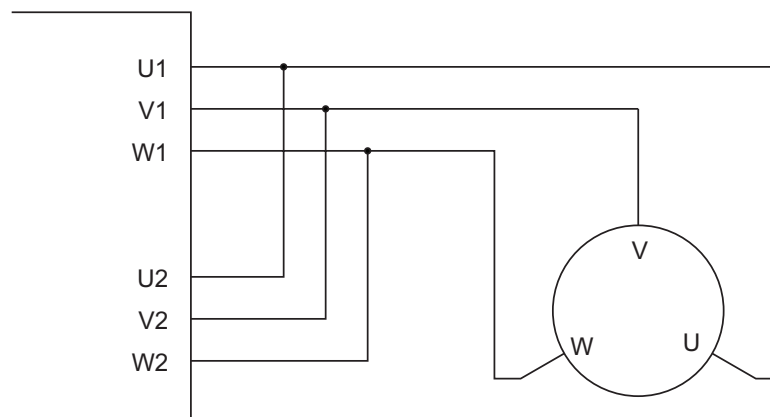


FIGURE 4. Single Channel wiring diagram

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## Important Note

**This wiring must be done only on the single channel version of the controller. Paralleling the wires on a dual channel product will cause permanent damage. Verify that your controller is an FIMG2360TS before you wire in this manner.**

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## Encoder Connection

Connection to the Encoder is done using a special connector on the front side of the controller. The Hall sensor connector is a 10-pin Molex Microfit 3.0, ref. 43025-1000. Pin assignment is in the table below.

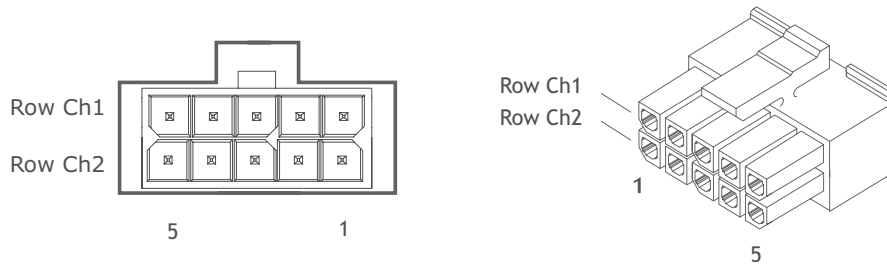


FIGURE 5. Encoder connector

Each input includes a 4.7K pull up resistor and can therefore accommodate encoders with open collector/open drain outputs. A 1nF capacitor to ground is present on each input for noise reduction.

TABLE 1.

| Pin Number | 1      | 2      | 3      | 4 | 5  |
|------------|--------|--------|--------|---|----|
| Row Ch1    | Ground | Enc1 A | Enc1 B |   | 5V |
| Row Ch2    | Ground | Enc2 A | Enc2 B |   | 5V |

### Warning

Encoder 1 and Encoder 2 inputs share pins internally with pulse inputs 5 to 8. If both encoder and pulse inputs are enabled, the encoder will have higher priority. For any modifications involving the use of these shared pins, the drive should be in Open Loop mode, an emergency stop should be activated, and the system must be in a safe position. This precaution is necessary because changing the usage can result in false input readings and unintended motor movement.

### Important Note

**Hardware revisions prior to 2.1 have a maximum supported sensor frequency of 1.6 kHz.**

## Commands and I/O Connections

Connection to RC Radio, Microcomputer, Joystick and other low current sensors and actuators is done via the DB25 connector. The functions of many pins vary depending on controller model and user configuration. Pin assignment is found in the table below.

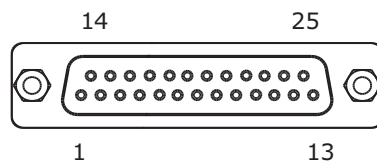


FIGURE 6. Main Connector pin locations

TABLE 2.

| Connector Pin | Power | Dout  | STO       | Com    | Pulse   | Ana  | Dinput |
|---------------|-------|-------|-----------|--------|---------|------|--------|
| 1             | GND   |       |           |        |         |      |        |
| 14            | 5VOut |       |           |        |         |      |        |
| 2             |       |       |           | RS TxD |         |      |        |
| 15            |       |       | STO 1 (1) |        | RC1 (2) | ANA1 |        |
| 3             |       |       |           | RS RxD |         |      |        |
| 16            |       |       | STO 2 (1) |        | RC2 (2) | ANA2 |        |
| 4             |       |       |           |        | RC3     | ANA3 | DIN3   |
| 17            |       |       |           |        | RC4 (3) | ANA4 | DIN4   |
| 5             | GND   |       |           |        |         |      |        |
| 18            |       | DOUT1 |           |        |         |      |        |
| 6             |       | DOUT2 |           |        |         |      |        |
| 19            |       | DOUT3 |           |        |         |      |        |
| 7             |       | DOUT4 |           |        |         |      |        |
| 20            |       |       |           | CANH   |         |      |        |
| 8             |       |       |           | CANL   |         |      |        |
| 21            |       |       |           |        | RC5     | ANA5 | DIN5   |
| 9             |       |       |           |        |         |      | DIN9   |
| 22            |       |       |           |        | RC6     | ANA6 | DIN6   |
| 10            |       |       |           |        |         |      | DIN10  |
| 23            |       |       |           | 485 +  |         |      |        |
| 11            |       |       |           | 485 -  |         |      |        |
| 24            |       |       |           |        | RC7     | ANA7 | DIN7   |
| 12            |       |       |           |        | RC8     | ANA8 | DIN8   |
| 25            | 5VOut |       |           |        |         |      |        |
| 13            | GND   |       |           |        |         |      |        |

Note 1: STO jumper must be removed for STO signals to be active. See STO section for details.

Note 2: Not compatible with multi-PWM.

Note 3: Input 4 has a large capacitance which may degrade the Pulse signal. Prefer any of the other pulse inputs.



## Enabling Analog Commands

For safety reasons, the Analog command mode is disabled by default. To enable the Analog mode, use the PC utility and set Analog in Command Priority 2 or 3 (leave Serial as priority 1). Note that by default the additional securities are enabled and will prevent the motor from starting unless the potentiometer is centered, or if the voltage is below 0.25V or above 4.75V. The drawing shows suggested assignment of Pot 1 to ANA1 and Pot 2 to ANA4. Use the PC utility to enable and assign analog inputs.

## Connecting Thermistors

NTC temperature sensors can be connected to the controller’s analog inputs. This enables reading of motor temperature through the controller’s runtime variables and allows for active temperature protection. This connection can be achieved by using a pull-up resistor with a value equal to the thermistor’s resistance between the analog input and the controller’s 5V output. For more information about motor temperature readings and controller parameterization, please refer to the Roboteq Controller’s User Manual.

## USB communication

Use the USB only for configuration, monitoring, and troubleshooting purposes. USB is not a reliable method of communication and can lead to disconnections when used in electrically noisy environments. These disconnections often require resetting the USB connection or even the controller. For more reliable interfacing with a computer, always opt for RS232 communication.

## Important Note

**Always use a USB isolator to protect both the drive and the PC from potential electrical damage. When using a portable PC, operate it on battery power to avoid an accidental ground path return via the charger.**

## CAN Communication

CAN is the FIMG2360T’s primary and recommended communication interface. Up to 127 drives can be networked on a twisted pair network up to 1000m long and at speeds up to 1Mbit/s. Roboteq support four CAN protocols:

- CANOpen for interoperability with other vendor’s DS301 and DS402 compliant devices
- RoboCAN, a simple and effective peer to peer meshed network protocol
- MiniCAN, a simplified subset of CANOpen PDOs
- Raw CAN, a low-level system used with scripting for constructing and parsing CAN frames to handle any protocols

TABLE 3. CANOpen Communications Specification

| Feature                    | Value  |
|----------------------------|--|
| Motion Network type        | CAN, CANOpen   |
| CANOpen Standards Support  | DS301, DS402   |
| Operating Modes            | Cyclic sync torque, cyclic sync velocity, cyclic sync position, profile position, profile velocity, profile torque modes, homing |
| Process Data Objects (PDO) | Cyclic sync and free run modes.<br>Cyclic messages can be set for 20 objects on 4 maps   |

## RS485 communication

RS485 is a robust industry standard for serial communication, well-suited for long distances and electrically noisy industrial settings. It uses balanced signaling for enhanced stability, allowing the connection of multiple receivers on a single network. The protocol supports half-duplex operation and is particularly compatible with Modbus. The 25-pin connector features designated pins for RS485+ and RS485-.

## Ethernet communication

The FIMG2360TE version supports all the controller’s serial commands over a TCP/IP connection. Modbus TCP protocols are also supported in that version.

## Important Note

**TCP Mode and CAN Mode cannot work in conjunction on “E” type controllers; only one can be active at a time. By default, TCP Mode is enabled and CAN Mode is disabled, allowing for a plug & play TCP connection. To switch to CANOpen, the user must manually disable TCP Mode and enable CAN Mode. To revert to Ethernet, TCP Mode must be enabled and CAN Mode disabled by the user.**

## Status LED Flashing Patterns

After the controller is powered on, the Power LED will turn on, indicating that the controller is On. The Status LED will be flashing at a two second interval. The flashing pattern and colour provides operating or exception status information.

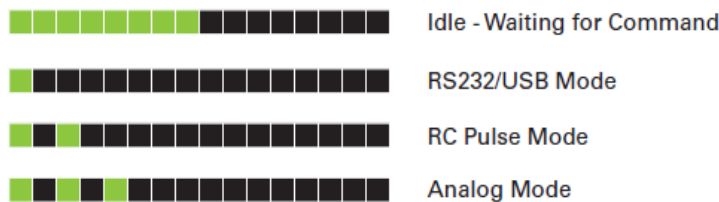


FIGURE 7. Normal Operation Flashing Patterns

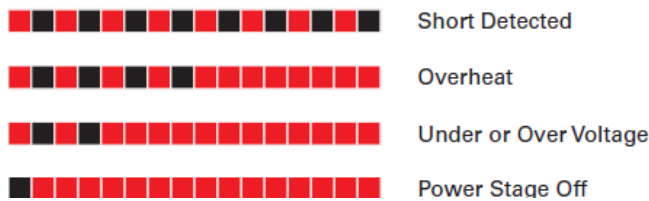


FIGURE 8. Exception or Fault Flashing Patterns

Additional status information may be obtained by monitoring the controller with the PC utility.

The communication LED gives status information on the CAN and USB.

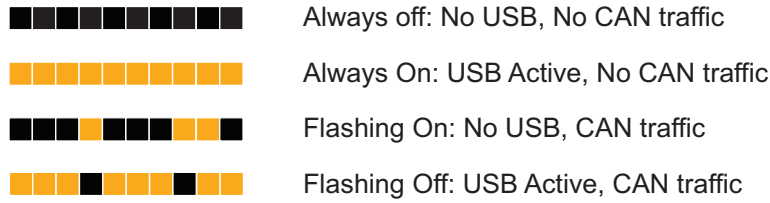


FIGURE 9. Communication LED Flashing Patterns

### Safe Torque Off - STO (Certification No. M6A 104504 0001)

Safe Torque Off (STO) is a secure method for switching the controller into a state where no torque is generated, regardless of whether the controller is operating normally or is faulty. The STO functionality is achieved through redundant circuitry, incorporated into the STO1 and STO2 inputs of the controller. For the controller to operate normally, both STO inputs must be supplied with a voltage ranging from 6 to 30V. The controller performs a self-test of the STO circuitry every time it powers on, or when both STO inputs go high. If the STO circuitry is found to be functioning properly, the controller will allow the motor to be energized. In the event of an STO failure or if not both STO inputs are in a high state, the power stage will be cut off. Since STO is a hardware implementation and has been verified and validated by Roboteq, it can be trusted to bring the motor to a no-torque condition without the need for an external relay to cut power to the motor. For more information about STO functionality, refer to the STO Manual.

By factory default, the STO functionality is disabled by adding a jumper that bypasses the STO circuitry. To enable the STO feature, remove the jumper located on the front side of the controller and then enable the STO function in the controller’s configurations. The exact location of the jumper can be observed in figure 1.

Figure 11 illustrates the STO operation. To properly trigger the STO, both STO inputs must be in a high state. To properly release the STO, both STO inputs must be low. Having only one of the two STO inputs in a high state will trigger the “STO fault” alarm.

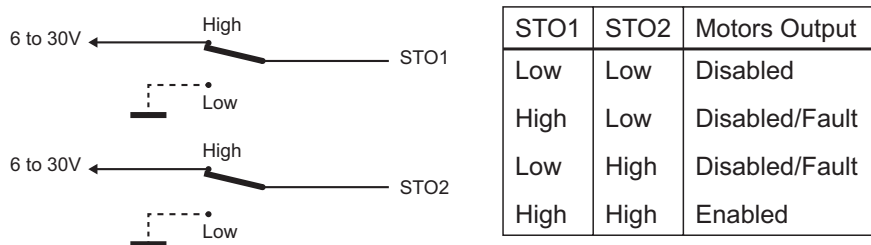


FIGURE 10. STO input levels effects on controller output

## Warning

Activating STO causes the motor to float and cease torque generation. Since the motor will not be actively braked, it will decelerate solely due to the system's friction. In mobile robot applications, the robot may continue moving for several meters before coming to a complete stop. For safe operation, additional braking measures should be implemented when STO is enabled, such as utilizing a mechanical or electrical brake. Roboteq offers one solution in the form of the SBSxxxx Safety Electric Brake Switch series, which quickly stops the motor by shorting its phases when STO is triggered.

## Secure Connection to AMP FASTON™ Tabs

Power Motor and Battery connections are made via standard 250mils (6.35mm) AMP FASTON Tabs. FASTON connectors provide a high current and very secure connection, proven over decades of use in the automotive industry. For maximum current handling, use connectors for AWG8 wires.

FASTON connectors have an extremely tight fit and will not come off on their own. It is recommended, nevertheless, that the wiring is made so that the cables are never pulling the connector outward.

Frequent disconnects and reconnects will eventually loosen the connector's grip on the tab. If frequent disconnection is required, consider using Positive Lock connectors from TE Connectivity or their equivalent. These connectors have a spring-loaded tab latch pin that will lock into the hole of the male tab.

## Electrical Specifications

### Absolute Maximum Values

The values in the table below should never be exceeded, permanent damage to the controller may result.

TABLE 4.

| Parameter   | Measure point                               | Min | Typical | Max    | Units |
|---|---|-----|---------|--------|-------|
| Battery Leads Voltage   | Ground to Vmot                              |     |         | 63     | Volts |
| Reverse Voltage on Battery Leads  | Ground to Vmot                              | -1  |         |        | Volts |
| Power Control Voltage   | Ground to Pwr Control wire                  |     |         | 63     | Volts |
| Motor Leads Voltage   | Ground to U, V, W wires                     |     |         | 63 (1) | Volts |
| Digital Output Voltage  | Ground to Output pins                       |     |         | 30     | Volts |
| Analog and Digital Inputs Voltage   | Ground to any signal pin on DB25            |     |         | 30     | Volts |
| Encoder inputs voltage  | Ground to Encoder inputs of Molex connector |     |         | 5.5    | Volts |
| RS232 I/O pins Voltage  | External voltage applied to Rx pins         |     |         | 30 (2) | Volts |
| Note 1: Maximum voltage in normal operation, including regeneration. Never inject a DC voltage from a battery or other fixed source |   |     |         |        |       |
| Note 2: No voltage must be applied on Tx pin  |   |     |         |        |       |

### Power Stage Electrical Specifications (at 25°C ambient)

TABLE 5.

| Parameter   | Measure point   | Model      | Min    | Typ     | Max      | Units |
|---|---|------------|--------|---------|----------|-------|
| Input Voltage   | Ground to Vmot  | All        | 0 (1)  |         | 60       | Volts |
| Output Voltage  | Ground to U, V, W wires   | All        | 0 (1)  |         | 60 (2)   | Volts |
| Power Control Voltage   | Ground to Power Control wire  | All        | 0 (1)  |         | 60       | Volts |
| Minimum Operating Voltage   | VBat or PwrCtrl wires   | All        | 14 (3) |         |          | Volts |
| Over Voltage protection range   | Ground to Vmot  | All        | 5      |         | 60       | Volts |
| Under Voltage protection range  | Ground to Vmot  | All        | 0      |         | 50       | Volts |
| Idle Current Consumption  | Vmot or PwrCtrl wires   | All        | 50     | 100 (5) | 150      | mA    |
| ON Resistance (Excluding wire resistance)   | Vmot to U, V or W.<br>Ground to U, V or W   | FIMG2360T  |        | 2.5     |          | mOhm  |
|   |   | FIMG2360TS |        | 1.25    |          | mOhm  |
| Max Current for 30s   | Motor current   | FIMG2360T  |        |         | 60       | Amps  |
|   |   | FIMG2360TS |        |         | 120      | Amps  |
| Continuous Max Current per channel  | Motor current   | FIMG2360T  |        |         | 40 (6)   | Amps  |
|   |   | FIMG2360TS |        |         | 80 (6)   | Amps  |
| Current Limit range   | Motor current   | FIMG2360T  | 10     | 50 (7)  | 60       | Amps  |
|   |   | FIMG2360TS | 20     | 100 (7) | 120      | Amps  |
| Stall Detection Amps range  | Motor current   | FIMG2360T  | 10     | 60 (7)  | 60       | Amps  |
|   |   | FIMG2360TS | 20     | 120 (7) | 120      | Amps  |
| Stall Detection timeout range   | Motor current   | All        | 1      | 500 (8) | 65000    | msec  |
| Short Circuit Detection threshold (9)   | Between Motor wires or<br>Between Motor wires and ground or<br>Between Motor wires and Vmot | FIMG2360T  |        |         | 72(10)   | Amps  |
|   |   | FIMG2360TS |        |         | 144 (10) | Amps  |
| Short Circuit Detection Threshold   | Between Motor wires and VBat<br><br>No Protection. Permanent damage will occur              |            |        |         |          |       |
| Power cable thickness   | Power input and output  | All        |        | 8       |          | AWG   |
| Note 1: Negative voltage will cause a large surge current. Protection fuse needed if battery polarity inversion is possible |   |            |        |         |          |       |
| Note 2: Maximum regeneration voltage in normal operation. Never inject a DC voltage from a battery or other fixed source    |   |            |        |         |          |       |
| Note 3: Minimum voltage must be present on VBat or Power Control wire   |   |            |        |         |          |       |
| Note 4: Factory default value. Adjustable in 0.1V increments  |   |            |        |         |          |       |
| Note 5: Current consumption is lower when higher voltage is applied to the controller's VBat or PwrCtrl wires               |   |            |        |         |          |       |
| Note 6: Estimate. Limited by case temperature. Current may be higher with better cooling                                    |   |            |        |         |          |       |
| Note 7: Factory default value. Adjustable in 0.1A increments  |   |            |        |         |          |       |
| Note 8: Factory default value. Time in ms that Stall current must be exceeded for detection                                 |   |            |        |         |          |       |
| Note 9: Controller will stop until zero command given in case of short circuit detection                                    |   |            |        |         |          |       |
| Note 10: Approximate value  |   |            |        |         |          |       |

## Command, I/O and Sensor Signals Specifications

TABLE 6.

| Parameter                              | Measure point              | Min   | Typical | Max     | Units |
|--|----------------------------|-------|---------|---------|-------|
| Main 5V Output Voltage                 | Ground to 5V pins on       | 4.6   | 4.9     | 5.2     | Volts |
| 5V Output Current                      | 5V pins on RJ45 and DSub15 |       |         | 200 (1) | mA    |
| Digital Output Voltage                 | Ground to Output pins      |       |         | 30      | Volts |
| Output On resistance                   | Output pin to ground       |       | 0.25    | 0.5     | Ohm   |
| Output Short circuit threshold         | Output pin                 | 1.7   |         | 3.5     | Amps  |
| Digital Output Current                 | Output pins, sink current  |       |         | 1.5     | Amps  |
| Input Impedances (except DIN11-19)     | AIN/DIN Input to Ground    |       | 53      |         | kOhm  |
| Digital Input 0 Level                  | Ground to Input pins       | -1    |         | 1       | Volts |
| Digital Input 1 Level                  | Ground to Input pins       | 3.8   |         | 15      | Volts |
| Analog Input Range                     | Ground to Input pins       | 0     |         | 5.1     | Volts |
| Analog Input Precision                 | Ground to Input pins       |       | 0.5     |         | %     |
| Analog Input Resolution                | Ground to Input pins       |       | 1       |         | mV    |
| Encoder Frequency                      |                            |       |         | 200     | kHz   |
| Pulse durations                        | Pulse inputs               | 20000 |         | 10      | us    |
| Pulse repeat rate                      | Pulse inputs               | 50    |         | 250     | Hz    |
| Pulse Capture Resolution               | Pulse inputs               |       | 1       |         | us    |
| Frequency Capture                      | Pulse inputs               | 100   |         | 10000   | Hz    |
| Minimum Pulse on or Pulse off duration | Pulse inputs               | 25    |         |         | us    |
| Note 1: Sum of all 5VOut outputs       |                            |       |         |         |       |

## Operating & Timing Specifications

TABLE 7.

| Parameter   | Measure Point            | Min   | Typical    | Max   | Units  |
|---|--------------------------|-------|------------|-------|--------|
| Command Latency   | Command to output change | 0     | 0.5        | 1     | ms     |
| Maximum PWM duty cycle  | Motor Output             |       |            | 94    | %      |
| Closed Loop update rate                                       | Internal                 |       | 1000       |       | Hz     |
| Current Loop update rate                                      | Internal                 |       | 16000      |       | Hz     |
| RS232 baud rate   | Rx and Tx pins           |       | 115200 (1) |       | Bits/s |
| RS232 Watchdog timeout  | Rx pin                   | 1 (2) |            | 65000 | ms     |
| Note 1: 115200, 8-bit, no parity, 1 stop bit, no flow control |                          |       |            |       |        |
| Note 2: May be disabled with value 0                          |                          |       |            |       |        |

## Motor Characteristics Requirement for FOC current control

For FOC speed and torque, if the resulted rotor resistance value ( $R_r$ ) is less than 15 mOhm and the resulted rotor time constant ( $T_r$ ) is more than 250 msec, slightly lower torque performance may be experienced in a specific speed range.

$R_r$ : Rotor resistance value  $T_r$ : Rotor time constant ( $L_r/R_r$ , where  $L_r$  is the rotor inductance)

## Scripting

TABLE 8.

| Parameter  | Measure Point | Min    | Typical | Max    | Units     |
|--|---------------|--------|---------|--------|-----------|
| Scripting Flash Memory   | Internal      |        | 32K     |        | Bytes     |
| Integer Variables  | Internal      |        | 4096    |        | Words (1) |
| Boolean Variables  | Internal      |        | 8192    |        | Symbols   |
| Execution Speed (2)  | Internal      | 30,000 |         | 70,000 | Lines/s   |
| Note 1: 32-bit words   |               |        |         |        |           |
| Note 2: Execution Speed was calculated based on low communication load with the controller. In high communication workload, minimum time might be reduced drastically. |               |        |         |        |           |

## Thermal and Environmental Specifications

TABLE 9.

| Parameter  | Measure Point         | Min | Typical | Max          | Units |
|--|-----------------------|-----|---------|--------------|-------|
| Heatsink Temperature   | Heatsink              |     |         | 75 (1)       | °C    |
| Thermal Protection range   | PCB                   | 0   |         | 90           | °C    |
| Power Dissipation  | Case                  |     |         | 70           | Watts |
| Thermal resistance   | Power MOSFETs to case |     |         | 0.8          | °C/W  |
| Humidity   | Case                  |     |         | 93 (2)       | %     |
| Ambient temperature  | Ambient               | -10 |         | 70           | °C    |
| Storage temperature  | Ambient               | -20 |         | 80           | °C    |
| Pollution Degree   | -                     |     |         | PD 2 (3)     |       |
| Fast fuse to install (4)   | FIMG2360T (5)         | 60  |         | 2 x 60       | Amps  |
|  | FIMG2360S (5)         |     | 2 x 60  |              | Amps  |
| Overload motor protection  | -                     |     |         | Check note 6 |       |
| Note 1: The motor drive features overtemperature protection, derating current and power when internal temperature reaches 85°C. Keep the cooling plate temperature below 75°C to maintain rated current at maximum ambient temperatures. |                       |     |         |              |       |
| Note 2: Non-Condensing   |                       |     |         |              |       |
| Note 3: The product was evaluated for use in and under the provisions for installation in a Pollution Degree 2 environment.  |                       |     |         |              |       |
| Note 4: There are two power terminal inputs. Fuse should be installed in both of them for safety.  |                       |     |         |              |       |
| Note 5: In dual channel controller, for operating only one channel install 60A fuse and for operating both channels 2 x 60A fuse should be installed. Power source must be capable to blow the fuse instantly in case of short circuit   |                       |     |         |              |       |
| Note 6: Current limiting mechanism available through firmware. External overload motor protection can be used if required (provided by user)   |                       |     |         |              |       |

## STO Specifications

TABLE 10.

| Parameter            | Measure Point   | Min | Typ  | Max    | Units |
|----------------------|---|-----|------|--------|-------|
| STO Input High Level | Ground to STO input pin   |     | 6    | 30 (1) | Volts |
| STO Input Low Level  | Ground to STO input pin   |     | 0    | 1      | Volts |
| STO Response Time    | Input to output change  |     | 5    |        | msec  |
| STO Self Check Time  | Internal  |     | 1080 |        | msec  |
| Cable Length         | 2   |     |      | m      |       |
| EMC Immunity         | According to IEC 61800-3 and IEC 61800-5-2 Annex E                |     |      |        |       |
| CE Declaration       | Available at <a href="http://www.roboteq.com">www.roboteq.com</a> |     |      |        |       |

## Mechanical Specifications

TABLE 11.

| Parameter              | Measure Point            | Min | Typical    | Max | Units       |
|------------------------|--------------------------|-----|------------|-----|-------------|
| Weight                 | Board                    |     | 500 (1)    |     | g (lbs)     |
| Power Connectors width | Terminal tab             |     | 0.25       |     | Inches      |
| Torque                 | D-sub standard connector |     | 0.4 (3.54) |     | Nm (in-lbs) |
| Torque                 | Terminal block           |     | 0.8 (7.10) |     | Nm (in-lbs) |
| Torque                 | Mounting screws (4/M2.5) |     | 0.36 (3.2) |     | Nm (in-lbs) |
| IP rating              | IP40                     |     |            |     |             |

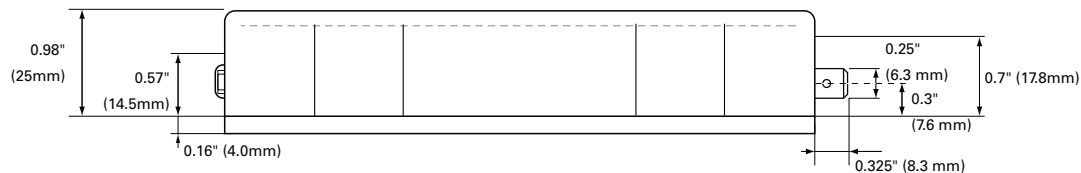


FIGURE 11. FIMG2360T side view and dimensions



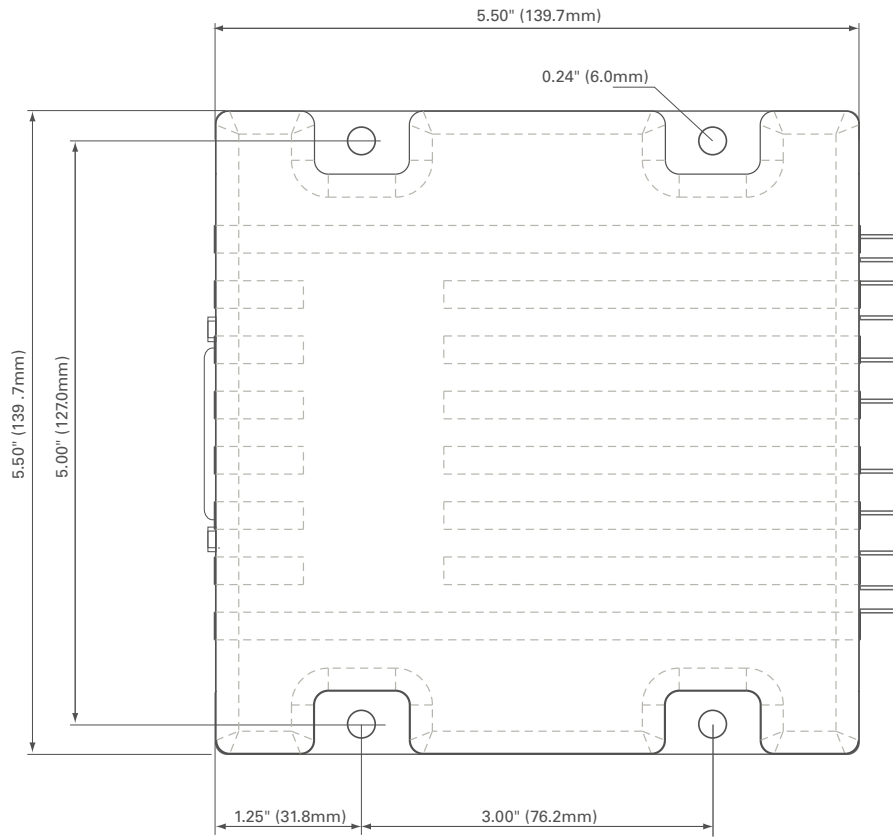


FIGURE 12. FIMG2360T top view and dimensions