NEMA Standards Publication TS 2-2021

Traffic Controller Assemblies
with NTCIP Requirements
Version 03.08

Published by:

National Electrical Manufacturers Association
1300 North 17th Street, Suite 900
Rosslyn, Virginia 22209

www.nema.org

NOTICE AND DISCLAIMER

The information in this publication was considered technically sound by the consensus of persons engaged in the development and approval of the document at the time it was developed. Consensus does not necessarily mean that there is unanimous agreement among every person participating in the development of this document.

The National Electrical Manufacturers Association (NEMA) Standards and guideline publications, of which the document contained herein is one, are developed through a voluntary consensus Standards development process. This process brings together volunteers and/or seeks out the views of persons who have an interest in the topic covered by this publication. While NEMA administers the process and establishes rules to promote fairness in the development of consensus, it does not write the document and it does not independently test, evaluate, or verify the accuracy or completeness of any information or the soundness of any judgments contained in its Standards and guideline publications.

NEMA disclaims liability for any personal injury, property, or other damages of any nature whatsoever, whether special, indirect, consequential, or compensatory, directly or indirectly resulting from the publication, use of, application, or reliance on this document. NEMA disclaims and makes no guaranty or warranty, expressed or implied, as to the accuracy or completeness of any information published herein, and disclaims and makes no warranty that the information in this document will fulfill any of your particular purposes or needs. NEMA does not undertake to guarantee the performance of any individual manufacturer or seller's products or services by virtue of this Standard or guide.

In publishing and making this document available, NEMA is not undertaking to render professional or other services for or on behalf of any person or entity, nor is NEMA undertaking to perform any duty owed by any person or entity to someone else. Anyone using this document should rely on his or her own independent judgment or, as appropriate, seek the advice of a competent professional in determining the exercise of reasonable care in any given circumstances. Information and other Standards on the topic covered by this publication may be available from other sources, which the user may wish to consult for additional views or information not covered by this publication.

NEMA has no power, nor does it undertake to police or enforce compliance with the contents of this document. NEMA does not certify, test, or inspect products, designs, or installations for safety or health purposes. Any certification or other statement of compliance with any health or safety-related information in this document shall not be attributable to NEMA and is solely the responsibility of the certifier or maker of the statement.

Contents

Tables

Figures

Foreword

NEMA Standards Publication TS 2-2021 *Traffic Controller Assemblies with NTCIP Requirements* has been developed as a design guide for traffic signaling equipment that can be safely installed and provide operational features not covered by NEMA TS 1-1989 *Traffic Control Systems*.

Within the Standard, any reference to a specific manufacturer is made strictly for the purpose of defining interchangeability where there exists no nationally recognized Standard covering all the requirements. The manufacturer references do not constitute a preference.

NEMA TS 2-2021 has been established to reduce hazards to persons and property when traffic signaling equipment is properly selected and installed in conformance with the requirements herein.

The user's attention is called to the possibility that compliance with this Standard may require use of an invention covered by patent rights. By publication of this Standard, no position is taken with respect to the validity of this claim or of any patent rights in connection therewith.

Comments and suggestions for improvement are encouraged, and should be sent to:

NEMA Technical Operations Department
National Electrical Manufacturers Association
1300 North 17th Street, Suite 900
Rosslyn, Virginia 22209

History

This Standards publication is predicated upon an industry-perceived need to overcome limitations of the NEMA Standards Publication TS 1 *Traffic Control Systems*, which in 1976 reflected the first industry documentation of technically adequate and safe traffic control equipment.

NEMA TS 1 as subsequently revised and expanded and reaffirmed in 1989:

1. Defined effective actuated intersection control.
2. As a complete package defined all equipment within the cabinet and test procedures.
3. Provided equipment interchangeability between manufacturers.
4. As a minimum functional Standard, facilitated design innovations.

Limitations inherent in NEMA TS 1 were seen as follows:

1. Reliance on point-to-point wire connection for all functions with termination points for all wires, many of which are not utilized.

    a. Numerous connections increase failure potential.
    b. Not cost-effective.
    c. Hardware limited expandability.

2. Out-of-date technology.
3. Lack of uniformity in the implementation of the following functions and the resulting loss in equipment interchangeability:

    a. Coordination.
    b. Time Base Control.
    c. Preemption.
    d. Uniform code flash.
    e. Communications.
    f. Diagnostics.
    g. User interface.

The following industry guidelines were established to overcome the limitations in NEMA TS 1:

1. Equipment requirements based on valid engineering concepts.
2. Interchangeability, performance-oriented, without precluding downward compatibility with TS 1 equipment.
3. Emphasis on use of enhanced diagnostic techniques.
4. Minimize potential for malfunctions.
5. Provide for future expandability.
6. Enhanced user interface.

Four basic proposals were considered over a four-year period. These were:

1. Standardize the functions being provided on the MSD connector.
2. Free up seldom-used pins on the MSA, MSB, and MSC connectors and reassign them to needed functions.
3. Develop an entirely new performance-oriented Standard.
4. Proceed with Proposal 1 then move on to Proposal 3 for a long-term solution.

During the investigations, each proposal involved debate within the industry and inputs were received from traffic engineers and those responsible for the selection, installation, and maintenance of traffic control equipment actions.

Industry debate of which approach to follow consumed approximately 2.5 years before approval of Proposal 3—proceed with the development of an entirely new performance-oriented Standard. While the majority of the industry tended to favor this proposal, some Members in opposition had concerns, many of which were valid, and each was carefully studied and evaluated, including joint consultations with delegations from the Institute of Transportation Engineers (ITE) and the International Municipal Signal Association (IMSA), as well as at NEMA-sponsored open forums at Annual Meetings of ITE.

The advantages of a new performance-oriented Standard were identified as:

1. Communication between major equipment within the cabinet over a data channel with virtually unlimited capacity. Potential for future expandability is thereby maximized.
2. Use of a high-speed data channel between the controller unit, malfunction management unit, detectors, and rear panel reduces the number of connections and facilitates diagnostic testing, thereby reducing the potential for malfunction.
3. Cost-effectiveness of communications protocols.
4. Enhanced user interface.

During the development of the new NEMA Standards Publication TS 2, two approaches evolved:

1. Type 1, which utilizes a high-speed data channel between all major equipment to maximize the functionality and expandability.
2. Type 2, which retains the MSA, MSB, and MSC connectors for data exchange with the rear panel, providing a degree of downward compatibility.

Document version numbers are assigned retroactively as follows:

1. TS 2-1992 v01.00, *Traffic Controller Assemblies*, is retroactively referenced as v01.00.
2. TS 2-1998 v02.04, *Traffic Controller Assemblies*, which includes updates described in the front matter section, “TS 2-1998 Update,” is retroactively referenced as v02.04. The letter ballot was of version 98.03.
3. TS 2 Amendment 1 v01, March 2001, was approved by NEMA in November 2001. The amendment revises Section 8.
4. TS 2-1998 v02.05, *Traffic Controller Assemblies*, which is the 1998 version when revised in accordance with Amendment 1 v01, is retroactively referenced as v02.05.
5. TS 2-2003 v02.06, *Traffic Controller Assemblies with NTCIP Requirements*, is the revised and re-balloted version, including the revisions from Amendment 1 v01 and minor revisions to sections 3, 5, and 6, as detailed on the “Update” page and as noted by change bars or bold rectangles for an entry in a table. TS 2-2003 v02.06 was balloted in January 2003 and approved by NEMA in May 2003.
6. TS 2-2014 v03.06, *Traffic Controller Assemblies with NTCIP Requirements*, is the Draft revision of the TCS Technical Committee, including the revisions as noted by change bars.
7. TS 2-2016 v03.07, *Traffic Controller Assemblies with NTCIP Requirements*, is the Draft revision of the TCS Technical Committee, including the revisions as noted by change bars.
8. TS 2-2021 v03.08, *Traffic Controller Assemblies with NTCIP Requirements*, is the Draft revision of the TCS Technical Committee, including the addition of 5.4.2.5.1.

TS 2-1998 Update

The following is a summary of the changes provided by the 1998 release of this Standards publication:

Section 2:

The Standards publication has been restructured to move all testing criteria into Section 2.

Section 3:

Type 129 MMU Inputs/Status frame has been updated to add “Start-Up Flash Call” bit. This status bit enables the CU to enter the Start-Up Flash state following any terminal and facilities flash mode.

NTCIP Requirements has been added. Additional Controller Unit types with two Conformance Levels has been added for NTCIP requirements.

Port 1 Frame Fault Flash has been modified to limit the number of times the device may exit this fault state in a specific time without user interaction.

Section 4:

Pin Assignments has been modified to add “Local Flash Status” input on Connector B. This and the Output Relay modification are key to enabling the CU to enter Start-Up Flash following any Terminal & Facilities flash mode.

Output Relay operation has been modified to add “Start-Up Flash Call” bit in Frame 129.

Display has been modified to add “Local Flash Status” input indication.

Minimum Yellow Change/Red Clearance Interval Monitoring has been modified to remain enabled when the load switch Flash bit is set to 1 in the Type 0 frame from the CU.

Port 1 Timeout operation has been modified to limit the number of times the device may exit the fault state in a specific time without user interaction.

Section 5:

Port 1 Communication Cables shielding has been modified to terminate to Earth Ground.

Malfunction Management Unit wiring has been modified to add “Local Flash Status” input.

Section 6:

Detector Configurations has been modified to add four new types (AC, BC, CC, and DC) with communications port TX and RX capability.

Detection Outputs and Status Outputs condition has been added for the Disable and Reset states.

Detector Connector Terminations has been modified to add Detector Address Bit #3.

Section 8:

BIU Configurations has been modified to add one new type (BIU2) with communications port TX and RX capability.

TS 2-2003 Update

The following is a summary of the changes provided by the 2003 release of this Standards publication:

Section 3:
Page 54: Section 3.3.1.4.2.2
Type 129 MMU Inputs/Status (Type 1 ACK)—revised
Page 128: Section 3.9.3.1.3 Port 1—revised

Section 5:
Page 163: Section 5.3.3 Port 1 Communication Cables—revised
Page 171: Section 5.4.2.1 Grounding System—revised

Section 6:
Page 198: Table 6–2 Connector Terminations—revised

Section 8:
Page 206: Section 8.5 Power Requirements—revised
Page 206: Section 8.5.1 Initialization—revised
Page 207: Section 8.7.1 Communication Port Electrical Requirements—revised
Page 209: Section 8.8.4
Outputs—revised
Page 210: Section 8.8.4.1.4 TX Output Shorts—revised
Page 210: Section 8.8.5.2 Opto Inputs—revised
Page 211: Section 8.8.5.4 24 Volt Signal Inputs—revised
Page 211: Section 8.8.5.4.2 Function Inputs—revised
Page 212: Section 8.8.5.5
Data Receive Input (RX) for BIU Type BIU2—revised

> Note: Page numbers refer to the page number on which these revisions appeared in NEMA TS 2-2003. The page number on which the cited section appears in NEMA TS 2-2016 may differ.

NEMA TS 2-2016 Update

The following is a summary of the changes provided in NEMA TS 2-2016:

Section 3:

Section 3.2.3.1 Materials—Printed Circuit Assembly specifications added
Section 3.2.3.4 Unit Identification—Printed Circuit Assembly specifications added
Section 3.2.3.5 Conductors—Printed Circuit Assembly specifications added
Section 3.2.3.6 Design—Printed Circuit Assembly specifications added
Section 3.2.3.7 Coating—Added specification for UV-traceable coating
Section 3.3.1.3 Data and Clock Communications Protocol—Added requirement
Section 3.3.1.4.2.2 Type 129 MMU Inputs/Status (Type 1 ACK)—Revised
Section 3.5.8.1 Flashing Yellow Arrow (FYA)—Added support for FYA
Section 3.7.2 Operation—Added specification for pulsing input state
Section 3.9.3.1.3 Port 1—Revised

Section 4:

Section 4.1.3 Flashing Yellow Arrow (FLA) Configurations—Added
Section 4.3.2.2 Pin Assignments—Added identifiers for Stop Time and Flash Drive
Section 4.6 Flashing Yellow Arrow (FLA) Support (MMU2 Only)—Added

Section 5:

Section 5.2.4 Printed Circuits—Moved to 3.2.3
Section 5.4.2.3 Signal Bus—Revised
Section 5.4.2.7 Lighting Fixture—Revised
Section 5.5.3 Malfunction Management Unit—Figure 5–5 redrawn

Section 6:

Section 6.2.1, Item 8, Material and Construction of Rigid Printed Circuit Assemblies—Moved to Section 3.2.3
Section 6.2.3 Input Electrical Characteristics, Item 4—Revised
Section 6.3.2, Item 8, Material and Construction of Rigid Printed Circuit Assemblies—Moved to Section 3.2.3
Section 6.3.3: General Electrical Characteristics, Item 4—Revised
Section 6.4.1.3: Transients—Revised
Section 6.5.2.4.1: Materials—Printed circuit board moved to Section 3.2.3

Section 8:

Section 8.2.2 Printed Circuits—Moved to Section 3.2.3
Section 8.2.3 Dimensions—Added half-width BIU to Figure 8–1
Section 8.8.5.2 Outputs—Added Item 8

Notes:
1. The term “AEI” previously identified recommendations, guidance, or declarative statements. NEMA has deprecated this practice. In a future version of NEMA TS 2-2016, the term “AEI” is slated for deletion.

2. Throughout NEMA TS 2-2016, certain terms are used in text with initial capitals, and some terms are boldface in text. NEMA has recently revised these practices. In a future version of NEMA TS 2-2016, these conventions are not slated to appear.

NEMA TS 2-2021 Update

The following is a summary of the changes provided in NEMA TS 2-2021:

Section 1:
Section 1.1 Definitions—Added definitions

Section 2:
Section 2.2.7.5 Test E: High-Temperature High-Voltage Tests—Rephrased item #3
Section 2.3.1 Test Facilities—Rephrased item #7
Section 2.3.10 DC Voltage Monitoring—Reordered items

Section 3:
Table 3–2 Response Frames—Updated note
Section 3.3.5.1.4 Outputs—Corrected usage of the ± symbol in item b.1
Section 3.3.6 NTCIP Requirements—Updated references to NTCIP Standards
Section 3.5.3.2 Phase Intervals—Corrected ordering of items; rephrased text of item #6
Section 3.5.8.1.1 Requirements—Corrected mention of fFa
Table 3–14 Timing Plan—Renumbered table
Table 3–15 Offset—Renumbered table

Section 4:
Section 4.3.5 Display—Rephrased item g
Figure 4–1 Programming Card—Updated figure and rephrased note 2
Section 4.4.1 MMU Power Failure—Reordered items

Section 5:
Section 5.4.2.5.2 Radio Interference Suppression—Added regulation compliance language
Section 5.2.8 Load Switch and Flasher Support—Corrected millimeter value

Section 6:
Figure 6–3 Flash Transfer Relay Wiring Diagram—Updated figure
Section 6.5.2.28.1 Connector Description—Corrected inch value

Throughout:
Deleted references to AEI

< This page intentionally left blank. >

Section 1
Scope

NEMA TS 2 covers traffic signaling equipment used to facilitate and expedite the safe movement of pedestrians and vehicular traffic.

Two approaches to the expansion of traffic features of NEMA TS 1 *Traffic Control Systems* are provided:

1. Type 1: Entirely new performance-oriented Standard.
2. Type 2: Use of the MSA, MSB, and MSC connectors in common use with NEMA TS 1 equipment.

The Type 1 approach embraces:

1. Controller Unit.
   a. Display.
      i. Alphanumeric Display: 32 Characters, 2 Lines Minimum.
   b. Port 1 Connector.
      i. High-speed full-duplex data channel connecting controller unit, conflict monitor (malfunction management unit), rear panel (terminals and facilities), and detectors.
      ii. All data exchange with rear panel.
      iii. Controller unit and conflict monitor exchange information on a regular basis, performing redundant checks on each other. Controller unit has access to all conflict monitor internal information, making enhanced event logging, remote intersection monitoring, and remote diagnostics feasible.
      iv. All detector information, including detector diagnostics.
      v. TIA-485-A serial communications interface with noise immunity characteristics.
      vi. SDLC (synchronous data link) communication protocol with a bit rate of 153,600 bits/second, utilizing sophisticated error checking.
      vii. Vast reduction in number of wires in the cabinet.
   c. Port 2 Connector.
      i. Interface to personal computer.
      ii. Interface to printer.
   d. Port 3 Connector.
      i. 1200 baud, FSK serial port for on-street communications.
   e. Standard Features.
      i. Actuated control.
      ii. Conditional service.
      iii. Additional detectors.
      iv. Delay/extension/switching detectors.
      v. Dual entry.
      vi. Alternate phase sequences.
      vii. Start-up flash.
      viii. Automatic flash.
      ix. Dimming.

x. Coordination: sixteen timing plans; one cycle length per timing plan; one Split per timing plan; three Offsets per timing plan.
xi. Preemption: six inputs; six sequences.
xii. Time base: yearly clock; daylight saving; leap year.
xiii. Internal diagnostics: memory diagnostics; processor monitoring; conflict monitoring checking; detector diagnostics.

2. Conflict Monitor (Malfunction Management Unit)
   a. Single Type: configurable as 12 four-input channels or 16 three-input channels.

   b. Port 1 Connector.

      i. Communications with controller unit, as described above.
      ii. MSA, MSB connectors downward compatible with those on a TS 1 conflict monitor; used primarily for sensing of voltages on field terminals.
      iii. Low-voltage monitoring: monitor will be the first unit in a cabinet to sense a low-voltage condition and will put intersection in flash in an orderly manner. This sequence will be reversed on power-up.

   c. Detectors.

      i. Rack mounted, 16 detector channels per rack, up to four racks.
      ii. Port 1 connector: pluggable, interchangeable bus interface unit to convert Port 1 high-speed serial data to format required by individual detectors.
      iii. Communications with controller unit, as described above.
      iv. Per channel diagnostic data: open loop; shorted loop; excessive inductance change; watchdog failure.
      v. Detector reset capability.
      vi. Operation from either 12 or 24 VDC power supply.

   d. Rear Panel (Terminals and Facilities).

      i. Conventional load switches, flasher, flash transfer relays.
      ii. Termination points for needed functions.
      iii. Port 1 connector: communications with controller unit, as described above, and pluggable, interchangeable bus interface unit to convert Port 1 high-speed serial data to format required by rear panel.

The TS 2 Type 2 is the same as the Type 1 with the following exceptions:

1. The MSA, MSB, and MSC connectors for the Controller Unit are compatible with equipment conforming with NEMA TS 1-1989.
2. MS connector pin-outs are configurable to one of eight modes to satisfy different applications and achieve different functionality. Default mode is pin compatible with NEMA TS 1-1989.