STATE OF NEW JERSEY
DEPARTMENT OF TRANSPORTATION
TRENTON, NEW JERSEY 08625

METRIC SPECIFICATIONS FOR SOFTWARE
(EIGHT PHASE 170E INTERSECTION SOFTWARE PROGRAM)

N. J. Specification No. EBM-TSC-170E-ISOFT Effective Date: July 1, 2001

New Jersey Department of Transportation Specifications for the local intersection firmware to operate a 170E Microprocessor Based, Eight Phase Controller Assembly with Internal Time Base Coordination.

The purpose of these specifications is to describe minimum acceptable design and operating requirements for the 170E local intersection software.

GENERAL - I

1-1 The software required must be fully compatible and designed to operate with the intersection assembly defined by EBM-TSC-170E. This configuration is a modified 170E controller and 332 cabinet which is downwards compatible with standard CALTRANS configurations.

1-2 The target firmware shall be delivered on a separate 27256 EPROM for every intersection location designated in the contract documents. The software must be configured to operate in the higher 32 kilobytes memory address range of the processor.

1-3 The firmware must fully support all standard NJDOT phase sequences as subsequently described. In addition, the software must fully support the intersection configurations designated in the contract documents.

1-4 An MSDOS PC program capable of reporting intersection status and uploading/downloading the entire intersection database shall be supplied. The firmware must be fully integrated with this support program and shall allow connection of the PC program from the front panel ACIA (#3 or #4) or through ACIA #1. (Asynchronous Communication Interface Adapter/RS232 Adapter)

1-5 The firmware shall support internal time based coordination and internal railroad and emergency vehicle preemption capabilities.

1-6 The firmware shall fully support the standard LED display and keyboard of a standard 170E controller. All data entry and reporting shall be possible through the standard interface.

1-7 Two copies of the local database shall be maintained. One operating copy shall be maintained in RAM while a backup copy is maintained in zero-powered RAM on the PROM module. Upon loss of the primary copy, the firmware shall have the ability to restore the backup copy from the PROM module. In addition, transfer of the database to and from the backup area shall be possible via user command from the keyboard or remote monitoring program.

1-8 The firmware shall be designed to operate with the standard C1 connector pin-out for a 332 cabinet, as subsequently modified. However, the firmware shall support input/output reassignments for the purpose of customizing operation to accommodate unique situations.

DEFINITIONS - II

2-1 Event time is the hour and minute of a 24 hour day. The function shall start at the first second of the minute assigned.

2-2 Day event is turning on or off an output circuit at a specified time. This output may be internal or external to the controller unit.

2-3 Coordination plan shall be composed of a programmed cycle length, offset and cycle split.

2-4 Day program is any combination of day events. These events specify which coordination plan is selected.

2-5 Week program is any combination of seven day programs.

2-6 Year program is any combination of fifty-two week programs.

2-7 An exception day shall override the normal day program and utilize a specified day program.

2-8 Firmware is target software stored in permanent semiconductor memory, such as an EPROM, which is designed to integrally function with control hardware.

2-9 Upload refers to the process of transferring a database from the 170E controller to a MSDOS PC.

2-10 Download refers to the process of transferring a database from the MSDOS PC to a 170E controller.

INTERSECTION PHASING/INTERVAL CONFIGURATION - III

3-1 The firmware shall be equipped for and be capable of immediate eight phase semi-actuated, fully actuated, fixed time, and volume density operations. All phases must be equipped with concurrent pedestrian timing. For those walk intervals not mapped to C-1 outputs on the base cabinet configuration, the program must support the ability to map

these outputs to unused circuits normally assigned to other phase displays. The program must be fully operational from the front panel of the 170E.

3-2 In addition to the eight phase dual ring quad left operation specified hereinbefore, the firmware shall be equipped to fully implement the phase sequences depicted in Diagram No. 1 of these specifications.

3-3 The firmware must be capable of omitting any phase, by programming a "no phase" or a phase omit in the local database. Once programmed in this fashion, the phase omit shall prevent the specified phase from being serviced during the start-up, normal operation, manual, and preempt operation.

3-4 The firmware shall support comparable interval operation as that defined in the current NEMA TS-1 specification. In addition, the program shall support a MAX-II timing set, as a function of time-of-day or manual entry.

3-5 All programmable functions shall be performed via the keyboard. In addition, access to the entire local intersection database shall be available via the MSDOS support program interface.

3-6 If EPROM replacement is utilized to obtain the four required sequences of operation as hereinbefore specified, the required EPROMs to implement each phase sequence shall be supplied. Each EPROM supplied shall be labeled to identify the sequence of operation which it provides.

3-7 Selection of steady or flashing "Walk" operation shall be programmable by keyboard entry for each phase.

3-8 The controller unit shall be capable of being programmed to start or initialize in any legal phase combination. Unless otherwise specified in the contract documents, the firmware shall default to initialize in artery green.

3-9 Manual control operation shall be fully supported and shall utilize the Manual Control Enable and Interval Advance inputs from the police panel. All initial and clearance intervals shall time normally while under manual control enable. However, the controller shall "HOLD" in dwell intervals until an interval advance is issued from the panel.

3-10 The firmware shall contain all necessary logic and database to produce up to four internally generated overlaps. The timing for Yellow Change and Red Clearance overlap signals shall be determined by the phase terminating the overlap and an independent adjustment for each overlap signal. Overlaps shall be programmable from the keyboard or MSDOS support program.

3-11 The firmware shall be capable of being programmed for dual or single entry mode of operation.

3-12 A guaranteed three second minimum Yellow Clearance shall be provided.

3-13 Internal pre-emption shall be incorporated into the controller program. All data for pre-emption shall be entered through the database. The unit shall provide a minimum of four pre-emption sequences, with one priority sequence. At least one sequence shall have keyboard inputs for memory on/or memory off.

The following shall be the minimum acceptable parameters for each pre-emption routine:

Parameter	Definition
Delay Time	Delay prior to start of pre-emption.
Hold/Inhibit Time	Time to hold active phase or to omit all other phases.
Min/Walk Time	Selects new or aborts active ped clear time.
EVP/Hold Phase(s)	Selects phase(s) to service pre-emption.
Dwell Time	Guaranteed pre-emption time.
Exit Calls	Calls phase(s) to be called and serviced following pre-emption.

3-14 The firmware shall have the logic to emulate MUTCD flash on a time-of-day or manual command basis.

LOCAL TIME BASED COORDINATION - IV

4-1 The coordination plan shall be selected by the time of year program. The time of the year shall be set to the time of day, day of week, and week of the year.

4-2 The firmware shall maintain and display, as a minimum, the day of week, hour, minutes and seconds, using military time. The controller unit shall, upon request from the keyboard, display output status and coordination plan data. The coordination plan data shall be capable of being scanned without affecting the plan in operation.

4-3 The internal coordinator shall automatically adjust for daylight savings time. The dates of transfer to and return from daylight savings time shall be user programmable. The dates shall be specified based on the month and week of month of the transfer. The transfers shall always occur on Sunday at 2:00 AM.

4-4 The firmware shall be capable of implementing coordination plans containing, as a minimum:

A. Four cycles

B. Four splits per cycle (Total 16 Splits)

C. Three offsets per cycle (Total 12 Offsets)

D. Eight permissive periods per split

E. Eight force-offs per split

F. One pedestrian permissive period per period per cycle

G. One dwell period per cycle

4-5 The firmware shall reserve memory for storage of the coordination plans. The programming of this memory shall be accomplished through data entry utilizing the keyboard and/or remote monitor program. All data shall be displayed for verification before it is accepted.

4-6 The coordination plans shall be programmable in one second increments to any value between the following limits:

	FUNCTION	SECONDS
1)	Cycle Length	30 - 255
2)	Offset	0 - 255
3)	Splits	0 - 255
4)	Maximum Dwell	0 - 255
5)	Permissive Periods	0 - 255

* This function may be a percentage of the background cycle.

4-7 The internal coordinator shall automatically "smooth" the change in offset and cycle length when a change is required by a new coordination program. The method of smoothing shall comply with Subsection 4-8 or shall be programmable and shall include the following options:

DWELL: The internal coordinator shall not permit the controller unit to dwell at its dwell point by more than the programmed period of time until offset is reestablished.

SMOOTH WAY: The internal coordinator shall shorten or extend the cycle length by no more that 50% until offset is reestablished.

4-8 The internal coordinator shall automatically "smooth" the change in offset and cycle length when a change is required by a new coordination program. The method of smoothing shall consist of the internal coordination software selecting a background cycle based on supplied minimum and maximum cycle lengths. The cycle length selected will achieve the new offset in the smallest number of cycles possible and then implement the background cycle required by the coordination plan in effect. The smooth way method shall be utilized unless otherwise specified in the contract documents.

4-9 Transfer from one cycle to another shall occur at the end of the cycle in effect. The end of the cycle shall be defined as the yield point of the coordinated phase(s).

4-10 The firmware's internal coordinator sub-system shall be capable of establishing a phase association for the force-offs, and permissive periods, defined in the database.

4-11 The force-off function shall terminate the right-of-way on the programmed phase or phases, and shall be maintained until the green of that phase terminates.

4-12 The internal coordinator shall be capable of providing permissive periods as follows:

A. During each permissive period, the coordinator will allow the controller to leave the coordinated phase(s) and selectively respond to vehicle and/or pedestrian calls from allowable phase(s). The allowable phase(s) for each permissive period shall be programmable.

B. The start and end of vehicle permissive periods shall be programmable through the keyboard. A pedestrian permissive period shall start with the vehicle permissive period for the associated phase. The end of the pedestrian permissive period shall be determined by a duration that is programmed in the database.

C. Permissive periods shall provide for the release and application of phase omits as programmed.

D. Once the coordinated phase(s) has terminated, all internal omits associated with permissives shall be removed and the controller shall be permitted to service the remaining phase sequence in a normal manner. The firmware shall not yield on subsequent permissive periods in the same cycle.

4-13 As an alternate to Subsections 4-10, 4-11 and 4-12, the coordinator may "automatically" provide for servicing and terminating phases through internal calculations based on the minimum green intervals, vehicle clearances, pedestrian walk and clearance intervals and the minimum and maximum cycle lengths supplied. Controllers utilizing automatic calculations shall provide an additional program to allow for a simple yield type of coordinated operation. That is, one release period occurring for approximately 3% of the cycle, whereas the coordinated phase(s) shall terminate and opposing calls are allowed to be serviced.

4-14 The firmware shall have the ability to display the following status information on the front panel:

A. Cycle 1 thru 4.

B. Offset 1 thru 3.

C. Split 1 thru 4.

D. Local Cycle Clock

E. Status of Force-offs, holds, and omits

4-15 The firmware shall be able to call for the following operations on a manual and/or time-of-day basis.

A. Flash.

B. Cycle 1 thru 4.

C. Offset 1 thru 3.

D. Split 1 thru 4.

E. Three external special functions. C1 harness outputs for these functions shall be user programmable.

F. Max-II Selection

4-16 The database for the TBC (Time Base Coordinator) shall be capable of supporting at least 10 day plans with no less than 200 event times distributed over the 10 day plans, 8 week plans assignable throughout the 52 weeks of the year, and at least 35 exception days. The exception day program may select "special days" or relate to an individual "normal" day plan.

4-17 Sync reference time shall be programmable or preset to midnight in order to provide a common point in time to reference the sync pulse for the cycle timers.

4-18 All unused green time from the actuated phases which do not time to their maximum or are skipped entirely, shall revert to the beginning of the coordinated green. If the programmed pedestrian time exceeds the programmed split value or max green time, the amount of time exceeded shall be subtracted from the coordinated phase (highway green). However, minimum fixed interval times shall not be violated.

4-19 The coordinated phase(s) shall be specified as part of the cycle definition allowing an alternate set of coordinated phases to be specified on a time-of-day basis.

MSDOS SUPPORT PROGRAM - V

5-1 An MSDOS support program shall be provided to remotely program and monitor the intersection software. This program shall be designed to operate via the front panel ACIA port. In addition, the program shall support ACIA #1. The program shall be designed to operate over dial-up modems, direct connections, or multi-drop audio or fiber optic modems.

5-2 A software address shall be part of the local intersection database to support multi-drop applications.

5-3 The MSDOS program shall be designed to operate on standard monochrome CGA displays under MSDOS 5.0 or greater. The program shall be operable under MSDOS on a standard 640 kilobyte computer. Connection to the controller shall be via RS232 port. The program shall support the selection of COM1, COM2, COM3, or COM4. Both 1 200 and 2 400 baud rates shall be supported.

5-4 The MSDOS program shall utilize user friendly state-of-the-art interactive input and display techniques.

5-5 The MSDOS program shall be capable of maintaining a separate database on disk for up to 1 000 intersections. Each intersection's database shall not require more than 5 kilobytes of disk space.

5-6 The MSDOS support program shall include the following capabilities:

A. Remote Reset Capability - The time and date of coordination module shall be resettable from the remote program.

B. Security Code - A security code capability shall be included in the controller unit. This code shall prevent any change to the data or to the mode of operation unless the current security code is first entered. The security code access shall be automatically rescinded after a period of time greater than 30 minutes. A means shall be provided to change or to remove the security code protection.

C. Printout Capability - The MSDOS software shall have the capability of producing a complete formatted report of an intersection's database to a standard printer. In addition, a complete status report shall also be available for printer output.

D. Upload/Download - The program shall allow the complete transfer of the intersection database to and from the MSDOS computer.

E. Status Report - The program shall produce a complete status report of the current operation of the selected intersection. The information on the report must be formatted on a single display screen. The report must be updated at least once a second and shall include the following information:

1. Current Phase and Interval Status for both Rings
2. Current Date and Time maintained by the Firmware
3. Current Mode of Operation: Free, Pre-empt, Manual, System Flash, Conflict, Cabinet Flash, etc.
4. Current Ring timers including initial, gap, extension, and max timers.
5. Current Time in Phase
6. Local Cycle Timers
7. Current Cycle, Split, and Offset in seconds and relative. (i.e., Cycle 1, Offset 2, Split 3)
8. Transition State and Cycles in Effect
9. Detector Activity including Presence and failed status.
10. Manual Selection of Cycle/Splits/Offset and free operation

5-7 One copy on 90 millimeter MSDOS disk (720 kilobytes) and one set of operations manuals shall be provided with every three firmware packages or fraction supplied under the contract.

PRIORITY OF CONTROL - VI

6-1 The order of priority of control from the highest to the lowest is as follows:

A. Manual Control from the Police Panel

B. Manual Control from the local keyboard

C. Manual Control from the Remote Monitor

D. Time Based Coordinator Operation

TESTING - VII

The 170E firmware shall be subject to factory testing prior to acceptance. This testing shall be designed to verify that the package complies with the specifications and shall include the operation of the MSDOS monitor. The vendor will be responsible for the preparation of a test procedure to verify compliance. The test will be held in New Jersey utilizing a cabinet in a laboratory facility.

TRAINING - VIII

8-1 Maintenance Training

The training shall be provided for a minimum of 24 hours for at least five (5) personnel with a signal maintenance background. The training shall include the use of the keyboard and remote terminal operation. The course shall thoroughly review diagnostic procedures, entry of data, and transfer of software between controllers.

8-2 Engineering Training

The training shall be provided for a minimum of 16 hours for at least twenty (20) engineering and operations personnel. The training shall include a complete demonstration of the operation and capabilities of the firmware. This session should include a complete review of the capabilities of the program and database development.

INSTRUCTIONS AND GUARANTEES - IX

9-1 One set of operation and database manuals for the 170E intersection firmware shall be supplied with every third controller assembly furnished.

9-2 No changes or substitutions in these requirements will be acceptable unless authorized in writing. Inquiries regarding this specification shall be addressed to the Manager, Office of ITS Engineering, New Jersey Department of Transportation, P.O. Box 613, 1035 Parkway Avenue, Trenton, New Jersey 08625.

9-3 The Supplier agrees upon the request of the Manager, Office of ITS Engineering to deliver to the Office, a sample of the control software to be supplied in compliance with these specifications for inspection and test before acceptance. After completion of the test, the sample shall be returned.

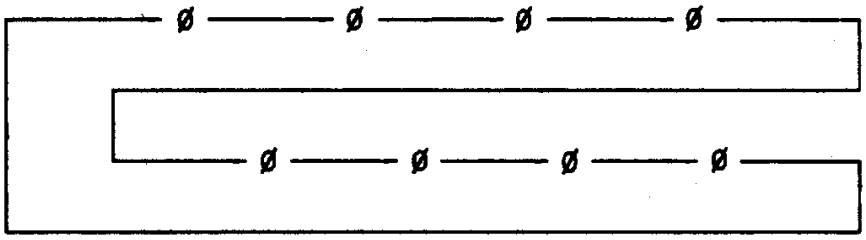
9-4 Software furnished under this specification must be currently supported by the vendor, comparable versions of which are field operational. Untried or prototype programs shall not be considered for acceptance.

9-5 In the event of a software revision made to the control program after the testing and approval of the package, the supplier must submit to the Office of ITS Engineering a letter explaining the changes, and the reasons for the changes. The updated software shall be made available in the form of an EPROM, at no additional cost.

9-6 The firmware and MSDOS program shall be warranted for a minimum of two (2) years from the date of turn-on to be free of errors. The vendor shall correct any errors or omissions in the software within 60 days of notification. The warranty shall include reasonable telephone consultation and support with the firmware vendor or qualified representative.

EIGHT PHASE SEQUENTIAL OPERATION

SEQUENCE #1



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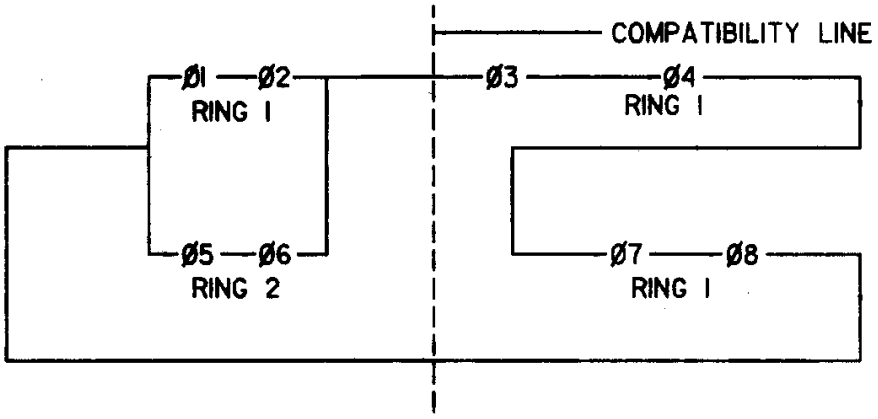

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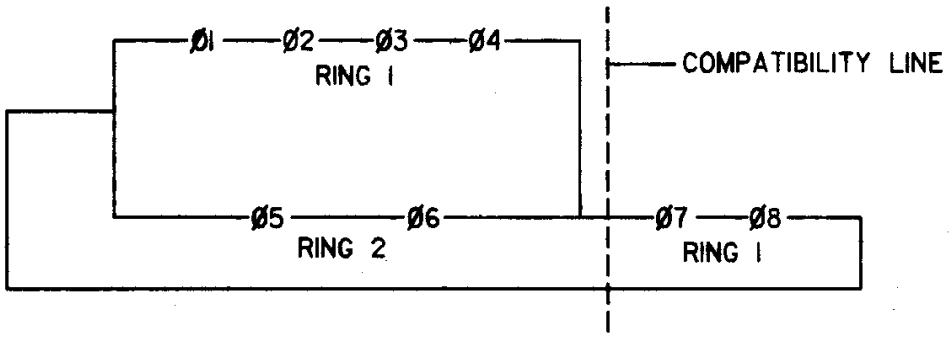

DIAGRAM No. 1