APPLICATION BULLETIN

Recommendations for Vehicle CAN-bus wiring

1. Introduction

This is an advisory notice giving recommendations for CAN wiring in multi-node systems, be it a simple single motor and display application or dual traction with pump, IO modules and a display. In general, care should always be taken in selecting appropriate cable and routing of that cable in a CAN system, but some systems and/or vehicle configurations generate more noise than others and subsequently the CAN wiring requires better shielding.

2. Reason for Change

Recent advances in MOSFET technology have allowed us to improve controller efficiency by reducing switching times in the MOSFET power stage. This leads to a high dv/dt in the controller, especially so in higher voltage controllers (80V +). Unfortunately this rapid change in voltage can be coupled to other parts of the system and this includes CAN wiring. Whilst CAN uses a differential signalling system which is intended to cancel out common mode noise (hence the general requirement for using twisted pair cables) sometimes the noise induced in the CAN wiring is not symmetrical. This leads to CAN errors and in extreme cases may cause the CAN controllers to enter a 'bus-off' state if error levels get too high. We therefore need to take steps to stop the noise being induced onto the CAN-bus wiring to prevent these errors.

3. Affected Products

The advice contained in this note can be applied to all Sevcon CAN-bus systems. Recent experience has shown that higher voltage systems are more likely to be affected by power frame switching noise and so greater care should be taken with these systems. In vehicle communications between controllers, displays and IO modules can be affected as well as communications with set-up tools such as DVT, Drive Wizard and the calibrator.

4. Recommendations

(a) General vehicle wiring

CANbus communications systems are intended to be robust, reliable systems for passing data between electronic devices located in different parts of a vehicle. Generally speaking the CANbus is used to reduce the complexity and cost of vehicle wiring harnesses and add functionality. The reliability of a CANbus system comes from its hardware arrangement (physical layer), low level protocol (data link layer) and the various higher level CAN protocols in use, such as Sevcon proprietary protocol and CANopen. Care must be taken to pay attention to both the hardware and software aspects to ensure a reliable and robust system:

- Software and protocol settings – check that you have the latest controller software and if possible use the auto-configuration feature, this will ensure correct settings for safety related aspects of the CANopen protocol such as heartbeats etc. If using other types of CAN nodes such as displays or IO modules ensure they also have the latest software installed. If you do not use the auto-configuration feature then you must pay particular attention to the set-up of safety related CAN messages and default values for control outputs in the case of communications faults.
- Baud rate – use the lowest baud rate possible.

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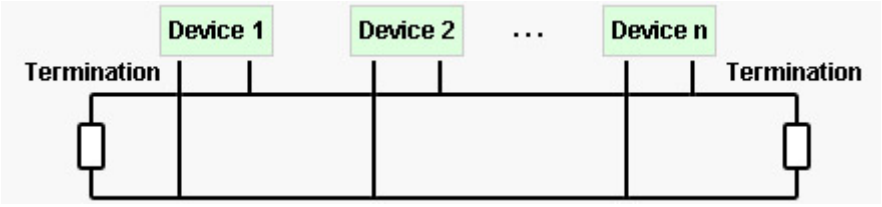
- Make sure that all COB-IDs are unique, i.e. not more than one node is set to transmit a particular TPDO. When using the auto-configuration facility this should not be a problem, but if additional TPDOs are added you must ensure that they do not conflict.
- Always use twisted pair cable to obtain the best noise immunity for the CANbus.
- Terminate the bus at both ends using a 120Ω resistor. Most Sevcon controllers have inbuilt termination resistors which can be selected by linking two pins in the customer connector.



- Choose the best possible route for the CANbus cable – the shortest possible route, away from noisy power cables and other noise sources such as contactors or other electrical equipment.
- If the installation is inherently noisy (as mentioned previously some higher voltage systems tend to be more noisy) then use shielded twisted pair cable. Accepted practice for using shielded cable is to terminate the shield only at one end of the cable, but recent experience in some noisy applications has shown that terminating the shield at both ends of the cable can be more effective. This may vary from application to application. When terminating the screened cable be careful only to expose the minimum amount of the inner twisted pair cable as possible. See photos below on the next page for how to and how not to terminate a screened cable:

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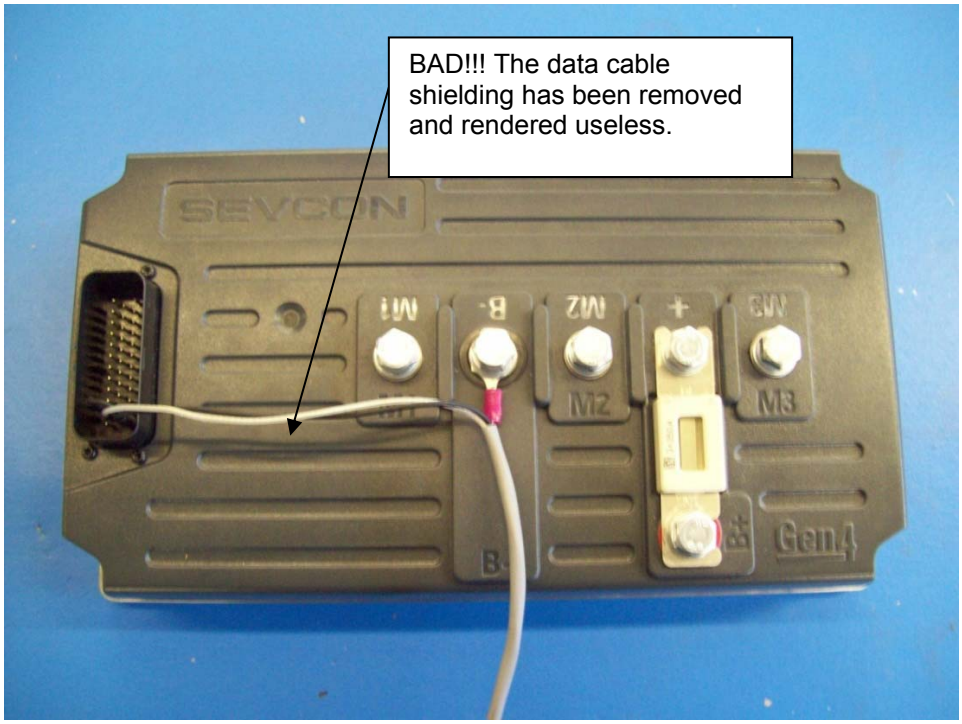

Figure 1 – How NOT TO terminate a screened cable

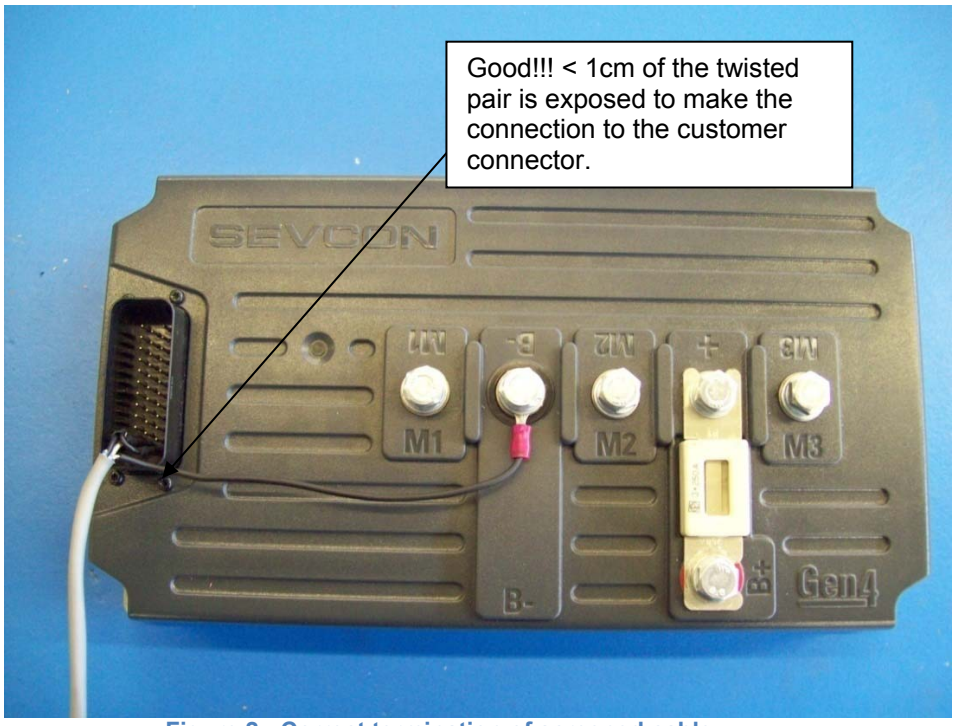

Figure 2 - Correct termination of screened cable

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(b) Recommendations for use of test equipment and tools

- Always make sure that you have the latest release of software for CANbus devices such as controllers and test tools (DVT, Drive Wizard, SCwiz etc).
- When using DVT, Drive Wizard or SCwiz (or any other PC based CAN debug tools) care should be taken not to inadvertently introduce ground loops. It is often best to use a laptop running on batteries (not plugged into the mains) to reduce the possibility of introducing a ground loop or mains born noise into the system.
- Use a galvanically isolated USB/CAN interface. The IXXAT part numbers are as follows:

  1.01.0087.10100 Non-isolated
  1.01.0087.10200 Isolated

- Ensure that the ground connection is made between any CAN/USB or other type of CAN-PC interface and the CANbus devices. A commonly used tool is the IXXAT USB to CAN converter. The pin-out is shown below for reference:

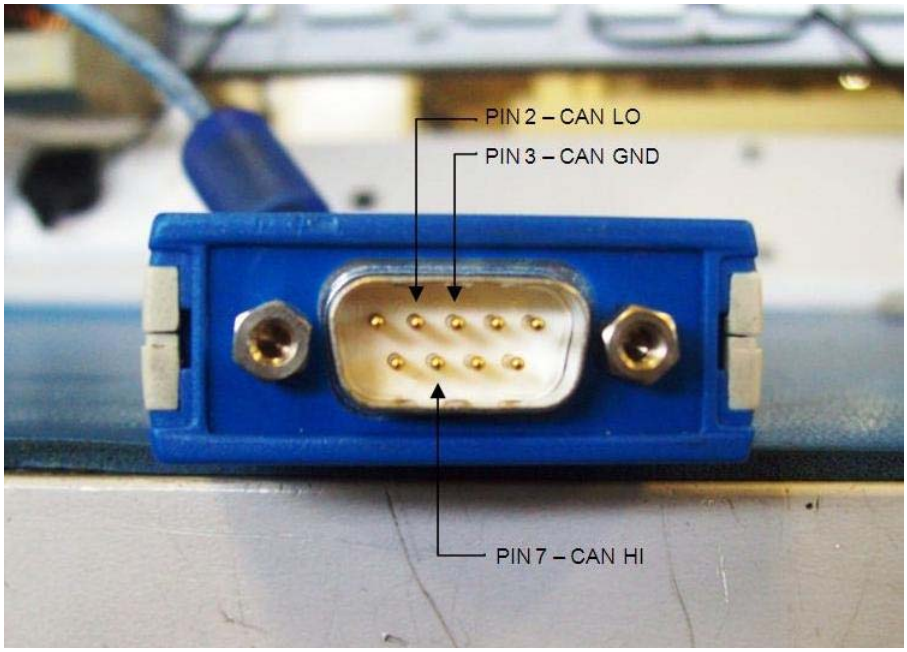

Figure 3 - IXXAT USB/CAN pin-out

Ensure pin 3 is connected to the CANbus ground reference (normally B-).

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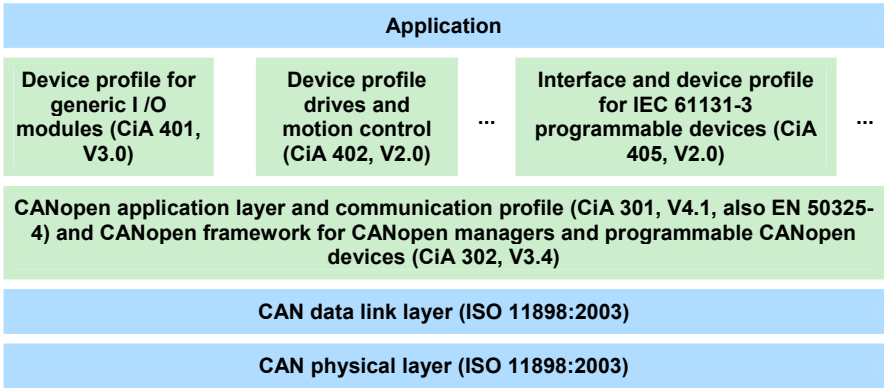
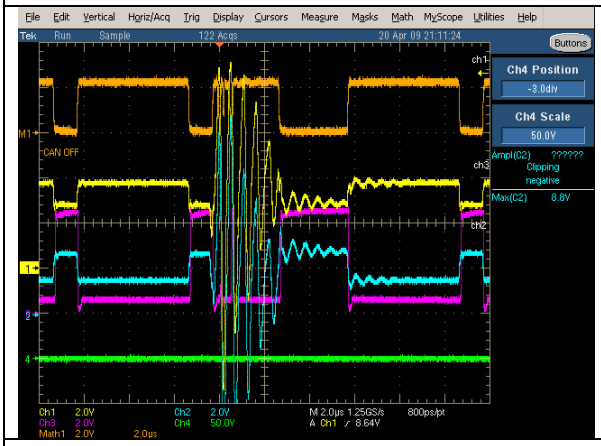
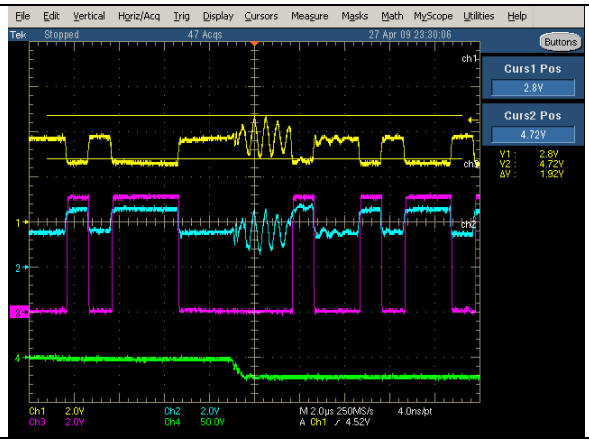
Appendix I - CAN standards



CANopen Bus

Appendix II – Effect of screened CAN cable

CANbus noise with un-screened cable. This level of noise is sufficient to cause CAN 'bus-off' errors.	CANbus noise with screened cable. This level of noise is easily cancelled by the CAN receiver.
	

NOTE: The test conditions for both the above traces were the same, apart from the cable used for the CANbus. The tests were run on a dual traction system at 94.5V. The complete report that these traces were taken from is available on the Sevcon intranet.

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