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STW Technic, LP
Mobile Controllers and Measurement Technologies

Application Note

AN1001: Grounding

Topics

- Definitions
- Basic Theory
- Specific Application
- Grounding and Shielding Communication Lines

1 Introduction

Proper grounding of an electrical system is necessary not only for normal operation, but also provides protection for the electronics and can extend the working life of the system. Below we will discuss the proper grounding of STW components in an effort to make your system the best and most stable system possible.

2 Definitions

- **Star Point** – Single point at which multiple wires converge, creating a star-type pattern. Star points for grounding should be centralized near electronics to minimize the length of connecting wires and straps.

- **Ground Strap/Earth Strap** – A tinned braided copper strap that is corrosion resistant* and flexible. The ground strap provides a low impedance path for current flow to ground. A low impedance strap is necessary to reduce the ohmic path for AC currents introduced to the system as well as to reduce the skin effect that occurs with AC currents at high frequencies. Flexibility is an important aspect that will prevent vibration from stressing and weakening the connection.

3 Basic Theory

All ground points should be connected such that they are common and allow a low impedance path to ground for all electronics. A common ground prevents unwanted currents (ground loops) and voltage differentials from appearing within the system, thereby preventing damage to electrical components.

In practice, all component chassis ground points and signal ground or common points should be tied together at a single star point via ground straps. This star point should then be tied via a single ground strap or grounding bolt to earth ground or vehicle chassis ground.

Groups of components, such as electronics mounted on ground planes within an enclosed housing (NEMA 4, etc…), are acceptable as long as the local ground plane is then connected to the star point via ground strap.

4 Specific Application

4.1 ESX, ESX-LT, ESX-Micro, DIOM, DIOS

These devices are designed with a grounding concept such that there are free-wheeling currents, in addition to the overvoltage and EMC currents, which can flow through the device housing. Because of this, every additional mΩ between the device housing and ground results in lower current for not only overvoltage and EMC currents, but also for currents flowing through PWM driven coils.

4.2 ESX-3XL, ESX-3XM

These devices have a grounding concept that differs from their predecessors. The free-wheeling currents are no longer able to travel through the device housing, so the total currents traveling through the housing are not very large. However, additional EMC circuits within these devices make a low-impedance grounding of the housing even more important than for the previous devices.

4.3 Connection Method Example (ESX-3XL)

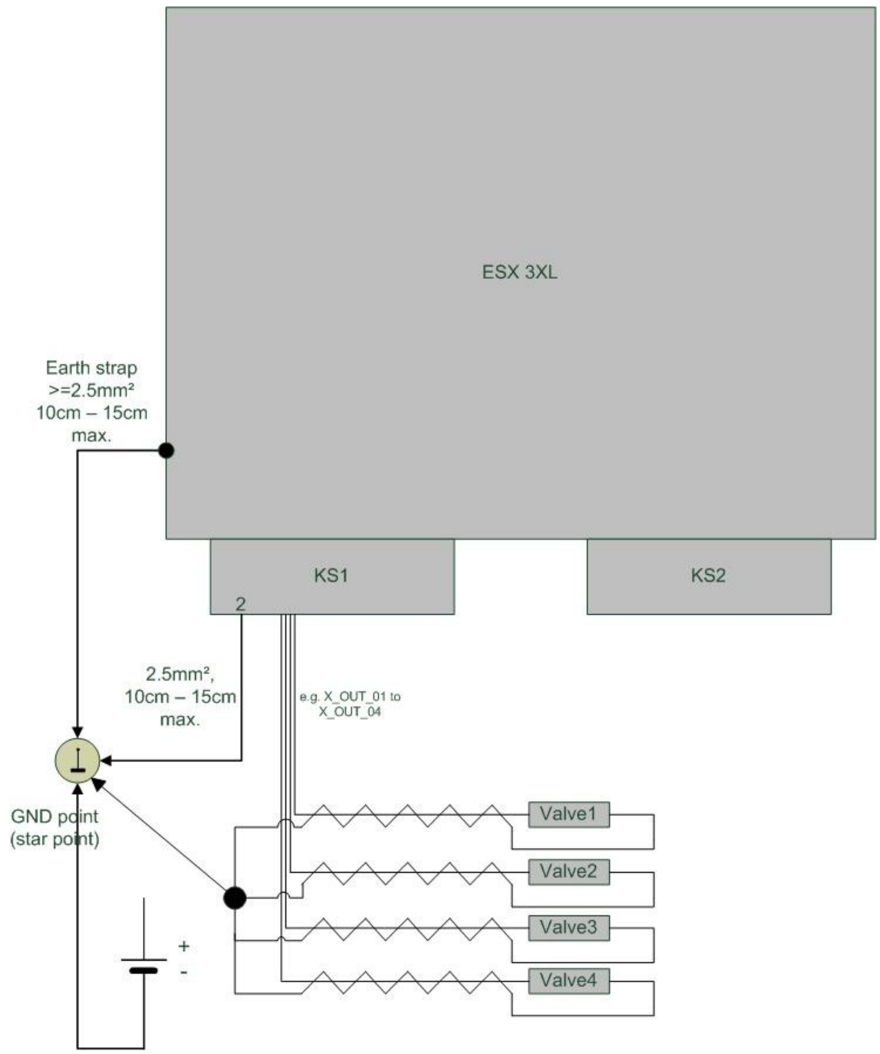

Diagram 1-1: ESX-3XL Grounding

- Mount the ECU in a position close to a good possible ground connection. Initially, it doesn't matter on what material the ECU is mounted, but blank steel will eventually corrode* where it touches the ECU housing over the time.
- Define a star point near the ECU
- Connect the ECU housing via an earth strap no longer than 10-15cm from the star point. This strap should be as short as possible.
- Connect the GND pin of the ECU to the star point (with as short a wire as possible)
- Connect other GND wires from sensors and other components (which are not powered by U_EXT, which has its own AGND) to the star point

5 Grounding and Shielding Communication Lines

Whenever possible, it is a good practice to shield any wires carrying low level signals in order to protect them from interference. When shielding such wires, connect only one end of the shield to ground. Connecting both ends of the shield will result in the creation of a ground loop. Insulate the unconnected end of the shield in to prevent accidental completion of the loop.

5.1 CAN bus

A dedicated CAN common line, used as a reference for both CAN-H and CAN-L signals, is often bypassed and instead tied directly to the shield, or is not present altogether. This is a common practice and generally does not interfere with CAN communication. Shield and common lines should be tied to the common ground of all devices on the CANbus. If devices are to be linked across multiple independent (or unknown) ground planes, optical isolation of the CAN bus between these planes may be required to remove ground differential issues.

Since CANbus use a differential signal, it is more tolerant against ground offsets between individual nodes. If one node has a higher ground level than another node, this will result in more common mode voltage at the transceiver of the second node. CANbus transceiver specifications generally state that this common mode voltage must not exceed -2V to 7V. However, some devices can withstand even higher common mode voltages.

Because of this common mode voltage tolerance, CAN devices are able to detect the “differentiality” of the CAN_H and CAN_L signal even when operating at a higher or lower common mode voltage level than other nodes on the CANbus.

5.2 RS232 (Serial)

RS232 has a low tolerance for ground differential between the electrical components communicating across it because its single ended signal levels are ground related. Therefore, a common ground is necessary to provide a reference between these components. Due to this low tolerance, RS232 is generally restricted to relatively short cable lengths.

Please note, that it is rarely possible to establish long-term communication connections between RS-232 components especially if they reside on different platforms (e.g. different vehicles).

6 Notes

* Please note the potential for Galvanic Corrosion when connecting different metals in electric circuits. Over time, corrosion buildup will increase impedance, weaken electrical and physical connections, and degrade grounding paths. Choose grounding materials with this in mind.

IMPORTANT - Specific grounding and wiring procedures listed in component manufacturer’s documentation should always be followed.

7 History

Revision	Date	Author	Comments
1	7/12/2010	J. Groeninger	Created.
2	8/27/2010	J. Groeninger	Modified per internal review (C. Appelt).

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About Us

STW Technic is the premier manufacturer of mobile electronics for on- and off-highway vehicles. A wholly owned subsidiary of STW GmbH, Germany, STW Technic is located in Atlanta, GA.

STW was founded in 1985, and has since provided electronic controls for world wide market leaders of agriculture, construction, municipal and military vehicles as well as many other kinds of mobile equipment. In 2007, STW will sell about 60,000 freely programmable controllers (more than any other manufacturer) in more than 200 different variations into these markets.

Due to highly demanding safety requirements for many applications in mobile equipment (i.e. cranes, fire equipment, etc.), many of STW's controllers are certified based on IEC 61508 (SIL2) and EN 954-1 (Cat. 3) standards. STW is also ISO 9001 certified, and further certification includes ISO/TS 16949:2002, the quality standard of the automotive industry.

In addition to the controller product range, STW offers displays, joysticks, sensors, and other electronic components to provide a complete electronic system for vehicles.

STW is also a supplier of robust pressure and force measurement sensors with thin-film, ceramic or silicon technology. STW specializes in applications in extreme conditions, which includes pressures up to 3,000 bar (44,000 psi) and media temperatures up to 300 °C (540 °F).

STW is a reliable partner, who not only supplies controllers, but can also train you to develop your own applications, write the applications for you, maintain inventory for you, and do everything a control engineering department would do.