

NEMA TS2 Standards

The “Intelligent Cabinet”

Standardization & Multiple Sourcing

TS2 specifies controllers and cabinets more fully than the TS1 or 170/179 standards by covering auxiliary functions such as coordination, preemption, time-based control, and automatic flash. Connections and communications inside the traffic cabinet are now fully specified. There is no more need for a manufacturer specific D connector, as used in some pre-TS2 controllers. System-level communications with devices outside of the traffic cabinet, such as system masters, will be fully specified by the NTCIP protocol. Also, for the first time, TS2 standardizes the mechanical dimensions of NEMA cabinets and specifies the foundation for base mounting.

The higher level of standardization provided by TS2 makes it easier for agencies to multiple-source controllers and cabinets, to upgrade from one model to another, and to interconnect cabinets from different manufacturers on the same system via standardized telemetry.

Enhanced Safety & Reduced Liability

TS2 assures substantially safer operation than the older TS1 or 170/179 standards. It also establishes diagnostics, which are not part of these standards. The combination of improved safety and the availability of diagnostics reduces liability exposure to agencies. The associated dollar savings, alone, more than justify the switch to TS2. Safety is enhanced in the following ways:

Simplified Cabinet Wiring

The SDLC data bus eliminates most of the point-to-point wiring and thick wiring harnesses inside the traffic cabinet. This reduces the chance for wiring errors and problems associated with electrical connections. The traffic cabinet becomes simpler and more reliable.

Redundant MMU Function

A TS2 controller can put an intersection into flash if the MMU fails to do so, thus providing redundancy of the MMU function. This represents a significant enhancement of traffic safety.

The TS2 controller is able to “see” the load switch outputs through the eyes of the MMU via the SDLC bus. This feature is not provided by the TS1 or 170/179 standards. The normal CMU only monitors the output of the load switches and has no way to communicate this information to the controller.

Features

- Specifies coordination, preemption, time-based control, and automatic flash operation
- Enhances traffic safety through redundant MMU function
- Establishes diagnostics for detectors and all cabinet electronics
- Defines open architecture for future ATMS/IVHS/ITS cabinet equipment

Specification

- Specifies all connectors in cabinet for hardware interchangeability
- Avoids manufacturer specific D connector
- Defines telemetry signal
- Enhances user interface
- Makes provision for 64 detectors
- TS2 Type-1 simplifies cabinet wiring with SDLC serial bus
- TS2 Type-2 maintains downward compatibility with TS1
- To be augmented by NTCIP for system-level standardization

Program Verification

The controller and MMU verify each other's programming via the SDLC bus, with a data exchange every 100 milliseconds. The controller will maintain an intersection in flash as long as its own program conflicts with that in the MMU. In the case of a TS1 or 170/179 cabinet, the problem would only have been detected following an actual conflict at the load switch level during on-street operation.

Cabinets Supported by a TS2 Controller

The thick A, B, and C cable harnesses of TS1 have been replaced by an SDLC serial data bus, which operates at 153,600 bps and provides two-way communication between all cabinet components. The serial bus interface to detectors and load switches is via Bus Interface Units (BIUs).

Use of the serial bus overcomes the pin limitations of TS1, simplifies cabinet wiring, enhances reliability, allows virtually unlimited cabinet expansion, and provides a standardized interface to as yet unspecified future devices. A manufacturer-specific D connector is no longer required. This, combined with standardization of auxiliary functions such as preemption, facilitates multiple sourcing of controllers.

The serial bus also allows cabinet level diagnostics, which represent a major safety enhancement. The controller and Malfunction Management Unit (MMU) verify each other's programming and operation. Each can put the intersection in flash in case of discrepancy, thus providing redundancy of the MMU function.

A point-to-point wiring harness is retained to allow the MMU to monitor the load switch outputs.

TS2 Type-2: A hybrid TS1/TS2 cabinet

In this hybrid cabinet, the controller provides both the SDLC serial interface of TS2 and the A, B, and C connectors of TS1. As a minimum, the serial data bus is used to interconnect the controller and MMU, thus enhancing safety through the redundant MMU monitoring function. In the typical Type-2 cabinet, the serial data bus is also used for the detectors. The A, B, and C connectors can be used to interface the controller to detectors and load switches and auxiliary equipment. The Type-2 configuration was included in the TS2 Standard because it provides an upgrade path for existing TS1 installations.

Even though this is not mandated by TS2, Econolite's Type-2 controllers can be used in a pure Type-1 cabinet, which bypasses the A, B, and C connectors and makes all controller signal connections via the SDLC serial data bus.

Downward compatibility with NEMA TS1

A TS2 Type-2 controller with A, B, and C connectors can be installed in a standard TS1 cabinet with a CMU and serve as a TS1 controller spare. The manufacturer-specific D connector associated with a TS1 controller may be avoided, since TS2

allows input and output pins to be reassigned through software. Type-2 controllers allow 24 input and 24 output pins to be reassigned.

When a TS2 controller is installed in a TS1 cabinet, many of the special features of the TS2 will not be available, such as the redundant MMU monitoring function and cabinet-level diagnostics. These require use of the bidirectional SDLC serial data bus.

In addition to the Type-2 controller, many TS2 cabinet components will also work in a TS1 cabinet and can serve as TS1 spares. A TS2 MMU can serve as TS1 CMU. TS2 rack-mount detectors, load switches, flashers, and flash relays can be used in a TS1 cabinet.

Output Monitoring

The MMU can compare the output of all load switches to their programmed input, as transmitted to the MMU via the SDLC bus. In case of discrepancy, the MMU can put the intersection into flash. This feature is implemented in MMUs by Econolite. Under TS1, the CMU only monitors the output of the load switches for conflicting movements of the absence of Reds. This is a more limited test, which leaves many failure modes undetected. Most Type 170/179 cabinets do not even monitor the absence of Reds.

Clearance Time Monitoring

The MMU times the interval between the end of an active Green and the beginning of the next conflicting Green, as well as the duration of each Yellow Change interval. If these times are too short, the MMU puts the intersection into flash. Under the TS1 or 170/179 standards, the CMU does not have to time these intervals, and there is then no way for an agency to disprove the allegation of a missing or short Yellow in case of a traffic accident.

AC Power Monitoring

If the MMU recognizes a low AC voltage condition below 95 Vrms, it places the intersection into flash. It will only return the intersection to normal operation once all cabinet components can operate safely. Intelligent handling of AC power prevents a brownout from latching a failed condition, which would require a needless trip to the intersection for manual reset.

Cabinet-Level Diagnostics

TS2 specifies, through self-test diagnostics for the controller and MMU, ongoing mutual checking of the controller and MMU, in addition to verification of the SDLC data bus by both the controller and MMU. TS2 allows ongoing verification of load switch performance. In the event of failure in any of these areas, the MMU or controller can put the intersection into flash. TS2 further specifies detector diagnostics and makes provisions for logging.

Detector Health Monitoring

Proper orientation of each detector is continually monitored by the controller via the SDLC bus, thus averting traffic problems due to unreported detector failures. SDLC bus data frames are specified for normal operation, watchdog failure, open-loop, and excessive change in inductance. In addition, detector diagnostics specified for the controller include no activity, maximum presence, or erratic output.

Provision for Failed Detector

In the event of failure, TS2 detectors will put out a constant call and also output a fault status message to the controller, which can then take appropriate action. Detectors used in TS1 and Type 170/179 cabinets may fail in the open mode, which can result in a phase not being served as well as in major traffic tie-ups.

Logging by Controller

TS2 specifies two logs or reports: the Detector Report for a minimum of 50 failed or on-line detector status changes, and the Events Report for a minimum of 100 controller events. Econolite's TS2 controllers also include an MMU Report, which captures the detailed intersection status for a minimum of 16 MMU flash events. All logged data is time and date stamped and is stored in the non-volatile memory of the controller.

Provision for Log Retrieval

Logged data can be viewed on the alphanumeric screen of the controller or can be output to an external printer or computer via the RS-232 port which is specified by TS2. Logging and the RS-232 port are not specified by TS1 and are not available with some TS1 controllers on the market.

Path to Expansion & Innovation

A near-term benefit of TS2 is that it makes provisions for up to 64 detectors. Such a large number is already practical with Econolite's Autoscope® wide-area vehicle detection system, which allows multiple detectors for each approach along with more advanced control strategies. In case of TS1, which is pin-limited, more than eight detectors can only be accommodated by a controller configuration that is non-standard.

A long-term benefit of TS2 is that the SDLC bus creates an open architecture, which allows virtually unlimited cabinet and interface expansion for currently unspecified future equipment. The systems interface is also standardized and in combination with the pending NTCIP standard, will extend the open architecture to the systems level. With TS2 and NTCIP, the traffic control system of the future will be able to integrate traffic cabinets by different manufacturers as well as non-traditional traffic control equipment, such as variable message signs. In combination, TS2 and NTCIP will open the door to the new world of ATMS and ITS/IVHS applications.

The TS2 Standard provides a "technology platform" which will not be obsolete in the foreseeable future. It assures that users will get the full value and life expectancy from their investment without being forced into premature upgrades or replacements. In due time, older, less capable traffic control equipment will go the way of 33-RPM records, 8-track tapes, and 5¼-inch floppy disks.

Background of TS2

The TS2 "Traffic Controller Assemblies" Standard was approved by NEMA in March of 1992. It represents the first major update of the familiar TS1 "Traffic Control Systems" standard, which was issued in 1975, reissued in 1983, and reaffirmed for another five years in 1994.

TS1 sets minimum requirements for safe and effective traffic controllers, conflict monitors (CMUs), loop detectors, load switches, flashers, terminals, and facilities. Its provision encompasses environmental and AC power specifications, functional specifications for 2 to 8-phase actuated controller operation and the pinout of cylindrical A, B, and C connectors of the controller.

TS1 has received widespread support. It has served the traffic community well for over the past 20 years, but limitations have become apparent as traffic control strategies have evolved.

TS1 Limitations in Standardization

TS1 does not specify auxiliary functions such as coordination, preemption, time-based control, automatic flash, diagnostics,

or telemetry. These functions have been implemented in different ways by different manufacturers. TS1 also does not specify the user interface, diagnostics, or event logging. As a result, some TS1 controllers on the market are deficient in these areas.

TS1 Limitations in Safety & Liability

While the CMU specified by TS1 assures a high degree of safety, there is room for improvement for today's litigious society. The CMU only looks for conflicting Green, Yellow, and Walk signals and for the absence of voltage for Red. Signals are only detected at the output of the load switches. There is no monitoring of the duration of Yellow Change intervals and a short Yellow is often alleged in case of a traffic accident.

There is no verification of proper cabinet operation upstream of the load switches and there is no backup for the CMU in case it malfunctions.

TS1 Limitations Due to Pinout & Wiring

The pinout and point-to-point wiring specified by TS1 have proven to be a limitation to expansion and technical innovation. Even though there are a total of 171 pins on the A, B, and C connectors, many functions assigned to these pins are typically unused. There can only be a maximum of eight phases with one vehicle detector and one pedestrian detector per phase. The point-to-point wiring also results in thick cable harnesses, which are difficult to work with and have a large number of electrical connections, all of which are potential failure points.

The TS2 Solution

The TS2 Standard was developed to fill in the omissions of the TS1 Standard to assure more interchangeability of equipment between manufacturers, to enhance safety, to provide cabinet-level diagnostics, to upgrade the user interface, to allow cabinet expansion, and to provide for future innovation while simultaneously offering a path for downward compatibility with existing TS1 equipment.

Two types of TS2 cabinets are defined: Type-1, where a high-speed, bidirectional SDLC serial data bus interconnects all cabinet components, and Type-2, where the serial data bus is augmented by the A, B, and C harnesses of TS1. An Econolite Type-2 controller provides upward and downward compatibility, since it can be used either in a Type-1 or TS1 cabinet.

Highlights of TS2 Standard by Section

1. Definition of Terms

2. Environment

Specifies operating temperatures (-34°C to +74°C), operating power (89-135VAC, 60± 3 Hz), power interruptions, transients, shock, and vibration. The brownout limit of 89 VAC is a substantial improvement over the 95 VAC limit of TS1.

3. Controller Unit (CU)

Defines four controller types: Type-1 or Type-2, actuated or pre-timed. Defines Port 1 (SDLC port for serial communications within cabinet), Port 2 (RS-232 port for interface to printer or PC), and Port 3 (system interface using four-wire full duplex FSK telemetry at 1200 bps). Specifies pinout of A, B, and C connectors for Type-2 operation. Allows seldom-used pins to be reassigned by selecting one of eight I/O modes. Defines functions which were not covered by TS1 including time-based control, coordination, preemption, automatic flash, system functions, hardware diagnostics, detector logging, and event logging.

4. Malfunction Management Unit (MMU)

Assures interchangeability of units by different manufacturers and downward compatibility with TS1. Specifies 12 and 16 channel versions. Specifies checks of AC power failure, power brownout, conflicting channels, absence of Red voltage, duration of Yellow Change and Red Clearance intervals, controller watchdog time-out, and +24 VDC voltage.

5. Terminals & Facilities

Assures uniformity in cabinet layout and field-terminal labeling. Specifies BIU for interface to SDLC bus. Makes provision for 16 BIU addresses. Specifies pin functions of BIUs 1-4 for load switches, preemption, ped calls, automatic flash, dimming, hold, recall, force-off, plan select, and other controller I/O functions. Specifies pin functions of BIUs 8-12 for up to 64 detectors. States that use of a BIU-interfaced detector rack is optional in a TS2 Type-2 cabinet. Reserves spare BIU addresses and pins for future expansion and manufacturer-specific functions.

6. Auxiliary Devices

Specifies minimum requirements for load switches, flashers, and flash transfer relays. Specifies four rack-mount detector types: 2-channel or 4-channel, with or without delay/extension timing. Specifies a health status output for each detector channel: normal operation, watchdog time-out, open-loop, shorted-loop, and excessive change in inductance. Assures that TS2 detectors, load switches, flashers, and flash transfer relays are usable in a TS1 cabinet.

7. Cabinets

This section, which is not found in TS1, sets mechanical standards for aluminum and steel cabinets. Defines six cabinets ranging from 24 inches to 72 inches in height. Specifies foundation for base-mount cabinets to facilitate replacement of cabinets by different manufacturers.

8. Bus Interface Unit (BIU)

Specifies dimensions, power, environment, connectors, and pin assignments for this plug-in unit, which interfaces the SDLC bus to a terminal and facilities back panel or detector rack.