Introduction

This application note deals with the precautions to be used to safely use a Roboteq controller.

Connecting the AX25590 case to Earth

The AX2550 is enclosed in an aluminum case; the case is floating, being insulated from the ground of the controller.

It is a must to connect the case to Earth to prevent that the case accidentally takes on a high voltage. Earthing the case will assure that in no event the case will become electrically "hot".

The maximum voltage allowed across the controller is 40 Volt DC absolute maximum.

When connecting the controller only to a battery (max 40 volt) and to two motors, as it happens with mobile systems, the user may decide to let the case float since the maximum voltage is within a safe limit, although Roboteq does not recommend it.

In the event that any kind of AC powered equipment is connected to the system incorporating the controller, even if only temporarily, there is the potential for accidental contact between the case and an unsafe voltage. The user must earth the case to avoid electrical shock.

The case has eight screws fixing the side panels to the case body; several of these screws can be unscrewed and put back holding a robust post to which the earthing cable can be crimped and soldered.

Fig - 1 shows the implementation of an earth cable.

FIGURE 1.

Ground loops

Roboteq controllers have multiple ground points, so care needs to be exercised in not creating multiple ground loops.

The ground points are:

- Power ground.
- Signal ground at the pin 5 of the 15 pin connector.
- Signal ground at the RJ45 encoder connector (AX2850 and AX3500 only).
- Thin black wire (AX2550 only)

A controller sits between a battery and a motor and handles currents of several tens of Ampere; it is therefore critical that ground loops are carefully avoided.

Should indeed the main ground wire become open, a secondary ground loop would be subject to the full current exceeding what it can handle, so it will overheat and possibly burn.

In the following paragraphs reference is made to the AX2550; it is simple to extend such considerations to the other controllers.

Dual supply

Fig - 2 shows how connecting the controller to two batteries can create a secondary ground loop. The schematic shows the main ground wire (thick black wire) open (unintentionally of course).

The motor current will flow through the thin black wire which size is inadequate to the load.

Eventually the thin wire will fail and burn, so this is a situation to be avoided.
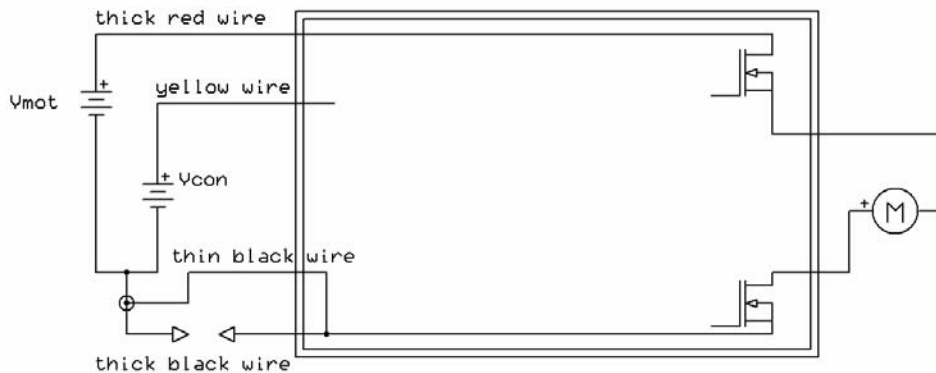

FIGURE 2.

The solution is to connect the thin black wire as close to the controller as possible so if the main ground wire becomes open, it breaks also the continuity through the thin wire.

Connecting a laptop computer

Secondary ground loops can be created when attaching equipment to the controller; the controller has a signal ground connected to pin 5 of the 15 pin connector and a secondary ground path might be created depending on how the signal ground becomes connected to the ground of the equipment.

Fig -3 shows a laptop computer connected to the controller using a custom made cable. Similarly it could be a board micro-controller driving the controller via the RS-232 port.

The ground connection could be erroneously make a loop around the main ground wire, in which case, should the wire become open, the motor current will flow through pin 15, damaging the ground connection to the laptop and the 15 pin connector.
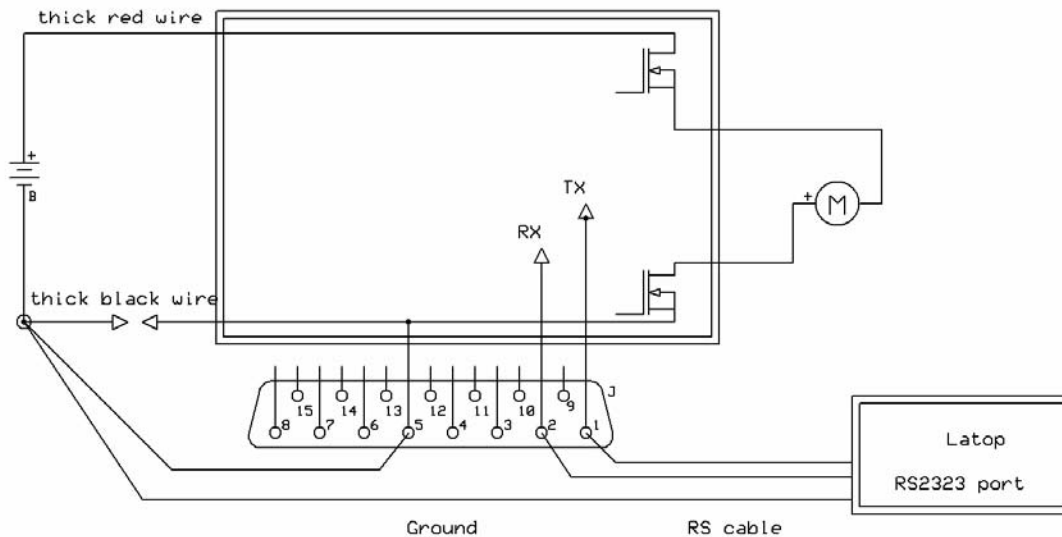

FIGURE 3.

Connecting multiple AC powered instruments

Exercise care when connecting multiple AC powered instruments.

AC instruments must always have their metallic chassis connected to earth for safety reasons. Sometimes their earth wire is also connected to the ground of their electrical circuit.

Typical examples are personal computers, which RS-232 ground is normally connected to earth, and power supplies, which either have the negative pole connected to earth or have a jumper mounted on the earth connector that can reach and can be secured to the negative pole.

In this case a ground loop can be created via the earth connections.

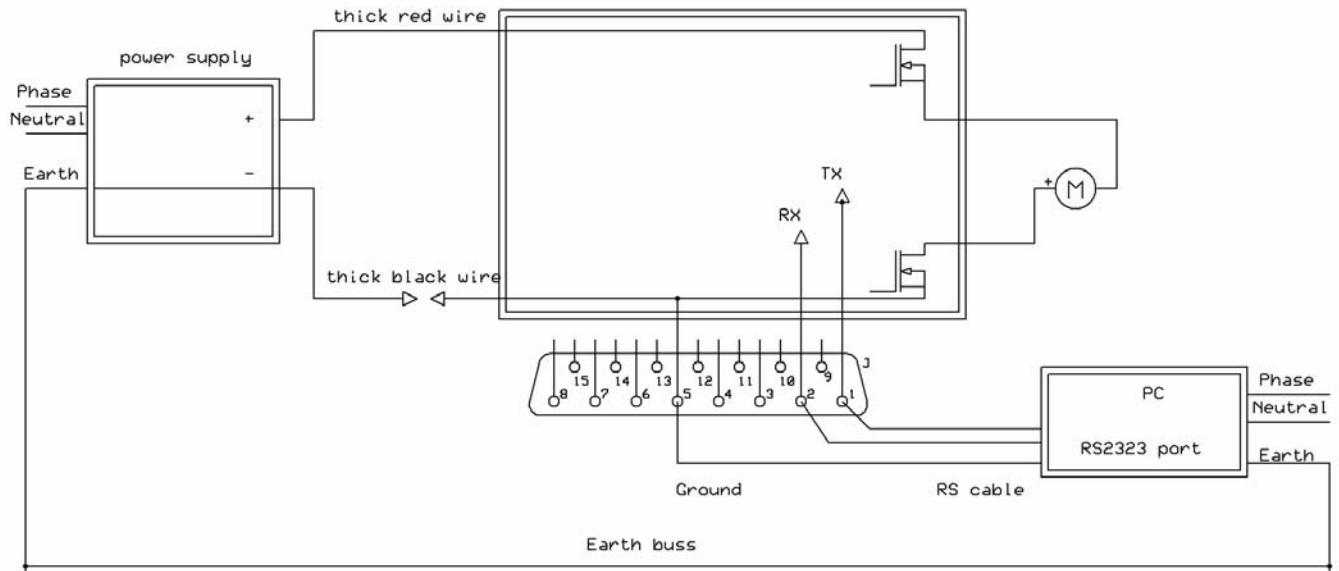Fig - 4 shows a ground loop created by a power supply and a PC connected to a controller.

FIGURE 4.

Also in this case the point most likely to fail is the 15 pin connector and the ground cable from the PC to the controller.

Another example is the connection of a PC and an oscilloscope, whose grounds are connected via the earth wire. Fig - 5 shows the connection and the ground loop.
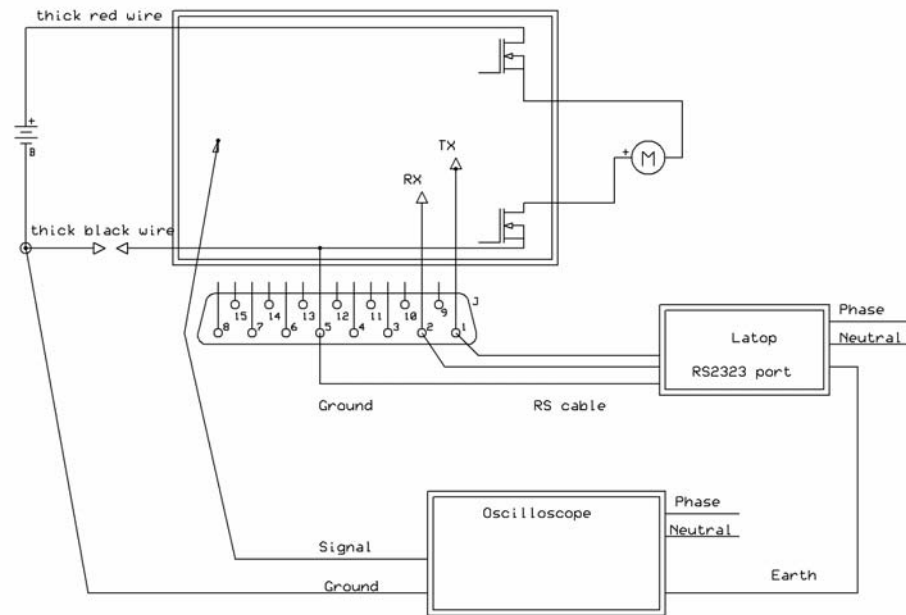
Connecting to multiple grounds

It is reasonably common to connect an I/O card to a controller so to control inputs and monitor outputs.

An I/O card could be associated to a laptop or to a single board micro-controller, which would drive the controller via the RS-232 port, and the I/O card via the USB port.

In this case there is the potential of connecting the two grounds (the USB ground and the RD-232 ground) to two different points, creating a ground loop.

Fig - 6 shows the schematic; it is clear that if the if the main ground black wire becomes open, the motor current will flow through the RS-232 and the USB grounds.
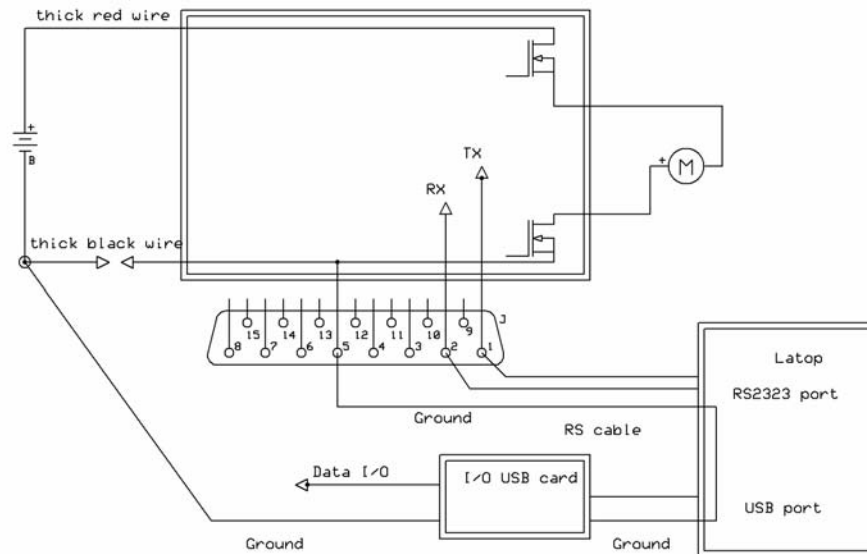

FIGURE 6.

Conclusion on ground loops

When connecting various equipments to a controller, a common ground point needs to be identified and all grounds need to go to that point, avoiding that ground loops are formed. That ground needs to be as close as possible to the controller.

Due to the high motor currents involved, damage and possibly fire may develop as a result of a continuity break in the ground power wire. **Therefore it is recommended that the power ground connection never be opened unless the connection to the positive of the battery is opened first.**

**Obviously "NEVER PUT A FUSE" in series with the ground wire.**

Using shunt motors

Shunt motors can be driven by a Roboteq controller emulating permanent magnet motors.

A shunt motor would have its field winding connected to a DC power supply, therefore generating a constant magnetic field like a permanent magnet, and the speed regulation and direction inversion would be obtained by connecting the armature to the controller.

Fig 7 shows a typical application diagram.

Using a shunt motor has one critical pitfall; the field must be always connected. If the field current drops to zero, then the armature current must be zero too, or damage to the motor and/or the controller will ensue.
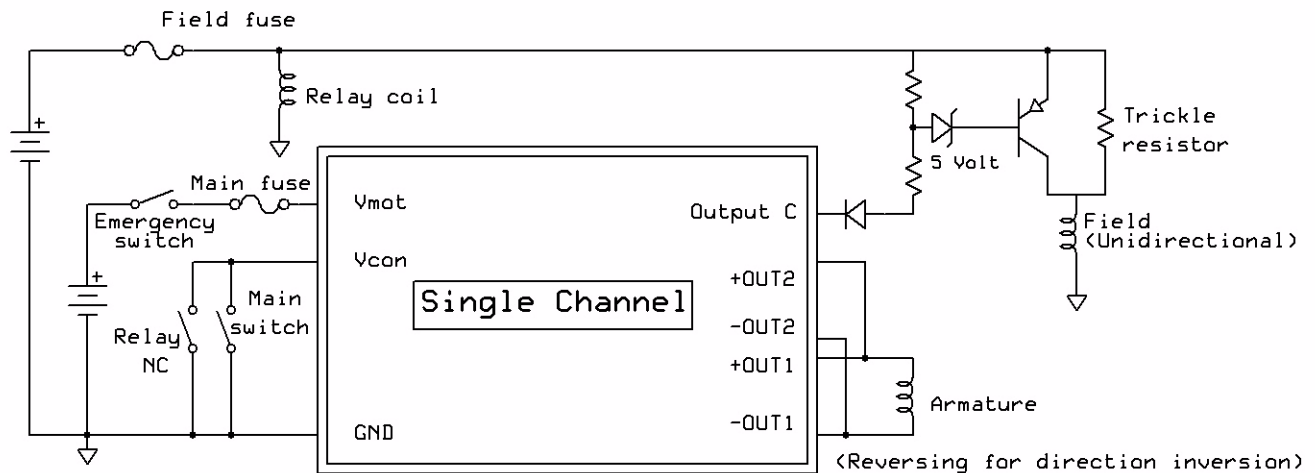
FIGURE 7.

Sometimes the field could be connected to one of the channels of the Roboteq controller, to add to the armature regulation also field control, known as "field weakening".

Furthermore the user may decide to use the "Output C" feature, consisting of Output C becoming active when a motor is activated, to turn on the field power supply. This is typically done to avoid the battery drain associated with the field being supplied when the armature is still.

There are several points whichnneed to be addressed in this application:

- If the field circuit becomes accidentally open the magnetic field disappears and the armature can no longer develop a counter electromotive force. This means that the current will be limited only by the armature resistance reaching therefore the stall value that can be harmful to the motor and to the controller.

- An accidentally reduction in field current may accelerate the motor past its maximum safe speed, harming the motor.
- The Output C drive current maybe be insufficient to directly drive a relay.
- A mechanical relay may malfunction if opening under current or in presence of vibrations.

For these reasons the user needs to implement a safety check that cuts off the current to the armature should any of these situations occurs.

Some known safety techniques are:

- Use a separate un-interruptible power supply for the field.
- Use a trickle resistor connecting the field to the field power supply. In this way there is always a current flowing in the field. Such field current must be equal to the minimum field current specified by the manufacturer.
- Make sure that if a fuse is used in series with the field, the armature current is cut-off should the field fuse blow.
- If the armature current is monitored to turn off the field any time the armature current drops to zero, make sure that there is redundancy so if there is a failure, it does not affect the integrity motor or the controller. A failure prone element in the ON/OFF switching circuit of the field is a mechanical relay opening the field circuit; relays are subject to fail under current or in repsence of vibrations. Using a trickle resistor is an example of redundancy.
- Timing of the ON/OFF switching of the field and armature currents must be implemented in a such a way that the field current comes on first and turns off last.

In conclusion the user needs to exert particular care in implementing this kind of application, since it is a known difficult application requiring a defensive and cautious design style.