MICHIGAN

DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION

FOR

**MALFUNCTION MANAGEMENT UNIT SMART MONITOR**

SIG:EMS 1 of 8 APPR:HLO:NJB:05-17-24

**a. Description.** This work consists of furnishing, delivering, and installing a Malfunction Management Unit (MMU) (also referred to as a Smart/Conflict Monitor).

This work includes furnishing and delivering the MMU to the maintaining agency for unit setup and transporting the MMU from the maintaining agency to the job site for installation. This work includes installation of the MMU, and accessories required to provide the traffic signal control operations as shown on the plans, in accordance with the *MMUTCD* and this special provision. As applicable this work includes mounting hardware, wiring, connectors, grounding, terminating signal wiring, conduit risers, and all appurtenant materials required to complete installation.

The maintaining agency for this project is:

City of Grand Rapids

Attn: Matt Van Dyke

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**b. Materials.** Furnish material meeting sections 918 and 921 of the Standard Specifications for Construction and this special provision.

1. Cabinet Integration. This special provision defines the minimum acceptable requirements for installing the MMU into the series of cabinets that differ in size, to house the controller unit (CU) and related devices.

A. Terminal Facility. This special provision defines the minimum acceptable requirements for terminal facilities to interconnect the related devices within a traffic control cabinet.

(1) Mechanical Construction. Ensure the terminal facility is in accordance with the following mechanical requirements.

(a) Load Switch, Flasher, and Flasher Transfer Positions.

(i) Wire the load switch sockets for triple-signal load switches in accordance with *Section 5 of NEMA Standards Publication TS 2* for Type 2 CUs. Ensure all load switch driver outputs coming out of the CU are on separate terminal points from the respective inputs to the load switches. Ensure these separate termination points are bussed for normal operation. Ensure all load switch outputs are on separate points from the respective inputs to the MMU inputs. Ensure these separate points are bussed for normal operation.

(b) Terminal Blocks. Ensure terminal blocks have mechanical characteristics to properly support the wiring connected without warping the terminal block. Ensure all materials including screws and threaded portions used in terminals and terminal blocks are stainless steel. Ensure the maximum number of wire terminations or metal jumpers used in any combination under a single screw does not exceed two in number.

(i) Control Terminal Blocks. Include control terminal blocks for inputs and outputs of the CU, MMU, flash transfer relays, load switches, etc. Ensure these blocks are either single terminal type with through-panel connections or double binder head screw terminals. Ensure either type of terminal block uses the correct ampacity for the application. Minimum acceptable ratings are 15 ampere (A), 250 volt (V), with 6-32 by 1/4-inch pan or binder screws. Ensure the maximum number of wire terminations or metal jumpers used in any combination under a single screw does not exceed two in number.

Ensure the control terminal block wiring provides groupings of functions based on probable interconnect (bussing) for normal operation rather than based on the source of the wiring (e.g., CU, MMU, etc.).

(c) CU and MMU Harnesses.

(i) Ensure the CU and MMU harnesses are neatly arranged and furnished with the flexibility for the connectors to reach at least 40 inches from the top of the terminal block panel which must be mounted directly below the CU shelf. Ensure the harness connectors do not have any sharp edges and the stress relief attachment screws do not extend greater than 1/4 inch beyond the stress relief.

Ensure terminal positions are furnished, completely wired, and neatly arranged, furnishing access to all inputs and outputs listed in the CU specification. Ensure all *NEMA Standards Publication* functions of the CU for the configuration selected are terminated, except those designated by *NEMA* as spares, reserved, no connection, and manufacturer's use need not be installed in the harness.

(ii) Ensure terminal positions are furnished, completely wired, and neatly arranged, furnishing access to inputs and outputs in the MMU. Ensure all MMU input is terminated. Ensure provisions are made to terminate any unused red monitoring inputs. Ensure type select and port one disable inputs are terminated.

(iii) Furnish a D connector for connection to the CU. Furnish a connector of the style for the controller approved for the project. Attach the connector terminal strip via channel nuts to the upper left side of the cabinet.

(iv) Ensure the MMU harness is configured for a 16 channel MMU operating in the type 12 mode. Ensure the MMU harness is configured as specified in Table 1.

**Table 1: MMU Harness Configuration**

|  |  |  |
| --- | --- | --- |
| Configuration | Load Switch | MMU |
| A2 | 8 | 12 Channel |
| A5 | 12 | 12 Channel |
| A16 | 16 | 12 Channel |

(2) Electrical Requirements. Ensure the terminal facility conforms to the following electrical requirements:

(a) Power Distribution. Ensure the terminal facility operates properly when supplied with single-phase AC power [95-135 V, 57-63 hertz (Hz)] when non-ITS cabinets and 240 V when an ITS type cabinet. Ensure all breakers and grounding devices are wired in accordance with the *NEC* and the *Michigan Electrical Code*.

(i) Circuit Breakers. Ensure provisions are made for mounting and wiring up to nine circuit breakers in the terminal facility. Ensure a quantity of seven circuit breakers are furnished with ampacities as specified in Table 2.

**Table 2: Circuit Breaker Ampacity (in A)**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Configuration | Main | Vehicle LoadSwitch | Pedestrian LoadSwitch | Flasher | Miscellaneous | Channel Reds | Illuminated Sign |
| A2 | 30 | 10 | 10 | 10 | 10 | 10 | 20 |
| A5 | 30 | 10 | 10 | 10 | 10 | 10 | 20 |
| A16 | 30 | 10 | 10 | 10 | 10 | 10 | 20 |

The 6-ITS cabinets must include an additional 30 A circuit breaker mounted on the main cabinet power panel, utilizing a single phase of the AC power to power the ITS compartment devices. Furnish two 15 A and one 10 A circuit breakers in the ITS compartment, wired to the load side of the 30 A breaker.

Ensure the main circuit breaker is wired to protect the entire facility and is identified as the “MAIN” breaker. Ensure the Vehicle Load Switch breaker and the Pedestrian Load Switch breaker are fed by the load side of the bus relay and furnishes power to the vehicle and pedestrian load switches, respectively. Ensure the Flasher breaker has the flasher connected to its load side. Ensure the miscellaneous breaker has the cabinet fan, light, and door mounted duplex receptacle connected to its load side. Ensure the Channel Red breaker is connected to the input to the MMU for the Red enable and cabinet control relay coils. Ensure the Illuminated Sign breaker is available to power auxiliary devices. Ensure the breaker for the ITS compartment (if used) is fed by a separate phase connected to the power disconnect. Ensure the circuit breakers are capable of manual operation with markings to indicate rating and whether it is in the open or closed position. Ensure Square D series QOB circuit breakers are used and mounted on QON3B triple position breaker blocks.

Ensure a four pole fuse holder with screw terminals for connecting individual illuminated sign loads is furnished and wired to the load side of Illuminated Sign breaker. Include a 5 A time delay fuse with each holder.

(ii) Cabinet Surge Protection. Ensure the power panel has devices to furnish both primary and secondary surge protection devices. Ensure the Line In, Neutral In, and Ground leads of the primary device are to be kept as short as possible (18 inches maximum), with no sharp bends and not bundled with other conductors.

Ensure the primary surge protection device (SPD) has two separate hot legs. For the non-ITS cabinets, ensure both legs of the SPD are connected to the load side of the main circuit breaker. Ensure for the 6-ITS cabinets, the second leg is connected to the load side of the main circuit breaker for the ITS compartment. Ensure the primary SPD is connected in parallel to the load and have a surge capacity of 160 kiloamperes (kA) per phase or greater. Ensure the let through voltage measured 6 inches outside the unit does not exceed 430 V for 3 kA 8/20 microseconds(u/s) pulse or 650 V for 10 kA 8/20 u/s pulse. Ensure modes protected are Line to Ground, Line to Neutral, Line to Line, and Neutral to Ground. Ensure the SPD furnishes Green LED indications that protection is operational and Red LED indications that a fault has occurred. Ensure in addition, an audible alarm sounds indicating a fault has occurred. Ensure there is a set of normally open and normally closed contacts available for remote monitoring of the SPD. Ensure the SPD is no larger than 9.3 inches wide by 3 inches high by 4.93 inches deep. Ensure the SPD is mounted on the lower right-hand side of the cabinet and easily accessible for replacement.

Ensure the secondary SPD is connected to the load side of the main circuit breaker and its output is used to supply AC power for the CU, MMU, and cabinet electronics power strip. Ensure the surge current capacity is 50 kA or greater, with the unit connected in series to the load. Ensure the secondary SPD is a 5-stage hybrid design with integrated filter with series load current of 12 A. Ensure the let through voltage measured 6 inches outside the unit does not exceed 260 V for 2 kA 8/20 u/s pulse or 300 V for 3 kA 8/20 u/s pulse. Ensure modes protected are Line to Ground, Line to Neutral, and Neutral to Ground.

Ensure a gas tube device is installed on the load side of the main circuit breaker. Ensure it is possible to replace this device without interrupting power to the rest of the terminal facility. The 6-ITS cabinets must have a second gas tube device installed on the load side of the main circuit breaker feeding the ITS compartment. For the ITS cabinets, ensure that the ITS compartment includes a switched, surge protected, outlet strip. This outlet strip is to furnish a minimum 3,300 joule suppression rating and is wired to the load side of one of the 15 A ITS compartment breakers. Ensure the outlet strip is mounted on the panel on the right side of the cabinet.

(b) Control Circuits.

(i) Flash Transfer Control. Ensure the control circuit to the flash transfer relay sockets can furnish flashing operation when the MMU or optional auxiliary equipment call for flash (e.g., police panel flash switch and maintenance panel). Ensure the flash transfer control also conforms to the following:

Ensure the flash transfer relay socket is wired so the coil of the relay(s) is(are) de-energized for flashing operation. Ensure the flash transfer relay sockets are near the load switches, flasher, and field signal terminals.

(ii) MMU Control. Ensure the MMU is wired to furnish flashing operation when the fault relay de-energizes or if the MMU is disconnected. Ensure it also provides "Stop Time" to the CU when the fault relay de-energizes. Ensure the MMU is wired to furnish an "External Start" signal to the CU upon the application of AC power to the MMU following a power interruption or upon initial turn-on.

(3) Auxiliary Equipment.

(a) Ensure the terminal facility includes provisions for the following equipment in a panel accessible from a police door on the front of the cabinet.

(i) Signals On-Off Switch. Ensure a signals on-off switch is included, installed, and wired.

Ensure the switch and wiring energizes or de-energizes the solid-state signal power relay. Ensure the AC signal power is not routed through this switch. Label the switch "Signal-Off". Ensure when in the “Off” position, all signal field terminals are de-energized and the Red Enable input to the MMU is inactive.

(ii) Flash Normal Switch. Ensure a flash-normal switch is included.

Ensure when in the Flash position, the flash transfer relays and solid state signal power relay is de-energized, and power is removed from the MMU and CU, resulting in flash being displayed to traffic. Ensure neither AC signal power nor flashing power is routed through this switch. Ensure the switch is labeled "flash-normal".

Ensure when the switch is returned to the “Normal” position, the signals return to the initialization phase and begin cycling.

Ensure operation of the signal-off switch overrides this switch. That is, when in the "Off" position, the signal-off switch prevents flashing operation as called for by all flash control circuits.

(b) Maintenance Panel Options.

(i) Stop Time Switch. Furnish a stop time switch in a panel on the inside of the front cabinet door. Ensure the switch and wiring furnishes three modes of operation which are:

1) Normal. Furnishes "Stop time" to the CU as required by the MMU.

2) Run. Prevents “Stop time” from being applied to the CU from other devices.

3) Stop. Applies “Stop time” to the CU.

(ii) Flash-Normal Switch. Furnish a flash-normal switch in a panel on the inside of the front cabinet door.

2. Accessories. This special provision defines the minimum acceptable requirements for plug-in accessories for the MMU into the controller assembly within a traffic control cabinet.

A. Malfunction Management Unit (MMU). Furnish an MMU from the following list.

(1) EDI Smart Monitor MMU2-16LE(ip).

(2) Approved Equal (AE). The AE must be evaluated, tested, and approved per the MDOT New Traffic Signal Device Product Review Guidelines. The review time is not justification to delay the project.

B. This subsection defines the minimum requirements for a shelf-mountable, 16 channel, Ethernet capable MMU. Ensure the MMU meets, all applicable sections of the *NEMA Standard TS-2-2003 (R2008)* for MMU2 configuration while maintaining compatibility with *NEMA TS1-1989* assemblies. Where differences occur, this special provision governs.

Furnish the following monitoring functions in addition to those required by the *NEMA* standard:

(1) Dual Indication Monitoring. Ensure the MMU can detect simultaneous input combinations of active green (or walk), yellow and red inputs on the same channel. Ensure the channels enabled for dual indication monitoring are user determined. Ensure dual indication monitor is disabled when the red enable input is not active.

(2) Field Check Monitoring. Ensure when the field signal inputs states sensed by the MMU do not correspond with the data furnished by the CU in the type #0 message for 10 consecutive messages, the MMU enters the fault mode and indicates the field check fail fault.

(3) Recurrent Pulse Monitoring. Ensure the MMU detects conflict, red fail, and dual indication faults that result from intermittent or flickering field signal inputs.

(4) Ensure when the MMU detects a conflict flash indication it provides an output to the “D” connector indicating an MMU/conflict flash status input.

(5) Ensure the MMU monitors an intersection with up to four approaches using the four section Flashing Yellow Arrows (FYA) movement outlined by the *NCHRP Research Project 3-54* on Protected/Permissive signal displays with FYA. Ensure the MMU furnishes the same fault coverage for the FYA approaches as it does for conventional movements including conflict, red fail, dual indications, and minimum clearance monitoring.

Ensure the MMU furnishes alternate configuration options as follows:

(a) Red/Yellow/Green (RYG) Only Red Fail Option. This function excludes the walk input from the red fail fault algorithm when operating the Type 12 mode.

(b) LED Signal Threshold Adjust. This function furnishes the capability to sense field inputs with an alternate set of voltage thresholds to better determine the state of LED signal indications. Conflict and dual indication thresholds for Green/Yellow/Red inputs are set for: No Detect is less than 15 root-mean-square voltage (Vrms). Detect is greater than 25 Vrms. Red fail thresholds for Green/Yellow/Red are set for: No Detect is less than 50 Vrms. Detect is greater than 70 Vrms.

(c) Controller Voltage Monitor (CVM) Log Disable Option. Ensure the MMU furnishes a means to disable the logging of CVM faults events.

(d) Furnish a 4 line by 20-character LCD to report MMU status, time and date, and menu navigation. Furnish a separate Red, Yellow, Green LCD indicator, display for the input status of signal inputs. Furnish individual icons to indicate channels involved in a fault.

(e) Furnish a mode to display the Vrms of each field signal input and each cabinet control signal voltage, and the frequency of the AC line, the ambient temperature measured at the MMU.

(f) Ensure when the MMU is in the fault mode, a display screen is furnished to identify all field signal inputs with field check status, and all field signal inputs with recurrent pulse status.

(g) Additional display functions include a configuration display of settings and all MMU configuration parameters; logs of previous fault, AC line, and MMU reset logs; clock set.

(h) Ensure the program card supplied with the MMU furnishes non-volatile memory that contains the configuration parameters for the enhanced features of the MMU, such that transferring the program card to a different MMU completely configures that MMU. Ensure the non-volatile memory device used on the program card does not utilize any input/output (I/O) pins designated as “Reserved” by *NEMA TS-2*.

(i) Ensure a minimum of five logs are furnished that graphically display all field signal states and red enable for up to 30 seconds prior to the current fault trigger event. Ensure the resolution of the display is at least 50 milliseconds. Ensure these signal sequence logs are accessible from the front panel registered jack (RJ)-45 Ethernet port with software available from the manufacture.

3. Warranty. Furnish materials with a standard manufacturer’s warranty, transferable to MDOT, so that the supplied materials are free from all defects in materials and workmanship. Furnish the warranty and other applicable documents from the manufacturer, and a copy of the invoice showing the date of shipment, to the Engineer prior to acceptance.

**c. Construction.** Complete this work in accordance with sections 818 and 820 of the Standard Specifications for Construction, as shown on the plans and as directed by the Engineer.

Install the device, as shown on the plans or as directed by the Engineer.

Integrate and test to meet specifications for integration and as shown on the plans.

**d. Measurement and Payment.** The completed work, as described, will be measured and paid for at the contract unit price using the following pay item:

**Pay Item Pay Unit**

Malfunction Management Unit Smart Monitor Each