ROAD COMMISSION FOR OAKLAND COUNTY

SPECIAL PROVISION
FOR
**DIGITAL / ITS TYPE NEMA TS2 TYPE 1 CONTROLLER**



## a. Description

This special provision outlines the Road Commission for Oakland County's specifications for the traffic signal controller. The traffic signal controller shall meet or exceed all requirements of the NEMA Standard TS2-2003 specification, except as detailed below. This specification describes a digital type traffic signal controller meeting the latest NEMA specifications, as well as providing advanced features for future requirements.

## b. Materials

1. **Traffic Signal Controller Unit (CU) (SCATS Compatible)**

This specification describes an advanced traffic signal controller meeting the latest NEMA specifications, as well as providing advanced features for future requirements. The traffic signal controller should also be SCATS compatible.

A. Provide a CU that is capable of running:
   (1) Fully actuated (4 to 16 phase)
   (2) 24-36 circuit solid state pretimed
   (3) Fully actuated (4 to 16 phase) closed loop master
   (4) Solid state pretimed closed loop master
   (5) A full complement of operational, programming and diagnostic capabilities.
   (6) A menu structured traffic oriented/English language operator interface providing comprehensive traffic control, analytical and management capabilities.

B. Environmental Standards. The CU must perform all of its functions within the environment as defined by NEMA Standards Publication TS 1 and TS 2. The CU must meet or exceed the applicable sections and clauses of NEMA Standards Publication TS 1 and TS 2, Section 2, with respect to each of the following functions:

| | |
|---|---|
| Operating Voltage | Transients, Power Service |
| Operating Frequency | Transients, Input-Output Terminals |
| Power Interruption | Non-destruct Transient Immunity |
| Temperature and Humidity | Vibration and Shock |

C. Provide a CU that meets the following physical, interface and functional requirements of solid state controller shelf mounted unit and complies with the current NEMA Standards Publication TS 2 - Type 2, A2 and P2, with MS A, B, and C connectors.

(1) Processor.
The control processor unit (CPU) must be a bit type, running at 25 megahertz (MHz) and provided with a Microware OS-9 operation system with runtime license. The CPU must be installed on a separate printed circuit board for ease of maintenance and upgrading.

D. Memory.
Provide a minimum of 8 MB of FLASH memory organized as a disk drive. Traffic application and intersection data must reside in FLASH memory. The FLASH memory must retain data without power, capacitor, or battery backup, and remain permanent until changed by user data entry or a new download.

Provide a minimum of 4 MB of dynamic random-access memory (DRAM) to be used to execute the traffic application software. DRAM must be capable of being reloaded from FLASH upon power restoration since it does not retain memory during power failures.

Provide 1 MB of static random-access memory (SRAM), for use as a scratchpad for temporary data storage, backed by a capacitor during power failures for a minimum of 30 days.

E. Power Supply.
Provide the CU with a modular power supply.

Provide the power supply with +5 volts direct current (VDC) for the CU electronics and +24 VDC to power devices in the control cabinet. Protect both these power supplies by 5 millimeter 2 amp slow blow glass cartridge fuses accessible from the front panel.

Include added safety circuitry to the power supply to measure line voltage and output voltage, as well as generate power fail interrupts, power up reset, and a 120 Hz signal for a time base.

Provide the power supply with a line frequency reference signal generated by a crystal oscillator that must synchronize to the 60-Hz volt alternating current (VAC) incoming power line at 120 and 300 degrees. A continuous square wave signal must be +5 VDC amplitude, 8.333 ms half-cycle pulse duration and 50± 1 percent duty-cycle. The line frequency reference must compensate for missing pulses and line noise during normal operation and continue through 500 ms power interruptions.

F. Physical Standards.
NEMA Standards Publication apply and are supplemented as follows:

(1) Dimensions.
The dimensions of the CU enclosure must conform to the following maximum limits:

Height = 7 inches Width = 16 inches Depth = 9 1/2 inches

(2) Design.
The CU housing must be formed of polycarbonate except the back panel, rear mounting tab, and power supply mounting plate must be aluminum. The housing must have a built-in carrying handle and be provided with two adjustable front mounting feet.

(3) Expansion.
There must be seven slots with card guides for standard 3U size Versa Module Europe expansion modules. The controller must also be provided with two slots with card guides for standard joint NEMA/AASHTO/ITE/Advanced Transportation Controller (ATC) modems.

The CU must also include two expansion slots that may be used to house standard 2070 ATC modules such as series modems.

G. Interface Standards.
The CU must provide an input-output interface to meet the following requirements.

(1) Ethernet Port.
There must be a built-in base-T Ethernet with RJ-45 connector on the controller front panel. There must be a unique, built-in Internet protocol (IP) address for each controller.

(2) Infrared Port.
The CU must be provided with a built-in infrared (IR) wireless port compatible with Microsoft TM Windows for Pocket personal computer (PC) infrared RAW mode. The IR port must work like the NEMA Port 2, but without the need for a cable.

(3) NEMA Port 1 SDLC. The CU must include a 15-pin “D” connector to communicate to hardware devices within the cabinet.

(4) NEMA Port 2. The CU must include a 25-pin connector compliant with the EIA-232 communications standard that serves 2 functions.

Port 2 must provide hardwired data communications to devices nearby such as laptop PCs, personal digital assistants (PDA’s), phone modems, or printers. Communications baud rates must be user selectable baud rates of up to 38400 bits per second (bps).

Port 2 must also provide signals that implement the C50 function of the Joint EMA/AASHTO/ITE Specification of the ATC and must be present on the secondary transmit and receive pins described in the EIA-232 specification for a 25-pin connector. The C50 section of this port is to be used to upload/download updated/new/alternate versions of the traffic applications software.

(5) NEMA Port 3. The CU must include an internal NEMA Port 3 communications port. This port must provide systems communications to on-street masters or central office computers. This port must be addressable with user selectable baud rates of up to 38400 bps.

The CU must come equipped, when called for on the plans, with a modular internal Frequency Shift Keying (FSK) two wire port 3 modem that is accessed on the controller front panel by way of an 9-pin “D” connector, and by way of the 37-pin “D” connector. The communications must be half duplex, time division multiplexed, 1200 BPS, asynchronous, bit serial. Output power is 0 dBM ±15 percent into a 600 ohm load. Receiver sensitivity is a minimum of -34 dBm. The FSK modem must have an anti-streaming option that will turn the modem transmitter off if the modem consistently transmits for greater than 7 seconds. The FSK modem must interface with existing FSK systems in use by the MDOT.

The CU must also be provided with a module that contains an additional 9-Pin RS-232 port and a 25-Pin RS-232 port. The module must provide an LED display for the TXD, RXD, RTS and CTS commands. The module must also provide a data key receptacle to program and read serial data keys. The data key must be provided with enough capacity to store data use by the software application. The data key must be removable and can be transferred to another controller. The data key must be designed for harsh environments with large contacts that are wiped by the rotation of the key within the receptacle. The data key must conform to Data Key TM “Key Link” serial data protocol. The data key receptacle must be attached to NEMA Port 2. One data key must be provided with each CU.

An optional Port 3 fiber optic modem must be provided when called for on the plans.

(6) C60 Connector. Provide a built-in C60 connector for use with a removable keyboard and display, PC, or PDA. The C60 protocol must conform to the joint NEMA/AASHTO/ITE ATC standard.

(7) Keyboard and Display.

(a) Programming. Programming the CU variables must be via a front panel keyboard and display. For ease of front panel programming, the controller must utilize English language menus.

The CU must prevent the alteration of keyboard set unit variables prior to the user having entered a specific code. This "Access" code must also be user programmable via the keyboard.

All variables must be displayed for visual verification concurrent with entry.

(b) Programming Security. The CU must maintain user programmable variables in non-volatile memory to assure continued safe and efficient CU operation in the event of power loss.

(c) Keyboard and Display. The keyboard and display must be contained in one unit that can be removed from the front of the CU without the use of any tools. An extension cord must be integral to the keyboard and display. The connector for the extension cord on the front of the controller must be compatible with C60 connector. The keyboard functions and terminal emulation must be per joint NEMA/AASHTO/ITE ATC standards. The liquid crystal display (LCD) must display 8 lines of 40 characters and must use a light-emitting diode for backlighting. The LCD must provide a keypad contrast adjustment. No contrast knob is allowed.

Programming of the CU variable must be via the keyboard and display. For ease of front panel programming, the controller must utilize English language menus. The CU must prevent alteration of keyboard set unit variables prior to the user having entered a specific code. The “Access” code must also be user programmable via the keyboard. All variables must be displayed for visual verification concurrent with entry.

The CU must maintain user programmable variables in non-volatile memory to assure continued safe and efficient operation in the event of power loss.

(8) A, B, C Connectors. The CU must include the A, B, and C connectors with inputs and outputs as defined by NEMA TS2-Type 2, A2 and P2, 2003. A number of the input definitions must be programmable in the CU to differ from NEMA specifications. Example: the phase omit, hold, and ped omit inputs can be redefined to provide an additional 24 vehicle detector inputs. A number of the output definitions must be programmable in the CU to differ from NEMA specifications. Example: the phase on, next, and check outputs can be redefined to provide an additional eight sets of green, yellow, red outputs.

(9) D Connector. There must be a 37-pin connector D on the front of the unit to provide for additional input/output functions and for systems communications. These functions must be manufacturer specified. A number of the input and output definitions must be programmable in the CU. This connector must provide the ability of the controller to be used in a systems environment.

H. Actuated Control. NEMA Standard TS2-2003 Publication, TS-2, 2003, Section 3 applies and are supplemented as follows:

(1) Per Phase. The CU must provide the following functional capability on a per phase basis:

(a) Conditional Service.
Conditional service must provide an optional method for phase selection and apply to vehicle phases only. If two concurrent phases are timing and a call exists on the other side of the barrier and one of the phases is prepared to terminate due to gap out or max time out, the ring containing the timed out phase must revert to a preceding vehicle phase if:

(i) A call exists on a preceding actuated vehicle phase. (Non-Actuated Phases must not be conditionally re-serviced).

(ii) The gaped/maxed phase is programmed for conditional service.

(iii) There is sufficient time remaining before max time of the other phase has elapsed.

(b) Special Detector Functions.
The following special vehicle detector functions must be provided:

(i) Detector Control.
There must be 64 vehicle detector assignments, 8 pedestrian detectors, and 8 special detectors. Each detector must be programmable for a standard vehicle detector input, pedestrian detector input, one call, stop bar A or stop bar B, Adaptive Protected Permissive Left Turn, Adaptive Protected Permissive Thru, and an AND code that only allows a call to be entered if calls are active on all detectors so programmed. In addition, each detector must be capable of being programmed to extend, delay, or switch.

(c) Extended Pedestrian Clearance.
The CU design must provide an alternate mode of operation for the Pedestrian `Don't Walk' Output to extend the flashing period (Ped Clearance) for each phase so programmed, so a portion (equal to the sum of the Yellow Change and/or Red Clearance time settings) may appear concurrently with the vehicle change intervals.

(d) Pedestrian Overlaps.
It must be possible to program phase ped outputs such that the ped outputs are active with two separate phases.

(e) Pedestrian Extend and Delay.
It must be possible to delay or advance the start of the walk display relative to the same phase green by up to 99.9 seconds in 0.1 second increments.

(f) Actuated Rest in Walk.
The CU design must provide an alternate mode pedestrian dwell for actuated phases. The actuated phase must rest in Walk when so programmed and there is no serviceable conflicting call at the end of the Walk timing.

(g) Automatic Pedestrian Clearance.
The CU design must provide an alternate mode of operation to enable timing of the pedestrian clearance interval when Manual Control Enable is active. When programmed, this feature will prevent the pedestrian clearance interval being terminated by the interval advance input.

(h) Last Car Passage.
Last car passage provides an alternate method of operation to control green termination with volume density operation.

(2) Per Unit. The CU must provide the following functional capability on a per unit basis:

(a) Simultaneous Gap Out.
Green timing termination in multiple ring controller configurations must provide for simultaneous termination. Simultaneous termination, when timing phases concurrently with the next serviceable call on a phase that conflicts with more than one of the phases timing (about to cross a barrier), insures that all phases which will terminate must simultaneously reach a point of being committed to terminate before green timing termination must begin (i.e., Gap-Out, Max-Out and/or Force-Off).

(b) Dual Entry.
Dual entry is a mode of operation (in a multiple ring CU) in which one phase in each ring must be in service, where possible subject to compatibility, at all times. If a call does not exist in a ring when it is committed to cross a barrier, a phase must be selected in that ring to be activated by the CU based on this programming.

(c) Variable Sequence.
The CU must provide controls for 16 Vehicle Phases, 16 Pedestrian Phases, and 4 Timing Rings with each phase being able to be assigned to any ring with the user definition of Ring, Phase Next, and Concurrent Phases.

(d) Overlaps.
The CU must provide controls for 16 Overlaps with each phase being able to be assigned to any overlap with the user definition of Trailing Green, Yellow, and Red Timing when needed.

(e) Detectors.
The CU must provide controls for 80 Detectors with each detector being able to be assigned as phase vehicle or pedestrian detector with Delay, Extend, and Switch capability, and assigned as System, Speed Trap, and Count Detector function.

(f) Signal Driver Outputs.
The CU must be capable to assign the Type 2 CU Signal Driver Outputs to any pin set (i.e., Overlap E outputs to Ped 1 output pins) or use Phase On, Phase Next, and Phase Check for signal driver outputs via alternate ABC connector I/O modes.

(g) Special Function Mapping Routines.

(i) Adaptive Maximum Routines.
The CU must provide, via Time Base Control (TBC), up to three separate Step values to cause the running maximum to increase or decrease smoothly based on current traffic conditions. Separate Dynamic Maximum Parameters must be available for each Step value. The Dynamic Maximum Value can be either larger or smaller than the normal maximum limit.

(ii) Adaptive Protected/Permissive Routines.
The CU must provide routines which measure the volume of left-turn vehicle traffic and available gap windows in the conflicting through-vehicle traffic to determine whether the Left Turn should operate protected or permissive.

(iii) Adaptive Variable Passage Time and Maximum Routine.
The CU must provide routines that have up to three separate values to increase or decrease the default passage time enabled via TBC.

(iv) Coord Adaptive Split.
The CU must provide a routine to allow the utilization of unused coord split time to be allocated to a split that is being forced during coordination.

(v) Permissive Red Flash Routine.
The CU must provide a routine to allow an in-cycle red flash during the through green phase(s), enabled via TBC.

(vi) There must be a Flashing Yellow Arrow (FYA) routine that is programmable in the CU. This routine must be used to provide for operation of a 4 section FYA left turn signal per National Cooperative Highway Research Program (NCHRP) project 3-54. Data entries in the CU must define when the signal face displays the protected (green arrow) and the permissive (flashing yellow arrow). It must be possible to logically AND a minimum of two phases as the control defining the permissive display.

(h) Alternate Sequences.
The CU must provide the capability of 15 alternates to the standard sequence. The alternate sequences may also be selected by the Alternate Sequence external interface inputs or the coordinator as a function of the pattern Dial/Split/Offset) in effect or as defined by the Start Up menu selection.

(3) Priority of Input Functions.
The priority of input functions must be in the following order:

(a) Power-Up.

(b) External Start.

(c) Phase Omit. Lower priority inputs must.

(d) Pedestrian Omit. Condition those of higher.

(e) Interval Advance. Priority as defined.

(f) Stop Time. Elsewhere in this standard.

(g) Remote Flash.

(h) Manual Control Enable.

(i) Ring Force Off.

(j) Phase Hold.

(k) Pedestrian Recycle.

I. Concurrent Real Time Displays.

The controller must display a dynamic current real time status of six active timers and status per ring for any combination of two of the four rings simultaneously. Real time displays must be provided for ring timer status, coordination, telemetry, preemption, detectors, intersection status, communications, connector input and output status, and TBC. As a minimum, the real time displays must provide concurrent active status for the following conditions:

(1) Ring timer status for 16 phases for any 2 of the 4 rings, minimum green, added initial, walk, ped clear, time before reduction, cars before reduction, time to reduce, effective gap in effect, MAX 1 or 2, passage time, gap out, max. out, force off, last car passage, walk hold or rest, green rest, yellow clearance, red clearance, red rest and red revert state. Phase status indicators for 16 phases concurrently displayed with the ring status indicators must be phase on or rest, vehicle call, non-actuated vehicle recall, minimum vehicle recall, maximum vehicle recall, soft vehicle recall, pedestrian call, pedestrian non-actuated recall, pedestrian recall, phase hold, omit and pedestrian omit. Additionally, the program and pattern in effect, cycle countdown, preemption program in effect, and stop time in effect must also be concurrently displayed. In addition, vehicle and detector calls may be placed through front panel entry while in the active ring timer display.

(2) Coordination active timers must simultaneously display, for up to four rings, the active phase(s) and/or force off active, current cycle length in seconds, offset in seconds, correction mode in effect, local cycle countdown, system cycle count up, offset in last cycle zero, correction of current cycle, time base interconnect, system, backup, manual control, or standby in effect or control.

(3) The telemetry status must simultaneously display the on line-off line status, active or non active carrier frequency, receiving or transmitting data and the validity of data received and/or transmitted for two ports.

(4) The preemption status must concurrently display the real time status for preemption in control, preemption call (preemption or low priority call), timing of (ped or minimum green, ped or vehicle clearance, track greens and clearance, dwell green), delay before preemption, and duration of preemption.

(5) The detector status display must simultaneously indicate the current status of up to 16 detectors. It must indicate the status of both special and phase detectors and whether they are on line or failed. The display must indicate, as a minimum, whether the failure was due to max presence, no activity or erratic count.

(6) The intersection display must simultaneously indicate the active status of 16 phases and the red, yellow, green, walk, don't walk and overlap status of each phase and whether the vehicle and/or pedestrian detectors have a call or recall. Vehicle and pedestrian calls may be placed through front panel entry while in the active intersection display.

(7) The TBC must simultaneously display the current month, day, year, time (hour, minute, second) and whether it is standard or daylight savings time; the day and week program in effect, the dial, split, and offset in effect, phase function mapping for 16 phases, 8 phase functions, the status of 3 auxiliary and diagnostic outputs, and the status of the dimming function. It must be possible to enable the auxiliary, special functions, and phase function options through front panel entry while in the TBC active status display.

J. Coordination.

Internal coordination must be a special program operating within the CU. There must be 16 Timing Plans (one for each Dial/Split combination) with 3 offsets in each. Each Timing Plan must provide a separate Cycle Timing, Phase Split Timing, and Phase Modes.

(1) Operation Modes.

There must be six operational modes which may be selected for continual operation or to operate only with a specific pattern (Dial/Split/Offset). Operational modes must be as follows:

(a) Permissive mode provides non-actuated coord phase vehicle and pedestrian modes with permissive windows opened phase-by-phase to the non-coord phases.

(b) Yield Mode provides non-actuated coord phase vehicle and pedestrian modes with a single permissive window for all non-coord phases.

(c) Permissive Yield Mode provides for actuated coord phase vehicle and pedestrian modes with permissive windows opened phase-by-phase to the non-coord phases. Additionally, the coord phase vehicle can extend its green time at the beginning of the first permissive window.

(d) Permissive Omit Mode provides operation similar to Permissive Yield except the coord phase, once terminated, is prevented from occurring prior to the end of the last permissive.

(e) Sequential Omit Mode provides operation similar to Permissive Yield except the permissive is a phase-by-phase sliding window (only one phase in a ring will be allowed service at any time).

(f) Full Actuated Mode provides operation similar to Permissive Yield except any phase can be serviced and re-serviced in the standard sequence following the first permissive and through the last permissive.

(2) Offset Correction Modes.
There must be a number of offset correction modes used to determine the method in which the coordinator will bring the running cycle in sync with the background cycle. These correction modes must include as a minimum:

(a) Dwell, correction will take place within one cycle.

(b) Max Dwell, maximum amount of correction per cycle user programmable.

(c) Shortway, cycle will be either shortened or lengthened by a maximum of 20 percent when correcting and will automatically take into consideration phase minimum times.

(d) Shortway+, same as Shortway except cycle will only be lengthened when correcting.

(e) Shortway 2, same as Shortway except the amount of correction will be proportional to the running split times.

(3) Maximum Modes.
There must be three Maximum Modes to determine whether Maximum 1, Maximum 2, or Maximum Inhibit will be effective when coordination is in control.

(4) Force Modes.
There must be two Force Modes to determine whether the non-coord phase force will be based on a position in the background cycle or on the Timing Plan Phase Split Time.

(5) Offset Position Modes.
There must be two Offset Position Modes to determine whether the Offset is calculated based on the Start or End of the first coord phase Green.

(6) Local Traffic Responsive Override.
There must be a Local Traffic Responsive Override to enable selection of patterns based on computed volume plus occupancy of selected detectors.

(7) Virtual Split Routine.
There must be a Virtual Split Routine on all operational modes that provides for actuated coord phase vehicle and pedestrian modes. This control provides for a period of time or each cycle that is distributed to the Coord Phase(s) or non-coord phases, based on Coord Phase vehicle traffic activity.

(a) Coord Adaptive Split.
When coord adaptive split is selected, the running pattern must automatically seek the most advantageous split possible for all non-coordinated phases. If a phase is forced, it is a candidate for an increase in its split. If a phase is gapped out, it is a candidate for a decrease in its split. Time will never be subtracted from a phase split except to give it to another phase. Time will only be added to a phase split if such addition does not cause the cycle length to change.

(8) Phase Times.
The coordinator must provide an adjustable time for each phase for each of the 16 programs. The phase time must be adjustable from 1 to 99 seconds. For the coord phase(s) this must become the minimum phase time and for the actuated phases it must become the maximum phase times. Green time for a phase is the phase time minus the phase vehicle clearance (yellow and red) times. The phase time begins when the respective phase is ON except for the coord phase(s) whose phase times may not begin until the local time zero.

(9) Phase Modes.

(a) Coord Phase(s).
The coordinator must provide for selecting in each of the 16 programs which phase(s) is/are to be the coord phase(s). The coord phase(s) must operate as non-actuated when coordinated. When no phases have been selected as the coord phases(s), the controller must run Free. When operating in multiple ring controller configurations, a phase in each ring must be selected as the coord phase unless compatibility does not exist within that ring to the coord phase in Ring 1.

(b) Dual Coord Phase(s).
The coordinator must provide for selecting in each of the 16 timing programs secondary coord phase(s) in each ring. The secondary coord phases must operate as non-actuated when coordinated.

The secondary coord phases must maintain a fixed position in the pattern cycle in relationship to the coord phase. It may begin early but must not terminate later than the allocated times would imply.

(c) Actuated Phase(s).
The coordinator must provide for operation modifiers to be selected for each actuated phases in each of the 16 timing programs. The five modifiers must be:

(i) Minimum Vehicle Recall.

(ii) Maximum Vehicle Recall.

(iii) Pedestrian Recall.

(iv) Maximum Vehicle Recall and Pedestrian Recall.

(v) Phase Omit.

(d) Alternate Sequences.
The coordinator must provide a means to select one of the alternate sequences or the standard sequence as a function of the pattern (Dial/Split/Offset) in effect.

When the coordinator is running a pattern, the external interface inputs must not override the pattern sequence.

(e) Permissive Periods.
The coordinator must provide two types of permissive periods. The permissive period must control the time period during which the coordinator releases the coord phase(s), allowing the CU to begin servicing calls on the non-coord phases.

(i) The first type of permissive operation must consist of a standard vehicle permissive. The length of the period must be determined by the phase time and the minimum time (minimum time = Minimum Green or Maximum Initial + Vehicle Yellow and Red Clear).

Minimum time must be based on the longer of Minimum Green or Maximum Initial when the Seconds/Actuation setting is greater than zero, otherwise minimum time must be based on Minimum Green. The minimum time must be internally set to 5 seconds in cases where the timings are programmed for less.

(ii) The second type of permissive operation must consist of a separate pedestrian permissive concurrent with the vehicle permissive. The length of this period must be determined by the phase time and Walk + Ped Clear + Phase Yellow + Red Clear.

In no case will the pedestrian permissive period be longer than the vehicle permissive period. When a phase is selected as next during the pedestrian permissive period, the pedestrian movement may start with the beginning of the associated vehicle movement (phase green) regardless of when the pedestrian call is received.

When the CU yields during any permissive period, the coordinator must allow the CU to service all the subsequent phase(s) in normal order before returning to the coord phase(s) and it must not yield on subsequent permissive periods in the same cycle.

(iii) Sync Monitor.
The coordinator must monitor the Offset command request for validity of the imposed sync reference.

The coordinator must discontinue offset correction when the length of time between sync pulses exceed the cycle in effect by 5 seconds and until the next sync pulse is received.

The coordinator must cause the CU to revert to Free mode when:

1) No sync pulse is received for three consecutive cycles.

2) No offset line is active for 15 seconds.

3) More than one offset line is active for 15 seconds.

The Sync Monitor "Free" mode may be replaced by a TBC event. See the "On-Line" definition in the Time Base section.

(iv) Manual Control.
The coordinator must be capable of being set to manually operate in any pattern (Dial/Split/Offset) by an entry through the front panel. A manual selection of pattern overrides the pattern interface commands.

A manual sync of the pattern must be controlled by an entry through the front panel.

(v) Free.
The coordinator must be capable of Free mode of operation. During this mode all coordinator control of the CU operation must be removed.

The coordinator must be capable of being set to the Free mode defined under Sync Monitor and by an entry through the front panel.

The coordinator must recognize input requests that conflict with the internal coordination operation and automatically revert to Free mode when the inputs are active. The inputs that conflict with internal coordination are:

1) Manual Control Enable Free

2) Stop Time (Either Ring) Free

3) Remote Flash Free

4) Preemption (Any) Free

(vi) Master Line Drivers.
Eight outputs for master type interconnect interface drivers must be available. The master line driver outputs echo the active program. All outputs must be constantly "on" when active except offset which is "off" for 3 seconds once each cycle beginning at the zero point of the cycle.

K. Preemption.
Internal Preemption must be a special program operating within the CU. The preemption program must accept commands from six high priority preempt inputs and six low priority inputs.

The preemption must be capable of cycling while in dwell. It must be capable of being linked to another preempt. It must provide for two modes of priority inputs, one for preempt (railroad, emergency vehicle) and one for low priority (bus or transit vehicles).

Preemption sequences must be programmable, as a minimum, for minimum green/walk, delay and duration, lock/non-lock memory, dwell, selective ped clearance, selective yellow, selective red, track green, track ped clear, track yellow, tract red, return ped clear, return yellow, return red, exit phases, flash override, lockout, exit calls and max recalls.

L. Time Base Coordination.
The internal TBC must be a special program operating within the CU. A minimum of 250 different TBC events must be capable of being programmed over a 99 year time frame on a Time-Of-Day, Day-Of-Week, and Month Day-Of-Year basis. TBC events must be entered through the CU front panel or transferred from another like CU. TBC settings and activity must be monitored on the CU display.

The TBC program must output dial, split and offset commands to the coordination program. It must be possible to perform functions not necessarily traffic related within the TBC program by programming and using the three auxiliary outputs.

(1) Clock Calendar.
The TBC must be provided with a line frequency driven clock and backed up by a super capacitor crystal controlled clock. During normal operation, the line frequency driven clock must control all timings and re-sync the crystal controlled clock to the line frequency clock once per minute. When power is removed and reapplied, the crystal controlled clock must provide the current time to the line frequency clock.

The TBC must provide a 99 year calendar for automatically determining the current day of week, day of month, month of year and year based on the data set as a starting point. The calendar must provide automatic compensation for leap years.

(2) Time of Day Clock.
A Time of Day Clock (TOD) that displays hours, minutes, seconds, month, year and automatic daylight savings time adjustment must be provided. The TOD must be implemented in the CPU via electronic circuitry, operating system software, Global Positioning System (GPS), or a combination. The GPS interface must require simple data entries in the CU to implement and must not require cycling power off/on to enable or disable the GPS function.

(3) Backup Power.
A super-capacitor must provide backup power during loss of service voltage. The super-capacitor must have a minimum of 15-farad nominal size. No batteries of any type must be allowed.

(4) Daylight Savings Time.
The TBC must provide for Daylight Savings Time to be programmed to occur automatically as defined by law in Michigan, to occur automatically at any user selected date, or not to occur.

When programmed to occur automatically at a user selected date, time must advance 1 hour on the date programmed at 02:00:00 a.m. and decrement 1 hour on the date programmed at 02:00:00 a.m.

Daylight Savings Time must only be capable of being implemented once per year.

(5) Program Day.
A program day must be the list of traffic and/or auxiliary events to occur in a 24-hour period. The TBC program must provide for 99 program days to be defined. It must be possible to equate program days which may require the same event listing to effectively multiply the event capacity.

It must be possible to copy an entire program day event listing to another program day to establish a data base for editing to create a similar but different program day event listing.

(6) Special Days.
The exceptions to the normal day-of-week event listings must utilize Time-Of-Year Special program days. Time-Of-Year Special program days 01 through 49 must be utilized for special day programs which occur on the same date (month and month day) every year. Program days 50 through 99 must be utilized for special days which occur on one date (year, month, and month day).

(7) Alternate Week.
The TBC events must be implemented from a weekly schedule of program days on a day-of-week (except for special days) basis.

The normal day-of-week (Sunday through Saturday) event listing must utilize program days 01 through 07 with Sunday being program day 01.

The Time-Of-Year event structure must provide a means of substituting 10 alternate weekly schedules for the normal weekly schedule.

(8) Event Capacity.
A minimum of 250 traffic and/or auxiliary events must be capable of being programmed. A minimum of 180 special days must be capable of being programmed. The capacity of either of the above may be inversely affected by the number of entries in any one.

(a) A traffic event must consist of a coordination pattern (Dial #, Split #, and Offset #) flash or free mode, Phase Function Mapping and the time of occurrence (hour, minute, and program day).

(b) An auxiliary event must consist of the condition of three Auxiliary outputs, Dimming control, detector diagnostics, special function outputs, and the time of occurrence (hour, minute, and program day).

(c) A time-of-year event must consist of a special day or alternate week plus date of occurrence (year, month, and month day).

(9) Traffic Programs.
In addition to dial, split and offset commands, the TBC program must provide the following as traffic events:

(a) Flashing (Voltage Monitor inactive).

(b) Free.

(c) Phase Function Mapping by phase for 16 phases.

(i) Phase function mapping must include: Max 2, phase omit, pedestrian omit, minimum vehicle recall, max vehicle recall, pedestrian recall, detector switching omit, detector switching now, detector switching also (switch and assigned detector input simultaneously) and overlap omits.

(ii) Phase Function Mapping features are Free Mode modifiers and must not be part of an event which selects a pattern (Dial/Split/Offset) or Flash.

(10) Auxiliary Events.
There must be three auxiliary outputs available. Each output must be non-cyclic, each totally independent of any other output. The outputs must not be affected by any other input including the On-Line input. The auxiliary outputs may begin and/or end concurrently with another program.

(11) Detector Diagnostics.
There must be three detector functions available. One must set the value of the detector diagnostic to be selected (four parameters can be set for each detector) and one to initiate or stop the detector log report. The third function is reserved for future use.

(12) Dimming.
There must be a dimming function that allows signals so programmed to dim their outputs.

(13) Special Function Mapping.
There must be eight special function mapping outputs available. There must be eight special functions, three alternate passage and maximum times, three

adaptive maximum settings, an Adaptive Protected/Permissive feature, an In Cycle Flashing Red feature, four sign control outputs, three diamond intersection control outputs, four queuing controls, and coord adaptive split. It must be possible to map more than one function to the same logical control.

(14) Input and Program Priorities.
The coordination programs must be capable of being selected based on manual (keyboard) inputs, TBC events and interconnect inputs. Program select priority must be:

(a) Manual Inputs.

(b) System Interface.

(c) TBC Events.

(d) Interconnect Inputs.

When the TBC On-Line input is active, the TBC events have no priority and program selection must be based on manual inputs or interconnect inputs.

When the On-Line input is active, the coordination routine reverts to TBC control based on sync monitor failure.

M. Miscellaneous.

(1) Flash

(a) Start-Up Flash.
The CU must have provisions whereby an adjustable timed period/state (Start-Up Flash) must occur prior to the Initialization routine.

The time range for Start-Up Flash must be 0 to 99 seconds in increments of 1 second.

When power is restored following a defined power interruption or Watchdog restart, the Start-Up Flash state must become operational. No input, other than alternating current (AC) Power, must prevent this state from the completion and/or exit to the Initialization routine.

(b) Remote Flash.
Activation of this input must cause vehicle and pedestrian calls to be placed on all phases. The CU must assure the completion of the Minimum Green or Walk plus Red Clearance time on the current phase(s) and must proceed

immediately, thereafter, to the vehicle clearance intervals followed by the phase(s) programmed as the Entry phase(s).

After the Entry Phase(s) Minimum Green or Walk plus Red Clearance, the CU must proceed to the vehicle clearance intervals.

Upon completion of the vehicle RED CLEARANCE interval, the CU must initiate flashing operation (Voltage Monitor output inactive). The CU must maintain this condition, Voltage Monitor inactive and Red Dwell as long as the Test A (Remote Flash) input is active. When the input becomes inactive, the CU must move immediately to the beginning of the phase(s) programmed as the Exit Phase(s), with a Green/Walk display, calls on all phase vehicle and pedestrian, and must cease flashing operation (Voltage Monitor output active).

N. Pretimed Control.
When selected, these specifications cover the minimum acceptable operating requirements for a pretimed fixed cycle traffic signal controller (CU) of solid-state microprocessor type, per NEMA Standard TS2-2003, P2, 2003. The CU must be designed for operation on 120 volt, 60 hertz, single phase A.C. electrical systems.

(1) The pretimed CU must be an interval oriented device. The conditions of the output circuits (load switch drivers) must be programmable as to condition in each of the Signal Plan intervals. The interval sequence, interval timing, and output circuit condition are used to control the order in which traffic movements are assigned the right-of-way at the intersection and the time allocated to each. The CU must be capable of operating as a master controller, isolated controller, or secondary controller without changes or additions.

(2) The CU must accept Timing Plan (Dial/Split) and Offset commands from traditional interconnect systems, the internal systems interface, and/or from a companion Time Base program.

O. Functional Operation.

(1) General.
The CU must provide the following operational features:

(a) A minimum of four Dials (cycles).

(b) Four Splits per Dial (cycle).

(c) Three Offsets per Dial/Split combination.

(d) A minimum of 32 intervals per Dial/Split.

(e) A minimum of 24 signal circuits but capable of 36 circuits.

(f) Four Signal Plans, each with alternate path programming and inputs from four vehicle and four ped detectors.

(g) Up to six complete and separate Preemption Programs and six Low Priority routines.

(h) Sync out for use as system master.

(i) Operation on standard 120 volt, 60 Hz, AC pretimed interconnect inputs without external interface.

(2) Dial (Cycle).

(a) A minimum of four cycles must provide 30-999 seconds minimum in 1 second increments. The cycle time of each Timing Plan must be the sum of the interval times of the longest path in the signal plan.

(b) The Dial (Cycle) must be selected by application of 120 volt, 60 Hz, AC to the input connector and also be able to be manually selected from the keyboard.

(c) A visual indication of the Dial currently in effect and a dynamic display of the cycle seconds must be provided.

(d) Transfer from one Dial to another must occur at the end of the interval in effect at the time of request for transfer, unless that interval is programmed to prohibit transfer.

(3) Offset.

(a) Three Offsets must be provided for each Dial/Split combination.
(b) Each Offset for each Dial/Split must be individually programmable from 0-999 seconds in 1 second increments. The programmed Offset must define the number of seconds by which the beginning of interval #1, local time zero, must follow the system sync pulse.

(c) Offset must be selected by TBC or via “D” Connector input and be manually synchronized from the keyboard.

(d) A visual indication of the offset currently in effect must be provided.

(e) Offset adjustment must be programmable to use shortway or dwell transfer procedures. If shortway method is programmed, the CU must seek a new offset in the shortest direction by adding or subtracting with the rate of offset change never exceeding 18.75 percent points per cycle. Shortway Add Only - must only add up to 18.87 percent. If dwell (maximum or variable) is called for, the CU must dwell in the programmed interval for a maximum (0-999 seconds in 1 second increments) or until a sync pulse is received while the CU is dwelling. Following the timing of a full offset dwell interval, the absence of a synchronization pulse prior to the beginning of the next dwell interval must cause the CU to ignore the dwell time and run free (non-interconnected) until the receipt of a valid synchronization pulse.

(4) Split.

(a) Four Splits must be provided for each Dial (cycle). Splits must be capable of being programmed independently of any signal plan and also must be capable of being "tied" to the corresponding signal plan.

(b) Each Split for each Timing Plan must consist of a programmed number of intervals, a minimum of 32 and must be individually programmed. The same number of intervals must not be necessary for all splits.

(c) Split must be selected by application of 120 volt, 60 Hz, AC to the input connector and also be able to be manually selected from the keyboard.

(d) A visual indication of the split currently in effect is provided.

(e) Transfer from one split to another must occur, upon command, at the end of the interval in effect at the time of request for transfer, unless that interval is programmed to prohibit transfer.

(5) Interval.

(a) A minimum of 32 intervals must be provided for each combination of Dial and Split.

(b) The timing for each interval must be programmable between 0-999.9 in 0.1 second increments for each of the four Splits in each of the four Dials.

(c) It must be possible to copy the timing values for any Dial and Split into any other Dial and Split in one operation.

(d) When less than 32 intervals are required, it must be possible to specify and program only the number used. Programming zero times for unused intervals must not be required.

(e) The following interval related intersection configuration data must be programmed in non-volatile EEPROM memory for each interval of each signal plan:

(i) Each interval must be capable of being named as an actuation interval through input 1 and/or through input 2. If a valid call is not placed on this interval, the allotted time must be automatically added to a designated default interval. Each interval must also have the capability of being a RESET interval of input 1 and/or input 2.

(ii) Each interval must be programmed as either fixed or variable for purposes of shortway offset changes. Each interval must be programmed as either self-timing or non self-timing when Manual Control Enable or System Control is asserted. Operation of Interval Advance input must immediately terminate non self-timing intervals, but must have no effect on self-timing intervals.

(iii) Minimum time for the intervals.
The range must be 0-99.9 seconds in 0.1 second increments. Minimum interval time must not be violated by programmed time. The CU will time no less than the minimum and indicate an error in programming.

(iv) Each interval must be able to be programmed to control the display shown on up to 12 load switches. The status of each load switch must be one of the following: RED, GREEN, YELLOW, FL-RED, FL-GREEN, FL-YELLOW, RED GREEN, or DARK.

(v) Each interval must be capable of specifying the signal plans (if any) to which transfer would be safely allowed.

(vi) Each signal plan must provide for a selection of three alternate signal sequences, plus a default sequence, based upon a detector 1, detector 2 or detector 1 plus 2 input. An alternate set of detectors (detector 3 and detector 4) may be used if required for the proposed sequence. This must provide a means of selecting one of the interval sequences in response to a detector input without the necessity of changing signal plans. Different interval paths, within a signal plan, may be followed during a given cycle, depending upon an external detector(s) input.

(f) Driver and Remote Flash control must be provided to allow:

(i) Driver control as either vehicle or pedestrian so that the intersection display status and preemption operation are correct.

(ii) Remote flash control to allow the CU to flash certain load switches when remote flash is called for. It must be possible to flash either Red or Yellow and alternate if desired.

(6) Displays.
The CU must provide a simultaneous dynamic display of the following operational status:

(a) Dial, offset, signal plan, split, preempt, and interval in effect.

(b) Time remaining in the cycle.

(c) Offset correction method in effect.

(d) It must be possible to display data previously programmed through the keyboard. The parameter called for and its current programmed value must be displayed. The CU must continue in uninterrupted cyclic operation during any interrogation of currently programmed values. After entry of the proper access code, it must be possible to change any front panel programmable values.

(e) Concurrent Real Time Displays.
The CU must display a dynamic current real time status of interval, interval time, and signal plan. Concurrent real time displays must be provided for, coordination timing, telemetry, preemption, detectors, intersection status and TBC. As a minimum, the real time displays must provide concurrent active status for the following conditions:

(i) Coordination active timers must simultaneously display, for interval timing cycle timing, offset active, current cycle length in seconds, offset in seconds, correction mode in effect, local cycle countdown, system cycle count up, offset in last cycle zero, correction of current cycle, time base interconnect, system, backup, manual control or standby in effect or control and interval minimum time set.

(ii) The telemetry status must simultaneously display the on line-off line status, active or non active carrier frequency, receiving or transmitting data and the validity of data received and/or transmitted for two ports.
(iii) The preemption status must concurrently display the real time status of a minimum of six preemptions for preemption in control, preemption call (preemption or low priority call), timing of (ped or min. green, ped or vehicle clearance, track greens and clearance, dwell green), delay before preemption, and duration of preemption.

(iv) The detector status display must simultaneously indicate the current status of up to 12 detectors. It must indicate the status of both special and group detectors and whether they are on line or failed. The display must indicate whether the failure was due to max presence, no activity or erratic count.

(v) The intersection display must simultaneously indicate the active status of 12 load drivers and the red, yellow, green, and walk, and don't walk status of each driver and whether the vehicle and/or pedestrian detectors have a call or recall.

(vi) The TBC must simultaneously display the current month, day, year, time (hour, minute, second) and whether it is standard or daylight savings time; the day and week program in effect, the dial, split, and offset in effect, the status of three auxiliary and diagnostic outputs and the status of the dimming function.

(7) Signal Circuits.

(a) The CU must provide a minimum of 36 signal circuits. The number implemented must be as required to provide the specified signal sequence.

(b) The ON/OFF FLASH and COLOR state of each implemented signal circuit during each interval for each signal plan must be programmed in EEPROM.

(c) The flash rate of any signal circuit programmed to FLASH must be 60 times per minute with a 50 percent duty cycle.

(8) Signal Plans.

(a) The CU must be capable of implementing four different signal plans.

(b) All signal plans need not have the same number of intervals.

(c) Signal plan must be selected via program entry or manually from the keyboard.

(d) Each of the four vehicle detector input must be capable of being programmed to operate in (1) NON-LOCK mode, (2) LOCK mode and (3) RECALL mode.

(i) Detector Delay/Extension.
The following special vehicle detector functions must be provided for each of the four group detectors:

1) Delay.
The group vehicle detector actuation (input recognition) must be capable of being delayed, by an adjustable (00-999 seconds), when not in the actuated interval associated with the detector. Once the actuation has been present for the delay time it must be continued for as long as it is present.

2) Extend.
The group vehicle detector actuation (input duration) must be capable of being extended from the point of termination by an adjustable time (0-99.9 seconds).

3) The special vehicle detector functions must be capable of being used in any combination. The sequence is that an actuation must be extended first and delayed second.

(e) The CU must operate in accordance with the programmed values for the selected dial, offset and split for the signal plan in effect. Signal Plan EEPROM programming must affect the ON/OFF/FLASH and COLOR condition of the load drivers for each interval.

(f) During any CU cycle, it must be possible to operate in any 1, 2, 3, or all 4 signal plans independent of split.

(g) A visual indication of the signal plan currently in effect must be provided.

(9) Preemption.

(a) The CU must provide for preemption capable of containing a minimum of six complete and separate sequences.

(b) It must be possible to program the ON/OFF FLASH and COLOR condition of all implemented signal circuits independently for each preempt interval.

(c) It must be possible to program preempt operation to proceed sequentially through the preempt intervals and hold at the end of a specified interval.

(d) It must be possible to specify the interval(s) in the preempt plan during which normal cyclic operation resumes.

(e) It must be possible to program a delay between the time the preempt input is asserted and implementation of the preempt plan. The range of this delay must be 0-999 seconds in 1 second increments.

(f) It must be possible to program the preempt input to operate as a LOCK or NON-LOCK input. When programmed NON-LOCK, termination of the preempt input during the delay before preemption must not initiate preempt operation.

(g) A visual display must be provided of the condition of the preempt inputs and the preempt plan interval in effect.

(10) Master-Secondary.

(a) The CU must provide a sync output for 3 seconds of the cycle length.

(b) Any CU must be able to operate as a master controller or as a secondary without requiring any changes in the unit itself.

(c) When used as a master controller, it must not be necessary to program the CU's offsets to 0.

P. Diagnostics.
The CU must be provided with a resident series of diagnostic capabilities describing its own internal state. It must not require internal access or changes to the CU to initiate diagnostic programs.

(1) Automatic Diagnostics.
The CU must perform diagnostics enabling operator verification of proper operation.

The "automatic" diagnostics must be performed without an operator request. The diagnostics evaluation must be displayed on the CU front panel display.

(a) Processor Monitor.
The CU must contain provisions to monitor the operation of the microprocessor. The monitor must receive signals, at least, once every 100 milliseconds from the microprocessor.

(b) When the signal is not received for 200 milliseconds ±20 percent, the processor monitor must initiate flashing operation (Voltage Monitor output inactive). When flashing is initiated as a result of the processor monitor, it must illuminate a front panel indication labeled "Watchdog." The monitor must be deactivated when there is a power failure and become active when restored.

(c) The monitor must attempt an automatic restart of the microprocessor to the power up Start Flash timing condition. The CU must operate as though power had been removed long enough for a full restart and reapplied. The front panel Watchdog indicator must remain illuminated until the CU front panel has been manually addressed.

(2) Operator Initiated Diagnostics.
The CU must perform diagnostics enabling operator verification of properly operating inputs, outputs, keyboard and display. The "operator initiated" diagnostics must be performed only after an operator request through the CU front panel. The technique used must be relatively simple and suspend normal traffic operation during the test and the CU must be plugged into Suitcase-Sized NEMA Standards Controller Test Set. The diagnostics evaluation must be displayed on the CU front panel display and/or indicators on the suitcase tester as an operator interface.

(a) Inputs.
The CU must provide test routines to enable operator verification that input functions are proper. This test must determine whether the input buffers are operating correctly.

(b) Outputs.
The CU must provide test routines to enable operator verification that output functions are proper. This test must determine whether the output drivers are operating correctly.

Each output must be actuated in a fixed sequence. The user must observe the output sequence and determine correct operation.

(c) Display.
The CU must provide test routines to enable operator verification that display functions are proper. This test must determine whether front panel drivers and decoders are operating properly. All the indicators must be activated. The user must observe the front panel display and determine correct operation.

(d) Keyboard.
The CU must provide test routines to enable operator verification that keyboard functions are proper. This test must determine whether the keyboard is operating correctly. The operator must test each of the CU keys. The numeric display must indicate the key pressed. The user must observe the front panel display and determine correct operation.

Q. Traffic Analysis Functions.

(1) Alarm Monitoring/Events Logging.

The CU must monitor and log the status of the following functions for subsequent uploading to an on-street or central office master:

| | | |
|---|---|---|
| Cycle Fault | Voltage Monitor | Preempt |
| Coord Fault | Conflict Flash | Local Free |
| Coord Failure | Local Flash | Special Status |
| Cycle Failure | Remote Flash | Power On/Off |

(2) Local Alarms Report.

A Local Alarms Report must be generated with the capacity for up to 120 alarm events, including date and time of occurrence. Once logged, the alarms must remain until the report capacity is exceeded at which time the oldest alarm must be deleted and the new one added. This report must be output to the front panel display, to the printer port, and to the 25 pin RS-232 port.

(3) System Detectors.

(a) Detector Data.

The CU must have the ability to receive input data from up to eight special (system) detectors in addition to the normal actuated CU phase detectors as system detectors.

The CU must process all system detector data, consisting of volume and occupancy, and must be capable of transmitting the results of this processing to either the on-street or central office master monitor. As a minimum the following parameters must be determined:

| | |
|---|---|
| Raw volume count, raw occupancy | Average occupancy percent |
| Average volume percent | Volume + occupancy percent |

(b) Detector Report.

The CU must generate a System Detector Report based on an operator determined logging interval and sample period. The report must include raw volume and occupancy along with averaged volume and occupancy percent for the sample period. This report must have the capacity to store up to 96 sample periods. A sample period data set must remain until the report capacity is exceeded at which time the oldest sample period data set will be replaced by the new data set.

The CU must provide a volume count report. Means must be provided to enable the use and vehicle, special or pedestrian detector inputs as count detector inputs for the volume count report. The detector volume count

report must have the capacity to store up to 72 count periods. Note: the detector volume count report parameters and output will not be capable of being entered or viewed via the front panel of the CU. It must be downloaded and viewed via a PC and the manufacturer’s software.

(c) Detector Diagnostics.
Each detector, both phase and special system must be tested by a diagnostics routine for conformance to specified parameters. The detector diagnostics must monitor activity on each detector for constant calls, absence of calls, and erratic output. These parameters must be user programmable.

A detector must be classified as `on-line' when the results of the monitoring and diagnostic procedures determine that data from the detector is within the allowable range.

Detectors which have failed the diagnostics and those subsequently operating within diagnostic parameters must be automatically logged in a Detector Failure Report, including date and time of occurrence. This report must have the capacity to store up to 60 diagnostic events and the event must remain until the report capacity is exceeded.

(4) Measures of Effectiveness (MOE's) must be accumulated and reported to enable the evaluation of coordination pattern parameters based on actual data collected during the periods the pattern is in control. MOE calculations must be made once each sequence cycle for Volume, Stops, Delay and Utilization for each phase in the CU and then averaged over the duration of the pattern. A MOE Report must be provided and must have the capacity to store up to 24 patterns of MOE's. The pattern MOE's set must remain until the report capacity is exceeded at which time the oldest pattern set must be deleted and the new MOE pattern added.

(a) Volume must represent the average number of actuations during the sequence cycle, for each phase, over the duration of the pattern.

(b) The Stops measurement must represent the average number of vehicles which must stop at an intersection during the cycle, for each phase, over the duration of the pattern.

(c) Delay must represent the average time, in seconds, that vehicles are stopped during the sequence cycle, for each phase, over the duration of the pattern.

(d) The Utilization measurement must represent the average seconds of green time used by each phase during the sequence cycle for the duration of the pattern.

(5) Speed Traps.
The CU must provide speed monitoring capability in the form of a Speed Trap function. The CU must provide for up to two independent Speed Traps with operator selectable detector spacing of either 11 or 22 feet, dependent upon the application. Provision must be made in the CU to monitor the speed in miles per hour (MPH).

A nominal speed range must be settable for each pattern, with the percent of vehicles higher, within and lower than this nominal speed ranged logged for reporting.

A Speed Report must be provided and must have the capacity to store up to 24 patterns of Speed data. The pattern Speed data must remain until the report capacity is exceeded at which time the oldest pattern speed data must be deleted and the new data added.

(6) Reports.
In addition to the above-described reports, the CU must provide a Communications Report which will allow the user to view a list of communications failures along with date and time of occurrence. This report must have a minimum capacity of storing up to 60 events (faults). The fault event, including date and time of occurrence, must remain until the report capacity is exceeded at which time the oldest fault must be deleted and the new fault event added.

In regard to communications, indication must be provided on the front panel of the CU to denote when a carrier signal is being received, valid data is being received and when the unit is transmitting.

R. Quality.
The CU must successfully meet the NEMA Standard TS2-2003 Publication requirements, as applicable, and must have been tested and certified by an independent test laboratory. An independent test laboratory is defined as one that has no relationship to the controller manufacturer, except as a supplier of services. The Contractor must supply the Engineer with documents certifying conformance to the requirements.

S. Compliance.
The supplier is required to complete, sign, and attach a Specification Compliance Sheet with respect to the equipment bid. Appropriate supporting documentation including one complete set of instructions for installation and maintenance of the

CU, manufacturer's literature, and wiring diagrams must be provided. Failure to provide this documentation will result in evaluation of equipment based on information already on file.

2. Delivery

The pay item shall include the cost of delivery to the Road Commission for Oakland County, 2420 Pontiac Lake Road, Waterford, MI 48328.

3. Warranty

Provide materials with a manufacturer's warranty/guarantee, transferable to the Road Commission for Oakland County, that the supplied materials will be free from all defects in materials and workmanship for 18 months from the date of final project acceptance. If requested by the Engineer, supply manufacturer's warranty or guarantee documents from the manufacturer and a copy of the invoice showing date of shipment.

4. Acceptance

Provide General Certification per the MDOT's *Materials Quality Assurance Procedures Manual* to the Engineer that the materials meet the requirements specified herein.

**c. Construction**

All work must be in accordance with the contract documents.

**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(s).

| **Pay Item** | **Pay Unit** |
|---|---|
| Controller, Digital Type, Delivered, SCATS, RCOC | Each |

**Controller, Digital Type, Delivered, SCATS, RCOC (Ea)** will be measured as a unit. The unit shall be as indicated on plans. The contract unit price each shall be payment in full for furnishing and delivering to RCOC for timing and set-up the controllers as specified herein and as shown on plans.