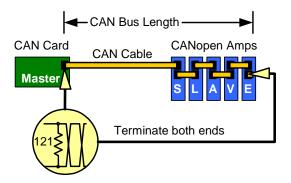# CANopen Network CAN bus Cabling Guide

Introduction

CAN (Controller Area Network) is a two-wire differential serial communication protocol for real-time control. Copley CANopen amplifiers use the *CAN Physical Layer* as defined by the DS-102 V2.0 and the *Cabling and Connector Pin Assignments* as defined by DR-303 V1.0.

Sr. Applications Engineer *"Network problems are often caused by not using proper termination at both ends of the CAN bus, wrong bit rates for cable lengths, and poor cabling. This technical note will help make efficient use of network bandwidth and achieve error free operation."*

Physical Medium (Bus line)

The bus line must be terminated at both ends by resistors that represent the characteristic impedance of the line. Copley supplies standard Giga-bit UTP (Unshielded Twisted Pair) cable with standard 121 Ω characteristic impedance thus; 121-Ω resistors must be installed at both ends of the network. Copley provides termination plugs for RJ-45 connectors and a jumper for development kits. Most manufacturers do not ship CAN cards with termination installed. Thus, for the CAN card at the end of the bus line, line termination must be installed.

The maximum CAN bus length is 1 kilometer at 50kbit/s. The bus line should be as close as possible to a straight line to keep reflections to a minimum. To extend the cable length (or to provide galvanic isolation) a bridge-device or repeater can be used. The diagram below represents a typical network implementation. However, it is not the only one. It is also possible to have the master connected in the middle with no termination, with termination at the amplifiers at the end of the bus line. If a cable stub (un-terminated cable) or T-connector is used to tap into the bus line, then the stub distance should not exceed 0.3m at 1Mbit/s rate per. DS 102 Version 2.0.

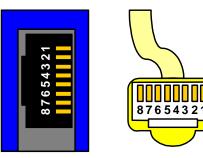Typical CANopen Network with Master at end of bus line.

Bit Rate

The CANopen DS 102 V2.0 Physical Layer for Industrial Applications, Appendix, provides recommended guidelines for cable length at several bit rates. See table below.

Bus length	Bit Rate	Bit time
25 meters	1000 kbit/s	1 us
50 meters	800 kbit/s	1.25 us
100 meters	500 kbit/s	2 us
250 meter	250 kbit/s	4 us
500 meters	125 kbit/s	8 us
1000 meter	50 kbit/s	20 us
2500 meters	20 kbit/s	50 us

Connectors and Cables

RJ-45 Connector

The RJ-45 female connector is standard on Copley CANopen panel amplifiers.

Female Connector   Male Cable

Pin	Signal	Description
1	CAN_H	CAN High bus line (dominant high)
2	CAN_L	CAN Low bus line (dominant low)
3	CAN_GND	CAN Ground (see grounding section)
4	Reserved	No connection, only pass-through
5	Reserved	No connection, only pass-through
6	(CAN_SHLD)	No connection, only pass-through
7	CAN_GND	CAN Ground (see grounding section)
8	(CAN_V+)	No connection, only pass-through

Copley provides RJ-45 male connectors on 10ft and 1ft 8-wire UTP (Un-shielded Twisted pair) Gigabit cable. STP (Shielded Twisted pairs) is not recommended but could be used.
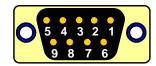
Copley Network Terminator Plug

Copley provides an RJ-45 terminator plug for use with the RJ-45 connector on Copley CANopen panel amplifiers. The plug connects a 121 Ω resistor between CAN_H and CAN_L.

General Purpose 9-pin D-sub

The 9-pin D-Sub male and female connectors are standard on Copley development kits for CANopen modular amplifiers.

Pin	Signal	Description
1	Reserved	No connection, only pass-through
2	CAN_L	CAN Low bus line (dominant low)
3	CAN_GND	CAN Ground (see grounding section)
4	Reserved	No connection, only pass-through
5	(CAN_SHLD)	No connection, only pass-through
6	(GND)	CAN Ground (see grounding section)
7	CAN_H	CAN High bus line (dominant high)
8	Reserved	No connection, only pass-through
9	(CAN_V+)	No connection, only pass-through

The development board provides a jumper on J4 to connect the 121Ω resistor (located on the development board) between CAN_H and CAN_L.

Non-Copley Device CANopen Connectors

From the CANopen DR-303 V1.0 Cabling and Connector Pin Assignment:

- RJ-10 for 4 wire twisted pair.
- Open style with screw terminals for flying lead wires.
- Multi-pole connectors for flat ribbon cable to 9-pin D-Sub
- Special purpose round style.

Grounding and Isolation

Copley recommends that the CAN_GND be connected between devices. Even when using isolation, Copley recommends that the CAN_GND still find a path to earth ground.
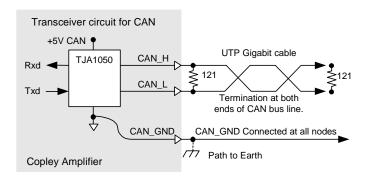
The Copley AccelNet and StepNet panel amplifiers have CAN isolation so a path to ground is required in the system.

The Copley Xenus has isolation from the power stage but has connection to the signal ground (floating until the signal ground is connected to earth or a path to ground is provided in the system).

The Copley Module and development kit board has CAN_GND connected to amplifier signal ground. This is good for single board design with a central point for earth ground connections. Isolation would require design on the mounting board.

Transceiver

Copley amplifiers use 3rd generation TJA1050 transceivers.

Troubleshooting

Network problems are often caused by not using proper termination at both ends, wrong bit rates for cable lengths, incorrectly installed cables, and poor signal quality. The CAN status LED indicates the status of the CAN physical layer. Flashing red indicates errors due to missing CAN messages (SYNC, Guarg or Heartbeat).

CML Copley Motion C++ Library can be used to create a cml.log file to log debug messages. Use cml.SetDebugLevel( ) to set the debug message level >0.

CAN card manufacturers provide a 'CAN Analyzer' to help debug the CAN bus. With the power off, use an Ohms meter to verify 60 Ω across CAN_H and CAN_L. With the CAN bus on, use an oscilloscope to differentially measure the signal levels at both ends of the CAN bus. (Two-channel scope set to BOTH with ADD and INVERT ON). Sending and receiving messages between the master and each node ID will test each node. Using the graph below, verify that dominant or recessive signals are out of the invalid range and that rise times are < 15% of bit time.