This is a draft document, and has no official standing. It has not been submitted to the NMRA Technical Department or the NMRA Board of Directors for approval.

NMRA Technical Note	
NMRANet ® **Physical Layer**	
All Scales	
01/08/10	**Draft TN-9.x.1**

1 Introduction

This Technical Note contains informative discussion and background for the corresponding S 9.x.1 Standard. This Technical Note is not normative in any way.

2 Intended Use

There is no intention that devices that connect more than on CAN segment (e.g. bridges) have to electrically interconnect those separate segments.

We don't discuss CAN terminators, because they're discussed in detail in the CAN documentation that the standard references. A simple resistor on a RJ45 plug can be used, or more complex devices can be created and sold that e.g. contain diagnostic readouts. So long as it provides in-spec termination, they're all fine.

3 References and Context

NMRA conformance testing is simplified when it can be done by referring to vendor documentation, rather than requiring specific tests of parameters. The standard therefore refers to other to existing standards, where possible, instead of repeating the information here.

4 Physical Interconnection

We're trying to enable two basic kinds of nodes: Board with 2 connectors and box with a pig-tail cable, e.g. a handheld throttle. But we don't want to rule out e.g. a board with two connectors and three pig-tails for attaching throttles, or anything else, hence the somewhat complex wording in this section.

The assignments to particular colors are for information only. These are the colors that users will encounter in the two popular ways of wiring commercial cables. If you're building a product using commercial cable, using one of these two color codes will reduce confusion, but most NMRAnet users will never need to refer to the colors in their cables.

The signal names refer back to the signal definitions in the CAN specifications. UTP is unshielded cable, so the CAN_SHIELD conductor is being used as a second conductor for the CAN ground reference, CAN_GND.

The discussion of connecting in parallel is to make sure that all 8 wires go through a board, whether it's got connectors, pig-tail cables or a combination of the two, so long as it's got more than one connection to other nodes.

We want all 8 wires present so people can add power later, or we can define the reserved conductors later, and still use them. The 1A on interconnects is to make sure they're at least as robust as the connectors and cable.

For information on sizing circuit board traces to carry the required interconnection current, please see "IPC-2152 — Standard for Determining Current-carrying Capacity in Printed Board Design, 2009."

All 8 wires don't have to go through the board if there's only one connection, e.g. a throttle with a single jack or pig-tail cable with plug. In that case, only two pairs are required.

If your product is providing power and has e.g. two jacks, you can either connect them together and provide a max of 0.5A to both combined, or separately power them up to 0.5A each. This is the only case where a conductor doesn't have to pass through the board as a continuous electrical circuit. Note that this means that your product has to provide power, however; if providing power is an option, not always present, you should connect conductor 8 across the board to ensure that downstream nodes aren't cut off from power when it's not provided by your board.

The 100V requirement on the reserved conductors is also there to make sure that when we later find a use for it, we don't blow up existing installations. The goal is to have all existing installations be able to move to newly-defined uses without having to retrofit cables nor non-involved nodes.

If you want to use the reserved conductors for experimental purposes, we recommend using jumpers (fixed or movable) for making connections to the conductors and/or splitting the reserved conductors between connectors so that you can restore normal usage later, should some other use be defined for them.

The 27V requirement comes from the S9.1 limitation on track voltage.

5 Data Transport

A 4V/microsecond slew rate is preferred to reduce the effect of stubs on the network.

This standard is silent on the use of specific CAN frame formats or features.

6 Supply of Power

The power supply section is meant to define a 12V nominal system with wide margins on production and consumption of power over the UTP cable. We expect that nodes will use this power in a range of ways, including having local power regulation ranging from simple analog regulators through more advanced supplies that increase current and/or voltage. 12V was chosen to reduce heat loads when using the simplest regulators. The current limit was required by use of 1 conductor in UTP wiring.

Power can be injected into the cable by simple "mid-span injector" devices, essentially just two RJ45 connectors and a 2.1mm jack for a wall-wart. It's not required that it comes from a NMRAnet node itself.

Note that the standard permits, but does not require, connecting the CAN signal ground on conductors 3 & 6 with the PWR_NEG power distribution ground on conductor 7. We expect that most power-supplying and power-consuming boards will connect PWR_NEG and the 3/6 grounds to simplify their internal structure. Designers should carefully consider noise immunity, the possibility of ground loop, and voltage offsets when doing this. A straight copper connection is within the letter of the requirement. An alternative to connecting them directly is e.g. a 10 ohm resistor and a 0.1uF capacitor in parallel.

The power provisions are for low-power uses that can be conveniently handled over short lengths of cable. Boards are welcome to have other connectors for power. These other connectors can be anything not otherwise forbidden by some other standard, including terminal blocks, 2.1mm jacks, Anderson PowerPole connectors, or whatever else is considered useful for the specific market.

Note the effect of the “must withstand” requirement is that power supply boards must be able to be connected to each other, even if their output voltages are not exactly the same. One way to handle this is an isolating diode on the PWR_POS output.

7 Consumption of Power

For their thermal calculations, node designers must assume that power is supplied at 15V.

For their power calculations, node designers must assume that power is supplied at 7.5V.

8 Termination

The CAN specification (ISO11898-x) specifies using a bus termination of 60 ohms, split between the two ends of the bus. Several alternate termination schemes have been proposed in the literature (see references), and these alternatives are discussed below.

8.1 Methods

8.1.1 Passive single resistor:

This consists simply of a 120 ohm connected etween CAN-H and CAN-L
, and is the commonest termination scheme. It main advantage is simplicity.

8.1.2 Passive split resistors to ground:

This consists of the CAN-L and CAN-H lines being connected by two 60 ohm resistors in series, with their common connected via a capacitor to ground. This is simple but also helps balance the two lines.

8.1.3 Passive split resistors to fixed voltage:

As in (2), but common is also tied to a fixed voltage. This can be to nominal 2.5V via a voltage divider (ref xx), or by other means, by using a voltage reference

8.1.4 Active termination:

This termination is accomplished by using active elements, such as transistors or op-amps to actively drive the bus to its active state. Note: active termination requires power.

8.1.5 Distributed termination:

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8.2 Placement:

Any termination can be supplied as a on-board option, or as a terminator- connector. Obviously, this is based on the preferences of the manufacturer and users. Using terminator-plugs would seem to provide the maximum flexibility. However, as long as on-board termination is de-selectable, flexibility is maintained. Manufacturers may want to provide a special termination node that as well as providing passive or active termination, also provides some indication of bus health.

Termination should, generally, <u>only</u> occur at the two distant ends of the bus, termination in the middle of a significant-length CAN bus is very disruptive because it causes reflections. The one downside to on-board termination is that it makes it much easier to have multiple terminators (customers think more must be good, and mistakenly turn them all on).

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