# IEC60204-1 Safety of Adjustable Speed electrical Power Drive Systems.

## IEC 61800-5-1 Adjustable speed electrical power drive systems. Safety requirements; electrical, thermal. energy

Safety is a critical aspect of electro-mechanical machines; everyone contributes to maintaining a safe environment, namely the user, the system integrator and the component manufacturer. Roboteq electronic speed controllers are used by system integrators to implement complex electro-mechanical machines, therefore safety is a primary concern for RoboteQ and its products.

Please note that a machine is an assembly of parts of which at least one moves.

There are two key specifications covering this subject:

- IEC 60204 -1 Safety of machinery; electrical equipment of machines
- IEC 61800-5-1 Adjustable speed electrical power drive systems. Safety requirements electrical, thermal. energy.

RoboteQ products are electronic speed controllers; therefore RoboteQ products fall within the scope of IEC 61800-5-1 which is specific to adjustable speed drives. Those subjects that IEC 61800-5-1 does not cover, will be analyzed according to IEC-60204-1.

IEC61800-5-1 covers the safety aspects of the electrical section of a machine with focus on the controller. This documents reviews the parts of such specification which applies to electronic speed controllers.

IEC6024-1 covers the electrical aspects of the whole machine. Consequently only a small fraction of its stipulations apply to the speed controller.

RoboteQ speed controllers are all battery operated; this means that all Spec considerations relevant to power supply from AC mains are not applicable.

Furthermore RoboteQ controllers have several internal DC voltages (12 Volt, 7 Volt, 5 Volt, 3.3 Volt) all derived from external battery voltage which does not exceed the ELV voltage of 120 Volt (61800-5-1, 3.9). This means that Decisive Voltage Class, DVC A and DVC B are applicable.

The protective class is class III (61800-5-1, 3.27)

Our controllers qualify as Safe Extra Low Voltage, SELV (61800-5-1, 3.35) meaning:

- Voltage does not exceed ELV (120 Volt DC)
- No other circuits exist that are not SELV
- No provision for earthing.
- The circuitry depends on basic insulation provided by PCB and cover.

Per 61800-5-1 our controllers are **protective class III,** being equipment in which protection against electric shock relies on supply at *ELV* and in which;
Voltages higher than those of *ELV* are not generated and there is no provision for *protective* earthing.

**Per 61800-5-1, 4.3.6.1.3** Protection Against electric Shock; Overvoltage Category
NOTE For equipment not intended to be powered from the supply mains, the appropriate overvoltage category should be determined as required by the application. Category I applies to equipment connected to a circuit where measures have been taken to reduce transient overvoltages to a low level.
Category I is incorporated in machines that are battery operated so transient overvoltages do not practically exist.
Regarding Decisive Voltage Class (DVC) 61800-5-1, 4.3.1.2 Specifically, limits of DVC.

Our controllers are divided Into two groups by maximum voltage:

- 30 and 60 Volt corresponding to class A
- 120 Volt corresponding to class B

**Class A:** Protection against direct contact not necessary. Protection against earthed parts is by basic insulation. Insulation to accessible conductive parts that are not earthed are not necessary.
Therefore all 30-60 Volt products do not require protection.

**Class B:** Protection against direct contact required. Protection against earthed parts, towards earthed parts, and to accessible conductive parts is by basic insulation, specifically SEL.
All products above 60 Volt need protection means against direct contact.
HDC and HBL series 96 Volt controllers feature attached wires and are therefore isolated from direct contact. Products with RGBL style connectors require protection, either by additional enclosure or protective insulating terminal boot.

### 4.3.11 Capacitor discharge
Capacitors within a *PDS* shall be discharged to a voltage less than 60 V, or to a residual charge less than 50 μC, within 5 s after the removal of power from the *PDS*.
Roboteq 96 volt controllers on average discharge to less than 60 volts in 1.8 seconds.

## 4.4 Protection against thermal hazards
### 4.4.1 Minimizing the risk of ignition

Where it is not practical to protect components against overheating under fault conditions, all materials in contact with such components shall be of flammability class V-1,

### Design
Roboteq controllers are designed with a thermal protection mechanism where the temperature of the controller is monitored and power progressively reduced starting at 70°C down to zero preventing the board temperature from exceeding 100°C.
The limit of 100°C is less then what may cause ignition of the surrounding materials.

### Component selection

Electrical components are used in such a way that their maximum working temperature under normal conditions is less than that necessary to cause ignition of the surrounding materials with which they are likely to come into contact.

### Construction

All materials are of flammability class V-1 or better, ensured by material data sheets.

Roboteq has on file data from the insulating material suppliers, showing compliance with the above limit.

**IEC61800-5, 4.4.4 Temperature limits**
**4.4.4.1 internal parts**

Roboteq designs controllers in such a way that the max temperature of each component (semiconductors, capacitors, resistors, printed circuit board) does not exceed the one specified by the manufacturer. The enclosure max temperature is limited by the temperature thermal protection mechanism below the max temperature of the components.
RoboteQ controllers have an automatic temperature control which limits the internal temperature below 90°C. We use special cables, specifically UL AWM style 1028, Tinned Copper Conductor. PVC Insulation. 105°C. 600V.

**Specification 60204-1**

**4.4 Physical environment and operating conditions**
**4.4.2 Electromagnetic compatibility (EMC)**
Regarding EMC electromagnetic disturbances generation, the Directive 2014/30/EU and the IEC/EN 61000-6-4 2011 apply. Since a dedicated specification exists for electronic power drives, this one will take over from IEC 61000-6-4. RoboteQ controllers applications fall under the spec IEC61800-3 2017-02 Edition 3.0 which covers: Adjustable speed electrical power drive systems Part 3: EMC requirements and specific test methods. Therefore the applicable spec for Europe is IEC 61800-3. See also the report on our website, "Verification Test Report for Radiated EMI".

**4.4.3 Ambient air temperature**
RoboteQ controllers are tested to –40°C; an automatic temperature control limits the upper temperature within the limit prescribed.
Electrical equipment shall be capable of operating correctly in the intended ambient air temperature. The minimum requirement for all electrical equipment is correct operation in ambient air temperatures outside of enclosures (cabinet or box) between +5°C and +40°C. Verified by Small Sample testing on a given Population Mean.

**4.4.4 Humidity**
The electrical equipment shall be capable of operating correctly when the relative humidity does not exceed 50 % at a maximum temperature of +40°C. Higher relative humidity is permitted at lower temperatures (for example 90 % at 20°C).

**4.4.5 Altitude**
**Altitude effects are unknown at this time**
Electrical equipment shall be capable of operating correctly at altitudes up to 1000 m above mean sea level.

**4.4.6 Contaminants**
**RoboteQ controller are IP55**
Electrical equipment shall be adequately protected against the ingress of solids and liquids.

**4.4.8 Vibration, shock, and bump: PASS, by third-party CA**
**Vibration test: EN61800-5-1 and IEC60068-2-6**
See Table 27 of document "2016 Product Vibration and Shock Testing report"
in quality page on website.
**Shock Test: IEC61131-2 and IEC60068-2-7**
See "2015 Product Vibration and Shock Testing report"
in quality page on website.

**Transportation 4.5 and storage**
Electrical equipment shall be designed to withstand, or suitable precautions shall be taken to protect against, the effects of transportation and storage temperatures within a range of –25°C to +55°C and for short periods not exceeding 24 hrs at up to +70 °C. Suitable means shall be provided to prevent damage from humidity, vibration, and shock.
See also the report on our website, MTTF life test report, for more detailed information..
NOTE Electrical equipment susceptible to damage at low temperatures includes PVC insulated cables.

### 5.4 Devices for switching off for prevention of unexpected start-up

Roboteq controllers must be used with an emergency switch carrying a handle which permits to be operated by hand, lockable in the OFF position, with a well marked ON/OFF position, capable of disconnecting the live conductor under the stall current of all connected motors.
The function of the main emergency switch must be integrated by the use of a fuse link in series.

All Roboteq controllers can be routinely turned ON and OFF by using a low current Power Control terminal.

*Note: The Power Control terminal is not a substitute for the main switch, which must be always be present.*

It is suggested that Roboteq controllers be used with a contactor that allows isolating the main power by opening the coil circuit. The contactor is not a substitute for the emergency switch.

### 4.3 Protection against electrical shock.

RoboteQ follows spec 68000-5-1

### 6.2.4 Protection against residual voltages

RoboteQ follows spec 68000-5-1

### 7.2 Over-current protection

Roboteq controllers incorporate max current control which allows to set the max current to a preset value.

It is user responsibility to set this control to the value compatible with the machine and integrate it with the installation of over-current protection devices to avoid the hazard of overcurrent. Fuses are an acceptable way of avoiding over-current.

### 7.3.3 Over-temperature protection

Roboteq controllers incorporate a thermal sensor that will reduce the power delivered to the motor if the controller temperature exceeds 85°C. Please note that, while this will prevent hazards of overtemperature in the controller, will not necessarily guarantee that the motor will not be subject to overtemperature, depending on the rating and nature of the motor and it is user responsibility to take the necessary steps to protect the motor itself.

### 7.2.4 Control Circuits

Roboteq controllers have a separate wire for powering the control section (auxiliary power). This allows implementing control functions that will survive a failure in the main power as long as the auxiliary power is independent of the main power. The Specification mandates a separate fusing of this power section.

## 8. Equipotential bonding (Connection to Earth)

### 8.2.7 Mobile machines

Roboteq recognizes that most of the applications of its controllers are for mobile machines (lawn mowers, autonomous robots, vehicles etc). If the mobile machine is meant to be connected to external equipment AC or high voltage powered, then the machine must have an earthing terminal and be earthed every time such connection is made. The text below is quoted from the IEC60204 Safety Spec.

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On mobile machines with on-board power supplies, the protective conductors, the conductive structural parts of the electrical equipment, and those extraneous conductive parts which form the structure of the machine shall all be connected to a protective bonding terminal to provide protection against electric shock. Where a mobile machine is also capable of being connected to an external incoming power supply, this protective bonding terminal shall be the connection point for the external protective conductor. When the supply of electrical energy is self-contained within stationary, mobile, or movable items of equipment, when there is no external supply connected (for example when an on-board battery charger is not connected), there is no need to connect the equipment to an external protective conductor.

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## 9.2 Control Functions

This section of the Specification includes many items which the user must implement on the machine and are not applicable to the controller which is only one of the components. It is user responsibility to read carefully this section and implement its provisions. We list here below the parts of the Specification which impact the controller.

It should be noted that this section deals with situations where malfunctions may occur and possible remedies (redundancy, multiple stop devices, emergency stop devices etc.) The user needs to assume that the controller may malfunction as a result of a hardware or firmware failure and implement the safety measures described in this section of the Specification at machine level which will prevent hazards in such an event.

### 9.2.5.4.2 Emergency stop

Roboteq controllers include an Emergency Stop function. After an Emergency Stop it will not be possible to restart the motor by a warm reset; the user must turn OFF and ON the power. It is user responsibility to integrate this feature with the use of emergency switches outside the controller to compensate for the event of hardware or firmware malfunction of the emergency stop of the controller (single fault).

### 9.2.7 Wireless remote control (Radio Control)

Roboteq controllers incorporate a feature where power to the motor is removed if a valid radio signal is not received.

It is user responsibility to integrate this feature with a clearly identified emergency radio control capable of stopping the motor in case of a controller malfunction (single fault).
A radio controlled machine must automatically stop

- when a stop signal is received;
- when a fault is detected in the wireless control system;
- when a valid signal (which includes a signal that communication is established and maintained) has not been detected within a specified period of time.

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### 10.3 Indicator lights and displays

Roboteq controllers follow the standard safety convention as described below:

RED Emergency
Hazardous condition

YELLOW or amber
Monitoring

GREEN Normal
Normal condition

### 16.2.2 Hot surface hazard

Although the controller has a thermal protection limiting its maximum temperature to avoid the hazard of fire, it still may become sufficiently hot to scald a person coming in contact with it.
It is user responsibility to determine if the controller is accessible to operators or maintenance people, and if it may reach scalding temperatures. In affirmative case, the user has to mark it with the appropriate symbol for "hot surface" as mandated by the spec.

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## IEC Certification.

IEC certification applies to the complete machine; IEC supports self-certification, although prefers certification by an independent body. Since electronic speed controller are a component in a machine, they cannot be certified in isolation, therefore Roboteq follows the line that its products comply with the applicable items of the specification based on its own analysis and judgment. In other words Roboteq detail which are the applicable items of the specification and self-certifies compliance. The integrator of the machine will have to establish compliance with the entire specification, using whichever method they deem suitable.

Please note: a machine is made of a power source, a controller and a motor [plus ancillary equipment] like, switches, fuses, thermal breakers etc. The word "applicable" needs to be put in this context, where only a subset of specification stipulations do apply to electronic speed controllers.

The following is an excerpt from the IEC official web site.

There are basically three types of CA (conformity assessment):

### First-party CA

The manufacturer or supplier declares on his own responsibility that tests and other CA activities, which are needed to show that a product is conformant, have been carried out. Generally the company will carry out typical CA activities, including testing and inspection, in-house. It then delivers an SDoC (Supplier's Declaration of Conformity).

This form of CA is quite common for products that don't represent any great danger and where the aim is to provide commercial partners with the reassurance that a standard has been followed. It's basically a form of information. Some national regulators will accept an SDoC for low risk products. This is the cheapest and easiest form of CA because no independent checking is applied.

### Second-party CA

This designates a CA activity that is performed by a person or organization that has a user interest in the object, for example, the purchaser.

A very large, important or demanding customer - typically a government, or a major manufacturer - will put in place its own CA for products or services it purchases. This may include test facilities and special assessment procedures that are conducted to guarantee the quality of the supplied goods.

The aim is usually to obtain better assurance that a supplier has carried out a first-party CA. This kind of CA is applied when mandated by law but is today not very common and often replaced by 3rd-party CA.

## Third-party CA

This denominates a CA activity that is performed by a person or body that is independent of the seller and the buyer. It is usually called *certification* and provides the highest level of confidence. Certification is an independently-provided unbiased assurance of the safety of products and processes. This CA is applied where a major market makes it cost-effective or where it is mandated by legislation. Since CBs (Certification Bodies) are usually for-profit companies it is also more expensive than first-party CA. While the IEC supports all three forms of CA, the IEC CA Systems are based on 3rd-party CA. They provide independent testing and certification to ensure the safety, reliability and performance of products and systems.