British Columbia
Ministry of Transportation and Infrastructure

TRAFFIC CONTROLLER ASSEMBLY MANUAL
VOLUME 1

Electrical and ITS Engineering

June 2019

TRAFFIC CONTROLLER ASSEMBLY MANUAL

500 INPUT MODIFIER CARDS

600 VEHICLE DETECTORS

700 POWER SUPPLY CARD

800 TRAFFIC CONTROLLER ASSEMBLY SUB-SYSTEMS

900 BASIC CONTROLLER ASSEMBLY OPERATION

1000 TRAFFIC CONTROLLER ASSEMBLY OPERATION AT MINISTRY INTERSECTIONS

1100 COMMUNICATIONS

PREFACE

This manual will be distributed to the participants in a three-day Traffic Controller Assembly course.

The manual is intended to provide course participants with three things:

1. A preview of the material covered in the course.
2. An authoritative reference that can be consulted during course assignments.
3. A combined review and trouble-shooting guide for reference when participants return to the job.

The scope of this manual is as follows:

1. The current edition of this manual is restricted to solid-state controllers.
2. The content of this manual is not intended to replace information contained in the technical documents customarily provided by the manufacturers of traffic controller assembly components.
3. The installation of new traffic controller assemblies is covered in material presented elsewhere.
4. Controller assembly components are treated in this manual as “black boxes”. Descriptions of all electronic components in this manual are at a functional level and exclude any information on the internal operation. The manual is intended to provide sufficient information for electrical personnel to identify faulty components in the event of a traffic controller assembly malfunction.
5. This manual is not a “stand-alone” learning aid or reference document. It is intended to be used in conjunction with formal classroom training. Course participants using this manual will have the opportunity to discuss the content during classroom sessions conducted by a qualified technical expert. They will also be given access to simulation equipment which will provide practical, hands-on experience following the procedures presented in the manual.

The target audience for this manual are journeymen electricians or senior apprentices operating and maintaining Ministry standard traffic controller equipment.

Electricians who have mastered the content of this manual are expected to meet the following learning objectives:

1. They will be able to determine the normal sequence of signal displays at an intersection by studying:
    a) Traffic Movements.
    b) Intersection drawings and timing sheet, where available.
    c) The electrical drawings which are supplied in each traffic controller assembly cabinet.
2. They will be able to identify the major components within the traffic controller assembly and understand the function of each.
3. They will be able to describe the normal sequence of operation of the controller unit “cycle” when it is functioning properly.
4. By observing the traffic controller assembly components’ displays, they will be able to ascertain and record in a standardized manner the function being attempted by a malfunctioning unit at the time normal operation was interrupted.
5. They will be able to follow a systematic trouble-shooting procedure to identify a faulty component and restore the traffic controller assembly to normal operation.

TRAFFIC CONTROLLER ASSEMBLY MANUAL

VOLUME 1

Section 100

Configuration of Common Ministry Intersections

Electrical and ITS Engineering

June 2019

100 CONFIGURATIONS OF COMMON MINISTRY INTERSECTIONS

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101 INTRODUCTION

This manual on traffic controller assemblies begins with a section describing common Ministry intersections, traffic movements and signal displays. The reasons for starting the manual in this way are quite straightforward. In order to understand what has gone wrong with a controller, it is necessary to know what the controller is supposed to do when it is operating correctly. To understand that, an electrician needs to have a mental image of the signals being displayed, the sequence in which they change and the traffic movements that are being regulated. This mental image must become second nature so that it can be easily recalled when the electrician encounters a faulty controller. Unless the electrician can quickly and easily visualize the regulated events, other diagnostic tools available within the traffic controller assembly will be meaningless. To properly understand a traffic controller assembly, one must first know the traffic movements and signal displays at the intersection.

After completing this section of the manual, it should be possible to work out the correct sequence of traffic signals for any of the common intersection configurations in your area. Studying the traffic flows at each intersection can do this. Make a habit of doing this whenever passing through an intersection. When called to work on a signal that has malfunctioned, mentally analyze the intersection prior to arriving. By the time you arrive at the intersection, you will already have a mental picture of the signal sequences when the controller is operating correctly.

Imagine arriving at the scene of a malfunctioning traffic controller assembly. All signals will probably be flashing, traffic will be building up rapidly, and everyone will be waiting impatiently for things to get back to normal. While getting out of the vehicle, take a quick look around for physical damage, such as broken or missing poles, smashed signal heads and so on. If there is nothing obviously broken, given the pressure situation it will be tempting to open the controller cabinet and begin looking for loose connections or even to start replacing components with the hope of finding the faulty unit by trial and error.

Resist those temptations! Open the controller cabinet and take a few moments to study the timing sheet. It shows the traffic patterns at the intersection, from which you can easily work out the correct signal sequence. Check that the timing sheet meets your expectations of the signal's normal operation.

102 SIMPLE INTERSECTIONS

102.1 DRAWING CONVENTIONS

.1 *Figures 1 and 2* show the intersection formed where a cross street meets the main highway. Study carefully the following explanations of the symbols shown.

.1 A vertical or horizontal arrow with a designation of A, B, C, A1 etc. in a circle or square indicates a green signal for traffic in the corresponding direction.

.2 An angled arrow indicates a green signal for left-turn traffic. There are two classifications of left-turn signals:

.1 An angled arrow with a traffic designation of $\overrightarrow{A1}$, $\overrightarrow{A2}$, $\overrightarrow{B1}$ or $\overrightarrow{B2}$ in a circle indicates a flashing green left-turn arrow or a “protected/permissive” left turn. The protected/permissive left turn movement consists of a flashing green arrow, followed by a solid yellow arrow. The flashing arrow for the left turn movement operates at 2 Hz. or 120 flashes per minute (fpm). This is twice the rate of flash for other flashing signals. There is no red indication for the left turn. Traffic may continue to turn left throughout the green portion of the adjacent through movement, when breaks in traffic occur. Left turn traffic is halted by the yellow and red signals of the adjacent through movement.

.2 An angled arrow with a traffic designation of Ax, Ay, Bx or By in a circle indicates a solid green left-turn arrow or a “protected” left turn. The fully protected left-turn movement consists of a solid green arrow, followed by a solid yellow ball, followed by a red ball. Left turns are only permitted during the solid green arrow portion of the movement.

.3 A line drawn across a traffic movement indicates a red signal. It is usually assumed that if a movement is not shown it is displaying red. Therefore, in most cases the red signal designation will not be seen.

.4 A dashed line with arrows on each end with a traffic designation of PA, PA1, PB, etc. indicates a pedestrian signal (i.e. a pedestrian movement controlled by "walk/don't walk" signal heads).

.5 Pedestrian movements usually occur with a corresponding vehicle movement. That is, PA occurs with the "A" movement, PA1 occurs with the "A1" movement and PB occurs with the "B" movement. For simplicity in the drawings, a reference to any phase includes the pedestrian movement associated with that phase. Pedestrian movements are not shown in *Figures 1 and 2*.

102.2 PHASE ASSIGNMENTS

.1 The Ministry customarily refers to distinct direction of traffic (movement) as a "phase". The word "phase" is represented by the symbol "∅". Hence, Phase A is normally written ∅A, Phase B is normally written ∅B and so on.

.2 For naming purposes, movements are grouped. Each group is given a letter designation (A, B, C, etc.). The groups are determined according to the following rules:

- .1 Through movements and separate left turn movements for the same approach are grouped together.
- .2 Movements on opposing approaches are grouped together provided that the opposing through movements may operate simultaneously during at least part of the traffic controller's cycle.
- .3 Highway movement groups are named first.

.3 When describing all the movements in a group, its letter alone is used. Thus, in our simple intersection, vehicles travelling along the main highway would be Phase A traffic. Vehicles on the cross street would be Phase B traffic

.4 When describing particular movements within a group, suffixes are appended to the group letter as follows:

- .1 A1 and A2 are opposing through movements.
- .2 Ax and Ay are opposing protected left-turn movements.
- .3 $\overrightarrow{A1}$ and $\overrightarrow{A2}$ are opposing protected/permissive left-turn movements.

.5 In naming opposing movements, cardinal directions such as ‘Northbound’ or ‘Southbound’ are appended. For highways, northbound or eastbound movements are named first. Whichever direction is chosen will always be the ∅A1 movement. Cross-street southbound or eastbound movements are named first. Other phase assignments are based on this initial assignment. *Figures 1 and 2* show the phase assignments for a north-south and east-west highway.

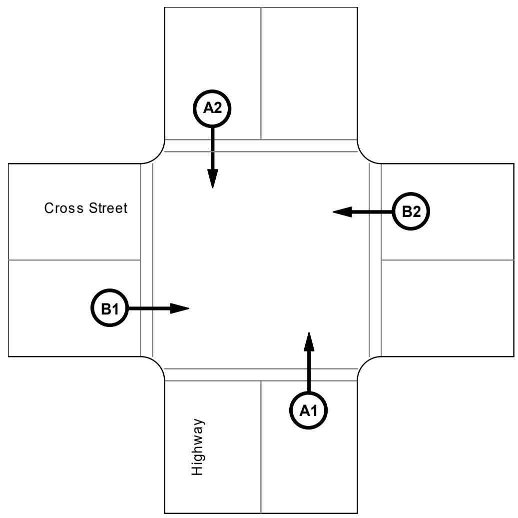

Figure 1. Direction Assignments for a North-South Highway

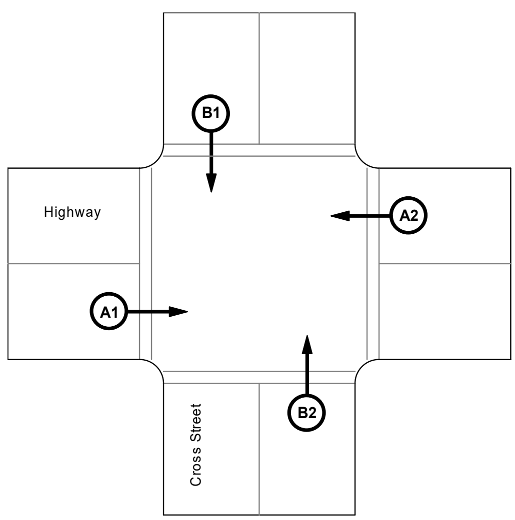

Figure 2. Direction Assignments for an East-West Highway

.6 For intersections turned 45 degrees to the cardinal directions, the assignment of directions is arbitrary, but should conform to nearby signals.

.7 An intersection which is part of a route or corridor that is designated north-south may not in fact be oriented north-south because of local geography. In these cases both true north and a designated National Electrical Manufacturer's Association (NEMA) north are indicated on the signal drawings. Phase assignments are oriented relative to the designated NEMA north.

102.3 TRANSFER OF RIGHT-OF-WAY

.1 At a simple intersection, the controller's job is to transfer the right-of-way from the highway to the cross street and back again. In our simple intersection, the right-of-way transfers between ∅A and ∅B traffic. An intersection at which the right-of-way is transferred between two phases is referred to as a "two-phase intersection".

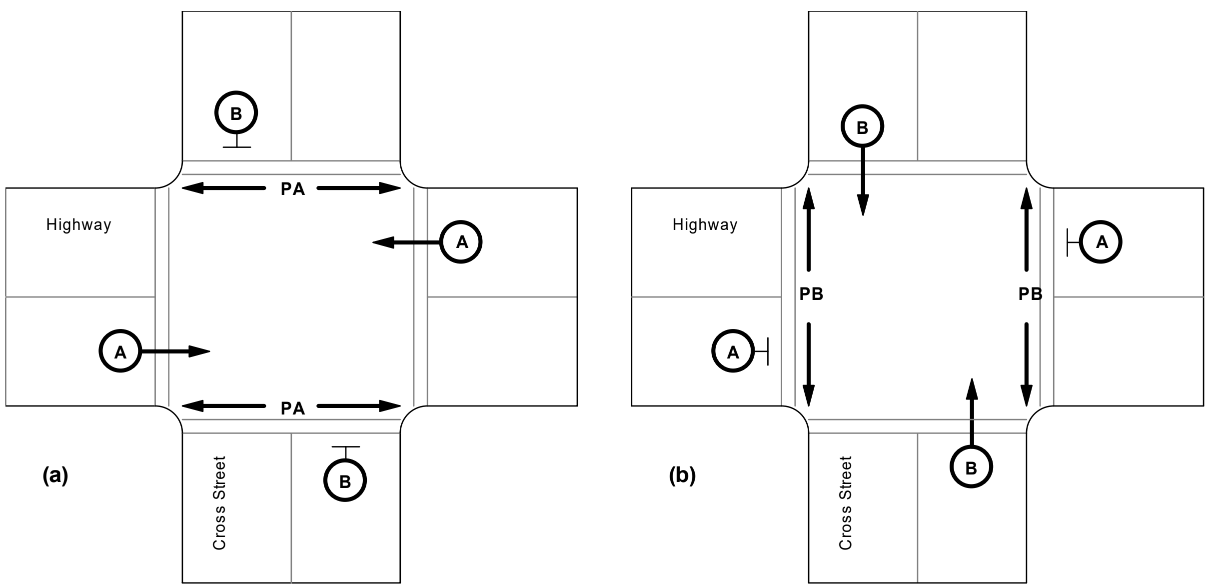

Figure 3. Transfer of Right-of-Way at a Two-Phase Intersection

.2 A single transfer of right-of-way is shown in *Figure 3*. In *Figure 3 (a)* the ∅A traffic (with associated pedestrian movement) has a green light, while ∅B traffic is halted by a red light. In *Figure 3 (b)*, the signal displays are reversed. Detailed drawings of the intersection are available from Electrical and ITS Engineering, and inside the traffic controller assembly. These drawings include sketches similar to the ones shown. Note that for clarity, the red signals are not shown in these sketches and will not be shown in other sections of this manual.

.3 Some two-phase intersections differ slightly from the previous example. *Figure 4 (a) and (b)* show the two phases of traffic movement at a T-intersection. In these cases, vehicles approaching from the cross street must either turn left or right. Note that only the left-turn or through movements of traffic flow are shown. Right turning traffic is never shown when it is permissible to turn right on a red signal (i.e. in most cases). Right turning traffic is only shown when there is a separate signal head for that vehicle movement as in *Figure 4 (c)*.

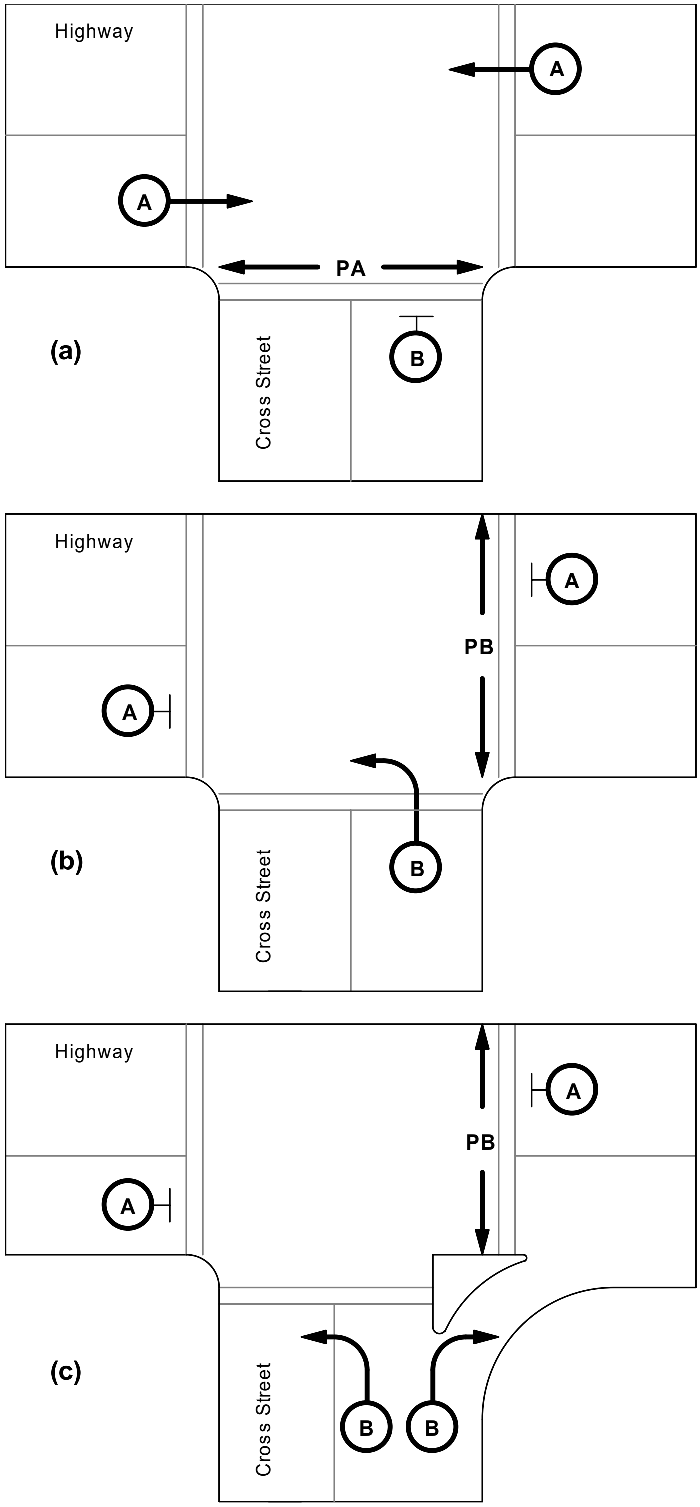

Figure 4. Transfer of Right-of-Way at a Two-Phase T-Intersection

103 INTERVALS AND COLOUR SEQUENCES

103.1 INTERVALS

.1 The signals at an intersection are in a fixed state at any given instant in time. The period of time during which any state prevails is referred to as an "interval". Refer to *Figure 5*. During this interval, the lights facing the highway traffic are green, while those directed at the cross street are red.

103.2 COLOUR SEQUENCES

.1 The combination of colours for Interval 1, shown in *Figure 5* is found in *Table 1* just below. This is referred to as a "colour sequence chart".

.2 In order to transfer the right-of-way safely to ∅B traffic, the drivers of ∅A vehicles must be warned that the transfer is about to occur. The signals must therefore change to a second interval. A yellow signal is displayed on the highway, while ∅B traffic continues to see a red light. This display is shown in Interval 2.

.3 For a simple two-phase intersection as shown in *Figure 5*, the signal displays would progress through the six intervals within a pre-set time, regardless of vehicle or pedestrian demand. The remaining colour sequences are shown in Intervals 3 through 6. Note that *Table 1* shows all six possible intervals for this intersection. Interval 1 will repeat following the end of Interval 6, then Interval 2 and so on. The sequence of colours will continue indefinitely in a circular fashion, hence this is referred to as the "cycle" of the intersection.

.4 The traffic controller assemblies used to regulate this type of intersection are referred to as "fixed-time" (non-actuated) controller assemblies. They are completely unresponsive to traffic demand and are typically suited for intersections experiencing constant traffic flow from all directions, at all times of the day.

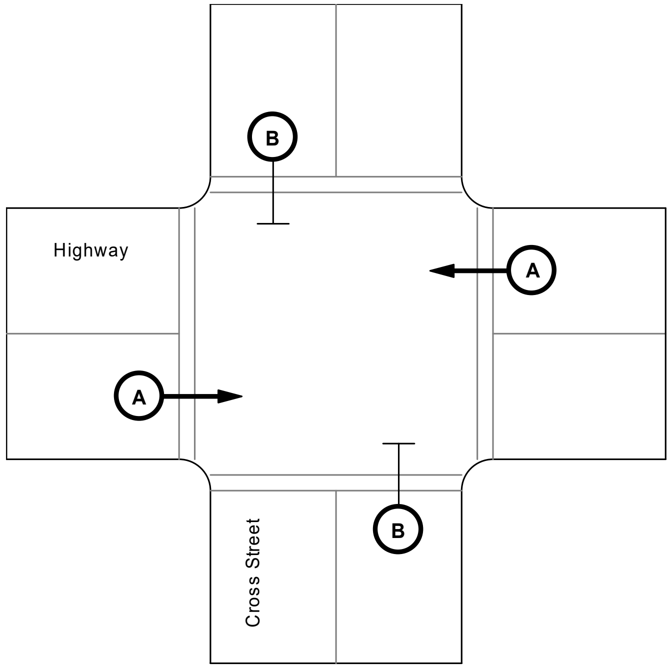

Figure 5. Simple Two-Phase Intersection

Interval	∅ A	∅B
1(rest)	G	R
2	Y	R
3	R	R
4	R	G
5	R	Y
6	R	R

Table 1. Colour Sequence for a Simple Two-Phase Intersection

.5 Obviously, traffic volumes need not be the same for each movement. If ∅A traffic occurs at a higher volume than ∅B traffic, then Interval 1 should be longer than Interval 4. Typically, however, the length of each interval should be adjusted to provide the most effective pattern of traffic movements.

.6 The controller unit is programmed to return to the highway and remain there indefinitely, when there is no cross-street demand. This is referred to as the “rest” interval.

104 FIXED-TIME, SEMI-ACTUATED AND FULLY-ACTUATED TRAFFIC CONTROLLER ASSEMBLIES

104.1 INTRODUCTION

.1 As traffic volumes change from one intersection to another, there is a need for different types of traffic controller assemblies. This chapter describes the three basic types:

.1 Fixed-time,

.2 Semi-actuated, and

.3 Fully-actuated.

104.2 FIXED-TIME TRAFFIC CONTROLLER ASSEMBLIES

.1 A fixed-time traffic controller assembly operates on a set of pre-programmed, fixed interval times. These times do not vary in response to changing vehicle demand.

.2 A fixed-time traffic controller assembly is typically used at an intersection that has a predictable traffic volume throughout the day and week.

.3 This type of control may also be used in an urban environment where adjacent signals are "co-ordinated". While the traffic controller assembly does not respond dynamically to vehicular demand, different pre-set timings may be used at different times of day.

104.3 SEMI-ACTUATED TRAFFIC CONTROLLER ASSEMBLIES

.1 Consider an intersection at which highway traffic is typically very heavy while traffic on the cross street varies from light to heavy. At many such intersections, ∅B traffic might sometimes dwindle to almost nothing and at other times reach an unusually high level. When the cross-street traffic is light or non-existent, there is no point in continuing to halt ∅A vehicles every minute or so. Conversely, heavy traffic on the cross street would soon back up if the cross-street interval was too short. Clearly, what is needed is a signal system that will adapt itself to variations in traffic demand on the cross street but deliver consistent green time to the highway. Control of this type is responsive to traffic demands from one or more phases, but not all phases. For this reason, it is referred to as "semi-actuated".

.2 The adaptability is achieved by equipping the cross street with vehicle detectors that signal to the traffic controller assembly whenever the presence of a vehicle is sensed. Refer to *Section 600* for more details on vehicle detectors.

104.4 FULLY-ACTUATED TRAFFIC CONTROLLER ASSEMBLIES

.1 At some intersections, traffic varies from light to heavy on both the highway and cross street. Traffic can be moved more efficiently at such intersections by installing vehicle detection in all directions. This allows the traffic controller assembly to respond to variations in vehicle demand from all directions. Control of this type is called "fully-actuated".

.2 Fully-actuated traffic controller assemblies provide a variable green time for all traffic phases. In other words, the green time for the cross street and highway has both a minimum and maximum limit. The actual green time experience in each cycle will vary between these limits according to demand. The allowable range of time will not typically be the same on the cross street as on the highway. The essential difference between the semi and fully-actuated traffic controller assembly is that only the fully-actuated provides variable green time for *all* phases.

105 TWO-PHASE INTERSECTIONS

105.1 FIXED-TIME INTERSECTIONS

.1 At a two-phase intersection controlled by a fixed-time traffic controller assembly, the interval times on the highway and cross street are pre-set. They do not vary in response to vehicle or pedestrian demand.

.2 The green times are based on predicted traffic volumes, for each direction, and are pre-programmed. The green times on the highway must be made sufficiently long to accommodate heavier volumes. This often results in traffic waiting on the cross street when there is minimal highway traffic. In addition, pedestrian movements occur, automatically, with the associated vehicle movement. The green times may be increased to allow sufficient time for pedestrians to clear the intersection. For these reasons, fixed-time operation is not the most efficient means of intersection control and is not used by the Ministry.

105.2 SEMI-ACTUATED INTERSECTIONS

.1 At a two-phase intersection controlled by a semi-actuated traffic controller assembly, the right-of-way will remain with the highway for at least the guaranteed green time or as long as there is no traffic on the cross street. When a ∅B vehicle reaches the intersection, the detector sends a signal to the traffic controller assembly. Right-of-way is then transferred to cross-street traffic. The minimum green interval for cross-street vehicles (Interval 4 - see *Table 1)* will be long enough for a stopped vehicle to clear the intersection. Unless additional vehicles are detected on the cross street, the controller will move on to Intervals 5 and 6, returning automatically to Interval 1. At this point, right-of-way has been returned to the highway. This type of traffic control is a very efficient way of granting adequate movement to cross-street vehicles while favouring highway traffic.

.2 Intersections such as the on just described were quite common on Provincial highways. Because traffic flow along the highway is fairly regular and often high-speed, the intersection rests in green on Interval 1. It will automatically pass through Intervals 5 and 6 and return to Interval 1 after Interval 4 has ended. Once the intersection returns to Interval 1, it will remain there for a guaranteed green time before responding to any calls from ∅B traffic. If there is no ∅B traffic at the end of the guaranteed green time, right-of-way will remain on the highway.

.3 Notice that the semi-actuated traffic controller assembly is capable of coping with an increase in ∅B traffic. For this purpose, the green interval for ∅B traffic ranges between "minimum" and "maximum" times. If traffic is detected after the minimum green time of Interval 4, the green signal will be extended. Detection of subsequent vehicles will result in further extensions of the ∅B green time up to the maximum limit. This process will continue until either:

.1 No further ∅B traffic is detected within a pre-set period of time, or

.2 The pre-set maximum limit has been reached.

.4 ∅B vehicles that are unable to enter the intersection before the maximum limit has been reached are halted by the signals as the intersection returns to Interval 1. The intersection begins the guaranteed green time for highway traffic.

.5 Where a semi-actuated controller has been installed, the green time for highway traffic is fixed. By contrast, the green time for cross-street traffic varies in response to changing traffic demands. The actual green time varies between the minimum and maximum times allowed.

.6 Consider now a two-phase intersection at which pedestrians occasionally wish to cross both streets. If ∅B traffic is typically very light, pedestrians can be given a "walk" signal to cross the secondary street safely during Interval 1. They may have to wait for a short time while the intersection is in Intervals 2 through 6, but this will only be a minor and infrequent inconvenience.

.7 Since ∅A traffic is halted only occasionally by the detection of cross-street traffic, pedestrians wishing to cross the highway require a "pedestrian push-button". When a pedestrian uses the push-button, a "pedestrian call", is sent to the traffic controller assembly. When a pedestrian call occurs, the right-of-way transfers to the cross street in the usual manner. Pedestrians at most intersections are allowed a longer time to cross the intersection than vehicles. The intersection will then automatically return to Interval 1 as before. In contrast, fixed-time traffic controller assemblies allow pedestrians to cross the intersection in conjunction with the fixed vehicle movements only.

105.3 FULLY-ACTUATED INTERSECTIONS

.1 At a fully-actuated intersection, the right-of-way remains with ∅A traffic until a vehicle is detected on ∅B. Thus, if the signals are green on the highway, and red on the cross street, they will remain in Interval 1 indefinitely, unless a different demand is sensed. Again, the traffic controller is said to rest in green on the highway. Note that the colour sequence chart presented in Figure 4 is still valid for the fully-actuated intersection. A vehicle call on ∅B causes the intersection to move through Intervals 2 and 3 to Interval 4, at which point the right-of-way has been transferred. A pedestrian wishing to cross the highway can also initiate a transfer of right-of-way by pushing the pedestrian push-button. The intersection will return to Interval 1 after the cross-street vehicle or pedestrian demands have been met. ∅A pedestrian movements occur in response to push-button as well, and start at the beginning of the green of the associated highway movement.

.2 Note that there is no difference in the colour sequence between signal changes caused by vehicle versus pedestrian demand. Often both will occur simultaneously. The observed difference in the intersection will be variable interval times due to the different programmed limits allowed for vehicles or pedestrians to safely cross the intersection.

106 THREE-PHASE INTERSECTIONS

106.1 T-INTERSECTION

.1 The major "T" intersection shown in *Figure 6* has moderate to heavy traffic in all through and left-turn movements. The highway is divided into two separate phases, ∅A and ∅B. The cross street movement is called ∅C. The right-of-way rests with ∅A when there are no demands from traffic in the other two phases. *Table 2*, shows the colour sequence.

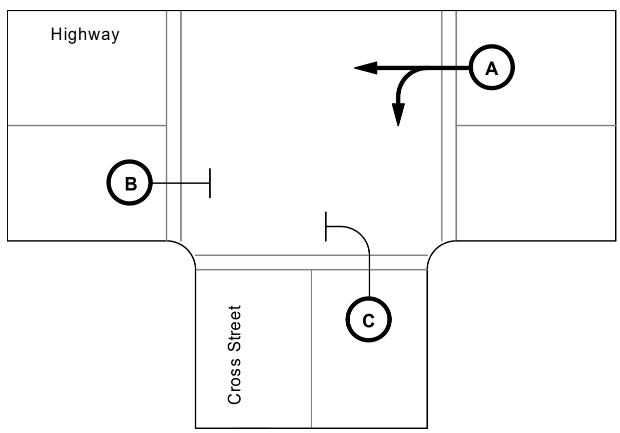

Figure 6. Three-Phase T-Intersection

Interval	∅ A	∅B	∅C
1(rest)	G	R	R
2	Y	R	R
3	R	R	R
4	R	G	R
5	R	Y	R
6	R	R	R
7	R	R	G
8	R	R	Y
9	R	R	R

Table 2. Colour Sequence for a Three-Phase T-Intersection

106.2 PROTECTED/PERMISSIVE LEFT TURN ON THE HIGHWAY

.1 Refer to the intersection shown in *Figure 7 (a) to (c)*. There are three true traffic phases: $\overleftarrow{\text{A1}}$, A2 and B. Notice that although the highway traffic is split into two phases, both are labelled “A”. The remaining phase A1 which can be on (i.e. green) with either ∅$\overleftarrow{\text{A1}}$ or ∅A2 is referred to as an “overlap”. These three movements share a common alphabetical label (i.e. are grouped) since the ∅A1 overlap green signal is always on when ∅A2 is green. This configuration is used where a two-lane highway meets a cross street. Sometimes the demand for left-turn traffic movement is too heavy to be satisfied by natural breaks in the opposing traffic. In this case the ∅A2 vehicles must be stopped periodically to avoid an excessive build-up of left-turn traffic. This intersection can be described as having an “advance left turn” (∅$\overleftarrow{\text{A1}}$) on the highway. This is a protected/permissive left turn.

.2 Let us assume that traffic demands are equal and continuous from all directions. Refer to *Figure 7 (a) to (c)* and *Table 3* for the following description of how the intersection operates:

.1 During Interval 1, the right-of-way remains with ∅A traffic, i.e. signals for the ∅A1 and ∅A2 lanes are simultaneously green. ∅B vehicles see a red light. Vehicles in the ∅A1 lane are permitted to turn left when adequate breaks appear in the oncoming (∅A2) traffic.

.2 The intersection now moves to Intervals 2 and 3. ∅A1/A2 lanes are warned to stop by yellow signals followed by red. ∅B traffic remains stopped.

.3 In Interval 4, ∅A1/A2 traffic will be halted by red lights and ∅B traffic will proceed with a green signal.

.4 During Interval 5, ∅B traffic is warned to stop by a yellow light. ∅A1/A2 traffic remains stopped.

.5 Interval 6 is an “all red” interval where all directions see a red light. This provides a “clearance” time for vehicles to leave the intersection prior to a transfer of right-of-way.

.6 In Interval 7, the ∅$\overleftarrow{\text{A1}}$ shows a flashing green arrow. The ∅A1 through traffic is allowed to proceed simultaneously on a solid green light. During this interval, ∅A2 and ∅B traffic are stopped.

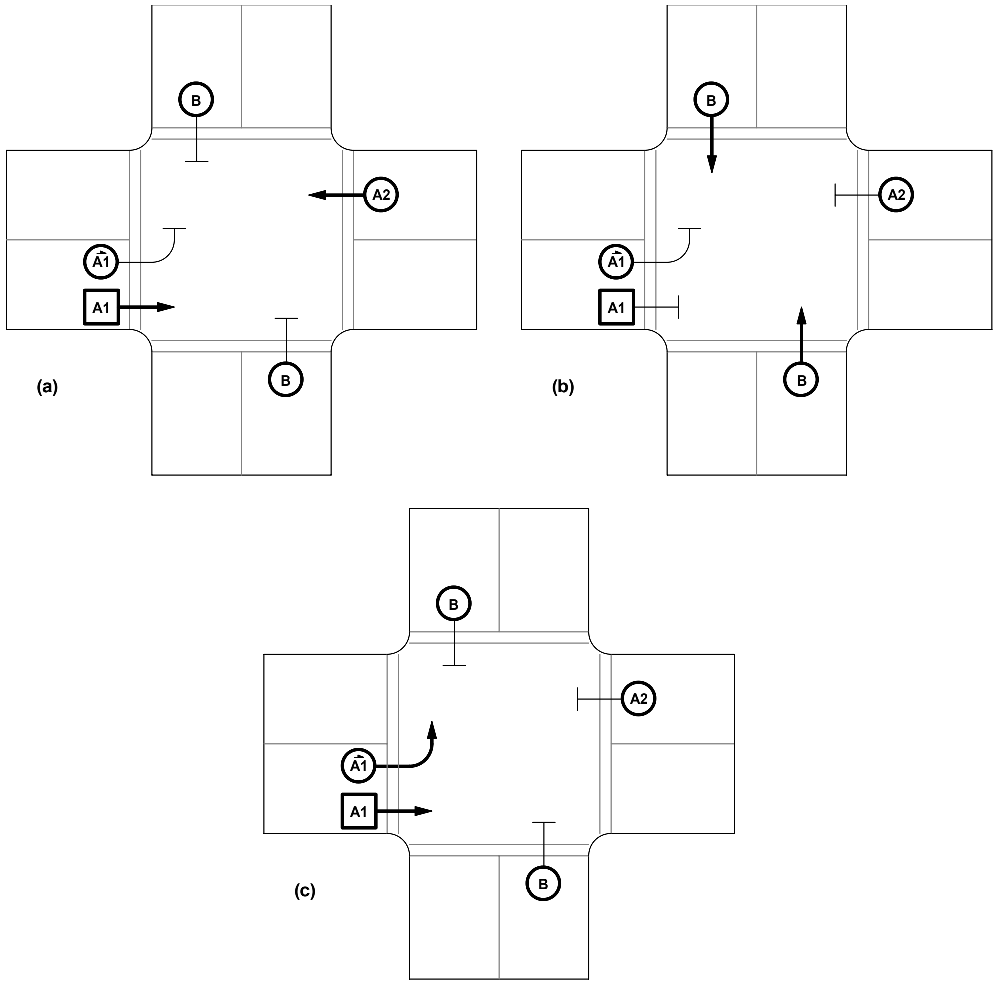

Figure 7. Three-Phase Intersection with Protected/Permissive Left Turn on the Highway

Interval	∅A1	∅A2	∅B	∅$\overrightarrow{\text{A1}}$
1(rest)	G	G	R	-
2	Y	Y	R	-
3	R	R	R	-
4	R	R	G	-
5	R	R	Y	-
6	R	R	R	-
7	G	R	R	G
8	G	R	R	Y
9	G	R	R	-

Table 3. Colour Sequence for a Three-Phase Intersection with Protected/Permissive Left Turn on the Highway

.7 At the end of the advance left turn time, the ∅$\overleftarrow{A1}$ first turns to a solid yellow arrow during Interval 8, followed by blank in Interval 9. Note that in all intervals except Intervals 7 and 8 ∅$\overleftarrow{A1}$ is blank, even though technically it is in the red state. There is no separate red light for a protected/permissive left turn. This is indicated by a dash in the colour sequence chart.

.8 The intersection automatically returns to Interval 1. A1/A2 traffic has right-of-way. Left turns are still permitted during breaks in ∅A2 traffic.

106.3 PROTECTED/PERMISSIVE LEFT TURN ON THE CROSS STREET

.1 In the intersection shown in *Figure 8*, the advance left turn arrow is provided for one direction of the cross street, instead of the highway. This configuration is used where left-turn traffic along the cross street is too heavy to be accommodated by breaks in the oncoming traffic. Cross-street traffic is split into two phases, namely ∅$\overleftarrow{B1}$ and ∅B2. Whenever the right-of-way is transferred from the highway to the cross street, ∅$\overleftarrow{B1}$ traffic gets a flashing green arrow and ∅B1 overlap gets a solid green light, while ∅B2 traffic remains stopped. After the advance left turn, yellow arrow and red clearance, both ∅B2 and ∅B1 get green lights. The right-of-way finally returns to the highway ∅A traffic. The intersection remains in Interval 1 until there is a demand from cross-street traffic.

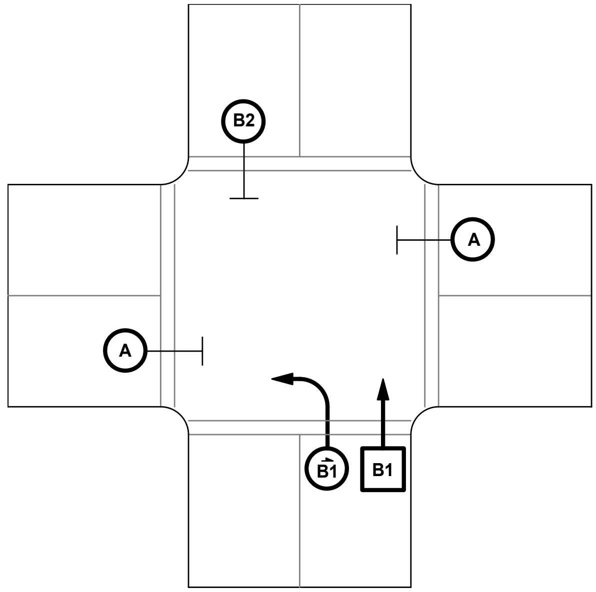

Figure 8. Three-Phase Intersection with Protected/Permissive Left Turn on the Cross Street

Interval	∅A	∅$\overrightarrow{B1}$	∅B1	∅B2
1(rest)	G	-	R	R
2	Y	-	R	R
3	R	-	R	R
4	R	G	G	R
5	R	Y	G	R
6	R	-	G	R
7	R	-	G	G
8	R	-	Y	Y
9	R	-	R	R

Table 4. Colour Sequence for a Three-Phase Intersection with Protected/Permissive Left Turn on the Cross Street

107 FIVE-PHASE INTERSECTIONS

107.1 DUAL LEFT TURN ON THE HIGHWAY

.1 The Ministry uses this intersection configuration where traffic is fairly continuous from all directions but highway volumes vary with the time of day. *Figure 9* shows an example of such an intersection.

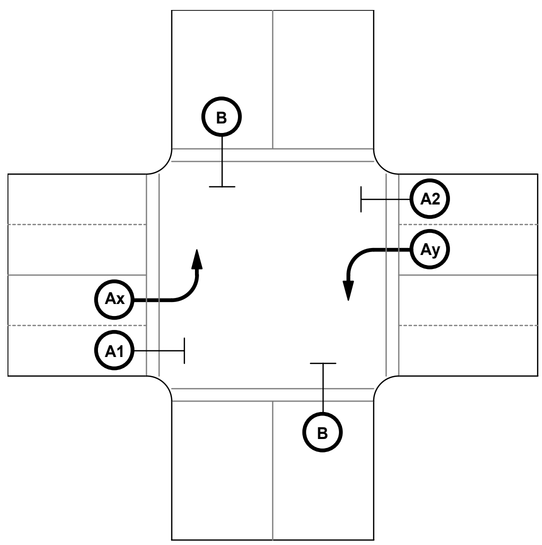

Figure 9. Five-Phase Dual Left Turn Intersection

Interval	∅Ax	∅Ay	∅A1	∅A2	∅B
1	G	G	R	R	R
2	Y	Y	R	R	R
3	R	R	R	R	R
4(rest)	R	R	G	G	R
5	R	R	Y	Y	R
6	R	R	R	R	R
7	R	R	R	R	G
8	R	R	R	R	Y
9	R	R	R	R	R

Table 5. Colour Sequence for a Five-Phase Dual Left Turn Intersection

.2 This intersection is configured in a special manner referred to as “Dual Ring”. A ‘ring’ refers to a group of phases that are serviced sequentially. There are two rings of four phases each. Not all phases may, however, be used at a given intersection. One phase from each ring may be green at the same time. Two phases in the same ring cannot be green at the same time except for three allowable combinations:

  .1 Two left turns may be on together (e.g. ∅Ax and ∅Ay).

  .2 Two through phases may be on simultaneously (e.g. ∅A1 and ∅A2).

  .3 One of the through phases and the adjacent left turn may be on at the same time (e.g. ∅A1 and ∅Ax or ∅A2 and ∅Ay).

.3 The right-of-way rests with highway through traffic (Interval 4) until there is a demand for left turn or cross-street movement.

.4 If there is a demand from cross-street traffic only, the intersection progresses to Intervals 5, 6, 7, 8 and 9 and then returns directly to Interval 4.

.5 If there is a demand for highway left-turn movement before the cross-street demand has been satisfied, the intersection progresses from Interval 9 through Intervals 1, 2 and 3 before returning to Interval 4.

.6 If there is a demand for highway left-turn movement, but no demand from the cross street, the intersection progresses through Intervals 5 and 6, then goes directly to Intervals 1, 2 and 3 before returning to Interval 4; Intervals 7, 8 and 9 are skipped.

108 SIX AND SEVEN-PHASE INTERSECTIONS

108.1 SIX-PHASE INTERSECTIONS

.1 As described below, the Ministry commonly employs two intersections of this type. Examples are shown in *Figures 10 and 11*. Notice the differences between the two configurations. Both are designed for situations in which traffic is fairly continuous, but variable from moderate to heavy, on all movements, throughout the day. The right-of-way is normally given to through traffic along the highway. Cross-street movement is permitted after the highway through movements have been serviced

108.1.2 Dual Left Turn with Split Cross Street

.1 In the case of heavy left-turn demand from both sides of the cross street, two entirely independent phases, B and C are used. This is done to maximize the cross-street left-turn time by allowing it to be on throughout the corresponding through movement. This method is used when normal advance left turn time can not be suitably increased without adversely affecting the traffic flow on the highway. In addition, this method is often used in conjunction with an extra centre lane on the cross street that allows both through and left-turn traffic.

.2 Traffic from one cross-street direction remains stopped while vehicles from the opposing direction are allowed to proceed through or to turn left. The right-of-way transfers first from ∅A to ∅B, then from ∅B to ∅C. Eventually, the right-of-way is transferred back to highway (∅A) traffic.

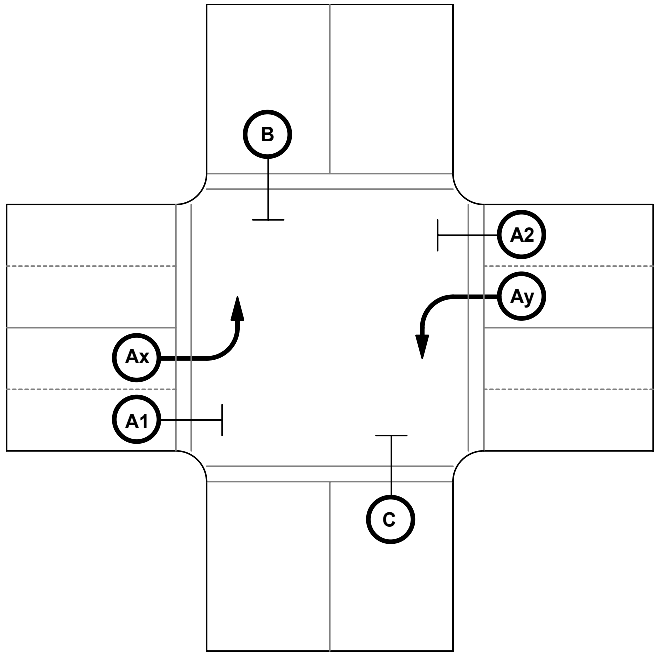

Figure 10. Six-Phase Dual Left Turn with Split Cross Street

Interval	∅Ax	∅Ay	∅A1	∅A2	∅B	∅C
1	G	G	R	R	R	R
2	Y	Y	R	R	R	R
3	R	R	R	R	R	R
4(rest)	R	R	G	G	R	R
5	R	R	Y	Y	R	R
6	R	R	R	R	R	R
7	R	R	R	R	G	R
8	R	R	R	R	Y	R
9	R	R	R	R	R	R
10	R	R	R	R	R	G
11	R	R	R	R	R	Y
12	R	R	R	R	R	R

Table 6. Colour Sequence for a Six-Phase Dual Left Turn with Split Cross Street

108.1.3 Dual Left Turn with Protected/Permissive on the Cross Street

.1 Sometimes left-turn demand is heavier from one cross-street direction than the other. In this case, a protected/permissive left turn, ∅$\overleftarrow{B1}$, on the B movement is used. Cross street through traffic is split into ∅B1 overlap and ∅B2. If, unlike this case, one of the through movements is not an overlap, a seven-phase configuration results. Refer to *Clause 108.2* below.

.2 The ∅B1 overlap signal is green and ∅$\overleftarrow{B1}$ traffic is given a flashing green arrow while the ∅B2 traffic remains halted (Interval 7). Following the yellow arrow and red clearance of ∅$\overleftarrow{B1}$, ∅B1 remains green and ∅B2 through traffic would be allowed to proceed. The right-of-way ultimately returns to the highway (Interval 4), where it rests pending demands from the cross street or highway left turns.

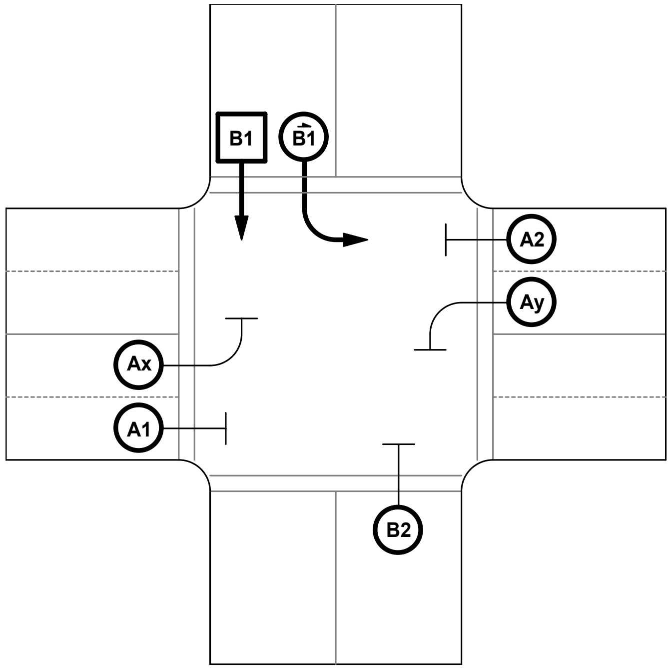

Figure 11. Six-Phase Dual Left Turn with Protected/Permissive on the Cross Street

Interval	∅Ax	∅Ay	∅A1	∅A2	∅$\vec{B1}$	∅B1	∅B2
1	G	G	R	R	-	R	R
2	Y	Y	R	R	-	R	R
3	R	R	R	R	-	R	R
4(rest)	R	R	G	G	-	R	R
5	R	R	Y	Y	-	R	R
6	R	R	R	R	-	R	R
7	R	R	R	R	G	G	R
8	R	R	R	R	Y	G	R
9	R	R	R	R	-	G	R
10	R	R	R	R	-	G	G
11	R	R	R	R	-	Y	Y
12	R	R	R	R	-	R	R

Table 7. Colour Sequence for a Six-Phase Dual Left Turn with Protected/Permissive on the Cross Street

108.2 SEVEN-PHASE INTERSECTIONS

108.2.1 Dual Left Turn with Protected/Permissive on the Cross Street

.1 This configuration is similar to the previous example. In this case, the through movement with the protected/permissive left turn is a true phase, instead of an overlap. This results in the seven-phase configuration shown in *Figure 12*. The protected/permissive left turn is shown on ∅B2 in this example.

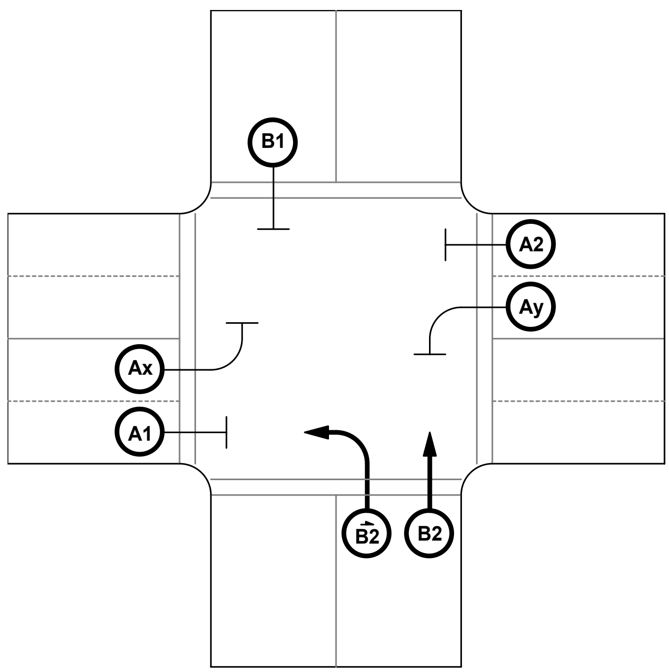

Figure 12. Seven-Phase Dual Left Turn with Protected/Permissive on the Cross Street

109 EIGHT-PHASE INTERSECTIONS

109.1 QUADRUPLE PROTECTED LEFT TURN

.1 The eight-phase, quadruple protected left turn configuration is used where traffic demand varies from moderate to heavy in all directions, throughout the day. Refer to *Figure 13* and *Table 8*. This is a dual-ring configuration as discussed earlier. Two phases are given a green signal at the same time. One of the following three conditions will exist:

.1 Two left turns of the same movement will be on together,

.2 Two opposing through phases will be on together, or

.3 One through phase and the adjacent left turn will be on together.

.2 Note that only A movement phases or B movement phases may be on simultaneously. A combination of A phases and B phases is not allowed.

.3 The fully protected left-turn movement consists of a solid green arrow, followed by a yellow light, followed by a red light. Left turns are not permitted, except during the green arrow.

109.2 QUADRUPLE PROTECTED/PERMISSIVE LEFT TURN

.1 The eight phase, quadruple protected/permissive left turn configuration is similar to the previous example. It differs in that left turns from all directions are permitted after the end of the protected left turn portion of the movement. Refer to *Figure 14* and *Table 9*.

.2 The protected/permissive left turn movement consists of a flashing green arrow (120 fpm), followed by a solid yellow arrow. There is no red indication specifically for the left turn. Traffic may continue to turn left during the green time of the adjacent through movement. Left turn traffic is halted by the yellow and red signals of the through movement.

.3 Left turns begin with the adjacent through movement when there is no demand from left-turn traffic in the opposing direction. Cross-street left turns may occur without any through movements at all, if there is demand for left turns in both opposing directions but no corresponding through movement demand in either direction.

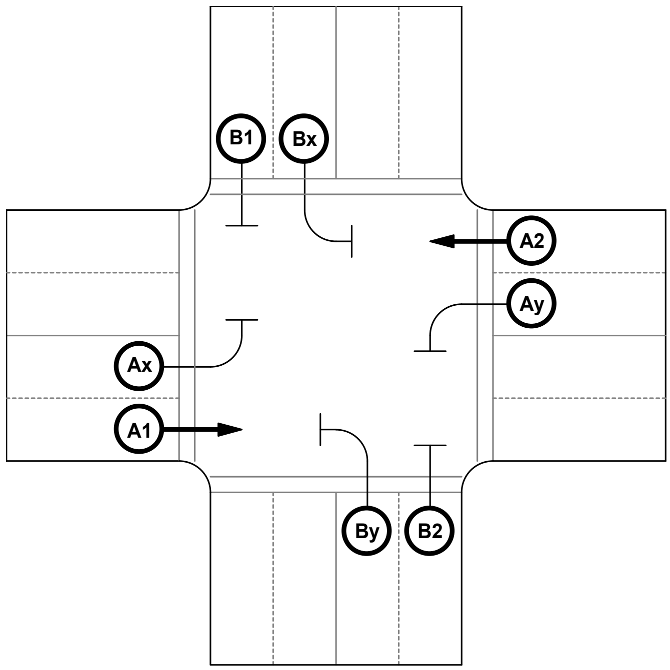

Figure 13. Eight-Phase Quadruple Protected Left Turn

Interval	∅Ax	∅Ay	∅A1	∅A2	∅Bx	By	∅B1	∅B2
1	G	G	R	R	R	R	R	R
2	Y	Y	R	R	R	R	R	R
3	R	R	R	R	R	R	R	R
4(rest)	R	R	G	G	R	R	R	R
5	R	R	Y	Y	R	R	R	R
6	R	R	R	R	R	R	R	R
7	R	R	R	R	G	G	R	R
8	R	R	R	R	Y	Y	R	R
9	R	R	R	R	R	R	R	R
10	R	R	R	R	R	R	G	G
11	R	R	R	R	R	R	Y	Y
12	R	R	R	R	R	R	R	R

Table 8. Colour Sequence for an Eight-Phase Quadruple Protected Left Turn

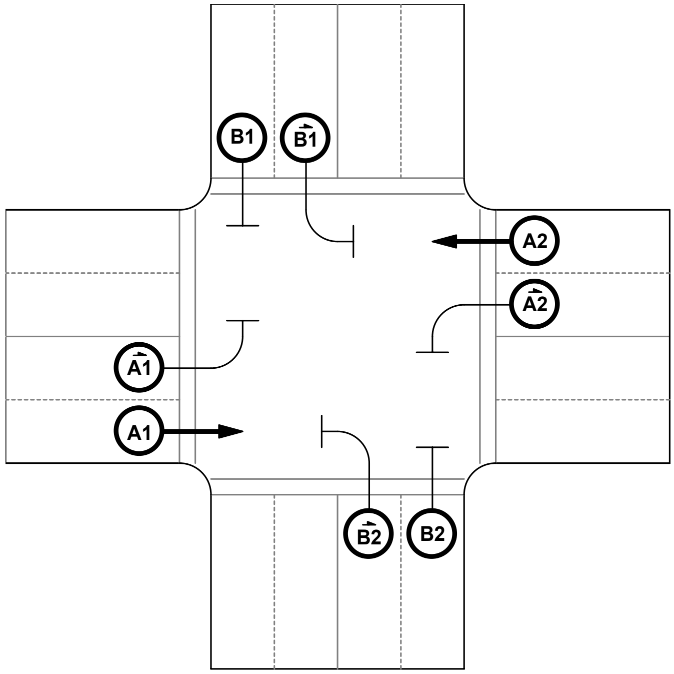

Figure 14. Eight-Phase Quadruple Protected/Permissive Left Turn

Interval	$\varnothing\overrightarrow{A1}$	$\varnothing\overrightarrow{A2}$	∅A1	∅A2	$\varnothing\overrightarrow{B1}$	$\overrightarrow{B2}$	∅B1	∅B2
1	G	G	R	R	-	-	R	R
2	Y	Y	R	R	-	-	R	R
3	-	-	R	R	-	-	R	R
4(rest)	-	-	G	G	-	-	R	R
5	-	-	Y	Y	-	-	R	R
6	-	-	R	R	-	-	R	R
7	-	-	R	R	G	G	R	R
8	-	-	R	R	Y	Y	R	R
9	-	-	R	R	-	-	R	R
10	-	-	R	R	-	-	G	G
11	-	-	R	R	-	-	Y	Y
12	-	-	R	R	-	-	R	R

Table 9. Colour Sequence for an Eight-Phase Quadruple Protected/Permissive Left Turn

109.3 DIAMOND INTERCHANGE

.1 The diamond interchange is typically used for access to/from on and off ramps of a freeway. In this case, the intersections may be located on, or in proximity to an overpass. This configuration, shown in *Figure 15*, may also be used at a level intersection where a cross street intersects a divided highway. Special programming is required to avoid congestion in the centre of the intersection.

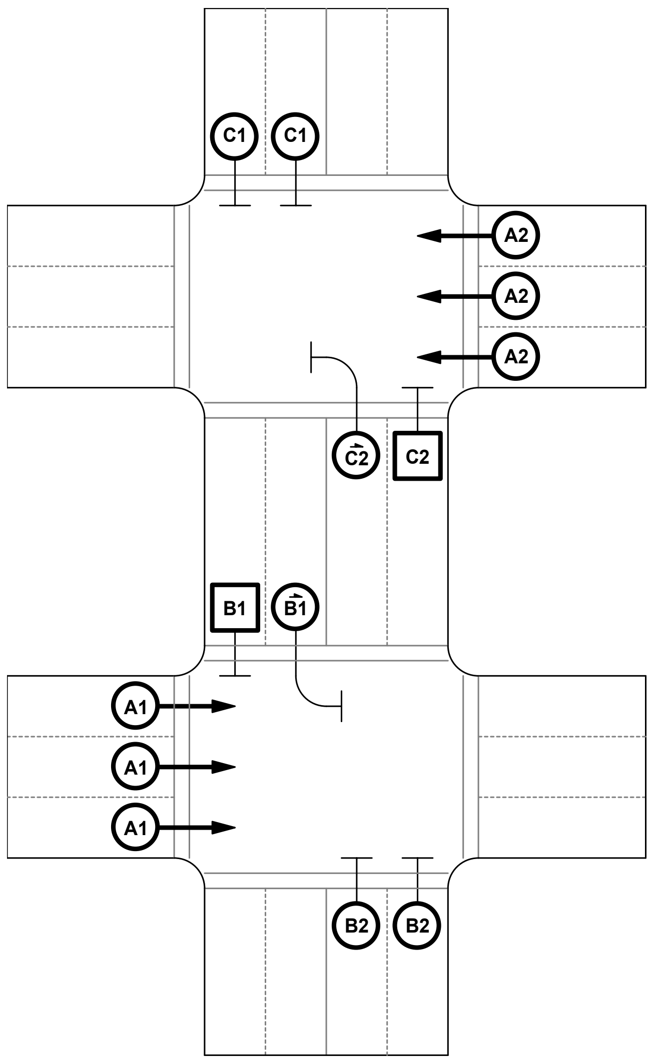

Figure 15. Diamond Interchange

110 INTRODUCTION TO ADVANCE WARNING AND PRE-EMPTION

This section deals with additional features of intersection operation. It is important to realize that many Ministry intersections have these enhanced features installed and that these modes of operation will occur in addition to the basic operation we have already learned.

110.1 ADVANCE WARNING

.1 An Advance Warning System is a safety feature that warns drivers to prepare to stop at an approaching intersection. The light is either red, or is about to turn red.

.2 An Advance Warning System consists of a set of flashing lights, mounted on a special warning sign. This sign is installed at a prescribed distance on an approach to an intersection. The warning lights are controlled by electronics within the traffic controller assembly.

.3 The use of advance warning is primarily governed by the speed limit at an intersection. Advance warning signs are normally installed on both highway approaches to an intersection where the speed limit is 70 km/h or higher. Advance warning signs will be installed on the cross street when its speed limit is 70 km/h or greater as well. Advance warning signs may be installed in areas with lower speeds when other hazards such as steep grades and/or limited visibility occur.

.4 The Advance Warning System begins to operate prior to the end of the green interval of the phase. The period of time prior to the end of the green light is called the “pre-termination interval”. The advance warning flashers, which are mounted on the advance warning sign, begin to flash alternately. At this time, the associated phase is still displaying green. At the end of the pre-termination interval, the phase times the yellow and red clearance intervals as normal. The advance warning flashers continue to flash until the phase returns to a green display.

.5 The pre-termination interval is programmed for each phase on which advance warning is installed. The interval time is determined by the length of time for a vehicle, travelling at the posted speed, to cover the distance from the site of the advance warning sign to the intersection. Thus, if a vehicle passes the advance warning sign just as it begins to operate, the associated phase will turn from green to yellow as that vehicle reaches the intersection. Vehicles that have not reached the advance warning sign will have enough time to stop before the end of the yellow clearance interval.

.6 The pre-termination interval is normally the same for opposing directions of travel. Exceptions to this may occur due to the grade or limited visibility on one approach. If one direction requires additional warning time, the pre-termination interval will be increased. Traffic approaching downhill will see the advance warning flashers operating a short time before traffic approaching from the other direction. In this case, the longer pre-termination interval is used to compensate for the increased stopping distance required for vehicles travelling downhill. For more information on Advance Warning, refer to *Chapter 503.*

110.2 PRE-EMPTION

.1 Pre-emption is the transfer of the normal control of signals to a special control mode. This mode of operation is most commonly required for emergency vehicles and railroad crossings. Pre-emption is also used for transit or High-Occupancy Vehicles (HOV) and for other special needs that are not within the normal operation of the traffic controller assembly.

.2 A special set of instructions call a “Pre-Empt Sequence” is used to determine intersection operation during pre-emption. A “Pre-Emption Request” is an electrical signal from an external source that can occur at any time.

.3 Upon receipt of a pre-emption request, the traffic controller assembly will immediately execute the operation specified in the pre-empt sequence. In order to maintain safe operation, certain steps must be followed. The time required to execute the pre-empt sequence instructions will vary depending upon the prevailing intersection conditions at the instant the pre-emption request occurs.

.4 The pre-empt sequence may occur for a predetermined length of time; long enough, for example, for an emergency vehicle to safely cross the intersection. Alternately, in the case of rail pre-emption, for example, pre-emption operation may remain in effect as long as the request for pre-emption prevails, i.e. until the train has passed by.

.5 Any intersection may have more than one source of pre-emption request and will have a pre-empt sequence program for each. Rail pre-emption is always the highest priority. Emergency vehicle pre-emption, which takes second priority, can have up to four different pre-empt sequences – one for each direction of approach to the intersection. Transit or HOV pre-emption is the lowest priority and may occur separately, or in addition to emergency vehicle or rail pre-emption. In each case, the traffic controller assembly responds to the highest priority request and will execute the associated pre-empt sequence.

.6 At the end of the pre-empt sequence program the traffic controller assembly returns to normal operation. For more information on pre-emption, refer to *Chapter 504*.

TRAFFIC CONTROLLER ASSEMBLY MANUAL

VOLUME 1

Section 200

Traffic Controller Assemblies

Electrical and ITS Engineering

June 2019

200 TRAFFIC CONTROLLER ASSEMBLIES

LIST OF FIGURES

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201 INTRODUCTION

201.1 GENERAL DESCRIPTION

.1 The traffic controller assembly is housed in an enclosure or cabinet containing all of the devices and circuitry necessary for the control of an intersection. The Ministry has standardized the manufacture of traffic controller assemblies for this purpose. Several types exist of which there are a number of different variations. The most common types of traffic controller assemblies are the "Four-Phase" and "Eight-Phase" assembly. The Ministry uses a letter designation to identify the different models. A number suffix that follows the letter designation is used to identify revisions within the particular model. The current four-phase and eight-phase assemblies have been assigned the letter designations "M" and "S" respectively.

.2 The type of control required at a given intersection determines the choice of traffic controller assembly. As the names suggest, the cabinets and installed equipment are largely determined by the number of phases or traffic movements required. Advance left turns along with other features, such as advance warning and pre-emption, are also factors.

.3 This section describes the location and purpose of the devices within the traffic controller assemblies. All of the devices are grouped together in a logical way, depending on their function and interaction with each other. You will be introduced to the different groups of electrical equipment that work together to provide control of the intersection. *Chapter 202* describes the "Four-Phase" traffic controller assembly and *Chapter 203* describes the "Eight-Phase" assembly. *Sections 300 to 800* of this document describe the equipment common to both types.

201.2 ELECTRICAL SIGNALS

.1 There are a variety of electrical signals in the traffic controller assembly. High-voltage (120 Vac) signals are used to operate the traffic signal lights while low-voltage (24 Vdc) signals are used for internal control.

.2 Some devices, such as “load switches” are used specifically for voltage level translation i.e. using low-voltage signals to control high-voltage signals.

.3 Electronic devices within the traffic controller assembly such as the “Controller Unit”, “Conflict Monitor” and “Input Modifier Cards” all use low-voltage, 24 Vdc signals. The “Power Supply Card” supplies all internal 24 Vdc power within the traffic controller assembly. The +24 Vdc signal is referenced to a common point called “Logic Ground”. There is a 24 Vdc potential between these two points.

.4 The low-voltage signals within the traffic controller assembly are called “Active-Low” signals. The devices will interpret signals as “on” or “true” when they are at the Logic Ground (0 Vdc) level. Signals are interpreted as “off” or “false” at the +24 Vdc level.

202 FOUR-PHASE TRAFFIC CONTROLLER ASSEMBLY

202.1 INTRODUCTION

.1 The four-phase traffic controller assembly, shown in *Figure 1*, is designed for use at intersections configured with two to four phases, or traffic movements.

.2 The standard four-phase traffic controller assembly currently in use is the base-mounted “Type-M” assembly.

202.2 GENERAL DESCRIPTION

.1 The four-phase traffic controller assembly consists of an aluminum enclosure measuring approximately 50” high by 36” wide by 18” deep.

.2 It has one door on the front for all normal access to the internal equipment. The bottom of the enclosure is left open for conduit access to all field wiring which includes 120 Vac service, signal heads, loops and pedestrian push-buttons.

.3 The enclosure has a heater to maintain the internal components at the correct operating temperature.

.4 It has a fan that draws air into the enclosure through a filtered opening in the door and exhausts through a vent in the ceiling.

.5 A 120 Vac receptacle is provided for the use of service personnel.

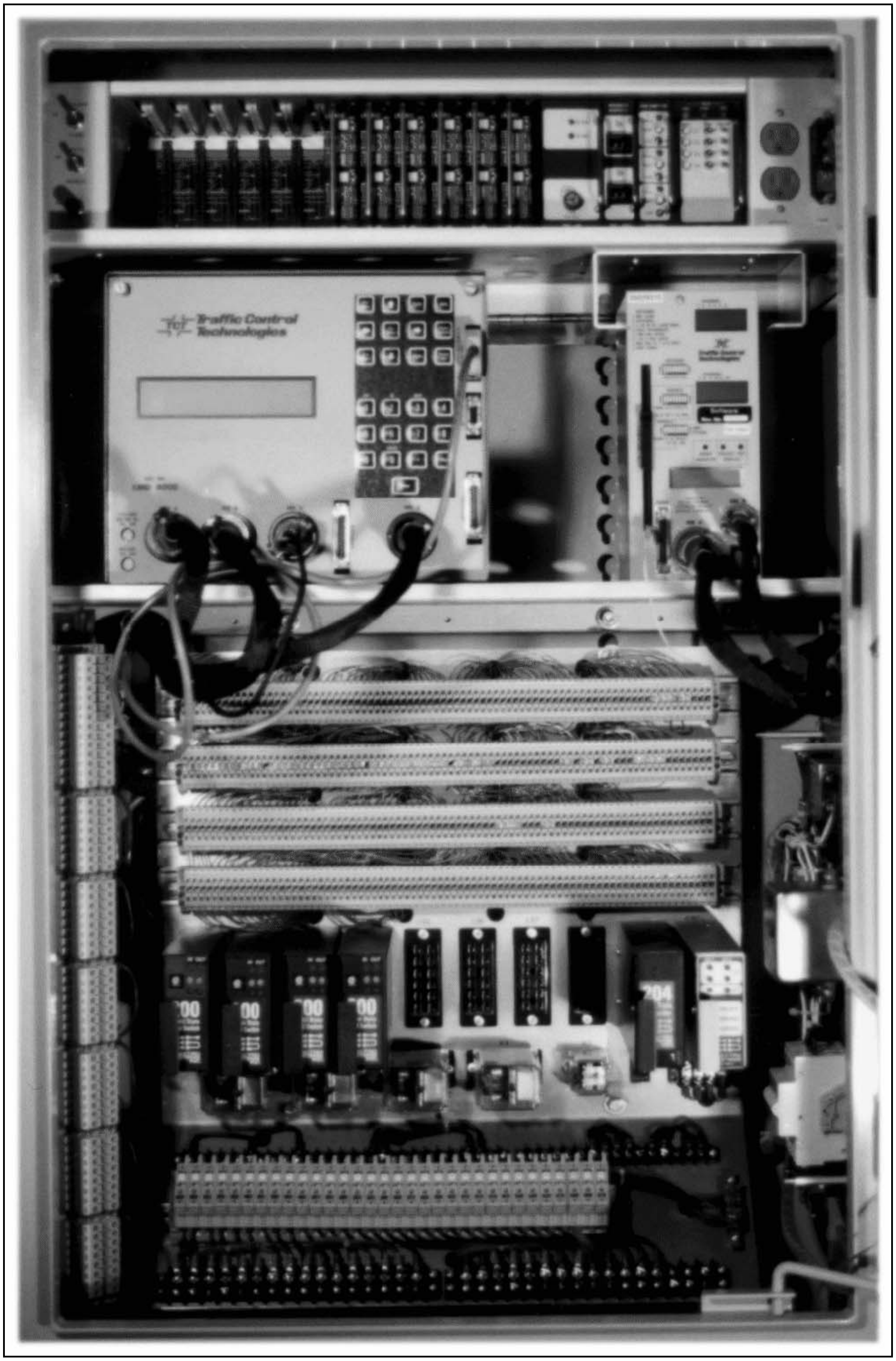

Figure 1. The Four-Phase Traffic Controller Assembly

202.3 EQUIPMENT LAYOUT

.1 At the top of the enclosure is a shelf on which the card rack assembly is mounted. This assembly houses the Input Modifier Cards, Power Supply, Loop Detectors, Inside Flash Switch and Manual Control Switches. The Input Modifier Section is described in detail in *Clause 204.2*. The Power Supply is described in *Section 700*.

.2 On the bottom of the card rack assembly shelf is a mounting bracket for a modem. This is used for external communications, which are described in *Section 1100*.

.3 Below the card rack assembly is a second shelf. This shelf accommodates the controller unit and conflict monitor. Both of these devices sit free on the shelf. Electrical connections to these devices are made by wiring harnesses which connect to the front panels. The wiring harness are referred to by the names “MS-A, MS-B, MS-C and MS-D” for the controller unit, and “CM-A and CM-B” for the conflict monitor. The other ends of the harnesses are connected to the terminal blocks, below, on the back panel.

.4 On the back panel, below the controller unit/conflict monitor shelf, four rows of terminal blocks are provided. These terminal blocks are the termination point for the inputs and outputs of the controller unit, conflict monitor and Input Modifier Cards. Access to these signals allows changes in the wiring configuration to be made for each intersection as required.

.5 Below the terminal blocks are the load switches, intersection flasher, and advance warning flasher. The flash transfer relays and flash control relay are located underneath. These devices are described in *Chapter 803*.

.6 At the bottom of the enclosure is a row of fuses, one for each signal output, and the terminal blocks for connecting the signal wiring to the field.

.7 On the lower left-hand side of the enclosure, just inside the door, is a row of terminal blocks. These are mounted vertically and are angled towards the door opening. This row of terminal blocks is used for the connection of loop inputs, pre-emption inputs and pedestrian push-buttons.

.8 On the lower right-hand side of the enclosure is a collection of equipment called the power distribution panel. This contains all of the 120 Vac service equipment, circuit breakers, filters, etc. The function of the power distribution panel is common to both four and eight-phase traffic controller assemblies. A photograph and detailed description of the power distribution panel can be found in *Chapter 801*.

203 EIGHT-PHASE TRAFFIC CONTROLLER ASSEMBLY

203.1 INTRODUCTION

.1 The eight-phase traffic controller assembly, shown in *Figures 2 and 3*, is designed for use at intersections configured with more than four phases, or traffic movements.

.2 The base-mounted "Type-S" assembly is the current standard model used by the Ministry.

203.2 GENERAL DESCRIPTION

.1 The eight-phase traffic controller assembly consists of an aluminum enclosure measuring approximately 72" high by 36" wide by 40" deep.

.2 It has two doors - one on the front and one on the rear - for all normal access to the internal equipment. The bottom of the enclosure is left open for conduit access to all field wiring which includes 120 Vac service, signal heads, loops and pedestrian push-buttons.

.3 The enclosure has a heater to maintain the internal components at the correct operating temperature.

.4 It has a fan that draws air into the enclosure through filtered openings in the doors and exhausts through a vent in the ceiling.

.5 Lights, front and rear, and a 120 Vac receptacle are provided for the use of service personnel.

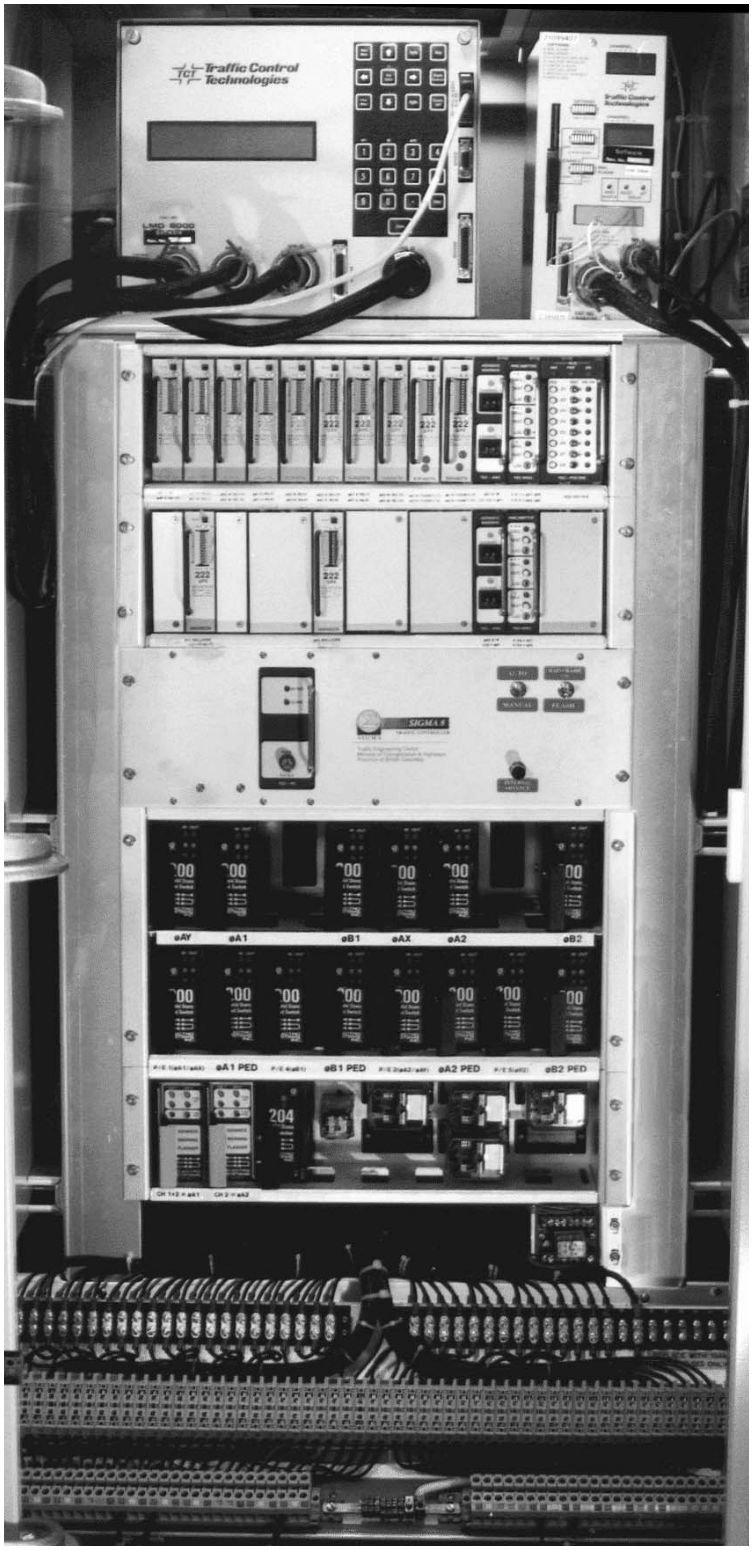

Figure 2. The Eight-Phase Traffic Controller Assembly (Front View)

203.3 EQUIPMENT LAYOUT

203.3.1 Enclosure Front

.1 All equipment in the eight-phase traffic controller assembly is mounted on a central tower which reaches from the bottom to approximately three-quarters of the enclosure's interior height. On the top of the central tower is a shelf which is accessible from both front and rear door openings.

.2 The front portion of the equipment mounting shelf accommodates the controller unit and conflict monitor. Both of these devices sit free on the shelf. Electrical connections to these devices are made by wiring harnesses which connect to their front panels. The wiring harness are referred to by the names "MS-A, MS-B, MS-C and MS-D" for the controller unit, and "CM-A and CM-B" for the conflict monitor. The other end of the wiring harnesses are connected to terminal blocks in the rear of the enclosure.

.3 Below the shelf are two card rack assemblies which house the Input Modifier Cards and Loop Detectors.

.4 Below the card rack assemblies is a solid panel. A slide-in opening is provided for the TEC-PS power supply. The Inside Flash and Manual Control Switches are also mounted here.

.5 The bottom area of the central tower accommodates the load switches, in two rows. Below are the advance warning flashers, intersection flasher, flash control relay and flash transfer relays.

.6 At the bottom of the enclosure are three horizontal rows of terminal blocks. The upper row is used for terminating the wiring from the load switches and flash transfer relays. These are in turn wired to the second row of terminal blocks. Each block in the second row contains a protective fuse - one for each field output. The fuse outputs are connected to the bottom row of terminal blocks which are used for the field connections to the signals. The conflict monitor channel inputs are connected here as well.

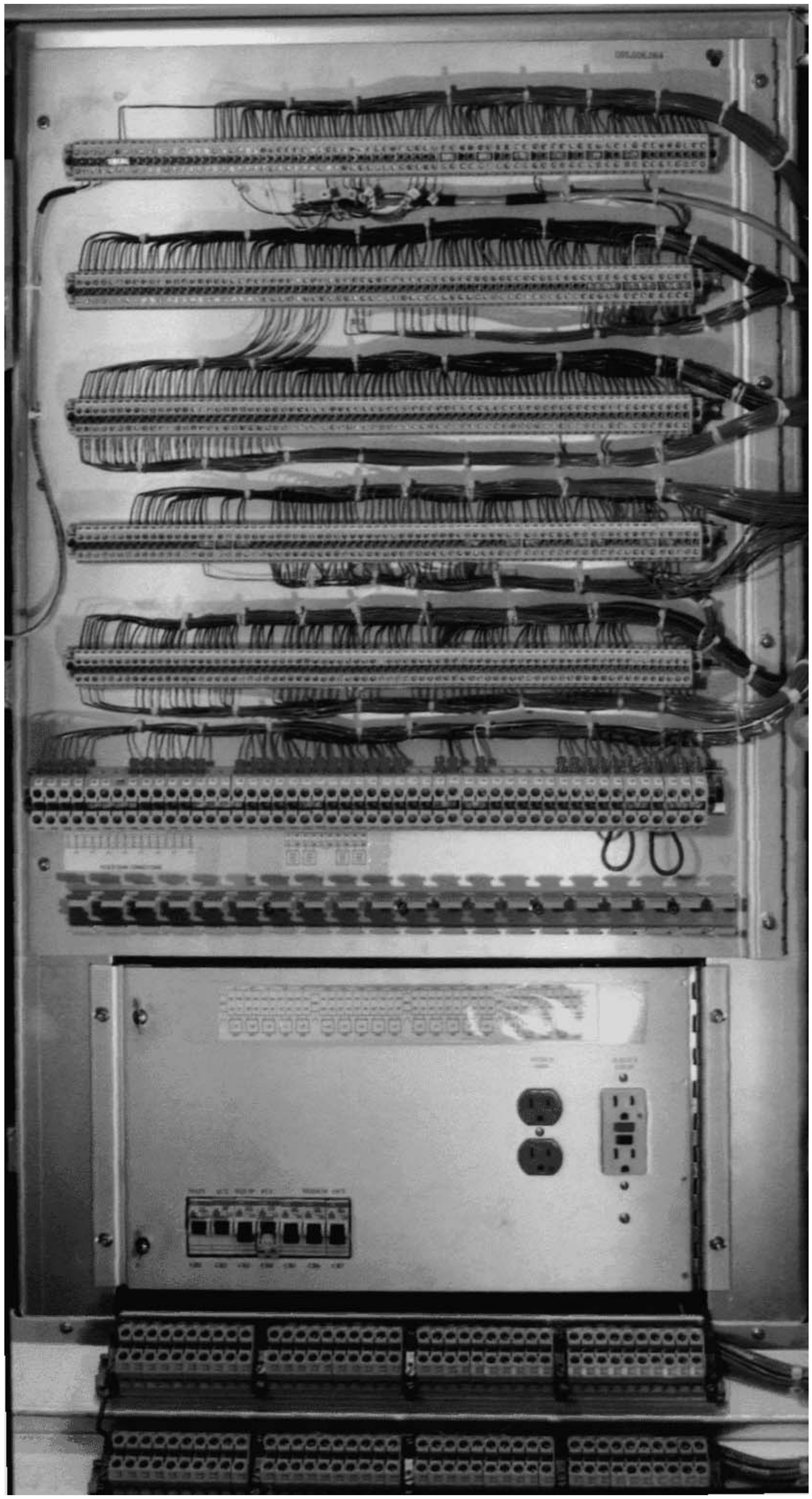

Figure 3. The Eight-Phase Traffic Controller Assembly (Rear View)

203.3.2 Enclosure Rear

.1 At the top of the enclosure there is access to the equipment mounting shelf. This area is used for non-standard equipment, such as a modem.

.2 Below the shelf is a hinged panel containing six rows of terminal blocks. This is the termination point for the inputs and outputs of the controller unit, conflict monitor and Input Modifier Cards. Access to these signals allows changes in the wiring configuration to be made for each intersection as required.

.3 The bottom row of terminal blocks is used for field connections to the pedestrian push-buttons and pre-emption inputs.

.4 The panel opens to provide access to the wiring on the back of the two card rack assemblies, the flash control switches and the power supply.

.5 Below the terminal-block panel is the power distribution panel. This has a hinged cover containing two 120 Vac receptacles: one utility receptacle for general use and an isolated ground receptacle for a modem. There is a cut-out in the panel cover allowing access to the circuit breakers when the cover is closed.

.6 Inside the power distribution panel is the 120 Vac service equipment, circuit breakers, filters, etc. This equipment is described in *Chapter 801*.

.7 At the bottom of the enclosure are two rows of terminal blocks used for field connections to the loop lead-in wires.

.8 On the left-hand side of the rear opening are the fan and heater controls and a special terminal block for connecting communications wiring.

204 CARD RACK ASSEMBLY

204.1 GENERAL DESCRIPTION

.1 The "card rack assembly" houses the loop detectors and input modifier cards. In the four-phase traffic controller assembly, it also houses the power supply card, Inside Flash and Manual Control switches.

.2 The card rack assembly consists of an aluminum frame with plastic "card guides" top and bottom to hold the input modifier card and loop detector circuit boards. The front panels of the input modifier cards, detectors and power supply are accessible from the front of the assembly when inserted.

.3 There is a single card rack assembly in the four-phase traffic controller assembly, two in the eight-phase. In the eight-phase traffic controller assembly, these are referred to as the "upper" and "lower" card rack.

.4 On the back of the card rack assembly are two printed circuit boards, one for connection of the detectors and one for the input modifier cards.

204.2 INPUT MODIFIER SECTION

.1 The input modifier section of the card rack assembly can accommodate up to four input modifier cards. The rear circuit board, called the "card back plane" (CBP-4) has four connectors which mate with the connector on an input modifier card. Each position is numbered, from left to right, P1 to P4 in the four-phase and eight-phase upper rack or P5 to P8 in the eight-phase lower rack.

.2 The left-hand position, P1 or P5, is used for the Advance Warning card. In the eight-phase traffic controller assembly, an Advance Warning card can be installed in both the upper and lower racks.

.3 The second position, P2 or P6, accommodates the Pre-Emption Interface card. In the eight-phase traffic controller assembly, the master Pre-

Emption Interface card is installed in the upper rack (P2), and the slave Pre-Emption Interface card is installed in the lower rack (P6).

.4 The third position, P3, is not used in the four-phase traffic controller assembly or the upper rack of the eight-phase. This position is obscured by the front panel of the Pedestrian Vehicle Interface card. In the eight-phase traffic controller assembly, this position, P7, can be used for the Relay Interface card, which is custom-wired for each application.

.5 The right-hand position, P4, is used for the Pedestrian Vehicle Interface card. Each traffic controller assembly uses only one Pedestrian Vehicle Interface card, therefore the right-hand position on the lower card rack, P8, is not used.

.6 All of the connector pins on the card back plane are joined to “pads” on the circuit board. Wires are installed here which connect to the traffic controller assembly terminal blocks for access to the input modifier cards’ circuitry.

204.3 POWER SUPPLY SECTION

.1 There is a slot for the power supply card in the four-phase traffic controller assembly only. In the eight-phase traffic controller assembly, the power supply card is located elsewhere.

204.4 DETECTOR SECTION

.1 The detector section accommodates up to twelve detectors in the four-phase traffic controller assembly. In the eight-phase, each rack accommodates up to ten detectors. Each card rack assembly has a rear circuit board, called the “detector back plane”, containing either twelve (DBP-12) or ten connectors (DBP-10) that mate with the circuit board of each detector. In the four-phase card rack assembly, each position is numbered, from left to right, J1 to J12. The eight-phase upper rack consists of positions J1 to J8, J17 and J18. The eight-phase lower rack consists of positions J9 to J16, J19 and J20.

.2 All of the connector pins on the detector back plane are joined to “pads” on the circuit board. Wires are installed here which connect to the traffic controller assembly terminal blocks for access to the detectors’ circuitry.

.3 Detectors can be installed in any slot in the section, as all positions are electrically identical. The Ministry has a standard for assigning slot positions based on the intersection's loop and phase assignments.

TRAFFIC CONTROLLER ASSEMBLY MANUAL
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Section 300

Controller Unit

Electrical and ITS Engineering

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300 CONTROLLER UNIT

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301 LMD8000 CONTROLLER UNIT

301.1 GENERAL CHARACTERISTICS

.1 At the core of any traffic signal control system is the controller unit. This device is also called the “mainframe”. One of the current controller unit used by the Ministry is the Peek Traffic (formerly Traffic Control Technologies) LMD8000, which is shown in *Figure 1*.

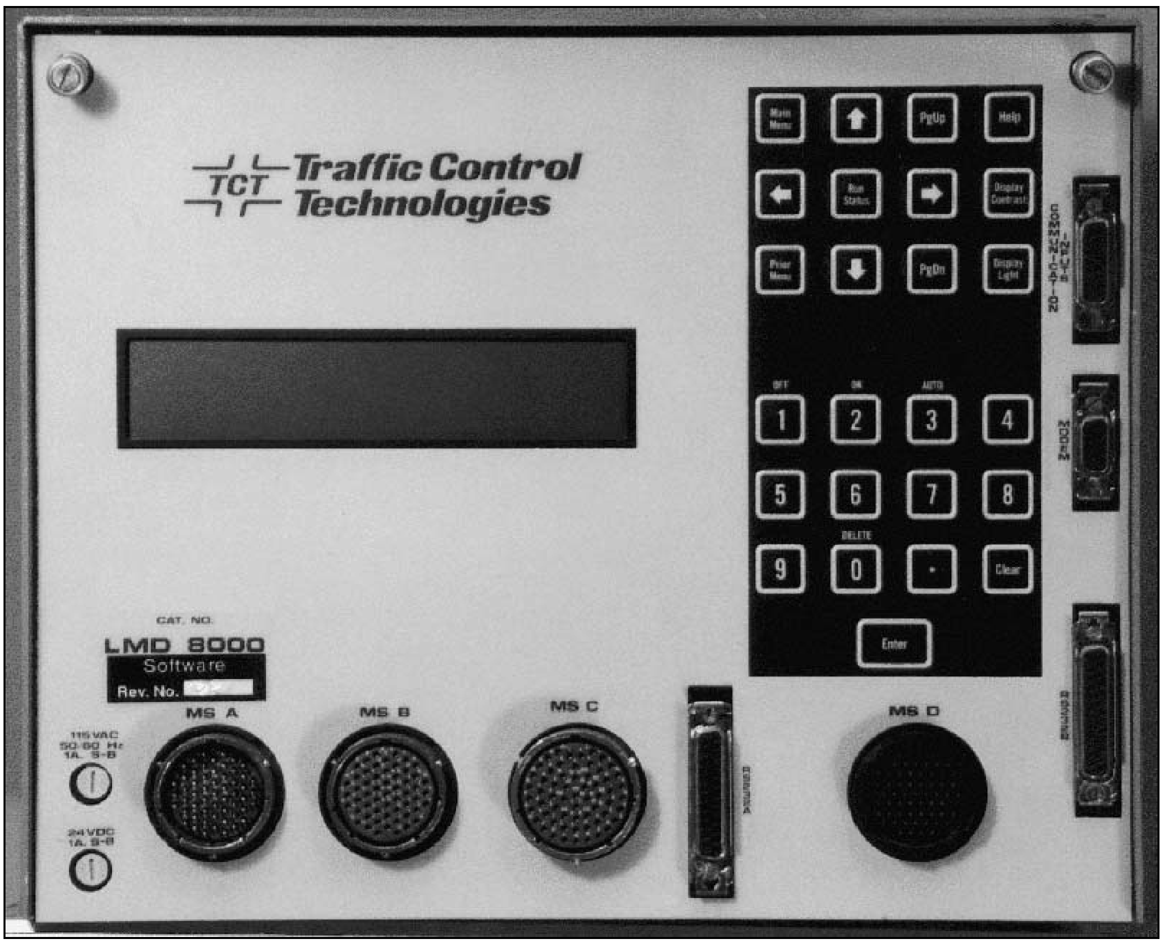


Figure 1. The LMD8000 Controller Unit

.2 The LMD8000 replaced the DM400 and DM800 (four-phase and eight-phase respectively) controller units previously used by the Ministry.

.3 The LMD8000 controller unit is a National Electrical Manufacturers Association (NEMA) 2 through 8 phase actuated controller, and conforms to *"Interface Standards for Advanced Two-Phase Through Eight-Phase Solid-State Traffic Signal Controller Units", TS 1-1989*.

.4 The LMD8000 controller unit provides traffic-responsive control of vehicles and pedestrians. It is characterised by micro-processor control, keyboard data entry and a 40 column by 4 row back-lit liquid crystal display (LCD). The LMD8000 can be programmed for either sequential or concurrent timing in various sequences, from 2-phase semi-actuated to 8-phase fully-actuated configurations.

.5 The LMD8000 is a self-contained, micro-processor-controlled shelf-mounted device.

.6 The LMD8000 has a built-in power supply which is fed from the controller cabinet's 120 Vac distribution system.

.7 The controller unit's program is stored on four memory IC's (EPROM's) which are installed in sockets on the processor circuit board for easy removal. The micro-processor sequentially "reads" and executes instructions from the memory IC's. This internal program is dedicated specifically to the functions of the LMD8000 only. This type of program is commonly referred to as "firm-ware". The IC's that contain the program are removable to facilitate the installation of new program revisions. This is a 'permanent' program, common to all Ministry controller units. It must not be confused with the programming data added for timings and configuration of a specific intersection.

301.2 SPECIFICATIONS

.1 Some of the LMD8000's general electrical specifications are listed in *Table 1*.

Power	Voltage:	95 - 135 Vac
	Frequency:	60 +/- 3 Hertz
	Power Consumption:	25 Watts
Fusing	120 Vac	1 ampere Slo-Blo.
	+24 Vdc	1 ampere Slo-Blo.
Power Interruption Response	500 milliseconds or less	The controller unit will continue operation as though the power interruption had not occurred.
	500 to 1000 milliseconds	The controller unit will either revert to the initialization routine or resume its operation.
	1000 milliseconds or more	The controller unit will revert to the initialization routine.

Table 1. LMD8000 Controller Unit Electrical Specifications

301.3 INFORMATION MEMORY

.1 The LMD8000 uses a 2.4 volt Nickel Cadmium battery to retain internal clock and Random Access Memory (RAM) values when 120 Vac power is removed. RAM is used to store non-programmed data such as message logs. The battery will last for a minimum of 10 years during normal operation. It will operate the clock for a minimum of 30 days without power supplied to the controller. All user-programmed data is retained in a special type of memory IC called an Electrically Erasable Programmable Read Only Memory (EEPROM) which is completely non-volatile.

.2 Timing and control data are entered into the EEPROM directly through the front-panel keyboard or downloaded from a computer. The battery and EEPROM, containing data and any real-time information are mounted on a removable Information Memory Card on the fold-down front panel.

301.4 MENU SYSTEM

.1 All LMD8000 programming options and current operating parameters are accessible through a combination of an alphanumeric keypad and LCD.

.2 The LMD8000 display operates in a menu format. The display lists the most general menu items at the top level. From this base menu, any category may be selected, revealing a sub-menu which lists further choices. Some menu items are used strictly for programming timings and other parameters. Other menu items contain displays of timings and status of inputs, outputs and so on. These status screens are commonly used by service personnel who are performing routine or corrective maintenance at the intersection. Refer to *Chapter 1003* for details.

.3 Help screens are provided, giving descriptions of the function of each screen and allowable values for programming parameters.

301.5 COMMUNICATION PORTS

.1 The LMD8000 has two RS232 communications ports with which external devices can be interfaced. RS232A, on the left side, serves a variety of functions including unit to unit data transfers, print outs, direct interface with Ministry laptop and personal computers and direct interface with a dial-up modem. Full programming of the LMD8000 is not practical through the front-panel keypad. It is more common to make use of a program, supplied by the manufacturer, call LMSYSTEM. Programming data is entered into the program, on a computer, and then transferred to the controller unit through the communication port. RS232B, on the right side, is designated to interface with the LNM12E Conflict Monitor. This feature can be used for remote access to the LNM12E conflict monitor message logs, compatibility card information, and switch settings. *Refer to Chapter 403 for more information*.

301.6 SECURITY CODE

.1 The Ministry does not currently use the security code feature in any of its controller units.

301.7 FEATURES

.1 The LMD8000 provides all basic NEMA timing features including Min Green, Min Yellow, Passage, Red, Max Timing, Walk and Ped Clearance.

.2 Phase sequence patterns can include 2 through 8 phases, single-ring, dual-ring or combinations of single and dual-ring. Controller unit phases are assigned to traffic movements in a standardized manner, described in *Chapter 1002*.

.3 Two types of overlaps are available. True overlaps and phases as overlaps. An overlap is a traffic movement which is conditionally serviced at the same time as another phase or phases (called “parent phases”). Both are programmable through the front-panel keyboard or through LMSYSTEM.

.4 An internal time clock is used to implement time-of-day commands based on a yearly program. This function can be used to implement various time-based functions as well as co-ordination between intersections. The battery-backup feature allows the clock to continue keeping time without power supplied and there is no need to reprogram the system after a short power failure.

.5 The LMD8000 is capable of direct communication, through a modem, to a central computer. The LMD8000 can be called upon request, or can be scheduled to call the central computer at a pre-set time. The controller unit can also initiate a call to service personnel, in the event of an emergency.

.6 The LMD8000 provides eight selectable service plans which provide additional phase timings and service parameters. Service plans include Min Green, Passage, Walk and Ped Clear timings and Recall Status. Service plans are used for co-ordination or selected by the time of day to respond to varying traffic demands. When a service plan is implemented, programmed service plan values become the controller's operating parameters in place of the normal settings.

.7 The LMD8000 also provides eight selectable "Max" plans. Each max plan provides two programmable maximum time values per phase: one for normal operation and one which may be used in the case of a vehicle detector failure. Max plans are normally selected by the time of day. When no max plan is implemented, the LMD8000 defaults to normal NEMA settings. When implemented, max plan values become the controller's operating parameters in place of the normal settings.

302 ECONOLITE COBALT TRAFFIC CONTROLLER UNIT

302.1 GENERAL SPECIFICATIONS

.1 The Econolite Cobalt (*Fig. 2*) is one of two TS2 Type 2 Controller Units approved for use by the Ministry. TS2 Type 2 Controller Units can operate in both NEMA TS1 and TS2 cabinets with little or no modification to the cabinet assemblies.

Figure 2. The Econolite Cobalt Type 2 Controller Unit

.2 The Cobalt controller unit meets all applicable sections of the *NEMA TS2-2003, NTCIP 1202 and ATC 5.2b & 6.10* standards.

.3 The TS2 Type 2 Cobalt includes the MS-A, -B, -C & -D circular connectors, allowing it to be installed in legacy TS1 ‘M’ & ‘S’ cabinets.

.4 When installed in TS1 'M' & 'S 'cabinets, the Cobalt requires a special cable to adapt its D connector to the D & TEC3 TS1 cabinet harnesses. Details on this adapter cable are found in Section 304 - Controller Unit I/Os.

.5 Additionally, a Cobalt in a TS1 M or S cabinet <u>IS NOT</u> compatible with the standard M or S cabinet Advance Warning Card (TEC-AW2). Information on how to disable the TEC-AW2 and setup the Cobalt for Internal Advance Warning functionality is found in Section 304 - Controller Unit I/Os.

.6 The Cobalt allows the control of 16 vehicle phases, and 16 pedestrian phases which can be configured as overlaps.

.7 The Cobalt can be programmed and operated in the ‘graphical’ touch-screen mode or in the ‘classic’ ASC/3 menu system via the keypad.

.8 It can be programmed with up to 200 schedule programs configurable for any combination of months, days of the week and days of the month.

.9 The Cobalt can accommodate up to 64 vehicle detector inputs.

.10 The Cobalt display is a backlit 7 colour TFT LCD display with touch capability. The CU can be programmed via the keypad or touch-screen.

.11 The Cobalt has 6 pre-emption inputs and can be programmed with up to 10 pre-emption sequences. It includes an input for a rail gate-down signal and timing.

.12 The Cobalt has a built-in power supply which is fed from the controller cabinet’s 120 VAC distribution system.

.13 The CU has 128MB of DRAM for application and OS program execution, 64MB of FLASH for OS software and user applications, and 2MB of non-volatile SRAM for parameter storage.

.14 The Cobalt has several communications ports: four integral Ethernet Switch ports, an FSK port configurable to RS232, and two USB ports which can be used to transfer CU programming via a USB hard-drive.

.15 The Cobalt has a Logic Processor allowing the user to use controller I/Os in IF-THEN-ELSE statements to affect controller outputs and programming.

302.3 CONTROLL ER MEMORY

.1 The 2MB of non-volatile SRAM allows for approximately one week's worth of vehicle volume counts to be stored.

.2 Controller programming can be entered into memory via: the front touch-screen/keypad, from central control software connected to an Ethernet port or from an Econolite configuration file on a USB hard-drive.

302.4 MENU SYSTEM

.1 The Cobalt has both a Graphical User Interface and the Classic Mode text based menu tree. The Classic Mode offers the same menu displays and menu system as an Econolite ASC/3 controller unit.

.2 The Cobalt display operates in a menu tree format. The display lists the most general menu items at the top level. From this base menu, any category may be selected, revealing a sub-menu which lists further choices. Some menu items are used strictly for programming timings and other parameters. Other menu items contain displays of timings and status of inputs, outputs and so on. These status screens are commonly used by service personnel who are performing routine or corrective maintenance at the intersection. Refer to *Section 1000* for details.

.3 The Cobalt offers context sensitive help for all menu screens.

302.5 COMMUNICATION PORTS

.1 The Cobalt has one SDLC communications port (Port 1) to interface the CU with a TS2 Traffic Controller Assembly.

.2 The Cobalt has four integral Ethernet Switch communications ports. These ports are used to interface with central monitoring and control software such as *Econolite Centracs*.

.3 The Cobalt has one 25-pin configurable serial port and a 9-pin console serial port.

.4 The two USB ports on the front panel can be used to update the Cobalt software, upload/download controller configurations and upload data logs.

302.6 FEATURES

.1 The Cobalt provides all basic NEMA timing features including Min Green, Min Yellow, Passage, Red, Max Timing, Walk and Ped Clearance.

.2 The CU can control up to 16 vehicle phases in as many as 8 configurable concurrent groups in 4 timing rings. It also supports up to 16 pedestrian phases which can be configured as overlaps.

.3 The Cobalt ring structure and sequence can be programmed in the standard NEMA ‘barrier’ mode or via a ‘compatibility’ mode.

.4 Time base programming allows for 200 schedule programs configurable for any combination of months, days of the week and days of the month. Up to 50 day plan events can be used to call any of the 100 possible action plans.

.5 Coordination programming allows for 120 coordination patterns each with its own cycle, offsets and split plan selection. Up to 120 split plans can be programmed, each with its own coordinated phases, vehicle and pedestrian recall and phase omits. A Transit Signal Priority (TSP) option is available.

.6 The Cobalt offers six pre-emption inputs which can be linked to ten pre-emption sequences. There is also a railroad gate-down input to provide more effective rail pre-emption sequence operation.

.7 Up to 64 vehicle detector inputs are available on the Cobalt. Four detector plans and diagnostics plans can be programmed for alternate detection operation by time of day or if a vehicle detector fails.

.8 The Cobalt has three standard communications ports: a NEMA-ATC SDLC serial port (Port 1), a 25-pin serial port (Port 2) and a 9-pin console serial port.

.9 Detector activity & failures, controller events and MMU events can be logged by the Cobalt. The logged data can be viewed on-screen or retrieved via the: RS-232 terminal port, USB flash drive or SD card.

.10 The Cobalt has NTCIP Level 2 compliance and supports Centracs, Aries and TS2 NTCIP Level 2 compliant central applications.

303 TRAFFICWARE/NAZTEC 980

303.1 GENERAL SPECIFICATIONS

.1 The Trafficware/Naztec 980 (*Fig.* 3) is one of two TS2 Type 2 Controller Units approved for use by the Ministry in the TS1 M & S Cabinets.

Figure 3. The Trafficware/Naztec 980 Type 2 Controller Unit

.2 The Naztec 980 controller unit meets all applicable sections of the *NEMA TS2-2003* standard.

.3 The TS2 Type 2 Naztec 980 includes the MS-A, -B, -C & -D circular connectors, allowing it to be installed in legacy TS1 ‘M’ & ‘S’ cabinets.

.4 When installed in TS1 M & S cabinets, the Naztec requires a special cable to adapt its D connector to the D & TEC3 TS1 cabinet harnesses. Details on this adapter cable are found in Section 304 - Controller Unit I/Os.

.5 The Naztec 980 allows the control of 16 vehicle phases, and 16 overlaps.

.6 The Naztec 980 can be programmed and operated via the keypad and the backlit LCD display.

.7 It can be programmed with up to 100 schedule programs configurable for any combination of months, days of the week and days of the month.

.8 The Naztec 980 can accommodate up to 64 vehicle detector inputs.

.9 The Naztec 980 has 6 pre-emption inputs and can be programmed with up to 6 pre-emption sequences.

.10 The Naztec 980 has a built-in power supply which is fed from the controller cabinet's 120 VAC distribution system.

.11 The Naztec 980 can store approximately a week of volume count data.

.12 The Naztec 980 comes standard with two RS-232 ports and an SDLC Bus Interface port. An FSK modem port and Ethernet port are optional.

303.2 CONTROLL ER MEMORY

.1 The non-volatile memory allows for approximately one week's worth of vehicle volume counts to be stored.

.2 Controller programming can be entered into memory via the front touch-screen/keypad or from a PC running Naztec's Streetwise software application via the RS-232 port.

303.3 MENU SYSTEM

.1 The Naztec display operates in a menu tree format. The display lists the most general menu items at the top level. From this base menu, any category may be selected, revealing a sub-menu which lists further choices. Some menu items are used strictly for programming timings and other parameters. Other menu items contain displays of timings and status of inputs, outputs and so on. These status screens are commonly used by service personnel who are performing routine or corrective maintenance at the intersection. Refer to *Section 1000* for details.

.2 The Naztec 980 has help available through the 'ALT FCN' button for all its menu screens.

303.4 COMMUNICATION PORTS

.1 The Naztec 980 has one SDLC communications port (Port 1) to interface the CU with a TS2 Traffic Controller Assembly.

.2 The Naztec 980 has two configurable 25-pin RS-232 serial ports.

.3 An FSK modem port and an Ethernet port are optional.

303.5 FEATURES

.1 The Naztec 980 provides all basic NEMA timing features including Min Green, Min Yellow, Passage, Red, Max Timing, Walk and Ped Clearance.

.2 The Naztec 980 can control up to 16 vehicle phases and overlaps.

.3 The Naztec 980's operating sequence is configured by assigning its 16 phases and 4 barriers to any of the 4 available rings.

.4 Time base programming allows for 100 schedule programs configurable for any combination of months, days of the week and days of the month. Up to 32 day plan events can be used to call any of the 100 action tables.

.5 Coordination programming allows for 48 coordination patterns each with its own cycle, offsets and split plan selection. Up to 32 split plans can be programmed, each with its own coordinated phases, vehicle and pedestrian recall and phase omits. A Transit Signal Priority (TSP) option is available.

.6 The Naztec 980 offers six pre-emption inputs which can be linked to six pre-emption sequences.

.7 Up to 64 vehicle detector inputs are available on the Naztec 980. Alternate detector plans can be programmed for alternate detection operation by time of day or if a vehicle detector fails.

.8 The Naztec has three standard communications ports: a NEMA-ATC SDLC serial port, and two 25-pin RS-232 serial ports.

.9 Detector activity & failures, controller events and MMU events can be logged by the Naztec 980. The logged data can be viewed on-screen or retrieved via an RS-232 port.

.10 The Naztec 980 is NTCIP compliant.

304 CONTROLLER UNIT INPUTS AND OUTPUTS

304.1 INTRODUCTION

The scope of this document does not permit a complete discussion of all of the many controller unit inputs and outputs. Instead, an overview has been provided which covers the majority of basic signals. An knowledge of the purpose and function of these signals is necessary in understanding the material presented later. For reference, a full listing of each Controller Unit's inputs and outputs has been provided in *Appendix A* at the end of this section.

304.2 INPUTS

.1 External inputs, when active, modify the normal operation of the controller unit in a pre-determined manner. Some of these inputs are provided on a "per-phase" basis while others are provided on a "per-ring" or "per-unit" basis. Because of their general function, these inputs are referred to as "input modifiers".

.2 Additional inputs are provided for special functions.

.3 All inputs to the controller unit use 24 Vdc logic. All "True" or "On" signals are at the Logic Ground level. All "False" or "Off" signals are at the +24 Vdc level. Control of these signals is provided by external devices.

304.2.4 Per-Phase Input Modifiers

.1 The following inputs are provided on a per-phase basis, meaning eight total:

.1 "VEHICLE CALL INPUTS" provide a means for the input of vehicle demand information from vehicle detectors (*Refer to Section 600*). One NEMA-specified Vehicle Call Input is provided for each phase. However, the Controller Units have many more vehicle detect inputs than this, with the LMD 8000 having the least with 24, 16 more than the NEMA specification. The signals from any of the CU detector inputs can be programmed to call or extend any phase. Each input has a variety of options:

.1 Memory/Lock On: the vehicle call is remembered until the associated phase is serviced. The memory is cleared at the end of the green interval. Calls which occur during the yellow and red intervals are stored in memory.

.2 Memory/Lock Off: the vehicle call must be active at the time the controller unit makes the decision to service the associated phase.

.3 Memory for vehicle detect inputs can be applied to either the phase itself (works on any detector input assigned to that phase) or a single detector input only (other detector inputs assigned to that phase do not have memory).

.4 Delay operation can be selected, providing a programmable delay from the activation of the detector input until the call is registered with the associated phase.

.2 "PEDESTRIAN DETECTOR INPUTS" provide a means for the input of pedestrian demand information. *Refer to information on the Pedestrian Vehicle Interface Card, Chapter 502*.

.3 "HOLD" is a basic co-ordination function. The activation of the Hold input will cause the controller to rest at the end of the walk or don't walk interval, depending on the controller's configuration.

.4 "PHASE OMIT" causes a phase to be omitted from the normal phase sequence, even if there are serviceable pedestrian or vehicle calls existing on the phase.

.5 "PED OMIT" prevents a phase from being serviced for pedestrian demand only. It also prevents any pedestrian service on that phase even if the phase is serviced for vehicle demand.

.2 The following inputs are provided on a per-ring basis. There are two of each input, one for Ring 1 and one for Ring 2. The function of these inputs is related to the assignment of phases in the current controller unit sequence.

.1 "FORCE OFF" causes termination of the green timing if there is a serviceable call on a conflicting phase. Force off is not effective during the minimum green, walk or pedestrian clearance timing.

.2 “STOP TIMING” causes cessation of all timing within the related timing ring. When stop timing is removed, all interval timers will resume from the point of interruption. While stop timing is on, vehicle calls will be registered on non-green phases.

.3 “RED REST” causes “rest-in-red” operation of all phases in the related ring. This results in the controller returning to an all red condition rather than remaining in the green of the last serviced phase, when there are no conflicting calls.

.3 The following inputs are provided on a per-unit basis, i.e. one only:

.1 “EXTERNAL MIN RECALL” causes a vehicle call to be placed on each phase while the phase is in the yellow interval. This causes the controller to cycle through each of the phases. The Ministry uses this feature for controller initialization.

.2 “INTERVAL ADVANCE”: a complete on and off operation of this input will cause immediate termination of the current timing interval. This operation may cause the controller to move to the next phase in the sequence depending upon the point of operation and the existence of pedestrian and/or vehicle calls. This input is used in conjunction with the Manual Control Enable input.

.3 “MANUAL CONTROL ENABLE” places vehicle and pedestrian calls on all phases and stops timing in all intervals except vehicle clearance. This input is designed for use with the Interval Advance input.

.4 “EXTERNAL START” is an input used to send the controller unit back to its initialization phase and interval. Timing of the interval will not begin until the input is turned off. The Ministry refers to this signal as “System Reset”.

304.2.5 Special-Purpose Inputs

.1 The controller unit provides a number of special-purpose inputs for a variety of advanced functions. Except for those listed below, most of these functions are beyond the scope of this document:

.1 “PRE-EMPT INPUTS”: the controller unit has six Pre-Empt inputs. Each one of these inputs initiates one of twelve unique Pre-Empt sequences programmed in the controller unit.

304.3 OUTPUTS

.1 Some controller unit outputs are provided on a “per-phase” basis while others are provided on a “per-ring” or “per-unit” basis.

.2 There are additional outputs provided for special functions.

.3 All outputs from the controller unit use 24 Vdc logic. All “True” or “On” signals are at the Logic Ground level. All “False” or “Off” signals are at the +24 Vdc level. Control of these signals is provided by the controller unit.

304.3.4 Per Phase Outputs

.1 The following outputs are provided on a per-phase basis, meaning eight of each:

- .1 Vehicle load switch drivers are provided for the “GREEN”, “YELLOW” and “RED” signals of each phase. These signals control the displays seen in the intersection while the traffic controller assembly is in three-colour operation. One vehicle output per phase will be on at all times.
- .2 Pedestrian load switch drivers are provided for the “WALK”, “PED CLEARANCE” and “DON’T WALK” signals of each phase. These signals control the displays seen in the intersection while the controller is in three-colour operation. The Ministry uses only the Walk and Don’t Walk outputs. The Don’t Walk output will be off during the walk interval. It will flash on and off at 60 flashes per minute during the Ped Clearance interval and will be on steady at all other times. One pedestrian output per phase will be on at all times.

304.3.5 Per Ring Outputs

.1 There is only one set of per-ring outputs. These are called the “CODED STATUS BITS”. There are three status bits for each ring, providing external status of the basic controller unit timing intervals. These outputs are not normally used by the Ministry.

304.3.6 Per Unit Outputs

.1 The following outputs are provided on a per-unit basis, meaning one only:

.1 "CONTROLLER VOLTAGE MONITOR" is an output which is maintained at Logic Ground by the controller unit while all internal voltage levels are normal. This output is monitored by the Conflict Monitor which puts the intersection into flashing operation if the controller unit fails.

.2 "+ 24 Vdc OUTPUT" is a regulated + 24 Vdc supply designed to provide power for external devices. The Ministry does not use this feature.

.3 "FLASHING LOGIC OUT" is a 1 Hertz square wave which alternates between 0 and + 24 Vdc. This output is monitored by the Conflict Monitor "Watchdog" feature.

304.3.7 Special-Purpose Outputs

.1 The controller unit provides a number of special-purpose outputs used for a variety of advanced functions. Except for those listed below, most of these functions are beyond the scope of this document:

.1 "PRE-EMPT OUTPUTS": the controller unit has six pre-empt outputs. Each of these outputs can be programmed to turn on and off during any one of the controller unit's pre-empt sequences.

.2 "OVERLAPS": The controller unit provides four overlaps, A, B, C, and D. An overlap is an independent movement of traffic that depends on other phases, called "parent phases". Each overlap has a Green, Yellow and Red output in the same manner as the normal phases. Programming determines the assignment of overlaps to parent phase or phases.

305 TS2 TYPE 2 CONTROLLER UNIT ADAPTER CABLES

.1 The TS1 M & S cabinets were originally designed around the LMD 8000 Controller Unit. The LMD 8000 supports all standard NEMA I/Os on its front panel Connectors A-C. However, the remainder of its I/Os are supported on the LMD 8000 D Connector and its D-Sub TEC3 (Comm Module) ports.

.2 The Naztec 980 and Econolite Cobalt also support all standard NEMA I/Os on its A-C Connectors. However the remainder of the I/Os are only supported on the D connector as they do not have a TEC3 port.

.3 Therefore an adapter cable is required when retrofitting a Naztec 980 or Econolite Cobalt TS2-Type 2 Controller Unit into a TS1 M or S cabinet. The adapter cable interfaces the D-port on the TS2-Type 2 Controller Unit to the M or S cabinet's D-harness AND TEC3 harness. The pin-out for these adapter cables is provided in Appendix B.

.4 Some I/O re-mapping is required of the Econolite Cobalt D-port to ensure all of the correct I/Os are connected between the Controller Unit, the adapter cable, and the TS1 cabinet. Note that he 'MSD' connector tables found in Appendix A are the default for each Controller Unit and do not reflect any re-mapping of I/Os.

.5 Table 2 shows which MSD pins must be re-mapped in the Econolite Cobalt for both the adapter cable and if Advance Warning is needed at the intersection. Only the pins that must be re-mapped are shown, the remainder are to stay as shown in the MSD connector table in Appendix A.

D-Connector Pin/Default Function		I/O Re-Mapped Pin Function
Pin/Wire	**Default Function**	**Re-Mapped Pin Function**
2	Sys. Command Offset Bit 3 Out	Internal AW 7 Out
3	Split Demand	Detector Input 17
4	Sys. Command Coord Sync In	Detector Input 18
6	Sys. Command Cycle Bit 3 In	Detector Input 19
9	Sys. Command Split Bit 2 In	Detector Input 20
10	Sys. Command Offset Bit 2 In	Detector Input 21
12	Sys. Command Offset Bit 1 In	Detector Input 22
16	Sys. Command Split Bit 1 In	Detector Input 23
25	Sys. Command Cycle Bit 1 In	Detector Input 24
33	Sys. Command Offset Bit 1 Out	Internal AW 2 Out
41	Spare Output 4	Internal AW 8 Out
42	Sys. Command Offset Bit 2 Out	Internal AW 6 Out
45	Spare Output 5	Internal AW 3 Out
51	Spare Output 6	Internal AW 4 Out
52	Spare Output 7	Internal AW 5 Out
54	Spare Output 8	Internal AW 1 Out

Table 2. MSD Pins for TS2 Type 2 Adapter Cable

305.1 Modifying TEC-AW2 Advance Warning for Cobalt Controllers

.1 The TEC-AW2 Advance Warning Card activates the STOP TIME input to the Controller Unit during the timed Advance Warning interval. This holds the CU in its current state while the TEC-AW2 manages the yellow and green field displays.

.2 The STOP TIME input is effective with the LMD 8000 regardless of what state, sequence or special operation it is in at the time of the input.

.3 In the Naztec 980, the TEC-AW2 STOP TIME assertion is effective provided that the Controller Unit has been programmed to allow Stop Time Over Pre-Empt. This programmable option is found in the Naztec 980's Unit Ring Parameters. If this is not done the traffic signal will go into flash anytime Advance Warning timing is occurring during a pre-emption sequence.

.4 The Econolite Cobalt will ignore its STOP TIME input while in a pre-emption sequence. Unlike the Naztec 980 there is no option to override this. Ignoring STOP TIME will result in the signal going into flash every time Advance Warning is timing in a pre-emption sequence. To avoid this, the TEC-AW2 card must be disabled from driving the Advance Warning Flashers in favor of using the Cobalt's internal Advance Warning features.

.5 The first step in disabling the TEC-AW2 card(s) is to adjust the thumb-wheel of all TEC-AW2 cards to zero.

.6 The second step is to disconnect the TEC-AW2 flash activation outputs from the rear cabinet terminals connected to the inputs of the Advance Warning Flasher modules. These rear cabinet terminals are: AW1 FLA DRV, AW2 FLA DRV, AW3 FLA DRV and AW4 FLA DRV.

.7 The third step is to jumper the rear cabinet terminals CLK CKT 1-8 to the Advance Warning Flasher inputs from the previous step. These terminals were re-mapped in the Cobalt to be 'INTERNAL AW 1-8' as shown in Table X. Only jumper the CLK CKT X outputs needed for Advance Warning where the 'X' is the phase number requiring Advance Warning.

.8 Example: An S cabinet is being retrofit with an Econolite Cobalt and the intersection STS shows Advance Warning for phases 2, 6, 4 & 8.

1. Both TEC-AW2 cards would have their front thumb-wheels zeroed out.

2. All the TEC-AW2 flash activation outputs would be disconnected from the AW1-4 FLA DRV rear cabinet terminals.

3. Jumpers would be installed between rear cabinet terminals: CLK CKT 2 to AW1 FLA DRV, CLK CKT 6 to AW2 FLA DRV, CLK CKT 4 to AW3 FLA DRV, and CLK CKT 8 to AW4 FLA DRV.

APPENDIX A CONTROLLER UNIT INPUTS AND OUTPUTS

MSA (All Controller Units)

PIN	WIRE	FUNCTION	PIN	WIRE	FUNCTION
A	A-1	Reserved	f	A-29	Ph 1 Vehicle Call Det
B	A-2	+24 VDC External	g	A-30	Ph 1 Ped Call Det
C	A-3	Voltage Monitor	h	A-31	Ph 1 Hold
D	A-4	Ph 1 Red driver	i	A-32	Force-Off (Ring 1)
E	A-5	Ph 1 Don't Walk driver	j	A-33	External Min Recall All Phases
F	A-6	Ph 2 Red Driver	k	A-34	Manual Control Enable
G	A-7	Ph 2 Don't Walk driver	m	A-35	Call to Non-Actuated 1
H	A-8	Ph 2 Ped Clear driver	n	A-36	Test Input A – D.C. Remote Flash
J	A-9	Ph 2 Walk driver	p	A-37	AC+ (Control)
K	A-10	Ph 2 Vehicle Call Det	q	A-38	(Spare 1)
L	A-11	Ph 2 Ped Call Det	r	A-39	Coded Status Bit B (Ring 1)
M	A-12	Ph 2 Hold	s	A-40	Ph 1 Green driver
N	A-13	Stop Timing (Ring 1)	t	A-41	Ph 1 Walk driver
P	A-14	Inhibit Max Term (Ring 1)	u	A-42	Ph 1 Check
R	A-15	External Start	v	A-43	Ph 2 Ped Omit
S	A-16	Internal Advance	w	A-44	Omit All Red Clear (Ring 1)
T	A-17	(not used)	x	A-45	Red Rest Mode (Ring 1)
U	A-18	AC- (Common)	y	A-46	(Spare 2)
V	A-19	Chassis Ground	z	A-47	Call to Non-Actuated 2
W	A-20	Logic Ground	AA	A-48	Test Input B (not used)
X	A-21	Flashing Logic Out	BB	A-49	Walk Rest Modifier
Y	A-22	Coded Status Bit C (Ring 1)	CC	A-50	Coded Status Bit A (Ring 1)
Z	A-23	Ph 1 Yellow driver	DD	A-51	Ph 1 Phase On
a	A-24	Ph 1 Ped Clear driver	EE	A-52	Ph 1 Ped Omit
b	A-25	Ph 2 Yellow driver	FF	A-53	Ped Recycle (Ring 1)
c	A-26	Ph 2 Green driver	GG	A-54	Max II Selection (Ring 1)
d	A-27	Ph 2 Check	HH	A-55	(Spare 3)
e	A-28	Ph 2 Phase On	--	A-56	Shell Ground

MSB (All Controller Units)

PIN	WIRE	FUNCTION	PIN	WIRE	FUNCTION
A	B-1	Ph 1 Phase Next	f	B-29	Ph 4 Phase Next
B	B-2	(Spare 1)	g	B-30	Ph 4 Phase Omit
C	B-3	Ph 2 Phase Next	h	B-31	Ph 4 Hold
D	B-4	Ph 3 Green driver	i	B-32	Ph 3 Hold
E	B-5	Ph 3 Yellow driver	j	B-33	Ph 3 Ped Omit
F	B-6	Ph 3 Red driver	k	B-34	Ph 6 Ped Omit
G	B-7	Ph 4 Red driver	m	B-35	Ph 7 Ped Omit
H	B-8	Ph 4 Ped Clear driver	n	B-36	Ph 8 Ped Omit
J	B-9	Ph 4 Don't Walk driver	p	B-37	OLA Yellow driver
K	B-10	Ph 4 Check	q	B-38	OLA Red driver
L	B-11	Ph 4 Vehicle Call Det	r	B-39	Ph 3 Check
M	B-12	Ph 4 Ped Call Det	s	B-40	Ph 3 Phase On
N	B-13	Ph 3 Vehicle Call Det	t	B-41	Ph 3 Phase Next
P	B-14	Ph 3 Ped Call Det	u	B-42	OLD Red driver
R	B-15	Ph 3 Phase Omit	v	B-43	(Spare 4)
S	B-16	Ph 2 Phase Omit	w	B-44	OLD Green driver
T	B-17	Ph 5 Ped Omit	x	B-45	Ph 4 Ped Omit
U	B-18	Ph 1 Phase Omit	y	B-46	(Spare 5)
V	B-19	Ped Recycle (Ring 2)	z	B-47	Max II Selection (Ring 2)
W	B-20	(Spare 2)	AA	B-48	OLA Green driver
X	B-21	(Spare 3)	BB	B-49	OLB Yellow driver
Y	B-22	Ph 3 Walk driver	CC	B-50	OLB Red driver
Z	B-23	Ph 3 Ped Clear driver	DD	B-51	OLC Red driver
a	B-24	Ph 3 Don't Walk driver	EE	B-52	OLD Yellow driver
b	B-25	Ph 4 Green driver	FF	B-53	OLC Green driver
c	B-26	Ph 4 Yellow driver	GG	B-54	OLB Green driver
d	B-27	Ph 4 Walk driver	HH	B-55	OLC Yellow driver
e	B-28	Ph 4 Phase On			

MSC (All Controller Units)

PIN	WIRE	FUNCTION	PIN	WIRE	FUNCTION
A	C-1	Coded Status Bit A (Ring 2)	i	C-32	Ph 5 Green driver
B	C-2	Coded Status Bit B (Ring 2)	j	C-33	Ph 5 Walk driver
C	C-3	Ph 8 Don’t Walk driver	k	C-34	Ph 5 Check
D	C-4	Ph 8 Red driver	m	C-35	Ph 5 Hold
E	C-5	Ph 7 Yellow driver	n	C-36	Ph 5 Phase Omit
F	C-6	Ph 7 Red driver	p	C-37	Ph 6 Hold
G	C-7	Ph 6 Red driver	q	C-38	Ph 6 Phase Omit
H	C-8	Ph 5 Red driver	r	C-39	Ph 7 Phase Omit
J	C-9	Ph 5 Yellow driver	s	C-40	Ph 8 Phase Omit
K	C-10	Ph 5 Ped Clear driver	t	C-41	Ph 8 Vehicle Call Det
L	C-11	Ph 5 Don’t Walk driver	u	C-42	Red Rest Mode (Ring 2)
M	C-12	Ph 5 Phase Next	v	C-43	Omit All Red Clear (Ring 2)
N	C-13	Ph 5 Phase On	w	C-44	Ph 8 Ped Clear driver
P	C-14	Ph 5 Vehicle Call Det	x	C-45	Ph 8 Green driver
R	C-15	Ph 5 Ped Call Det	y	C-46	Ph 7 Don’t Walk driver
S	C-16	Ph 6 Vehicle Call Det	z	C-47	Ph 6 Don’t Walk driver
T	C-17	Ph 6 Ped Call Det	AA	C-48	Ph 6 Ped Clear driver
U	C-18	Ph 7 Ped Call Det	BB	C-49	Ph 6 Check
V	C-19	Ph 7 Vehicle Call Det	CC	C-50	Ph 6 Phase On
W	C-20	Ph 8 Ped Call Det	DD	C-51	Ph 6 Phase Next
X	C-21	Ph 8 Hold	EE	C-52	Ph 7 Hold
Y	C-22	Force Off (Ring 2)	FF	C-53	Ph 8 Check
Z	C-23	Stop Timing (Ring 2)	GG	C-54	Ph 8 Phase On
a	C-24	Inhibit Max Term (Ring 2)	HH	C-55	Ph 8 Phase Next
b	C-25	(Spare 1)	JJ	C-56	Ph 7 Walk driver
c	C-26	Coded Status Bit C (Ring 2)	KK	C-57	Ph 7 Ped Clear driver
d	C-27	Ph 8 Walk driver	LL	C-58	Ph 6 Walk driver
e	C-28	Ph 8 Yellow driver	MM	C-59	Ph 7 Check
f	C-29	Ph 7 Green driver	NN	C-60	Ph 7 Phase On
g	C-30	Ph 6 Green driver	PP	C-61	Ph 7 Phase Next
h	C-31	Ph 6 Yellow driver			

MSD (LMD 8000 Only)

PIN/WIRE	FUNCTION	PIN/WIRE	FUNCTION
1	Flash	33	SGO/Conditional Service
2	Offset 1 (Flasher mon 1)	34	Pre-empt 5 In
3	Interconnect Common	35	Pre-empt 1 Out
4	User Defined Input 6	36	Pre-empt 2 Out
5	Offset 2 (Flasher mon 2)	37	Interconnect Inhibit
6	Offset 3 (User Defined Input 1)	38	Time Clock Sync
7	Cycle 2 (User Defined Input 2)	39	Sync Inhibit
8	User Defined Input 7	40	Pre-empt 1 In
9	User Defined Input 8	41	Pre-empt 2 In
10	Call to Free Operation	42	Pre-empt 3 In
11	Call to Week Program 10	43	Pre-empt 3 Out
12	Cycle 3 (User Defined Input 3)	44	Polarizing Key (no wire)
13	Split 2 (User Defined Input 4)	45	F Flash Active (Pre-empt 4 Out)
14	Split 3 (User Defined Input 5)	46	F Flash Image (Pre-empt 5 Out)
15	Lag Phase 1	47	System Out
16	Lag Phase 3	48	FL Out (Pre-empt 6 Out)
17	Lag Phase 5	49	Pre-empt 4 In
18	Dimming	50	Clock Ckt 9 (Aux 1)
19	Dual Entry	51	Clock Ckt 10 (Aux 2)
20	System In	52	Clock Ckt 11 (Aux 3)
21	Lag Phase 7	53	Clock Ckt 12 (Aux 4)
22	Spare Input	54	Clock Ckt 13 (System)
23	Spare Input	55	Clock Ckt 8 (Flash)
24	DET INPUT 13	56	Clock Ckt 3 (Offset 1)
25	DET INPUT 9	57	Clock Ckt 4 (Offset 2)
26	DET INPUT 10	58	Clock Ckt 5 (Offset 3)
27	DET INPUT 11	59	Clock Ckt 1 (Cycle 2)
28	Polarizing Key (no wire)	60	Clock Ckt 2 (Cycle 3)
29	DET INPUT 12	61	Clock Ckt 6 (Split 2)
30	DET INPUT 14	62	Clock Ckt 7 (Split 3)
31	DET INPUT 15	63	Pre-empt 6 In
32	DET INPUT 16		

COMM MODULE/TEC3 (LMD 8000 Only)

COMMUNICATION INPUTS		MODEM CONNECTOR	
PIN/WIRE	FUNCTION	PIN/WIRE	FUNCTION
1	Detector 17	1	Receive 1
2	Detector 18	2	Receive 2
3	Detector 19	4	Xmit 1
4	Detector 20	5	Xmit 2
5	Detector 21		
6	Detector 22		
7	Detector 23		
8	Detector 24		
9	Conflict Monitor Status Bit B		
10	Conflict Monitor Status Bit A		
11	Conflict Monitor Status Bit C		
12	DC User Defined Input #1		
13	Logic Ground		
14	DC User Defined Input #2		
15	DC User Defined Input #3		

MSD (Naztec 980 Only- Diamond Mode)

PIN/WIRE	FUNCTION	PIN/WIRE	FUNCTION
1	System Detector 2	33	External Alarm 1
2	System Detector 7	34	External Alarm 2
3	System Detector 8	35	Not Assigned
4	Flash	36	Not Assigned
5	System Detector 3	37	Not Assigned
6	System Detector 4	38	Not Assigned
7	System Detector 1	39	External Alarm 3
8	System Detector 5	40	External Alarm 4
9	System Detector 6	41	N/A
10	Special Function 2	42	Not Assigned
11	Free	43	Special Function 1
12	Not Assigned	44	Split 3/Preempt 2
13	Not Assigned	45	Split 2/Preempt 1
14	Not Assigned	46	Offset 4/Preempt 5
15	Reserved	47	Offset 3/Preempt 6
16	Reserved	48	Offset 2
17	N/A	49	Flash
18	Reserved	50	Cycle 3/Preempt 4
19	Preempt 1	51	Cycle 2/Preempt 3
20	Preempt 2	52	Offset 1
21	Preempt 3	53	+24VDC
22	Preempt 4	54	Logic Ground
23	Preempt 5	55	Chassis Ground
24	Preempt 6	56	Not Assigned
25	Detector 45P	57	Not Assigned
26	Detector 25S	58	N/A
27	Detector 18P	59	N/A
28	Detector 16S	60	N/A
29	Det. Cir. 2b/1P	61	N/A
30	Det. Cir. 2a	62	N/A
31	Det. Cir. 1b/5P	63	N/A
32	Det. Cir. 1a		

MSD (Econolite Cobalt Only)

PIN/WIRE	FUNCTION	PIN/WIRE	FUNCTION
1	Preemptor #1 Active	33	System Command Offset Bit 1 Out
2	System Command Offset Bit 3 Out	34	Preemptor #4 Active
3	Split Demand	35	System Command Cycle Bit 2 In
4	System Command Coord Sync In	36	System Command Offset Bit 3 In
5	Cross Street Sync	37	Test Input D
6	System Command Cycle Bit 3 In	38	Dual Coord
7	N/A	39	Expanded Detector #6
8	NIC Special Function 2	40	Expanded Detector #7
9	System Command Split Bit 2 In	41	Spare Output 4
10	System Command Offset Bit 2 In	42	System Command Offset Bit 2 Out
11	NIC Special Function 4	43	System Command Cycle Bit 1 Out
12	System Command Offset Bit 1 In	44	System Command Cycle Bit 2 Out
13	Expanded Detector #8	45	Spare Output 5
14	Time Reset	46	System Command Split Bit 2 Out
15	Preemptor Flash Control	47	Expanded Detector #2
16	System Command Split Bit 1 In	48	Preemptor #6 Active
17	Expanded Detector #1	49	Preemptor Call #2
18	Expanded Detector #4	50	Preemptor Call #3/Bus Preempt #1
19	Test Input E	51	Spare Output 6
20	Test Input C	52	Spare Output 7
21	System Command Split Bit 1 Out	53	System Command Sync Out
22	Preemptor #3 Active	54	Spare Output 8
23	Preemptor #1 Active	55	Preemptor Call #4/Bus Preempt #2
24	NIC Special Function 3	56	Preemptor Call #5/Bus Preempt #3
25	System Command Cycle Bit 1 In	57	Preemptor Call #1
26	Coord Free	58	CMU Stop Time (Conflict Flash)
27	Coord Status	59	Preempt CMU Interlock
28	NIC Special Function 1	60	Automatic Flash
29	System Command Cycle Bit 3 Out	61	Preemptor Call #6/Bus Preempt #4
30	Expanded Detector #5	62	N/A
31	Expanded Detector #3	63	N/A
32	Preemptor #2 Active		

APPENDIX B TS2 TYPE 2 CONTROLLER ADAPTER CABLE PIN-OUTS

ECONOLITE COBALT D HARNESS ADAPTOR FOR MoTI TYPE S OR M TRAFFIC CONTROLLER CABINET		
FROM S CABINET MSD HARNESS (AMP-205843-2)	TO ECONOLITE COBALT MSD CONNECTOR (AMP-205842-1)	FUCNTION
4	20	USER DEFINED INPUT 6
8	37	USER DEFINED INPUT 7
9	19	USER DEFINED INPUT 8
10	26	CALL TO FREE OPERATION
24	30	DETECTOR INPUT 13
25	17	DETECTOR INPUT 9
26	47	DETECTOR INPUT 10
27	31	DETECTOR INPUT 11
29	18	DETECTOR INPUT 12
30	39	DETECTOR INPUT 14
31	40	DETECTOR INPUT 15
32	13	DETECTOR INPUT 16
34	56	PRE-EMPT 5 INPUT
35	23	PRE-EMPT 1 OUTPUT
36	32	PRE-EMPT 2 OUTPUT
38	14	TIME CLOCK SYNC
40	57	PRE-EMPT 1 INPUT
41	49	PRE-EMPT 2 INPUT
42	50	PRE-EMPT 3 INPUT
43	22	PRE-EMPT 3 OUTPUT
45	34	PRE-EMPT 4 OUTPUT
46	1	PRE-EMPT 5 OUTPUT
48	48	PRE-EMPT 6 OUTPUT
49	55	PRE-EMPT 4 INPUT
55	41	INTERNAL AW 8 *
56	45	INTERNAL AW 3 *
57	51	INTERNAL AW 4 *
58	52	INTERNAL AW 5 *
59	54	INTERNAL AW 1 *
60	33	INTERNAL AW 2 *
61	42	INTERNAL AW 6 *
62	2	INTERNAL AW 7 *
63	61	PRE-EMPT 6 INPUT
FROM S CABINET TEC3 HARNESS	---	---
TEC3-1	3	DETECTOR INPUT 17 *
TEC3-2	4	DETECTOR INPUT 18 *
TEC3-3	6	DETECTOR INPUT 19 *
TEC3-4	9	DETECTOR INPUT 20 *
TEC3-5	10	DETECTOR INPUT 21 *
TEC3-6	12	DETECTOR INPUT 22 *
TEC3-7	16	DETECTOR INPUT 23 *
TEC3-8	25	DETECTOR INPUT 24 *

NOTE: * = ECONOLITE COBALT PIN MAPPING REQUIRED

TRAFFIC CONTROLLER ASSEMBLY MANUAL
VOLUME 1

Section 400

Conflict Monitors

Electrical and ITS Engineering

June 2019

400 CONFLICT MONITORS

APPENDICES

LIST OF FIGURES

LIST OF TABLES

401 GENERAL OPERATION

401.1 PURPOSE

.1 In the application of technology to traffic control, no single item is more important than safety. Within a traffic controller assembly, the most important safety device is the conflict monitor.

.2 A conflict monitor is installed in every Ministry intersection and is so integral to the traffic controller assembly that it cannot operate without one. The conflict monitor enables the display of normal signals in the intersection. The conflict monitor simultaneously monitors a variety of signals within the controller and only allows the intersection to operate when these signals are maintained in a correct state.

.3 Conflict monitors are exchanged annually and must go through a complete re-certification process before going back into use.

.4 The conflict monitor fulfils four main functions:

  .1 It detects the presence of conflicting Green, Yellow or Walk signal indications on different movements, e.g. green signals on two crossing approaches.

  .2 It detects the presence of overlapping Green, Yellow, Walk or Red signal indications on the same movement, e.g. red and green signals on the same approach.

  .3 It detects the absence of any Green, Yellow, Walk or Red traffic controller assembly output on a given movement.

  .4 It monitors various traffic controller assembly devices for correct electrical operation.

.5 The functions performed by conflict monitors are specified by the National Electrical Manufacturer's Association (NEMA). These specifications provide requirements for general operation as well as detailed specifications of proper operating voltages, etc.

.6 The Ministry currently uses three conflict monitors. The LSM12, LNM12E and NSM12E. These conflict monitors provide all basic NEMA functions, as well as additional non-NEMA-specified features. The LNM12E and NSM12E also has message logging and remote communications access that the LSM12 does not.

401.2 GENERAL OPERATION

.1 Each current Ministry conflict monitors have twelve input channels. Each channel has a green, yellow, walk and red input circuit, giving a total of forty-eight signal monitoring circuits. Normally each channel is assigned to a specific movement. For example, channel one monitors phase one, channel two monitors phase two, etc. Refer to *Chapter 1002* for details.

.2 The conflict monitor's signal inputs are connected to the "field outputs" of the traffic controller assembly. This ensures that the traffic controller assembly outputs are being correctly provided to the intersection. It does not, however, guarantee the current state of the signal heads in the field. A burned out display will not be detected by the conflict monitor.

.3 The conflict monitor has two electro-mechanical relays to control the operation of the intersection. These relays are called the "Start-Delay Relay" and the "Output Relay".

.4 The Start-Delay Relay is applies a general reset signal called "System Reset" to various devices within the traffic controller assembly. This reset signal is applied for 2.5 seconds upon power up of the traffic controller assembly.

.5 Upon power up, or after a fault has occurred, the traffic controller assembly is in a state known as "in flash". In this state, advance warning signals are operating, and the highway and cross street signals are flashing. The highway through signals will flash either yellow or red. The highway left-turn signals and all cross-street signals will flash red.

.6 While the intersection is in flash, the controller unit continues to operate, cycling through all currently assigned phases. The traffic controller assembly red, yellow and green signal outputs are not displayed in the field. When it is safe to do so, the intersection comes out of flash into normal "three-colour" operation. The "Flash Control Circuit" determines whether three-colour or flashing indications are seen. The conflict monitor “Output Relay”, along with other devices, determines flash control circuit operation. *Refer to Chapter 803 and Section 900* for details.

.7 In the event of a fault, the conflict monitor de-energizes its Output Relay, putting the intersection into flash.

.8 When the Output Relay is de-energized, in response to a fault condition, a Stop-Time signal is applied to the controller unit, stopping all phase timing. This allows service personnel to determine the prevailing conditions at the time the fault occurred. Stop-Time is removed when the fault is corrected and the conflict monitor resets.

401.3 NEMA FAULT MONITORING

401.3.1 Conflicts

.1 The monitor detects conflicting signal indications on different movements. Only red signals are never in conflict. In its initial state, the monitor is programmed so that any signals (other than red) that occur simultaneously on different channels will be considered a conflict.

.2 In practice however, certain signals must be allowed to occur simultaneously. For example, ∅2 and ∅6 green may need to be on at the same time. To allow such indications, a printed circuit board called a “Compatibility Programming Card” is used. This Programming Card allows the user, by soldering in wire jumpers, to assign compatibility between any two channels. This allows green, yellow and walk signals of the “programmed” channels to be on at the same time as each other.

.3 The conflict monitor continuously observes the signal indications on all twelve channels and will put the intersection into flash if a conflict occurs. NEMA specifications provide a range of allowable signal voltages which are used in determining the presence or absence of a signal. A red signal is on when its voltage is at 60 Vac +/- 10 Vac. A green, yellow or walk signal is on when its voltage is at 20 Vac +/- 5 Vac. Conflicts are deemed to occur after a concurrent signal display of 325 milliseconds (ms) +/- 125 ms.

.4 The conflict monitor latches all conflicts. Once a conflict is detected and the conflict monitor puts the intersection into flash, it will only allow the intersection to come out of flash after it has been manually reset. The conflict monitor has a failure carryover capability. If 120 Vac power is interrupted while the monitor is in a failed state, the monitor will continue in the failed state when power is restored.

401.3.2 Red Failure

.1 In addition to monitoring for conflicting displays, the conflict monitor detects the absence of any signal input on a given channel. This indicates the failure of some component(s) within the traffic controller assembly and causes the conflict monitor to put the intersection into flash.

.2 Not all channels are always used. Any unused channels must have their red input circuits connected to 120 Vac.

.3 The voltage levels specified for red failures are the same as for conflicts. The time from the absence of any signal on a given channel to a fault condition is defined as 850 ms +/- 150 ms.

.4 A red failure is also latched the same as conflicts.

401.3.3 Controller Voltage Monitor

.1 The Controller Voltage Monitor or CVM is a signal generated by the controller unit. This signal is maintained at a True state (Logic Ground) at all times. In the event of a controller unit failure, this signal becomes false and the conflict monitor will disable intersection operation. Unlike conflicts and red failures, CVM failures are non-latching. If the CVM signal returns to the True state, the monitor will allow the traffic controller assembly to return to normal operation if no other faults are present.

401.3.4 +24 Volt Monitor

.1 The conflict monitor provides two inputs, called +24 Volt **I** and +24 Volt **II** which are connected to monitor 24 Vdc operation within the traffic controller assembly. The original source of +24 Vdc, in both cases, is the Power Supply Card. Refer to *Section 700* for details.

.2 +24 Volt **I** monitors the voltage output of the Power Supply Card. +24 Volt **II** monitors the presence of the Input Modifier Cards. The +24 Vdc signal from the Power Supply is "daisy-chained" through each of the card positions so that if a card is removed or inserted in the wrong location the signal path is interrupted. These inputs are True at +20 +/- 2 Vdc.

.3 CVM, +24 Volt **I** and +24 Volt **II** faults are non-latching. In the event of a failure on either of these inputs, the intersection is put into flash. If the failed signal returns to the True state, the monitor will automatically allow the intersection to come out of flash if no other faults are present.

401.3.5 Power Interruption Monitoring

.1 The conflict monitor continually observes the traffic controller assembly 120 Vac distribution. The conflict monitor will put the intersection into flash if the supply level drops below 95 Vac for longer than 850 ms +/- 150 ms.

.2 Power interruption faults are non-latching. Once the supply returns to an acceptable level, the monitor will allow the intersection to come out of flash if no other faults are present.

401.4 NON-NEMA FEATURES

.1 The following features are not NEMA specified, and therefore vary from one manufacturer to another. All are provided on each of the Ministry approved conflict monitors.

401.4.2 Minimum Flash

.1 A safety feature call Minimum Flash or "Min Flash" ensures a user-selectable minimum delay from power up, until the monitor energizes its Output Relay (*Chapter 902*), allowing the intersection to come out of flash. The range of delay time is selectable between 0 (4s for NSM12E) and 15 seconds. The Ministry standard is 5 seconds.

401.4.3 Minimum Clearance

.1 The Minimum Yellow Clearance or “Min-Clear” feature is used to verify that a period of at least 2.7 seconds exists between any two consecutive conflicting green signals. It is during this time that the yellow and red clearance intervals are timed by the controller unit.

401.4.4 Watchdog

.1 An input of the conflict monitor is provided to detect the “Flashing Logic” output of the controller unit. This input recognizes a periodic DC square wave. When the Watchdog option is enabled, failure of the input to periodically change state constitutes a fault. This is a latched failure and requires a manual reset to clear.

401.4.5 Green/Walk versus Yellow

.1 Green or Walk vs Yellow is called an “overlapping” signal indication. This refers to dual indications on the same channel. With this feature enabled, the green and walk inputs are monitored against the yellow of the same channel. Concurrent green and yellow or walk and yellow signals on the same channel are not permitted, resulting in a fault condition. Overlapping signals, when not allowed, cause a failure condition after 850 ms. This is a latched failure and requires manual reset to clear.

401.4.6 Green/Walk or Yellow versus Red

.1 Green, Walk or Yellow vs Red is also an overlapping signal indication. With this feature enabled, the green, walk and yellow inputs are monitored against the red of the same channel. Concurrent green and red, yellow and red or walk and red signals on the same channel are not permitted, resulting in a fault condition. Overlapping signals, when not allowed, cause a failure condition after 850 ms. This is a latched failure and requires manual reset to clear.

401.5 OPTION SWITCHES

.1 Use of the various features and options provided by the conflict monitor is user-selected by means of Channel and Option switches mounted on the unit front panel. All basic NEMA functions are permanently enabled and are not affected by the switch selections.

.2 Option selection differs between each conflict monitor model and is described in more detail in the following chapters.

402 THE LSM12 CONFLICT MONITOR

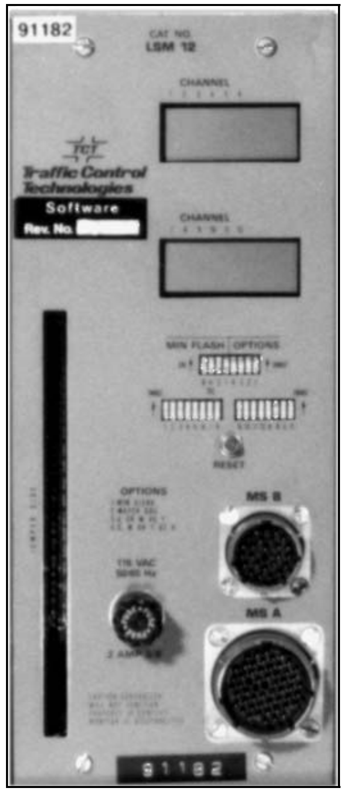


Figure 1. The LSM12 Conflict Monitor

402.1 GENERAL DESCRIPTION

.1 The LSM12 conflict monitor, shown in *Figure 1*, has been in use with the Ministry for many years. The LSM12 replaced the M12L and M12LA monitors which are no longer in use.

.2 The LSM12 provides all basic NEMA functions plus additional functions not specified in the NEMA standard.

.3 The LSM12 is a twelve-channel monitor. The twelve input channels are assigned to phases, overlaps and pre-emption outputs. Each channel is capable of monitoring a Red, Yellow, Green and Walk signal.

.4 The LSM12 has user configuration switches mounted on the front panel.

.5 The LSM12 has two Liquid Crystal Displays (LCD) showing fault conditions and the current status of inputs on each of the twelve channels.

.6 The LSM12 has a built-in power supply which is fed from the traffic controller assembly's 120 Vac distribution system.

.7 The monitor's program is stored on a memory IC which is installed in a socket on the circuit board for easy removal. The micro-processor sequentially "reads" and executes instructions from the memory IC. This internal program is dedicated specifically to the functions of the LSM12 only. This type of program is commonly referred to as "firm-ware". The IC which contains the program is removable to facilitate the installation of new program revisions. This is a 'permanent' program, common to all Ministry LSM12 conflict monitors.

402.2 OPTION SWITCHES

.1 Use of the various features and options provided by the LSM12 is user-selected by means of "CHANNEL" and "OPTION" switches mounted on the unit front panel. All basic NEMA functions are permanently enabled and are not affected by the switch selections.

.2 The twelve channel (1-12) switches allow each channel to be individually included or excluded from the unit-wide options that are enabled separately. The individual channel switches are selected to correspond only to phases that have displays in the field. These selections provide a safeguard against Red being on with any other colour of the same channel. Combined with the four option switch settings, Green and Walk is the only combination permitted on the same channel.

.3 Five of the eight Option switches (1 – 4, A, B, C and D) are used to enable the non-NEMA features: Minimum Clearance, Watch Dog, Green/Walk vs Yellow and Green/Walk/Yellow vs Red. Option switch B is used to remove Walk from the Red Failure determination. Option switches A, C and D are not used. *Table 1* lists the standard Ministry switch settings for the LSM12 monitor.

.4 Four additional switches are provided to select the desired Min Flash time, from 0 to 15 seconds.

OPTION SWITCH	NORMAL STATE	FUNCTION
1	ON	This option ensures that minimum yellow clearance timing is enforced.
2	ON	The Watchdog option monitors the flashing logic output of the controller unit.
3	ON	Green and Walk are monitored against the Yellow of the same channel. Green and Yellow or Walk and Yellow of the same channel is not permitted.
4	ON	Green, Walk and Yellow are monitored against the Red of the same channel. Green and Red, Walk and Red or Yellow and Red of the same channel is not permitted.
A	OFF	Not used.
B	ON	Walk is removed from the Red Failure determination. A Walk alone on any given channel will not prevent a failure. In addition, this allows Green or Yellow vs Red to be disabled on a per-channel basis using the twelve individual Channel switches.
C	OFF	Not used.
D	OFF	Not used.

Table 1. LSM12 Option Switch Settings

402.3 INPUTS AND OUTPUTS

.1 A complete listing of all the LSM12's inputs and outputs can be found in *Appendix A* at the end of this section.

403 THE LNM12E CONFLICT MONITOR

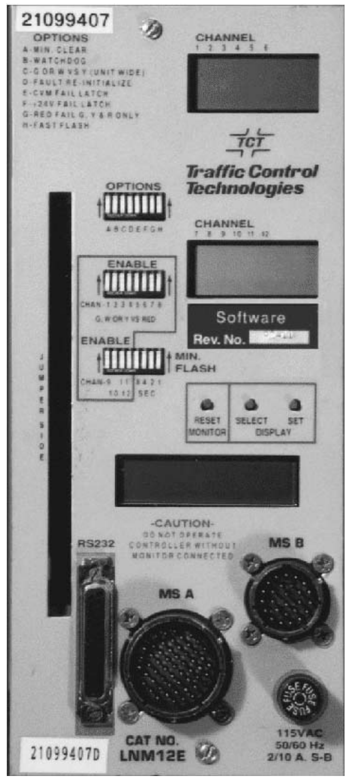


Figure 2. The LNM12E Conflict Monitor

403.1 GENERAL DESCRIPTION

.1 The LNM12E conflict monitor, shown in *Figure 2*, has been in use with the Ministry for a number of years. The LNM12E replaced the majority of LSM12 monitors, some of which are still in limited use.

.2 The LNM12E provides all of the basic NEMA functions plus additional features not specified in the NEMA standard.

.3 The LNM12E is a twelve-channel monitor. The twelve input channels are assigned to phases, overlaps and pre-emption outputs. Each channel is capable of monitoring a Red, Yellow, Green and Walk signal.

.4 The LNM12E has user configuration switches mounted on the front panel.

.5 The LNM12E features three Liquid Crystal Displays (LCD). Two show fault conditions and the current status of inputs on each of the twelve channels. The third shows the current time and date and also is used to view historical fault and status information that has been saved in the event log.

.6 The LNM12E has a built-in power supply which is fed from the traffic controller assembly's 120 Vac distribution system. The internal power supply in turn supplies regulated DC power for the logic circuitry of the monitor.

.7 The monitor's program is stored on a memory IC which is installed in a socket on the circuit board for easy removal. The micro-processor sequentially "reads" and executes instructions from the memory IC. This internal program is dedicated specifically to the functions of the LNM12E only. This type of program is commonly referred to as "firm-ware". The IC which contains the program is removable to facilitate the installation of new program revisions. This is a 'permanent' program, common to all Ministry LNM12E conflict monitors.

.8 The LNM12E has message logging capability. All faults, option switch changes and compatibility card changes are logged. Message logs are stored on non-volatile EEPROM for later viewing or retrieval. The LNM12E stores up to 140 unique messages after which messages are over-written, beginning with the oldest message. Messages can be viewed at any time on the LCD, printed, or retrieved remotely through a connection to an LMD8000 controller unit.

403.2 OPTION SWITCHES

.1 Use of the various features and options provided by the LNM12E is user-selected by means of "CHANNEL" and "OPTION" switches mounted on the unit front panel. All basic NEMA functions are permanently enabled and are not affected by the switch selections.

.2 Twelve Channel switches enable the Green, Walk or Yellow vs Red feature individually for each channel. There is no "unit-wide" selection of this feature as on the LSM12. This feature provides a safeguard against Red being on with any other colour of the same channel. Combined with the determinations of the Option switches, Green and Walk is the only combination permitted on a single channel.

.3 The LNM12E has a total of eight Option switches (A - H). Four are currently used by the Ministry to enable the non-NEMA features: Minimum Clearance, Watch Dog Monitor, Green/Walk vs Yellow and Green/Walk/Yellow vs Red. *Table 2* lists the standard Ministry switch settings for the LNM12E monitor.

.4 Four additional switches are provided to select the desired Min Flash time, from 0 to 15 seconds.

OPTION SWITCH	NORMAL STATE	FUNCTION
A	ON	This option ensures that proper yellow clearance timing is enforced.
B	ON	The Watchdog option monitors the flashing logic output of the controller unit.
C	ON	Green and Walk are monitored against the Yellow of the same channel. Green and Yellow or Walk and Yellow of the same channel is not permitted.
D	OFF	Not used.
E	OFF	Not used.
F	OFF	Not used.
G	ON	Walk is removed from the Red Failure determination. Therefore a Walk alone on any given channel will not prevent a failure.
H	OFF	Not used.

Table 2. LNM12E Option Switch Settings

403.3 INPUTS AND OUTPUTS

.1 A complete listing of all the LNM12E's inputs and outputs can be found in *Appendix B* at the end of this section.

404 THE NSM12E CONFLICT MONITOR

Figure 3. The NSM12E Conflict Monitor

404.1 GENERAL DESCRIPTION

.1 The NSM12E conflict monitor, shown in *Figure 3*, is the most recent addition to approved Ministry conflict monitors.

.2 The NSM12E provides all of the basic NEMAfunctions plus additional features not specified in the NEMA standard.

.3 The NSM12E is a twelve-channel monitor. The twelve input channels are assigned to phases, overlaps and pre-emption outputs. Each channel is capable of monitoring a Red, Yellow, Green and Walk signal.

.4 The NSM12E has user configuration switches mounted on the front panel.

.5 The NSM12E features five columns of LEDs. Four show the current status of inputs on each of the twelve channels. The fifth displays the fault condition.

.6 The NSM12E has a built-in power supply which is fed from the traffic controller assembly’s 120 Vac distribution system. The internal power supply in turn supplies regulated DC power for the logic circuitry of the monitor.

.7 The NSM12E has event logging capabilities. Event logs can be retrieved from the front panel serial comm port using a computer with EDI's free ECom software. After connecting to the CMU the ECom software report will provide the unit: status, previous fault events, previous AC Line events, Manual Reset events, Configuration Change events, and the Signal Sequence Log. The Signal Sequence Log provides a time-based graph of all input channel statuses for the previous 5 fault events to aid in troubleshooting signal faults.

404.2 OPTION SWITCHES

.1 Use of the various features and options provided by the NSM12E is user-selectedby means of “SSM ENABLE” and “OPTION” switches mounted on the unit front panel. All basic NEMA functions are permanently enabled and are not affected by the switch selections.

.2 The SSM ENABLE twelve channel switches enable the Green, Walk or Yellow vs Red ("Dual Indication") and Minimum Clearance monitor feature individually for each channel. There is no “unit-wide” selection of these features as on the LSM12. This feature provides a safeguard against Red being on with any other colour of the same channel. Combined with the determinations of the Option switches, Green and Walk is the only combination permitted on a single channel.

.3 The NSM12E has a total of eight Option switches. Four are currently used by the Ministry to enable the non-NEMA features: GY ENABLE, RP DISABLE, WD ENABLE and WALK DISABLE. *Table 2* lists the standard Ministry switch settings for the NSM12E monitor.

.4 Four additional switches are provided to select the desired Min Flash time, from 4 to 15 seconds.

OPTION SWITCH	NORMAL STATE	FUNCTION
GY ENABLE	ON	Unit-wide option looks for Green/Yellow simultaneously active on same channel for channels with SSM switch off.
RP DISABLE	ON	Disables feature that looks for channels rapidly pulsing on & off but fall beneath fault-time thresholds.
WD ENABLE	ON	Enables monitoring of the watchdog signal from the controller unit.
WALK DISABLE	ON	Disables the CMU from including the Walk in all Red Fail or Dual Indication monitoring.
CVM	OFF	When enabled , requires a manual reset of the unit to recover from a CVM fault.
LATCH 24V	OFF	When enabled , requires a manual reset of the unit to recover from a 24V input fault.
CVM LOG DISABLE	OFF	Enabling this feature prevents CVM faults from being recorded in the unit's logs.
LED GUARD	OFF	This option enables special monitoring specific to LED signal loads.

Table 3. NSM12E Option Switch Settings

404.3 INPUTS AND OUTPUTS

.1 A complete listing of all the NSM12E’s inputs and outputs can be found in *Appendix C* at the end of this section.

APPENDIX A LSM12 INPUTS AND OUTPUTS

MSA

PIN	WIRE	FUNCTION	PIN	WIRE	FUNCTION
A	1	AC+ 1 (jumpered to AC+ 2)	f	29	Channel 6 Yellow
B	2	Output Relay 1 Open	g	30	Channel 5 Yellow
C	3	Output Relay 2 Closed	h	31	Channel 3 Yellow
D	4	Channel 12 Green	i	32	Channel 3 Walk
E	5	Channel 11 Green	j	33	Channel 2 Yellow
F	6	Channel 10 Green	k	34	Channel 1 Yellow
G	7	Channel 9 Green	m	35	Controller Voltage Monitor
H	8	Channel 8 Green	n	36	+24 VDC Monitor Inhibit
J	9	Channel 7 Green	p	37	Output Relay 1 Closed
K	10	Channel 6 Green	q	38	Output Relay 2 Open
L	11	Channel 5 Green	r	39	Channel 12 Walk
M	12	Channel 4 Green	s	40	Channel 11 Walk
N	13	Channel 3 Green	t	41	Channel 9 Walk
P	14	Channel 2 Green	u	42	Channel 8 Walk
R	15	Channel 1 Green	v	43	Channel 7 Walk
S	16	+24 VDC Monitor 1	w	44	Channel 5 Walk
T	17	Logic Ground	x	45	Channel 4 Yellow
U	18	Chassis Ground	y	46	Channel 2 Walk
V	19	AC-	z	47	Channel 1 Walk
W	20	Output Relay 1 Common	AA	48	(Spare 1)
X	21	Output Relay 2 Common	BB	49	Reset
Y	22	Channel 12 Yellow	CC	50	Cabinet Interlock A
Z	23	Channel 11 Yellow	DD	51	Cabinet Interlock B
a	24	Channel 10 Walk	EE	52	Channel 6 Walk
b	25	Channel 10 Yellow	FF	53	Channel 4 Walk
c	26	Channel 9 Yellow	GG	54	(Spare 2)
d	27	Channel 8 Yellow	HH	55	(Spare 3)
e	28	Channel 7 Yellow	--	56	Shell Ground

MSB

PIN	WIRE	FUNCTION	PIN	WIRE	FUNCTION
A	1	AC+ 2 (jumpered to AC+ 1)	R	15	+24 VDC Monitor II
B	2	Start Delay Relay Common	S	16	Watch Dog
C	3	Start Delay Relay Open	T	17	Fast Flash Image
D	4	Channel 12 Red	U	18	Start Delay Relay Closed
E	5	Channel 11 Red	V	19	Channel 10 Red
F	6	Channel 9 Red	W	20	Red Threshold
G	7	Channel 8 Red	X	21	Status Bit A
H	8	Channel 7 Red	Y	22	Status Bit B
J	9	Channel 6 Red	Z	23	Channel 3 Red
K	10	Channel 5 Red	a	24	Red Enable
L	11	Channel 4 Red	b	25	Status Bit C
M	12	Channel 2 Red	c	26	(Spare 8)
N	13	Channel 1 Red	--	27	Shell Ground
P	14	Fast Flash Enable			

APPENDIX B LNM12E INPUTS AND OUTPUTS

MSA

PIN	WIRE	FUNCTION	PIN	WIRE	FUNCTION
A	1	AC+ 1 (jumpered to AC+ 2)	f	29	Channel 6 Yellow
B	2	Output Relay 1 Open	g	30	Channel 5 Yellow
C	3	Output Relay 2 Closed	h	31	Channel 3 Yellow
D	4	Channel 12 Green	i	32	Channel 3 Walk
E	5	Channel 11 Green	j	33	Channel 2 Yellow
F	6	Channel 10 Green	k	34	Channel 1 Yellow
G	7	Channel 9 Green	m	35	Controller Voltage Monitor
H	8	Channel 8 Green	n	36	+24 VDC Monitor Inhibit
J	9	Channel 7 Green	p	37	Output Relay 1 Closed
K	10	Channel 6 Green	q	38	Output Relay 2 Open
L	11	Channel 5 Green	r	39	Channel 12 Walk
M	12	Channel 4 Green	s	40	Channel 11 Walk
N	13	Channel 3 Green	t	41	Channel 9 Walk
P	14	Channel 2 Green	u	42	Channel 8 Walk
R	15	Channel 1 Green	v	43	Channel 7 Walk
S	16	+24 VDC Monitor 1	w	44	Channel 5 Walk
T	17	Logic Ground	x	45	Channel 4 Yellow
U	18	Chassis Ground	y	46	Channel 2 Walk
V	19	AC-	z	47	Channel 1 Walk
W	20	Output Relay 1 Common	AA	48	(Spare 1)
X	21	Output Relay 2 Common	BB	49	Reset
Y	22	Channel 12 Yellow	CC	50	Cabinet Interlock A
Z	23	Channel 11 Yellow	DD	51	Cabinet Interlock B
a	24	Channel 10 Walk	EE	52	Channel 6 Walk
b	25	Channel 10 Yellow	FF	53	Channel 4 Walk
c	26	Channel 9 Yellow	GG	54	(Spare 2)
d	27	Channel 8 Yellow	HH	55	(Spare 3)
e	28	Channel 7 Yellow	--	56	Shell Ground

MSB

PIN	WIRE	FUNCTION	PIN	WIRE	FUNCTION
A	1	AC+ 2 (jumpered to AC+ 1)	R	15	+24 VDC Monitor II
B	2	Start Delay Relay Common	S	16	Watch Dog
C	3	Start Delay Relay Open	T	17	Fast Flash Image
D	4	Channel 12 Red	U	18	Start Delay Relay Closed
E	5	Channel 11 Red	V	19	Channel 10 Red
F	6	Channel 9 Red	W	20	DC Red Monitor Inhibit
G	7	Channel 8 Red	X	21	Status Bit A
H	8	Channel 7 Red	Y	22	Status Bit B
J	9	Channel 6 Red	Z	23	Channel 3 Red
K	10	Channel 5 Red	a	24	Red Enable
L	11	Channel 4 Red	b	25	Status Bit C
M	12	Channel 2 Red	c	26	(Spare 8)
N	13	Channel 1 Red	--	27	Shell Ground
P	14	DC Remote Flash			

APPENDIX C NSM12E INPUTS AND OUTPUTS

MSA

Pin	Function	I/O
A	AC Line	[I]
B	Output Relay 1 Open (Closes when fault occurs)	[O]
C	Output Relay 2 Closed (Opens when fault occurs)	[O]
D	Channel 12 Green	[I]
E	Channel 11 Green	[I]
F	Channel 10 Green	[I]
G	Channel 9 Green	[I]
H	Channel 8 Green	[I]
J	Channel 7 Green	[I]
K	Channel 6 Green	[I]
L	Channel 5 Green	[I]
M	Channel 4 Green	[I]
N	Channel 3 Green	[I]
P	Channel 2 Green	[I]
R	Channel 1 Green	[I]
S	+24 Monitor I	[I]
T	Logic Ground	[I]
U	Earth Ground	[I]
V	AC Neutral	[I]
W	Output Relay 1 Common	[I]
X	Output Relay 2 Common	[I]
Y	Channel 12 Yellow	[I]
Z	Channel 11 Yellow	[I]
a	Channel 10 Walk	[I]
b	Channel 10 Yellow	[I]
c	Channel 9 Yellow	[I]
d	Channel 8 Yellow	[I]
e	Channel 7 Yellow	[I]
f	Channel 6 Yellow	[I]
g	Channel 5 Yellow	[I]
h	Channel 3 Yellow	[I]
i	Channel 3 Walk	[I]
j	Channel 2 Yellow	[I]

Pin	Function	I/O
k	Channel 1 Yellow	[I]
m	Controller Voltage Monitor	[I]
n	+24V Monitor Inhibit	[I]
p	Output Relay 1 Closed (Opens when fault occurs)	[O]
q	Output Relay 2 Open (Closes when fault occurs)	[O]
r	Channel 12 Walk	[I]
s	Channel 11 Walk	[I]
t	Channel 9 Walk	[I]
u	Channel 8 Walk	[I]
v	Channel 7 Walk	[I]
w	Channel 5 Walk	[I]
x	Channel 4 Yellow	[I]
y	Channel 2 Walk	[I]
z	Channel 1 Walk	[I]
AA	Spare 1	[-]
BB	Reset	[I]
CC	Cabinet Interlock A	[I]
DD	Cabinet Interlock B	[O]
EE	Channel 6 Walk	[I]
FF	Channel 4 Walk	[I]
GG	Spare 2	[-]
HH	Spare 3	[-]

MSB

Pin	Function	I/O
A	AC Line II	[I]
B	Start-Delay Relay Common	[I]
C	Start-Delay Relay Open (Closes during Start Delay period)	[O]
D	Channel 12 Red	[I]
E	Channel 11 Red	[I]
F	Channel 9 Red	[I]
G	Channel 8 Red	[I]
H	Channel 7 Red	[I]
J	Channel 6 Red	[I]
K	Channel 5 Red	[I]
L	Channel 4 Red	[I]
M	Channel 2 Red	[I]
N	Channel 1 Red	[I]
P	Spare 1	[-]
R	+24V Monitor II	[I]
S	External Watchdog (Spare 2)	[-]
T	Spare 3	[-]
U	Start-Delay Relay Closed (Open during Start Delay period)	[O]
V	Channel 10 Red	[I]
W	Spare 4	[-]
X	Spare 5	[-]
Y	Spare 6	[-]
Z	Channel 3 Red	[I]
a	Red Enable	[I]
b	Spare 7	[-]
c	Spare 8	[-]

TRAFFIC CONTROLLER ASSEMBLY MANUAL
VOLUME 1

Section 500

Input Modifier Cards

Electrical and ITS Engineering

June 2019

500 INPUT MODIFIER CARDS

APPENDICES

LIST OF FIGURES

501 INTRODUCTION

501.1 GENERAL DESCRIPTION

.1 This section describes a series of electronic devices developed by the Ministry to perform a variety of interfacing requirements within the traffic controller assembly cabinet. These devices are known as Input Modifier Cards. While each has a specific function, they all provide a bi-directional interface to the controller unit. That is to say, they interface external inputs to modify the controller unit's operation.

.2 The four Input Modifier Cards, shown in *Figure 1*, are from left to right, the Pedestrian Vehicle Interface Card, the Advance Warning Card, the Pre-Emption Interface Card and the Relay Interface Card.

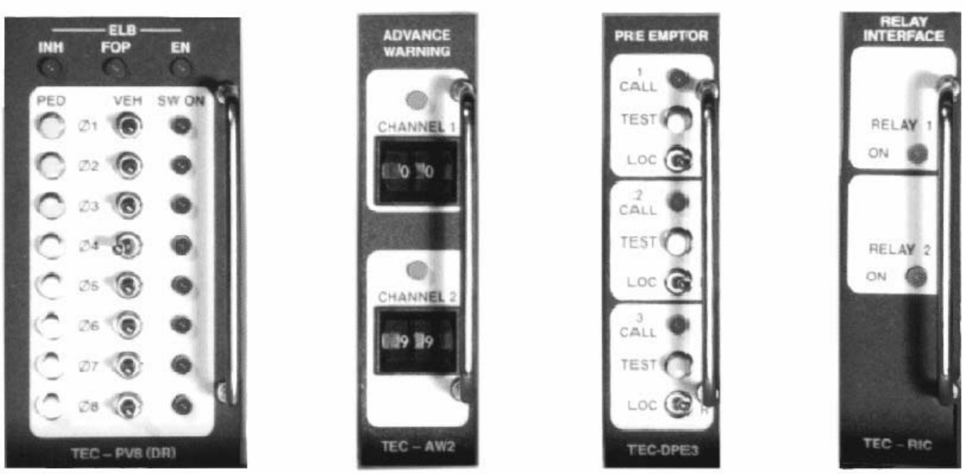


Figure 1. The Input Modifier Cards

.3 The Input Modifier Cards were designed and built in-house by the Ministry. These devices were designed to perform enhanced functions, not found on standard, off-the-shelf traffic controller assemblies. In addition, they provide a safe electrical interface to signals which originate externally.

.4 The Input Modifier Cards are constructed of a printed circuit board, rear connector and front panel. The circuitry on each card is specific to its intended function. The front panels of the cards contain switches and/or indicators.

501.2 INPUT/OUTPUT SIGNALS

.1 There are a variety of external signals interfaced by the Input Modifier Cards. They will be described in more detail, later in this section.

.2 A complete listing of the Input Modifier Cards' inputs and outputs can be found in *Appendices A through D* at the end of this section.

502 PEDESTRIAN VEHICLE INTERFACE CARD

502.1 GENERAL DESCRIPTION

.1 The Pedestrian Vehicle Interface Card, shown in *Figures 1 and 2*, has three main functions:

  .1 It provides an electrical interface between the Pedestrian Push Buttons in the field, and the controller unit.

  .2 It provides test switches allowing pedestrian and vehicle calls to be simulated on all controller unit phases.

  .3 It provides logic circuitry to ensure a safe transition of the intersection from flashing to three-colour operation.

.2 The Pedestrian Vehicle Interface Card is integral to the operation of all current Ministry traffic controller assemblies. There is always one Pedestrian Vehicle Interface Card per assembly.

.3 The current Pedestrian Vehicle Interface Card replaces the older “External Logic Board” and “ELB Cube”. The original External Logic Board was a panel-mounted printed circuit board. The later “ELB Cube” was a self-contained device, still found in some older Ministry traffic controller assemblies. Neither of these devices provided the pedestrian and vehicle interface circuits and test switches. Vehicle call simulation switches were provided in a separate location. The modern Pedestrian Vehicle Interface Card incorporates all of these functions.

.4 The Pedestrian Vehicle Interface Card comes in three formats which differ in the number of pedestrian and vehicle interface circuits and test switches provided. They are the 8-phase (TEC-PV8), 4-phase (TEC-PV4) and 2-phase. The number of phases at the intersection determine which format is used. The three formats are shown in *Figure 2*.

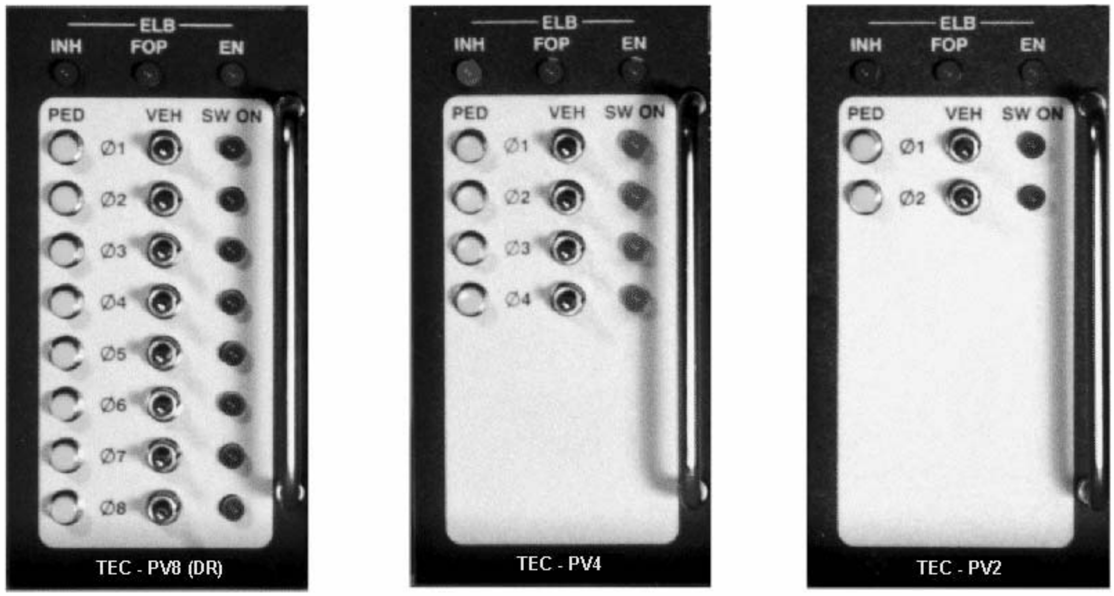


Figure 2. Eight, Four and Two-Phase Pedestrian Vehicle Interface Cards

502.2 PEDESTRIAN PUSH BUTTON INTERFACE

.1 The TEC-PV8 front panel contains eight momentary push-button switches. Each switch is labelled for a corresponding phase from ∅1 to ∅8. The TEC-PV4 has four switches labelled ∅1 to ∅4 and the TEC-PV2 has two switches labelled ∅1 and ∅2.

.2 There is an interface circuit on the card for each phase supplied with 12 Vac L1 directly from the TEC-PS Power Supply Card (*Section 700*). 12 Vac L2 is supplied to the circuit from the front-panel test switch and the pedestrian push button in the field. When either switch is operated, the circuit is completed and a Logic Ground signal is sent to the controller unit. This signal constitutes a "Pedestrian Call" for the associated phase.

502.3 VEHICLE CALL INTERFACE

.1 The TEC-PV8 front panel contains eight toggle switches. Each switch is labelled for a corresponding phase from ∅1 to ∅8. The TEC-PV4 has four switches labelled ∅1 to ∅4 and the TEC-PV2 has two switches labelled ∅1 and ∅2. The toggle switches can be operated in either a latched-on or momentary-on position. On the front panel there are also indicators (LED's), one for each switch. These indicators light only when the corresponding vehicle switch is operated.

.2 When a switch is operated, in either the latched or momentary position, a Logic Ground signal is sent to the controller unit. This signal constitutes a "Vehicle Call" for the associated phase.

.3 The switches provide a convenient method for manually simulating vehicle traffic.

502.4 EXTERNAL LOGIC BOARD SECTION

502.4.1 Introduction

.1 The External Logic Board (ELB) section of the Pedestrian Vehicle Interface Card is used to ensure a safe transition of the intersection from flashing to three-colour operation.

.2 The ELB section is common to all three formats of the Pedestrian Vehicle Interface Card. For convenience, only the TEC-PV8 will be mentioned in the following paragraphs. *Figure 3, Figure 4 and Figure 5* located at the end of this chapter illustrate the operation of the ELB section. Refer to these figures while reading the following description. Note that active signals are shown in black/solid lines; inactive signals are in grey/dashed lines.

502.4.2 Full Operating Point

.1 The interval at which the intersection transfers from flashing to three-colour operation is called the "Full Operating Point" (FOP). This is not the same as the controller unit initialization interval. FOP is detected by four user-defined sensor inputs on the TEC-PV8 which are connected to per-phase outputs of the controller unit. The intersection will not come out of flash until all four inputs are True. If less than four inputs are required to detect the FOP, all unused inputs are wired to the used one(s). There is an indicator on the TEC-PV8 front panel labelled "FOP" which is lit whenever all four inputs are True.

.2 Until FOP is reached, the TEC-PV8 applies the “External Min Recall” (EMR) signal to the controller unit causing it to cycle through all currently-used phases. Once FOP is reached, the TEC-PV8 removes the EMR signal and turns on an output called “Solid-State Relay Enable” (SSR-EN). The SSR-EN output turns on a solid-state relay in the Flash Control Circuit which allows the intersection to enter three-colour operation. There is an indicator on the TEC-PV8 front panel labelled “SSR” which is lit whenever the SSR-EN output is on.

.3 The TEC-PV8 has a feature known as “All Red Time” (ART). The ART feature is enabled by permanently connecting the appropriate card input to Logic Ground. ART causes the TEC-PV8 to apply the “Stop Time Ring 1” and “Stop Time Ring 2” signals to the controller unit for exactly 3 seconds when FOP is reached. Therefore, whatever interval is chosen for FOP is the signal indication that will be seen in the field for the first 3 seconds of three-colour operation. The ART feature is used only when the intersection flash colour is red in all directions. It ensures adequate vehicle clearance time between flashing operation and the first green interval of the next active phase.

.4 Eight-phase Pedestrian Vehicle Interface Cards have an additional feature known as “Dual Ring”. This version of card is labelled “TEC-PV8 (DR)”. Dual Ring operation is limited to NEMA dual-ring intersections only. The Dual Ring feature is enabled by permanently connecting the appropriate TEC-PV8 input to Logic Ground. When enabled, the four FOP inputs are split into two pairs of inputs, one pair for each ring. When one ring’s FOP inputs become true, the TEC-PV8 applies a Stop Time signal to the controller unit for that ring only. When both FOP inputs for the other ring become true, EMR is removed and SSR-EN is turned on. If ART is used in conjunction with Dual Ring, both Stop Time Ring 1 and Stop Time Ring 2 are applied for an additional 3 seconds.

502.4.3 Inhibit Inputs

.1 The TEC-PV8 can put the intersection into flashing operation. This occurs either as a result of a fault condition or manual intervention.

.2 The TEC-PV8 places the intersection into flash by turning off its SSR-EN output. It does so in response to one of two inputs called “Inhibits”. The inhibit inputs are “External Start” and “Flash In”. There is an indicator on the TEC-PV8 front panel labelled “INH” which is lit when either of the inhibit inputs are applied.

.3 External Start is a Logic Ground signal applied for 2.5 seconds on power-up by the conflict monitor’s Start Delay Relay.

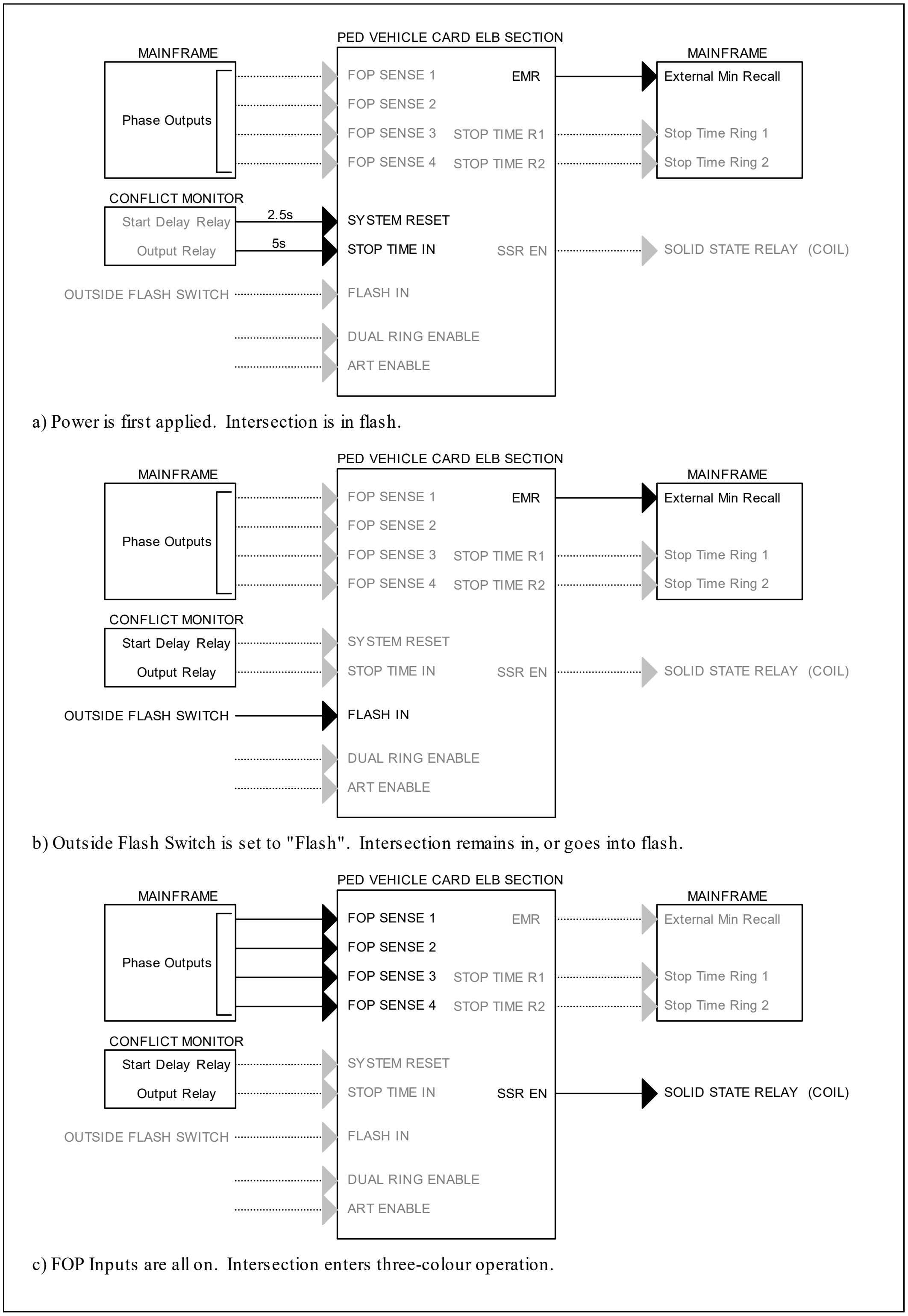
.4 Flash In is a Logic Ground signal applied by the Inside or Outside Flash switch. These switches are used to manually put the intersection into flashing operation.

.5 When both inhibit inputs are removed, the TEC-PV8 turns on its SSR-EN output and removes EMR at the next occurrence of FOP. If the inhibit inputs are removed exactly at FOP, the SSR-EN output will not be turned on, and EMR removed, until the controller unit has left FOP and executed one complete cycle.

502.4.4 Stop Time Input

.1 The Stop-Time signal is applied by the conflict monitor Output Relay while it is in a fault condition. This causes the controller unit to stop all timings so that service personnel can determine what conditions prevailed at the time the fault occurred. The Stop-Time signal is removed when the conflict monitor resets.

.2 The TEC-PV8 does not turn off its SSR-EN output or apply EMR until the conflict monitor removes Stop-Time, i.e. when the fault is cleared. This prevents the intersection from entering three-colour operation until the next occurrence of FOP. If Stop-Time is removed at FOP, the SSR-EN output will not be turned on, and EMR removed, until the controller unit has left FOP and executed one complete cycle. Refer to *Chapters 903 and 904* for more details.

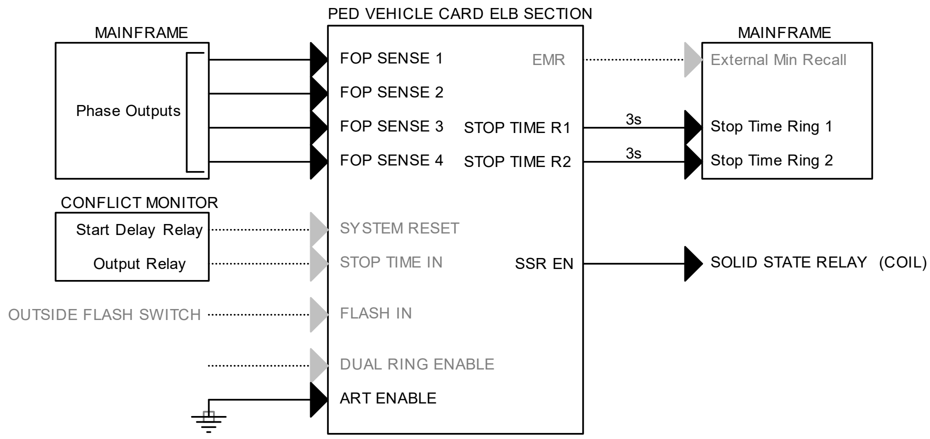


a) Power is first applied. Intersection is in flash.

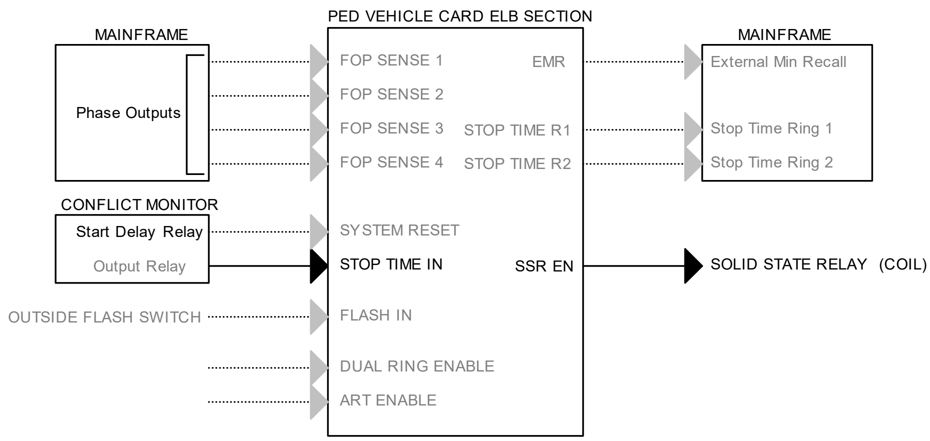
b) Outside Flash Switch is set to "Flash". Intersection remains in, or goes into flash.

c) FOP Inputs are all on. Intersection enters three-colour operation.

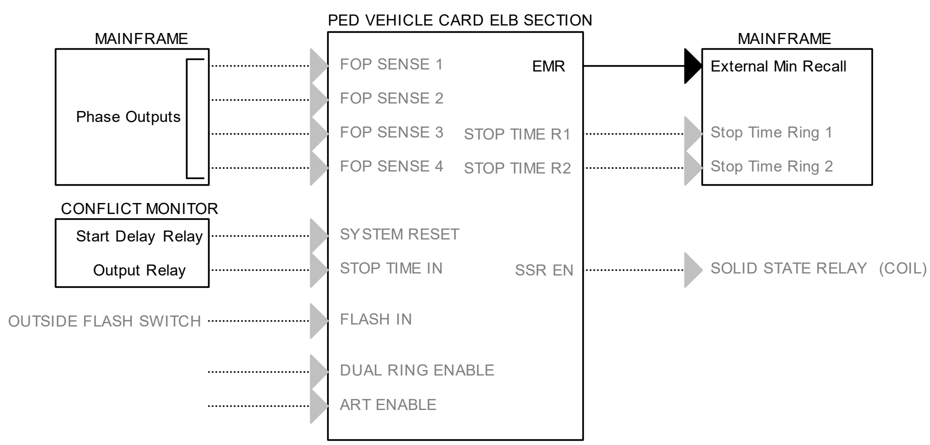
Figure 3. ELB Section Operation (a to c)



d) FOP Inputs are all on. Stop Time is applied for 3s when ART Enable is connected to Logic Ground. Intersection enters three-colour operation.

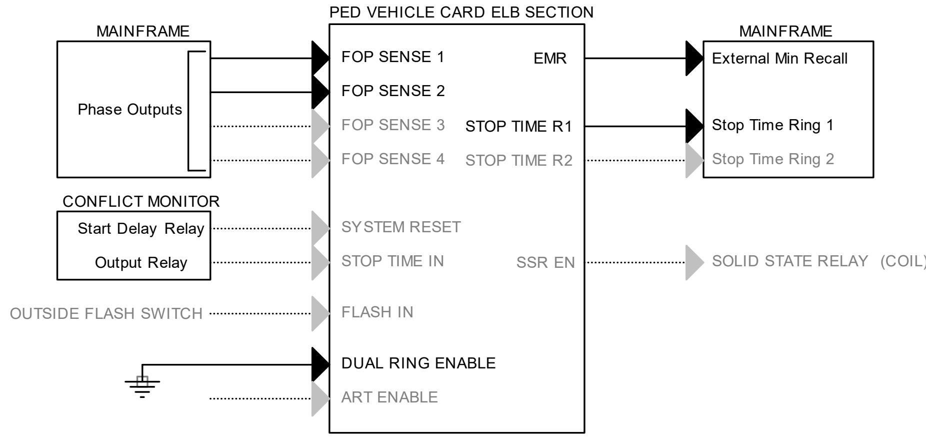


e) Conflict Monitor Output Relay de-energizes due to a fault. Stop Time is applied. Intersection goes into flash.

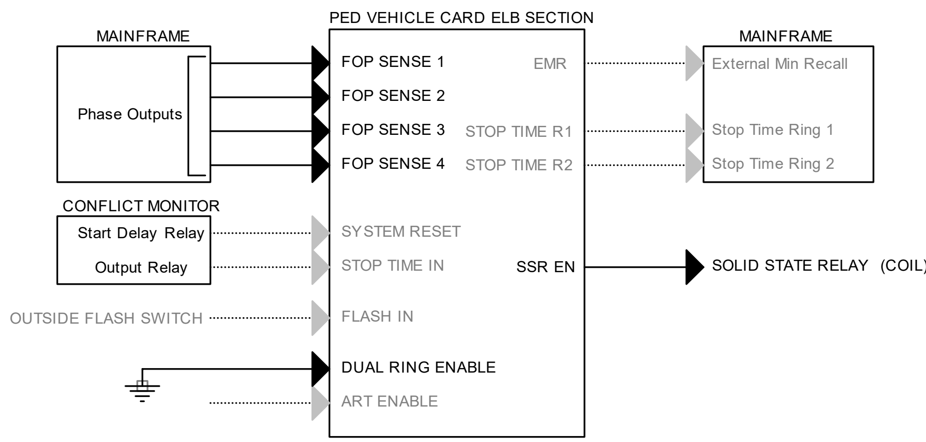


f) Conflict Monitor Output Relay engergizes turning off Stop Time. ELB resets. Intersection remains in flash.

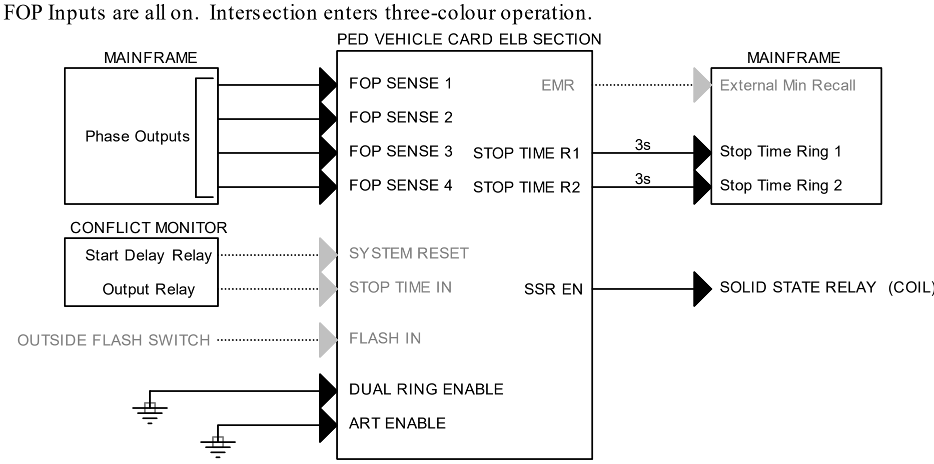
Figure 4. ELB Section Operation (d to f)



g) FOP Inputs for Ring 1 are on. Stop Time is applied to Ring 1 when Dual Ring Enable is connected to Logic Ground. Ring 2 continues to cycle. Intersection remains in flash.



h) FOP Inputs are all on. Intersection enters three-colour operation.



i) FOP Inputs are all on. Stop Time is applied for an additional 3s when ART Enable is also connected to Logic Ground. Intersection enters three-colour operation.

Figure 5. ELB Section Operation (g to i)

503 ADVANCE WARNING CARD

503.1 GENERAL DESCRIPTION

.1 The Advance Warning Card (TEC-AW2), shown in *Figure 1*, controls the operation of advance warning signs, located on the highway approaches to an intersection. Advance warning is commonly used by the Ministry but is not required at all intersections.

.2 The TEC-AW2 replaces the TBSS Advance Warning Unit which is a shelf-mounted device, still found in some older Ministry traffic controller assemblies.

.3 Each TEC-AW2 can control up to two advance warning signs. The TEC-AW2 circuitry is divided into two sections called “channels”, one channel for each sign. Normally, one TEC-AW2 is required per traffic controller assembly.

.4 When two directions of approach require different pre-termination intervals due to grade or visibility, a scheme called “Cascaded Advance Warning” is used. In this case, two TEC-AW2 cards are required.

.5 The TEC-AW2 controls the advance warning sign flashers by means of a +24 Vdc logic output. There is an indicator (LED) on the front panel of the TEC-AW2 for each channel. The indicator is lit whenever the TEC-AW2 sends a signal to turn on the advance warning sign flashers.

.6 On the front panel of the TEC-AW2 there is a thumb-wheel switch for each channel. These switches are used to set the desired pre-termination interval from 0 to 9.9 seconds, in increments of 0.1 seconds.

503.2 ADVANCE WARNING CHANNEL OPERATION

.1 If a phase does not require advance warning, the red, yellow and green controller unit outputs are directly connected to the assigned Load

Switches. If a phase requires advance warning the controller unit's yellow and green outputs are re-directed to the TEC-AW2 inputs. The TEC-AW2 in turn controls the assigned Load Switches. The red controller unit output is connected to the TEC-AW2, but still controls the Load switch directly. *Figure 6* shows the appropriate signal connections. Refer to it while reading the following description. Note that active signals are shown in black/solid lines; inactive signals are in grey/dashed lines.

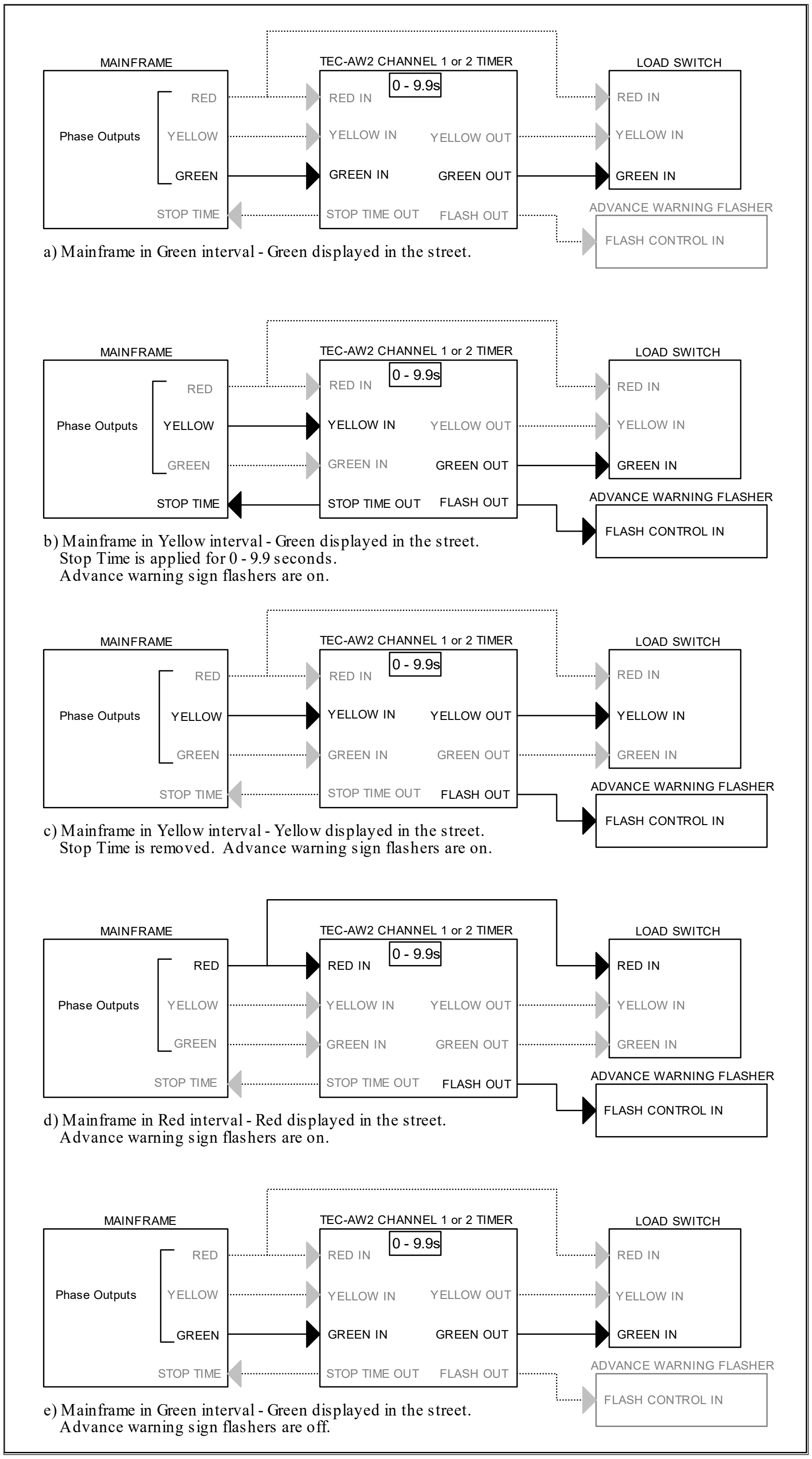
.2 When the phase begins the yellow clearance interval, this is detected by the TEC-AW2. The TEC-AW2 temporarily keeps its green output on so that approaching traffic continues to see a green light. See *Figure 6 (b)*. Meanwhile, it applies a Stop-Time signal to the controller unit, stopping timing of the phase at the beginning of the yellow interval. The TEC-AW2 turns on the advance warning sign flashers and starts the pre-termination interval timer.

.3 At the end of the pre-termination interval, the TEC-AW2 removes the Stop-Time signal allowing the controller unit to time the yellow interval normally (*Figure 6 (c)*). At the same instant, it turns off its green output and turns on its yellow output. Approaching traffic now sees a yellow indication for the first time. The advance warning sign flashers remain on.

.4 When the phase changes from yellow to red, the TEC-AW2 turns off its yellow output. The controller unit red output is seen in the field (*Figure 6 (d)*). The advance warning sign flashers remain on.

.5 When the phase returns to a green display the cycle is completed and the advance warning sign flashers are turned off (*Figure 6 (e)*).

.6 When cascaded advance warning is used, the yellow and green controller unit outputs are routed through Channel 1 on the TEC-AW2. Channel 1's yellow and green outputs are then routed through Channel 2 on the same card. Channel 2's yellow and green outputs control the load switch for one direction of approach. The red controller unit output is monitored by both Channel 1 and Channel 2. The same configuration is used on the other TEC-AW2 for the other direction. Both Channel 1 timers of the TEC-AW2's are set the same and both Channel 2 timers are set the same. The pre-termination interval for one direction is the time set on Channel 2 only. The longer pre-termination interval for the other direction is the total of the Channel 1 and Channel 2 timers.



a) Mainframe in Green interval - Green displayed in the street.

b) Mainframe in Yellow interval - Green displayed in the street.
Stop Time is applied for 0 - 9.9 seconds.
Advance warning sign flashers are on.

c) Mainframe in Yellow interval - Yellow displayed in the street.
Stop Time is removed. Advance warning sign flashers are on.

d) Mainframe in Red interval - Red displayed in the street.
Advance warning sign flashers are on.

e) Mainframe in Green interval - Green displayed in the street.
Advance warning sign flashers are off.

Figure 6. Advance Warning Card Channel Operation

504 PRE-EMPTION INTERFACE CARD

504.1 GENERAL DESCRIPTION

.1 Pre-Emption is a special mode of operation which changes the normal operation of the intersection to a predictable, pre-programmed sequence. It is most commonly required for emergency vehicles and railroad crossings. Pre-emption is also used for transit or High-Occupancy Vehicles (HOV) and for other special needs which are not within the normal operation of the controller.

.2 Pre-emption consists of a pre-emption Interface Card (TEC-DPE3) and a special set of instructions in the controller unit called a Pre-Empt sequence.

.3 The TEC-DPE3, shown in *Figure 1*, is used in all Ministry traffic controller assemblies in which pre-emption is required. It performs three functions:

- .1 It provides an electrical interface between external non-Ministry pre-emption request devices and the controller unit.
- .2 It enforces the relative priority of external devices requesting pre-emption to ensure that the controller unit receives only one high-priority request at a time.
- .3 It may control lights in the intersection signalling pre-emption status to approaching emergency vehicles.

.4 The current TEC-DPE3 replaces three older Pre-Emption Interface Card versions as well as the shelf-mounted TBSS Pre-Emption Unit.

.5 The word "request" refers to the action of an external device initiating a pre-emption sequence. "Call" refers to the action of the TEC-DPE3 in transmitting the pre-emption request to the controller unit.

.6 The TEC-DPE3 has the capability to interface two types of pre-emption requests:

.1 High-Priority pre-emption, including rail and emergency vehicle

.2 Low-Priority pre-emption.

.7 Each TEC-DPE3 has three channels of pre-emption. Channels 1 and 2, in high-priority mode, are dedicated to emergency vehicle pre-emption. Channel 3, in high-priority mode, is dedicated to rail pre-emption. All three channels are configured for low-priority pre-emption by permanently connecting the appropriate TEC-DPE3 input to Logic Ground.

.8 TEC-DPE3 cards can be used singly or in pairs, providing up to six channels of pre-emption total. A four-phase traffic controller assembly can accommodate one TEC-DPE3 while the eight-phase assembly can accommodate two.

.9 When emergency vehicle detection such as siren or strobe activated is used as the external pre-emption request source, it is referred to as "Directional Emergency Pre-Emption" (DEP). One Pre-Empt sequence is used for each intersection approach used by emergency vehicles. If two directions of approach are required, a single TEC-DPE3 is used. If four directions of approach are required, two TEC-DPE3's are installed.

.10 The TEC-DPE3 has two front-panel switches, and an indicator (LED) for each of its three channels. The indicators provide status information. The switches labelled "LOC/R" (Local/Remote) are used to enable or disable the external request inputs. The push-button switches labelled "TEST" are used to simulate external pre-emption requests. The function of these are described, in detail, later in this chapter.

504.2 PRE-EMPTION REQUEST INPUTS

.1 The Ministry has standardized on a 24 Vdc logic, normally-closed circuit for the external pre-emption request source. The external switch or electro-mechanical contact is installed across the channel input. The contact is held closed until pre-emption is required. Continuous opening of the contact for longer than 30 milliseconds is recognized by the TEC-DPE3 as a pre-emption request.

.2 The Local/Remote toggle switch on the TEC-DPE3 front-panel remains in the “R” (Remote) position during normal operation. If the switch is moved to the “LOC” (Local) position, opening of the external contact is ignored.

.3 The Test switch on the TEC-DPE3 front-panel is installed in series with the external contact. Operation of the push-button opens the circuit simulating an external pre-emption request. The Test switch works in either position of the Local/Remote toggle switch.

504.3 CHANNEL PRIORITY

.1 Rail channels (Channel 3, in high-priority mode) have the highest priority. Emergency-vehicle channels (Channels 1 and 2 in high-priority mode) have equal priority with each other but are lower in priority to either rail channel. Only one emergency vehicle channel is permitted to operate at a time. In the event that simultaneous requests are placed on more than one emergency-vehicle channel, only the first request recognized will be allowed to proceed. The second request will be ignored until the Pre-Empt sequence initiated by the first request has completed.

.2 Emergency-vehicle operation is terminated by any rail request. New incoming emergency-vehicle requests are ignored until rail operation is complete.

.3 Low-priority channels can operate concurrently with any other channel.

504.4 DIRECTIONAL EMERGENCY PRE-EMPTION

.1 Used with an external source capable of detecting the direction of an approaching emergency vehicle, the TEC-DPE3 implements Directional Emergency-Vehicle Pre-Emption (DEP). A siren or strobe detector can be used to detect emergency vehicles approaching the intersection from up to four directions.

.2 When either three or four directions of pre-emption are required, two TEC-DPE3 cards are used. One card is referred to as the “Master” and the other as the “Slave”. In this case, the traffic controller assembly has four emergency-vehicle channels, all of equal priority.

.3 Communication between the master and slave card is achieved by interconnecting the two TEC-DPE3 cards in the traffic controller assembly. Various signals pass back and forth between the cards as pre-emption requests occur. This is called “handshaking”.

.4 DEP signals, if used, are controlled by the TEC-DPE3 throughout pre-emption operation. These signals consist of up to four sets of white and blue lights mounted in the intersection – one for each approach. These signals convey right-of-way information to the operator of the emergency vehicle. A flashing white light indicates that an emergency vehicle has been detected and will be given the right-of-way. A solid white light indicates that the traffic controller assembly has reached the desired pre-emption phase and that right-of-way is now granted. A flashing blue light indicates that right-of-way is being given to an emergency vehicle approaching from a different direction.

504.5 PRE-EMPTION CALL SIGNALS

.1 Each channel has an output that signals to the controller unit requesting pre-emption. Rail and emergency vehicle calls use a steady Logic Ground signal applied on the appropriate controller unit pre-emption input. Low-priority calls use a 6.25 Hertz square wave alternating between 0 and +24 Vdc. This signal is recognized by the controller unit as a low-priority call.

.2 Rail calls are applied in “presence mode”. The TEC-DPE3 will continue to place a call to the controller unit for as long as it recognizes a valid external request. This is required since the amount of time required for a train to cross and clear the roadway cannot be predetermined. Once the external request ends, the TEC-DPE3 will continue to apply the call for an extra 5 seconds. The Pre-Empt sequence is designed to hold in as long as the TEC-DPE3 is applying the call.

.3 Emergency-vehicle and low-priority channel calls can be user-configured to operate in one of two modes. The desired mode of operation is selected by a configuration switch setting on the TEC-DPE3 circuit board. One mode of operation is presence mode. The TEC-DPE3 will continue to apply the call signal to the controller unit for as long as it recognizes a valid external request. This mode is always used for DEP. Unlike rail, there is a maximum time allowed for emergency vehicle and low-priority calls. This is called the “Maximum Pre-Emption Interval Timer” (MPIT). The timer is selected by a configuration switch setting, from 60 to 180 seconds. If the external request ends before the MPIT expires, the TEC-DPE3 will continue to apply the call for an additional 10 seconds. This provides extra time for emergency or transit vehicles to clear the intersection.

.4 The other mode of output operation is called “pulse mode”. In this mode of operation, the TEC-DPE3 applies the call to the controller unit for exactly 1 second. The required pre-emption time is predetermined and is designed into the controller unit Pre-Empt sequence program. The length of the pre-emption cycle is not affected by the duration of the external request.

.5 The controller unit has six Pre-Empt sequences that can be used for either high or low-priority pre-emption. The controller unit automatically recognizes the type of signal applied by the TEC-DPE3 and automatically executes the appropriate instructions. For this reason, priority arbitration is not required between rail or emergency-vehicle and low-priority channels.

.6 The controller unit has six pre-emption outputs which can be turned on during a Pre-Empt sequence. One sequence is programmed for each TEC-DPE3 channel in operation. The output is turned on only when the program reaches the pre-emption phases and tells the TEC-DPE3 when the sequence begins and ends.

504.6 PRE-EMPTION OPERATION

504.6.1 Rail Pre-Emption

.1 When the TEC-DPE3 recognizes a valid external request on a rail channel, it applies a continuous call signal to the controller unit. Simultaneously, the front-panel indicator is turned on, steady. Any current emergency-vehicle pre-emption calls are terminated immediately. No emergency-vehicle requests will be recognized until at least 5 seconds after the rail request ends.

.2 The controller unit begins to execute the appropriate Pre-Empt sequence. When the sequence reaches the pre-emption phases, the controller unit will turn on its pre-emption output if it is programmed to do so.

.3 When the external request ends, the TEC-DPE3 continues to apply the call to the controller unit for exactly 5 seconds. At the end of the 5 seconds the TEC-DPE3 front-panel indicator is turned off and the controller unit begins to terminate the Pre-Empt sequence. When the sequence terminates, the controller unit turns off its pre-emption output. The TEC-DPE3 is now ready to accept any new pre-emption requests.

.4 If an emergency-vehicle call is terminated by a rail call, and the emergency-vehicle request is still on 5 seconds after the rail request ends, the emergency vehicle request will be handled as a new call.

504.6.2 Non-Directional Emergency-Vehicle Pre-Emption

.1 When the TEC-DPE3 recognizes a valid external request on an emergency-vehicle channel, it applies a call signal to the controller unit for exactly 1 second. Simultaneously, the front-panel indicator begins to flash.

.2 The controller unit begins to execute the appropriate Pre-Empt sequence. When the program reaches the pre-emption phases, the controller unit turns on its pre-emption output. The TEC-DPE3 front-panel indicator now remains on steady. The controller unit's output may be used to turn on a white pre-emption signal in the intersection. This light indicates to the operator of an approaching emergency vehicle that the intersection is in the pre-emption phases.

.3 At the termination of the programmed Pre-Empt sequence time, the controller unit turns off its pre-emption output. The TEC-DPE3 front-panel indicator is turned off and the TEC-DPE3 is ready to accept another request.

504.6.3 Directional Emergency-Vehicle Pre-Emption

.1 When the TEC-DPE3 recognizes a valid external request on an emergency-vehicle channel, it applies a continuous call signal to the controller unit. Simultaneously, the front-panel indicator begins to flash.

.2 The TEC-DPE3 flashes the white pre-emption signal in the intersection corresponding to the direction of approach for which the request was made. The TEC-DPE3 simultaneously flashes the blue pre-emption signals in all other directions.

.3 The controller unit begins to execute the appropriate Pre-Empt sequence. When the program reaches the pre-emption phases, the controller unit turns on its pre-emption output. The TEC-DPE3 front-panel indicator now remains on steady. The white pre-emption signal also remains on steady while the blue pre-emption signals continue to flash as before.

.4 When the external request ends, the TEC-DPE3 continues to apply the call to the controller unit for exactly 10 seconds. At the end of the 10 seconds the controller unit begins to terminate the Pre-Empt sequence. When the sequence terminates, the controller unit turns off its pre-emption output. The white and blue pre-emption signals and the TEC-DPE3 front-panel indicator are turned off.. The TEC-DPE3 is now ready to accept another request.

.5 The MPIT begins timing when the external request is first recognized by the TEC-DPE3. If the MPIT expires before the external request ends, the white and blue signals, the TEC-DPE3 front-panel indicator and the call to the controller unit are turned off immediately. The controller unit begins to terminate the Pre-Empt sequence. When the sequence terminates, the controller unit turns off its pre-emption output. The TEC-DPE3 will not recognize another emergency-vehicle request until the circuit closes, ending the current request.

504.6.4 Low-Priority Pre-Emption

.1 When the TEC-DPE3 recognizes a valid external request on any channel configured for low-priority pre-emption, it applies a 6.25 Hertz square wave signal to the controller unit. Depending on the selected output mode, the call will be placed continuously, or for exactly one second. Simultaneously, the TEC-DPE3 front-panel indicator flashes. Rail or emergency-vehicle calls may operate concurrently.

.2 The controller unit will recognize the low-priority call signal but will not execute the associated Pre-Empt sequence if sequences of equal or higher priority are already in effect. If the controller unit is able to execute the low-priority Pre-Empt sequence, the pre-emption output will be turned on when the appropriate phase is reached. At this time, the TEC-DPE3 front-panel indicator remains on solid.

.3 If the channel is operating in presence mode, the TEC-DPE3 will continue to apply the call to the controller unit for an additional 10 seconds when the external request ends,. At the end of the 10 seconds the TEC-DPE3 front-panel indicator is also turned off. The controller unit begins to terminate the Pre-Empt sequence. At the termination of the sequence, the controller unit turns off its pre-emption output.

.4 If the channel is operating in pulse mode, the TEC-DPE3 will apply the call for exactly one second only. The controller unit will execute the Pre-Empt sequence as instructed, turning on its output for the duration of the sequence. When the Pre-Empt sequence ends, the TEC-DPE3 turns off its indicator and is ready to accept another request.

504.6.5 Fault Handling

.1 Two types of faults can affect both emergency-vehicle and low-priority pre-emption channels. The external contact can remain open indefinitely, or the controller unit can fail to respond correctly. If either or both of these events occur, the affected channel will enter fault mode when its MPIT expires. For safety reasons, rail channels only do not enter fault mode, and will operate continuously in the event of a contact opening.

.2 When a channel enters fault mode, all of its outputs are turned off. Its front panel indicator will flash every three seconds, indicating the nature of the fault that has occurred: one flash for a contact fault, two flashes for a controller unit fault and three flashes for both.

.3 Low-priority channels will automatically reset from fault mode if a controller unit fault, only, has occurred. Otherwise, all fault conditions must be corrected before the channel is reset to accept a new request. While an emergency-vehicle channel is in fault mode, other emergency-vehicle channels are able to operate normally.

505 RELAY INTERFACE CARD

505.1 GENERAL DESCRIPTION

.1 The Relay Interface Card (TEC-RIC), shown in *Figure 1*, is a general-purpose card used for special interfacing or control applications. It is used for logic functions not provided by the controller unit or any of the other Input Modifier Cards. The TEC-RIC is completely generic and its actual use is unique to each application.

.2 The TEC-RIC contains two electro-mechanical, form-C relays. One side of each relay's coil is directly connected to +24 Vdc. The relay is energized when a Logic Ground signal is applied to the other side of the coil.

.3 The relays each have four poles. All four sets of contacts (common, normally-open and normally-closed) are available for general use within the traffic controller assembly or for connection to external devices.

.4 There is an indicator (LED) on the front panel of the RIC card for each relay. The indicator is lit when the relay is energized.

APPENDIX A PEDESTRIAN VEHICLE INTERFACE CARD INPUTS AND OUTPUTS

ROW A	FUNCTION	ROW C	FUNCTION
32	∅1 Pedestrian Call	32	Pedestrian Call 1
31	∅2 Pedestrian Call	31	Pedestrian Call 2
30	∅3 Pedestrian Call	30	Pedestrian Call 3
29	∅4 Pedestrian Call	29	Pedestrian Call 4
28	∅5 Pedestrian Call	28	Pedestrian Call 5
27	∅6 Pedestrian Call	27	Pedestrian Call 6
26	∅7 Pedestrian Call	26	Pedestrian Call 7
25	∅8 Pedestrian Call	25	Pedestrian Call 8
24	∅1 Vehicle Call	24	
23	∅2 Vehicle Call	23	
22	∅3 Vehicle Call	22	
21	∅4 Vehicle Call	21	Dual Ring
20	∅5 Vehicle Call	20	12 Vac +
19	∅6 Vehicle Call	19	12 Vac -
18	∅7 Vehicle Call	18	Stop Time In
17	∅8 Vehicle Call	17	External Start
16		16	Flash In
15	External Min Recall	15	Full Operating Point Sense 4
14	Solid State Relay Enable	14	Full Operating Point Sense 3
13	Stop Time Ring 1	13	Full Operating Point Sense 2
12	Stop Time Ring 2	12	Full Operating Point Sense 1
11		11	All Red Time Enable
10	Card Monitor Out	10	Card Monitor In
9	Logic Ground	9	Logic Ground
8		8	
7		7	
6	Card Select	6	
5		5	
4		4	
3		3	
2	+24 Vdc	2	+24 Vdc
1	Chassis Ground	1	Logic Ground

APPENDIX B ADVANCE WARNING CARD INPUTS AND OUTPUTS

ROW A	FUNCTION	ROW C	FUNCTION
32	Channel 1 Green Out	32	Channel 1 Green In
31	Channel 1 Yellow Out	31	Channel 1 Yellow In
30	Channel 1 Flash Out	30	Channel 1 Red In
29	Channel 1 Stop Time Out	29	System Reset
28	Channel 2 Green Out	28	Channel 2 Green In
27	Channel 2 Yellow Out	27	Channel 2 Yellow In
26	Channel 2 Flash Out	26	Channel 2 Red In
25	Channel 2 Stop Time Out	25	
24		24	
23		23	
22		22	
21		21	
20		20	12 Vac +
19		19	12 Vac -
18		18	
17		17	
16		16	
15		15	
14		14	
13		13	
12		12	
11		11	
10	Card Monitor Out	10	Card Monitor In
9	Logic Ground	9	Logic Ground
8		8	
7		7	
6		6	
5	Card Select	5	
4		4	
3		3	
2	+24 Vdc	2	+24 Vdc
1	Chassis Ground	1	Logic Ground

APPENDIX C PRE-EMPTION INTERFACE CARD INPUTS AND OUTPUTS

ROW A	FUNCTION	ROW C	FUNCTION
32	Channel 1 Pre-empt	32	Channel 1 White Out
31	Channel 2 Pre-empt	31	Channel 1 Blue Out
30	Channel 3 Pre-empt	30	Version Select
29	Channel 1 Low-priority	29	External Start
28	Channel 2 Low-priority	28	
27	Channel 3 Low-priority	27	Channel 1 Call
26	High-priority Delay Disable	26	Channel 1 Common
25	Low-priority Delay Disable	25	Channel 2 Call
24	Channel 1 Out	24	Channel 2 Common
23	Channel 2 Out	23	Channel 3 Call
22	Channel 3 Out	22	Channel 3 Common
21	Fault Status Bit 0	21	Channel 2 White Out
20	Fault Status Bit 1	20	12 Vac +
19		19	12 Vac -
18		18	Channel 2 Blue Out
17	Channel 3 Negative	17	Master/Slave*
16	Channel 3 Power	16	Channel 3 Return
15	Channel 2 Negative	15	Railroad Inhibit In
14	Channel 2 Power	14	Channel 2 Return
13	Channel 1 Negative	13	External Pre-empt Request
12	Channel 1 Power	12	Channel 1 Return
11		11	External Pre-empt Acknowledge
10	Card Monitor Out	10	Card Monitor In
9	Logic Ground	9	Logic Ground
8	Card Select A	8	Railroad Inhibit Out
7	Card Select B	7	External Blue In
6		6	External Blue Out
5		5	Monitor Inhibit Out
4		4	
3		3	
2	+24 Vdc	2	+24 Vdc
1	Chassis Ground	1	Logic Ground

APPENDIX D RELAY INTERFACE CARD INPUTS AND OUTPUTS

ROW A	FUNCTION	ROW C	FUNCTION
32	K1 Coil - Neg	32	K2 Coil - Neg
31	K3 Coil - Neg	31	K4 Coil - Neg
30	K1A Common	30	K2A Common
29	K1A Normally Open	29	K2A Normally Open
28	K1A Normally Closed	28	K2A Normally Closed
27	K1B Common	27	K2B Common
26	K1B Normally Open	26	K2B Normally Open
25	K1B Normally Closed	25	K2B Normally Closed
24	K3A Common	24	K4A Common
23	K3A Normally Open	23	K4A Normally Open
22	K3A Normally Closed	22	K4A Normally Closed
21	K3B Common	21	K4B Common
20	K3B Normally Open	20	
19	K3B Normally Closed	19	
18	K3C Common	18	K4B Normally Open
17	K1C Common	17	K2C Common
16	K1C Normally Open	16	K2C Normally Open
15	K1C Normally Closed	15	K2C Normally Closed
14	K1D Common	14	K2D Common
13	K1D Normally Open	13	K2D Normally Open
12	K1D Normally Closed	12	K2D Normally Closed
11	K3C Normally Open	11	K4B Normally Closed
10	Card Monitor Out	10	Card Monitor In
9	Logic Ground	9	Logic Ground
8		8	K4C Common
7		7	K4C Normally Open
6		6	K4C Normally Closed
5		5	K3C Normally Closed
4		4	
3		3	
2	+24 Vdc	2	+24 Vdc
1	Chassis Ground	1	Logic Ground

Ministry of Transportation and Infrastructure

TRAFFIC CONTROLLER ASSEMBLY MANUAL

VOLUME 1

Section 600

Vehicle Detectors

Electrical and ITS Engineering

June 2019

600 VEHICLE DETECTORS

LIST OF FIGURES

601 INTRODUCTION

601.1 VEHICLE DETECTORS

.1 In Section 100 we were introduced to the term "actuated controller". This term describes the operation of a traffic controller assembly in response to traffic and pedestrian demand.

.2 Pedestrian demand is recognized through a simple push-button switch. This switch is interfaced through the Pedestrian Vehicle Interface Card, which is described in *Chapter 502*.

.3 Vehicles, on the other hand, require a more sophisticated approach. An electrical interface is required between some device, capable of recognizing a vehicle, and the controller unit. In addition, a typical intersection requires many such inputs since there are usually four directions of approach and may be multiple lanes in each direction.

.4 The device that fulfils such a role is known as a "vehicle detector". By far the most common form of vehicle detector is a "Loop Detector". A loop detector operates on the basis of inductance. In addition, there are many other forms of vehicle detectors, including Ultra Sonic and Infrared. We will discuss these modes of vehicle detection in the following chapters.

602 LOOP DETECTORS

602.1 BASIC THEORY

.1 Loop detectors are the most common form of vehicle detection used by the Ministry. They are relatively inexpensive and are reliable over a wide range of operating conditions. Three common models, used by the Ministry, are shown in *Figure 1*.

Figure 1. Common Loop Detectors

.2 Loop detectors make use of the fact that vehicles are mostly made of metal.

.3 A loop detector is essentially an inductance meter. A loop of wire is embedded in the pavement and connected to the detector unit's input. Thousands of times each second, the detector unit sends a pulse of electricity into the loop wire. The inductance of the loop wire, in conjunction with a capacitor in the loop detector unit, creates a reflected electrical signal. The frequency of this signal is called a "resonant frequency".

.4 When no vehicles are in proximity to the loop, its resonant frequency will remain relatively unchanged. The loop detector unit measures this frequency as a baseline or "rest" frequency. A large mass of metal, such as a vehicle, in proximity to the loop, causes a decrease in the loop's inductance and hence a decrease in the loop's resonant frequency. This frequency change is registered by the loop detector unit as the presence of a vehicle.

.5 Most loop detectors have two channels. Each channel is connected to a single loop. The current Ministry eight-phase traffic controller assembly can accommodate up to twenty detector units and twelve in a four-phase assembly. This results in a total of up to forty and twenty-four loops respectively. The Ministry has adopted a standard method for assigning loops to detector channels.

.6 Each detector channel has an electro-mechanical relay output. One side of the normally-open contact is permanently connected to Logic Ground. The other side of the contact is connected to the appropriate controller unit vehicle detect input. The LMD8000 controller unit has twenty-four vehicle detect inputs, assigned by programming to a specific phase. When a vehicle is detected, the relay is energized, thus placing a vehicle call to the controller unit for the associated phase.

.7 Most detector channel outputs can be set for either "pulse" or "presence" mode. When set to pulse mode, the output turns on for a short time only when the vehicle is first detected. In presence mode, the detector unit's output remains on for as long as the vehicle is detected.

.8 Some detectors offer additional features such as "delay" and "extend". The delay feature prevents the detector unit output from placing a call to the controller unit until a pre-set time after the vehicle is detected. Extend works the opposite of delay. In this case, the call is placed as soon as the vehicle is detected but remains on a pre-set time after the vehicle moves on. The LMD8000 controller unit has similar programming capability, preventing the necessity to use hardware delay and extension.

.9 Occasionally, the outputs of two or more detector channels are physically connected in parallel. Alternately, this function may also be accomplished by programming. A valid detection on any of the channels will place a vehicle call to the controller unit for the same phase. This scheme is used when there are multiple loops whose traffic will be serviced by the same traffic phase. One detector channel per loop is still required.

.10 In some applications, the outputs of two or more detector channels may be connected in series. In this case, a valid detection is required on all channels before a valid call is placed to the controller unit. By varying the position of the loops, a specific type of vehicle may be detected. This scheme is often used for detection of transit vehicles.

602.2 FREQUENCY SELECTION AND SENSITIVITY

.1 The loop detector provides separate frequency and sensitivity switches for each channel.

.2 Normally, each channel has four available frequency settings and up to seven different levels of sensitivity.

.3 Different frequencies are required so that signals from adjacent loops do not interfere with each other. Such interference, called “cross-talk” can cause false vehicle calls to be sent to the controller unit. The Ministry has a standard method for assigning frequencies to detector units.

.4 The sensitivity level of a detector channel determines the relative change in frequency (inductance) required to qualify as a valid detection. The higher the sensitivity, the lower the relative change required. If the sensitivity is set too low, there is a risk that not all vehicles will be detected. If the sensitivity is too high, there is a risk of the loop responding to vehicles in adjacent lanes. For normal operation, a mid-range sensitivity is used. The sensitivity may be adjusted to ensure accurate detection is achieved.

602.3 LOOPS

.1 Loops are normally formed by placing multiple turns of wire into a saw cut in the pavement. Sometimes the wire is placed in a flexible conduit and laid in the road before paving occurs. This method is called a "pre-formed" loop.

.2 The loops are connected to the detector unit by a length of wire called a "lead in". The "lead-in wire" is the portion of the loop running from the loop itself to a junction box at the edge of the pavement. The "lead-in cable" or "Belden" is a shielded cable running from the junction box to the traffic controller assembly. Lead-in wire and cable pairs are twisted to reduce electrical interference.

.3 The ratio of the length of the lead-in wire/cable to the length of wire in the loop itself (number of turns) is important in determining the performance of the loop. If the lead-in is too long relative to the loop, adequate sensitivity cannot be achieved. When the loop is located a long distance from the traffic controller assembly, the number of turns in the loop must be increased to compensate.

.4 When the detector unit sends an electrical pulse into the loop, a magnetic field is generated around the loop wire. A vehicle must pass through this field in order to be detected. The field must be shaped correctly to allow this to happen. The shape of the loop determines the shape of the field.

.5 Loops can be formed in a variety of shapes. The most common shapes now used by the Ministry are the "circle" and "diamond" loop. The diamond shape is oriented so that the side corners of the diamond are pointing towards the adjacent lane(s). This reduces the chance of the detector unit responding to vehicles in these lanes since the field will be weakest at those points.

.6 The shape of the loop determines the height of the field above the pavement surface. The field must be of sufficient height to reach the underside of large vehicles such as tractor-trailers. The height of the field is approximately two-thirds of the shortest side of the loop. The Ministry's diamond loops have a field height of approximately four feet.

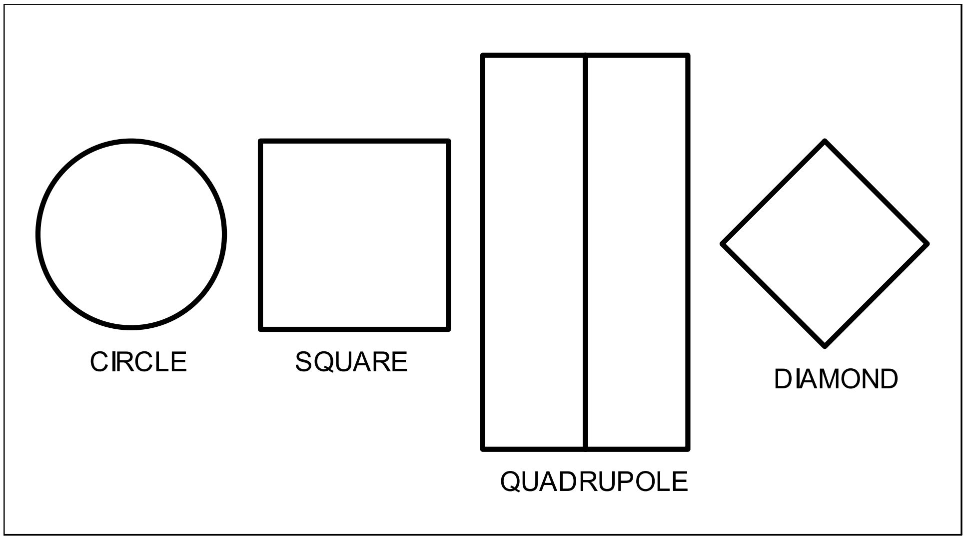


Figure 2. Common Loop Shapes

.7 Older Ministry intersections have loops called “quadrupole” loops. These loops are long rectangles oriented in the direction of travel in the lane. There is a saw cut down the middle of the lane and the loop wire is laid in a figure-eight pattern. These loops are inferior to the diamond and circle loops in both the field height and possible overlap with adjacent loops.

.8 Other loop shapes such as squares may be seen.

.9 Careful installation and routine maintenance of loops is critical to ensure continued reliable operation. Pavement cracking, water intrusion or poor wire-splicing techniques can all lead to poor detector performance and/or failure.

602.4 DETECTOR FAILURES

.1 As with any electrical device, loop detectors are subject to failures from time to time. Complete failure of the detector unit can result in no vehicle calls being placed at all. Alternately, partial failure of the detector unit may lead to either no calls being placed or a continuous call on one or both channels.

.2 Even if the detector unit is operating correctly, problems with the loop may cause similar symptoms to occur. In some cases, this can be corrected by adjusting the frequency or sensitivity of the channel. In the worst case, such problems may require the loop to be completely replaced.

.3 Most modern loop detectors have the capability to perform self-diagnosis on a continuous basis. Any unusual changes in loop performance can be detected and dealt with in a variety of ways. Usually a detector will be configured to respond in a predictable way to loop failures. The detector will return to normal operation if the problem is corrected. Most detectors also provide some visible fault indication. This allows service personnel to easily determine that faults exist, even if they are intermittent.

.4 Most detectors are equipped to take corrective action if a vehicle becomes stalled over one of the loops. This action is called "re-tuning". The detector unit measures the amount of time the vehicle has been continuously detected. After a pre-set maximum time (usually several minutes), the detector unit re-tunes itself so that the frequency of the loop becomes the new rest frequency. At this point, the detector unit turns off the vehicle call. Subsequent changes in the frequency will result in new calls being placed to the controller unit. Once the stalled vehicle is removed, the detector unit will again re-tune back to its original frequency.

603 OTHER VEHICLE DETECTORS

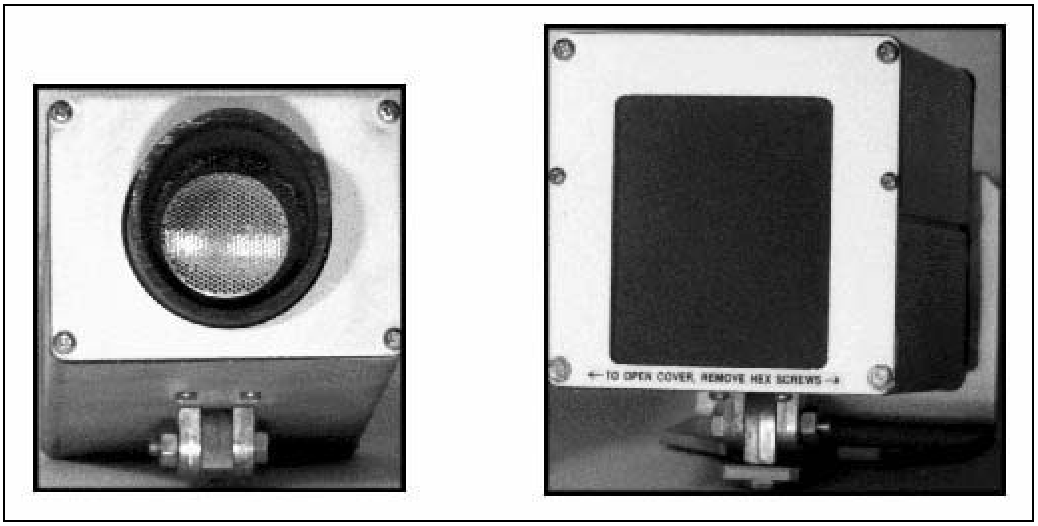


Figure 3. Ultrasonic and Microwave Detectors

603.1 INFRARED DETECTORS

.1 Like loop detectors, infrared detectors are used to sense the presence of a vehicle. Instead of inductive resonance, infrared detectors use light in the infrared portion of the spectrum as the detection medium.

.2 Infrared light is not visible to the human eye. However, to a device capable of detecting infrared light, it presents objects in a clear and recognizable form.

.3 Infrared detectors are completely passive. They do not emit any type of signal but operate instead on infrared light reflected off of other objects.

.4 Infrared detectors are normally mounted on a signal pole, some height above the pavement surface. The detector is oriented towards an area of the intersection in which vehicle detection is required. The presence of a vehicle within the detection zone produces a change in the light received by the detector. This change is recorded as a vehicle call.

.5 Infrared detectors usually interface to the controller unit in a manner similar to loop detectors, using an electro-mechanical relay.

.6 Infrared detectors have adjustable settings to control the range, detection zone area and sensitivity.

603.2 ULTRASONIC DETECTORS

.1 Ultrasonic detectors are another form of vehicle presence detector. Instead of inductive resonance or infrared light, ultrasonic detectors use sound waves in the ultrasonic frequency range as the detection medium.

.2 Ultra sound is not audible to the human ear. However, to a device capable of emitting and receiving ultra sound, it renders objects in a clear and recognizable form.

.3 Ultrasonic detectors are normally mounted on a signal pole, some height above the pavement surface. The detector is oriented towards an area of the intersection in which vehicle detection is required. The detector sends out pulses of ultra sound. By measuring the time taken for echoes to return to the detector, the presence of a vehicle within the detection zone can be determined. This is recorded as a vehicle call. Ultrasonic detectors work in a similar way to the sonar on a ship.

.4 Ultrasonic detectors usually interface to the controller unit in a manner similar to loop detectors, using an electro-mechanical relay.

.5 Ultrasonic detectors have adjustable settings that affect the range, detection zone area and sensitivity.

603.3 MICROWAVE DETECTORS

.1 Microwave detectors are vehicle presence detectors as well. They use microwave radar as the detection medium.

.2 Microwave detectors emit low-power high-frequency radiation signals. The signals reflected by objects in the detection zone are analyzed by the detector to determine the presence of vehicles. They have adjustable settings which affect the range, detection zone area and sensitivity

.3 The detectors are normally mounted on a signal pole, some height above the pavement surface. The detector is oriented towards an area of the intersection in which vehicle detection is required.

.4 Microwave detectors usually interface to the controller unit in a manner similar to loop detectors, using an electro-mechanical relay.

.5 More sophisticated models of microwave detectors can detect vehicles in multiple detection zones. Just one or two of this type of detector can typically monitor an intersection.

603.4 VIDEO DETECTORS

.1 Video detectors are the most technically sophisticated form of vehicle detector. As a result, the associated cost limits their use, but they are now becoming more common.

.2 Video detectors use a video cameras, mounted on signal poles, to generate real-time images of the intersection. Advanced computer software is used to process these images to achieve vehicle recognition.

.3 During the installation and set up of a video detection system, a video image is used to define detection zones, for each camera, within the intersection. This is done graphically by outlining areas of the image on a computer monitor.

.4 Once the detection zones are defined, the computer can respond to the changing video images and produce vehicle calls for each area, or areas defined.

.5 Video detection computer programs usually allow the user to manipulate a variety of parameters to customize the system's operation.

.6 Video detectors have the advantage that the whole intersection can often be viewed from about four camera locations.

.7 Like Infrared and Ultrasonic detectors, video detectors also require no loops or other in-ground sensors. This feature makes them a good choice for applications in which it is impractical or too expensive to install loops.

British Columbia

Ministry of Transportation and Infrastructure

TRAFFIC CONTROLLER ASSEMBLY MANUAL

VOLUME 1

Section 700

Power Supply Card

Electrical and ITS Engineering

June 2019

700 POWER SUPPLY CARD

LIST OF FIGURES

LIST OF TABLES

701 GENERAL DESCRIPTION

.1 The Ministry has standardized on the use of an external device to supply all +24 Vdc power requirements within the traffic controller assembly. This device, called the “Power Supply Card” (TEC-PS), is shown in *Figure 1*.

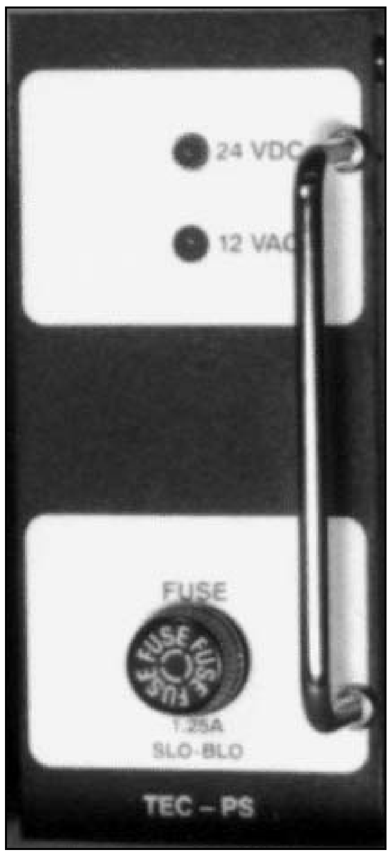


Figure 1. Power Supply Card

.2 The TEC-PS is supplied with 120 Vac from the traffic controller assembly's power distribution panel. It in turn supplies regulated +24 Vdc power and unregulated 12 Vac power for other devices.

.3 The +24 Vdc output of the TEC-PS supplies the input modifier cards, load switches, advance warning flasher, solid-state relay (SSR) and the loop detectors.

.4 The +24 Vdc output of the TEC-PS is monitored by the conflict monitor 24 Volt Monitor circuits.

.5 The 12 Vac output provides power for the pedestrian pushbuttons, and is used as a timing-reference signal in the pedestrian vehicle and advance warning cards.

.6 In the four-phase traffic controller assembly, the TEC-PS is installed in the card rack assembly. In the eight-phase traffic controller assembly, it is installed in a special socket in the panel directly underneath the card rack assemblies.

702 ELECTRICAL SPECIFICATIONS

.1 *Table 1* lists the TEC-PS's specifications:

Power	Outputs	24 Vdc at 2.2 A Regulated. 12 Vac at 0.5 A Unregulated.
	Inputs	90 Vac / 1.25 A to 135 Vac / 0.76 A full load
	Frequency	60 Hertz
	Power Factor	0.8
Fusing	120 Volt	1.25 A Slow Blow

Table 1. Power Supply Card Electrical Specifications

TRAFFIC CONTROLLER ASSEMBLY MANUAL

VOLUME 1

Section 800

Traffic Controller Assembly Sub-Systems

Electrical and ITS Engineering

June 2019

800 TRAFFIC CONTROLLER ASSEMBLY SUB-SYSTEMS

LIST OF FIGURES

801 POWER DISTRIBUTION PANEL

801.1 GENERAL DESCRIPTION

.1 The (120 Vac) power distribution panel contains the same components and provides the same function in both the four and eight-phase traffic controller assemblies. *Figure 1* is a photograph of the power distribution panel in the eight-phase traffic controller assembly. A key to the location of the components is shown below.

.2 The power distribution panel in the four-phase traffic controller assembly is mounted on the right-hand side and is covered by a protective Plexiglas screen. The power distribution panel in the eight-phase traffic controller assembly is mounted near the bottom of the central tower in the rear of the enclosure. It has a hinged cover containing two 120 Vac receptacles.

801.2 POWER DISTRIBUTION

.1 *Figure 2* is a schematic diagram of the power distribution system in the eight-phase traffic controller assembly. The four-phase traffic controller assembly has only four circuit breakers and the fan, heater and utility receptacle power is fed from the line filter (LF) output.

.2 The 120 Vac service is connected to the main breaker. It is distributed through the down-stream breakers to other devices in the traffic controller assembly. There is a neutral and earth-ground bus in the power distribution panel as well as a remote neutral bus, located in the front of the enclosure, for field signal connections.

.3 Incoming 120 Vac power is connected to a lightning arrestor (LA) and metal-oxide varistors (MOV's). In the eight-phase traffic controller assembly only, the inside lights, heater, fan and utility receptacle are fed directly from the main breaker.

.4 The main breaker output passes through a transient suppression line filter (LF). Power is tapped off here for the intersection flasher (FL1), advance warning flashers (FL2 and FL3) and mercury contactor (K71).

.5 The 120 Vac supply for the remaining breakers passes through a radio-frequency interference (RFI) filter. This supplies power for the controller unit, conflict monitor, TEC-PS power supply, modem, solid-state relay (SSR), flash control relay (K7) and flash transfer relays (K1 to K6).

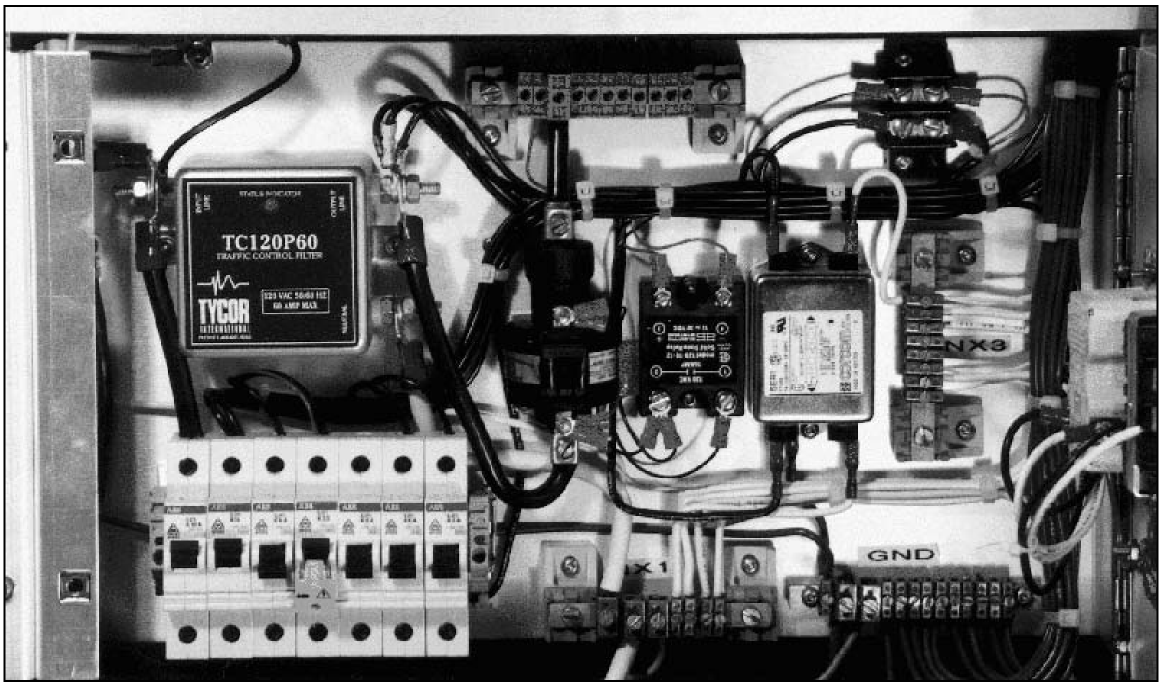
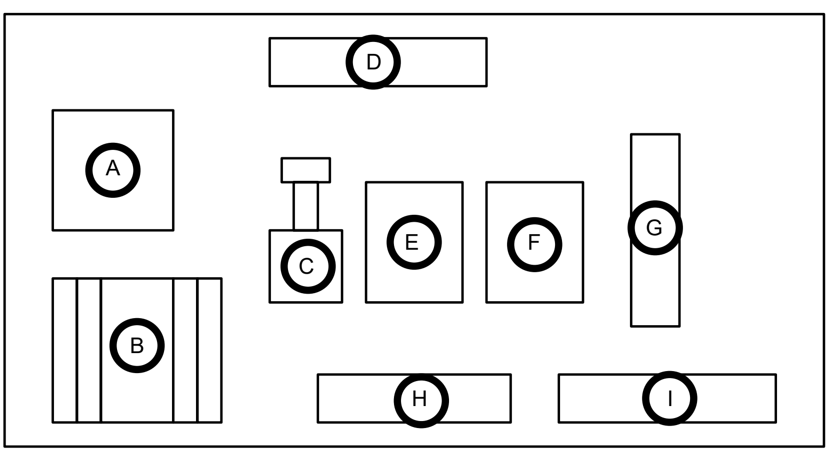


Figure 1. Eight-Phase Traffic Controller Assembly Power Distribution Panel



A) Line Filter
B) Circuit Breakers
C) Mercury Contactor
D) Contactor Output Power Bus
E) Solid State Relay
F) RFI Filter
G) RFI Filtered Power Neutral Bus
H) Service Neutral Bus
I) Service Ground Bus

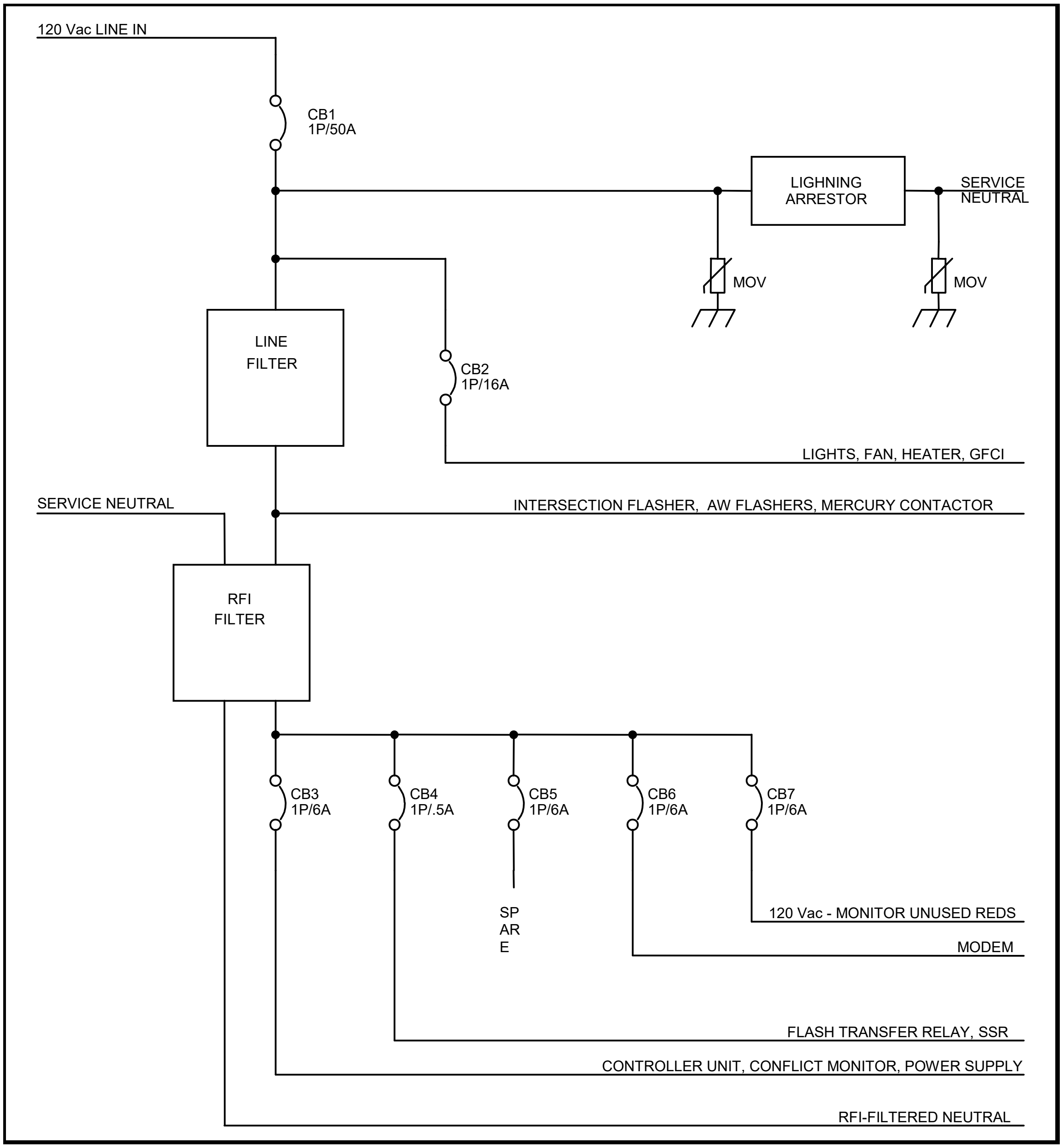


Figure 2. Eight-Phase Traffic Controller Assembly Power Distribution Panel Schematic

802 FIELD OUTPUTS

802.1 INTRODUCTION

.1 The function of the traffic controller assembly is to operate signal lights at the intersection. Within the traffic controller assembly are connection points for wiring to all signals in the intersection. These are referred to as “field outputs”.

Figure 3. Load Switch, Advance Warning Flasher and Intersection Flasher

802.2 LOAD SWITCHES

.1 During three-colour operation, all signals in the intersection are controlled by the controller unit, advance warning card and pre-emption card. The outputs of these devices use "low-voltage" or 24 Vdc logic and are not designed to supply power to the signal lights. High-voltage (120 Vac) power is supplied to the signals by devices called "load switches". An example is shown in *Figure 3*.

.2 A load switch has three solid-state circuits. Each of the three circuits has a low-voltage input and a high-voltage output. The outputs are controlled by the controller unit, advance warning card and pre-emption card. The outputs supply 120 Vac power to the signal lights when the controlling device applies a Logic Ground signal to the low-voltage input.

.3 Each one of the load switch's three circuits to corresponds to one of the controller unit's phase outputs: red, yellow or green. One load switch is required for each assigned controller unit phase. In addition, a separate load switch is required for each set of controller unit pedestrian outputs. One load switch is also used for each direction of emergency-vehicle pre-emption. These load switches, if required, are controlled directly by the pre-emption interface card.

.4 The load switch has two sets of indicators (LED's) on the front. One set shows the state of the inputs and the other shows the outputs. The indicators' colour corresponds to the controller unit phase output (red, yellow or green) or pedestrian outputs (green for walk, yellow for don't walk). In normal operation, only one input/output pair is on at a time.

802.3 ADVANCE WARNING FLASHER

.1 A special device, similar to a load switch, is used for the control of the advance warning sign lights. This device, shown in *Figure 3*, is called an "advance warning flasher".

.2 The advance warning flasher has three inputs. Two low-voltage inputs are controlled by the "flash" outputs of the advance warning card and are used to turn the advance warning flasher on and off, during normal operation. For each low-voltage input, there is a pair of high-voltage outputs, one for each of the two warning lights on the advance warning sign. Each input-output pair is called a "channel". A third input, called "120 Volt Monitor", is used to detect the presence of 120 Vac power, which is continuously applied to the input during three-colour operation. If the intersection goes into flash, the flasher will automatically turn on the outputs for both channels, regardless of the state of the low-voltage inputs.

.3 There is a set of three indicators (LED's) on the front of the flasher unit for each channel. One indicator shows the input status and the other two indicators show the state of the two outputs.

.4 When the advance warning card applies a Logic Ground signal to the advance warning flasher's low-voltage input, the outputs flash alternately at a rate of 60 flashes per minute. This produces the alternating or "wig-wag" signal on the advance warning sign.

.5 One advance warning flasher can operate two advance warning signs. Each advance warning flasher channel is controlled by the corresponding channel on the advance warning card.

.6 When cascaded advance warning is used, one advance warning flasher is used for each direction. Refer to *Chapter 503* for more information on advance warning.

802.4 PROTECTIVE FUSING AND FIELD TERMINALS

.1 The load switches' and advance warning flashers' outputs are connected to a set of fused terminal blocks. Each has an integral, replaceable fuse to protect the field wiring, load switch and flasher outputs. There is one fused terminal block for each load switch and advance warning flasher output. The traffic controller assembly is pre-wired for the maximum number of load switches and advance warning flashers possible, although they are not all typically required.

.2 Each fused terminal block is connected to a field terminal in the bottom of the enclosure. There is one fuse/field terminal per phase output, pedestrian signal, etc., however each phase output typically controls more than one signal in the intersection. There are normally at least two sets of signal heads for each movement. All signals of the same colour, for the same movement, are controlled by one output.

.3 Adjacent to the fuse blocks and field terminals, there is a separate neutral bus (NX2) for terminating the neutral wires from the field. This bus is connected to the traffic controller assembly's main neutral bus (NX1), located in the power distribution panel.

803 FLASH CONTROL CIRCUIT

803.1 INTRODUCTION

.1 Upon power up, or after a fault has occurred, the intersection is in flashing operation. During this time, the controller unit cycles through all assigned phases. Its phase outputs are prevented from being displayed in the field by a section of the traffic controller assembly called the "flash control circuit" (FCC). The pedestrian vehicle interface card, conflict monitor, inside and outside flash switches control its operation.

.2 When safe conditions prevail, there are no faults and both flash-control switches are in the three-colour operation position, the intersection enters three-colour operation.

.3 *Figure 4* is a schematic diagram of the FCC. Note that all relays and switches are shown in the three-colour operation position.

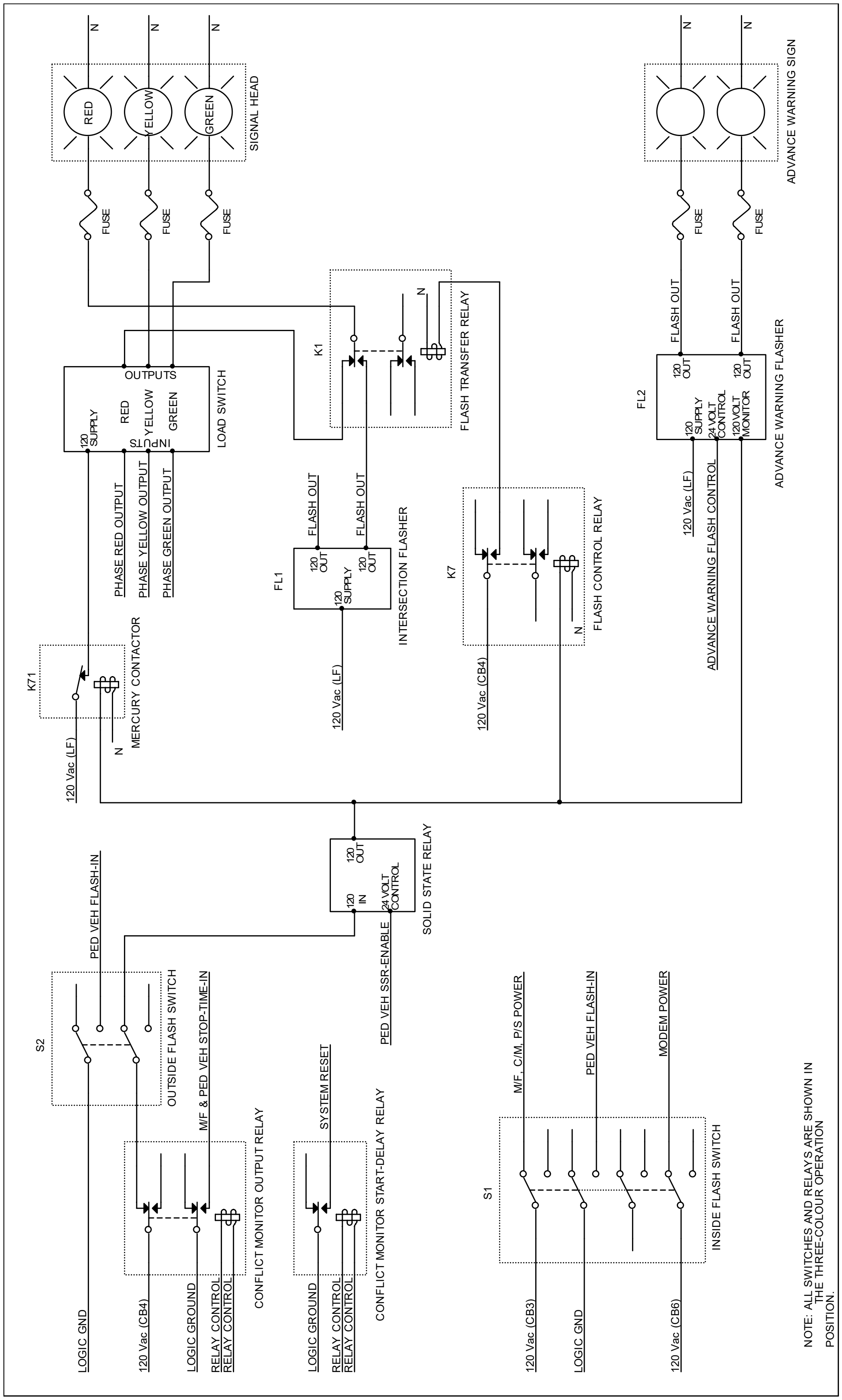


Figure 4. Flash Control Circuit Schematic

803.2 FLASH CONTROL CIRCUIT COMPONENTS

803.2.1 Inside Flash Switch

.1 Inside the traffic controller assembly is a four-pole switch called the "inside flash switch" (S1). This switch is used to manually place the intersection into flashing operation.

.2 When the inside flash switch is placed in the flashing operation position, three things happen:

- .1 The 120 Vac power supply to the controller unit, conflict monitor and power supply card is removed.
- .2 A logic ground signal is placed on the flash-in inhibit input of the pedestrian vehicle card.
- .3 The 120 Vac power supply to the modem receptacle is removed.

803.2.2 Outside Flash Switch

.1 In a compartment, accessible from the exterior of the enclosure, is a two-pole switch called the "outside flash switch" or "police switch" (S2). The compartment is commonly referred to as the "police door". It is used by maintenance personnel and emergency services to manually place the intersection into flashing operation.

.2 When the outside flash switch is placed in the flashing operation position, two things happen:

- .1 The 120 Vac power supply to the solid state relay (SSR) is removed.
- .2 A logic ground signal is placed on the flash-in inhibit input of the pedestrian vehicle card.

803.2.3 Conflict Monitor Output Relay

.1 One of the conflict monitor's internal two-pole electro-mechanical relays is called the "Output Relay". Each pole is separately named "output relay 1" and "output relay 2".

.2 The output relay is controlled by the internal circuitry of the conflict monitor. The relay is energized during three-colour operation and is de-energized on power up or when the monitor detects a fault condition.

.3 During three-colour operation, output relay 1 supplies 120 Vac power to the outside flash switch, which in turn supplies power to the solid-state relay.

.4 On power up or during a fault condition, output relay 2 places a Logic Ground signal on the controller unit stop-timing inputs. This allows service personnel to observe existing conditions when the fault occurred.

803.2.4 Solid State Relay

.1 The Solid State Relay (SSR) is energized by the SSR-Enable signal from the pedestrian vehicle interface card (TEC-PV8). It is energized by the TEC-PV8 when the full-operating point is detected.

.2 120 Vac is supplied to the SSR through the conflict monitor output relay 1 and the outside flash switch.

.3 When the SSR is energized by the TEC-PV8 and its 120 Vac is supplied by the conflict monitor and outside flash switch, it energizes the mercury contactor (K71) and the flash control relay (K7). It also supplies power to the advance warning flashers' 120 Volt monitor inputs.

803.2.5 Mercury Contactor

.1 The K71 is an electro-mechanical relay. It is energized by the 120 Vac output of the SSR.

.2 During three-colour operation, K71 supplies 120 Vac power to the load switches for all traffic movements. Note that it does not supply power to the advance warning sign flashers.

803.2.6 Flash Control Relay, Flash Transfer Relays and Intersection Flasher

.1 The flash control relay (K7) determines the source of 120 Vac power to the flash transfer relays, fuse outputs and field signals.

.2 During three-colour operation, the flash control relay is energized by the 120 Vac output of the SSR.

.3 When the flash control relay is de-energized during flashing operation, it energizes the flash transfer relays. There are four flash transfer relays in the four-phase traffic controller assembly and six in the eight-phase.

.4 Each flash transfer relay is a two-pole electro-mechanical relay. The common of each pole is connected to the fuse terminal for a field output. One contact is connected to the corresponding load switch output and the other contact is connected to an output of the intersection flasher.

.5 The intersection flasher, shown in *Figure 3*, is a two-pole flasher which is continuously supplied with 120 Vac power. Its two outputs flash alternately at a rate of 60 flashes per minute.

.6 During three-colour operation, the flash transfer relays are de-energized. Power is supplied to the field outputs by the mercury contactor, through the load switches and flash transfer relays.

.7 During flashing operation, the flash transfer relays are energized. Power is supplied to the field outputs by the system flasher, through the flash transfer relays. This produces the display, seen in the intersection during flashing operation.

.8 All traffic controller assemblies are pre-wired for an all-red flash. Therefore only the red controller unit phase outputs are wired through the flash transfer relays. If a particular movement requires a yellow flashing display, the red and yellow outputs must be interchanged prior to installation.

804 MANUAL CONTROL SWITCHES

804.1 EQUIPMENT LOCATION

.1 In the four-phase traffic controller assembly, the manual control switches are located on the side of the card rack assembly.

.2 In the eight-phase traffic controller assembly, the manual control switches are located on a panel, in the front of the enclosure, adjacent to the power supply card and inside flash switch.

804.2 AUTO/MANUAL SWITCH

.1 The Auto/Manual switch (S3) is used to enable manual operation of the traffic controller assembly.

.2 During normal operation, S3 remains in the “AUTO” position. When S3 is placed in the “MANUAL” position, a “Manual Control Enable” signal is applied to the controller unit and Logic Ground is supplied to the Interval Advance switch.

.3 Manual Control Enable places vehicle and pedestrian calls on all assigned controller unit phases and stops timing in all intervals except yellow and red clearance.

804.3 INTERVAL ADVANCE SWITCH

.1 The Interval Advance pushbutton switch (S5) is used to advance the controller unit to the next timing interval.

.2 During normal operation, S5 is not used. When S3 is placed in the “MANUAL” position, operation of S5 applies an “Interval Advance” signal to the controller unit.

.3 A complete on and off operation of the controller unit interval advance input will cause immediate termination of the current timing interval except yellow and red clearance. This operation may cause the controller to move to the next phase in the sequence depending upon the point of operation and the existence of pedestrian and/or vehicle calls.

TRAFFIC CONTROLLER ASSEMBLY MANUAL
VOLUME 1

Section 900

Traffic Controller Assembly Operation

Electrical and ITS Engineering

June 2019

900 TRAFFIC CONTROLLER ASSEMBLY OPERATION

901 INTRODUCTION

This section describes the electrical operation of the traffic controller assembly. Until now, the location and purpose of each piece of equipment has been discussed in isolation. In normal operation, each component interacts with external elements and other devices within the traffic controller assembly. In this section we begin to tie each of the previous sections together to understand how the controller functions as a complete system in real time.

The section begins with a description of traffic controller assembly operation when power is first applied. It is followed by a description of the transfer from flashing to three-colour operation. The final chapter explains how the traffic controller assembly operates when faults occur, or when the intersection is put into flash through manual intervention.

902 POWER UP OPERATION

902.1 INTRODUCTION

.1 When 120 Vac power is first applied to the traffic controller assembly, the same sequence of events occur whether the main circuit breaker is manually turned on, or there is a recovery from a power interruption. In the case of a manual power up, it is assumed that all other circuit breakers have been turned on prior to the main being energized. It is also assumed that both the inside and outside flash switches are in the three-colour operation position, and that the conflict monitor is not in a fault state.

902.2 POWER-UP INITIALIZATION

.1 The conflict monitor powers up, energizing its start-delay relay after 2.5 seconds. A system-reset signal is applied to the controller unit and input modifier cards until the start-delay relay is energized.

.2 The conflict monitor output relay energizes 5 seconds after power up. The configuration switch setting on the monitor determines the amount of delay time. While the relay is de-energized, it applies a stop-timing signal to the controller unit and TEC-PV8. When the relay energizes, it supplies 120 Vac power to the Solid State Relay (SSR) through the outside flash switch.

.3 The controller unit powers up and begins timing its initialization interval once the system-reset and stop-timing signals are removed. This interval is configured in the user program.

.4 The controller unit phase outputs are applying signals to the load switches, but the intersection remains in flash.

.5 The TEC-PV8 remains in its initialization state at this time. It applies the external min recall (EMR) signal to the controller unit, causing it to cycle through all assigned phases. Its SSR-EN signal is off, so the SSR's 120 Volt output is also off.

.6 The flash control relay (K7) is de-energized and is supplying power to the flash transfer relays (K1 to K6). The flash transfer relays are energized and are connecting power from the intersection flasher (FL1) to the field terminals. Only those signals which have displays during flashing operation are switched through the flash transfer relays. The other phase outputs connect directly to the load switches only. Those signals are dark during flashing operation.

.7 The advance warning flashers (FL2 and FL3) detect the absence of 120 Vac power from the SSR output and turn on the advance warning sign flashers.

903 FLASHING TO THREE-COLOUR OPERATION

903.1 INTRODUCTION

.1 A transfer of the intersection from flashing to three-colour operation can occur for one of the following reasons:

.1 Power has just been applied to the traffic controller assembly (transfer from power-up initialization).

.2 The conflict monitor has been reset (transfer from a fault condition).

.3 One of the flash switches has been restored to the three-colour operation position (transfer from manual flashing operation).

.2 The following clauses describe the sequence of events that occur under each circumstance.

903.2 TRANSFER FROM POWER-UP INITIALIZATION

.1 The controller unit continues to cycle through all assigned phases following power-up initialization due to the EMR signal from the TEC-PV8. The TEC-PV8 is standing by to initialize the intersection once the full operating point (FOP) is reached.

.2 When the TEC-PV8 detects FOP, it applies a stop-time signal to the controller unit for 3 seconds if the “All Red Time” feature is enabled. At the same time, it turns off EMR and turns on its SSR-EN output. This energizes the SSR which then supplies 120 Vac power to the mercury contactor (K71), the flash control relay (K7) and the advance warning flashers’ 120 Volt monitor inputs.

.3 K71 energizes, supplying 120 Vac power to the load switches.

.4 K7 energizes, removing 120 Vac power from the flash transfer relays (K1 to K6).

.5 K1 to K6 now supply power to the field terminals from the load switches instead of the intersection flasher. The phase outputs that are not switched by K1 to K6 are seen in the field now that the load switches have 120 Vac power.

.6 The controller unit will unconditionally service all used phases while EMR is applied. Once the intersection comes out of flash, service is provided on a demand basis as normal.

903.3 TRANSFER FROM A FAULT CONDITION

.1 If the intersection is in flash due to a fault detected by the conflict monitor, the controller unit will remain in the interval where the fault occurred. The conflict monitor applies a stop-time signal to the controller unit and TEC-PV8 through its output 2 relay.

.2 The SSR-EN output of the TEC-PV8 remains on but the card monitors the stop-time signal from the conflict monitor, standing by to reset when stop-time is removed.

.3 The fault condition is reset in one of two ways:

  .1 If it is a non-latching fault, the monitor will automatically reset when the fault clears.

  .2 If it is a latched fault, service personnel must manually reset the conflict monitor using the front-panel reset button.

.4 When the conflict monitor resets, it immediately energizes its output relay. Output relay 1 supplies 120 Vac power to the SSR. Output relay 2 removes the stop-time signal from the mainframe and TEC-PV8. The TEC-PV8 resets, turning off its SSR-EN output, keeping the intersection in flash.

.5 The TEC-PV8 applies the EMR signal to the controller unit. The controller unit begins cycling again through all assigned phases. The TEC-PV8 is standing by to initialize the intersection once FOP is detected.

.6 When the TEC-PV8 detects FOP, it applies a stop-time signal to the controller unit for 3 seconds if ART is enabled. At the same time, it turns off EMR and turns on its SSR-EN output. This energizes the SSR which then supplies 120 Vac power to the mercury contactor (K71), the flash control relay (K7) and the advance warning flashers' 120 Volt monitor inputs.

.7 K71 energizes, supplying 120 Vac power to the load switches.

.8 K7 energizes, removing 120 Vac power from the flash transfer relays (K1 to K6).

.9 K1 to K6 supply power to the output terminals from the load switches instead of the intersection flasher. The phase outputs that are not switched by K1 to K6 are seen in the field now that the load switches have 120 Vac power.

903.4 TRANSFER FROM MANUAL FLASHING OPERATION

.1 The intersection can be placed into flash by either the inside or outside flash switch. When the inside flash switch (S1) is placed in the flash position, power is removed from the controller unit, conflict monitor and TEC-PS power supply. Power is also removed from the SSR since the conflict monitor's output relay is de-energized while the monitor is off.

.2 When S1 is placed in the three-colour operation position, power is applied to the controller unit, conflict monitor and TEC-PS power supply.

.3 From this point on, the sequence of events is identical to the power-up initialization and transfer into three-colour operation described earlier. Refer to *Clauses 902.2 and 903.2* for details.

.4 When the outside flash switch (S2) is placed in the flash position, power is removed from the SSR and a Logic Ground signal is applied to the TEC-PV8 flash-in inhibit input. This causes the TEC-PV8 to reset, turning off its SSR-EN output and applying EMR to the controller unit.

.5 The controller unit continues to cycle through all assigned phases.

.6 When S2 is placed in the three-colour operation position, power is applied to the SSR but the intersection remains in flash because the TEC-PV8 SSR-EN output is still off.

.7 When the TEC-PV8 detects FOP, it turns on its SSR-EN output, energizing the SSR and the intersection comes out of flash.

904 THREE-COLOUR TO FLASHING OPERATION

904.1 INTRODUCTION

.1 A transfer of the intersection from three-colour to flashing operation can occur for one of the following reasons:

.1 The conflict monitor puts the intersection into flash (transfer due to a fault condition).

.2 One of the flash control switches has been moved to the flashing operation position (transfer due to the flash control switches).

.2 The following clauses describe the sequence of events that occur under each circumstance.

904.2 TRANSFER DUE TO A FAULT CONDITION

.1 When the conflict monitor detects a fault condition, it de-energizes its output relay. Output relay 1 removes power from the SSR. This in turn removes power from the mercury contactor (K71), the flash control relay (K7) and the advance warning flashers (FL2/FL3) 120 Volt monitor inputs.

.2 K71 de-energizes removing power from the load switches. All signals not having a flashing display go dark.

.3 K7 de-energizes, supplying power to the flash transfer relays (K1 to K6). K1 to K6 supply power from the intersection flasher (FL1) to the signals displaying colour during flashing operation.

.4 FL2 and FL3 detect the loss of power on their 120 Volt monitor inputs and turn on the advance warning sign flashers.

.5 The conflict monitor output relay 2 applies a Logic Ground signal to the controller unit and TEC-PV8 stop-time inputs. The controller unit remains in the interval at which the fault occurred. The TEC-PV8 does not turn off its SSR-EN output or apply the EMR signal to the controller unit at this time. It does, however, detect the presence of the stop-time signal and is standing by to reset as soon as it is removed (when the conflict monitor is reset).

904.3 TRANSFER DUE TO THE FLASH CONTROL SWITCHES

.1 When the inside flash switch (S1) is placed in the flashing operation position, three things happen:

- .1 Power is removed from the controller unit, conflict monitor and TEC-PS power supply.
- .2 A Logic Ground signal is applied to the TEC-PV8 flash-in inhibit input.
- .3 Power is removed from the modem receptacle.

.2 The conflict monitor output relay de-energizes when the monitor turns off, removing power from the SSR. The TEC-PV8 SSR-EN output is also off. This removes power from K71, K7 and FL2/FL3 120 Volt monitor inputs.

.3 K71 de-energizes removing power from the load switches.

.4 K7 de-energizes, supplying power to K1 to K6. K1 to K6 now supply power from FL1 to the signals displaying colour during flashing operation.

.5 FL2 and FL3 detect the loss of power on their monitor inputs and turn on the advance warning sign flashers.

.6 When the outside flash switch (S2) is placed in the flashing operation position, two things happen:

- .1 Power from the conflict monitor output relay to the SSR is interrupted.
- .2 A Logic Ground signal is applied to the TEC-PV8 flash-in inhibit input.

.7 The TEC-PV8 SSR-EN output is turned off de-energizing the SSR. This removes power from K71, K7 and FL2/FL3 120 Volt monitor inputs.

.8 K71 de-energizes removing power from the load switches.

.9 K7 de-energizes, supplying power to K1 to K6. K1 to K6 now supply power from FL1 to the signals displaying colour during flashing operation.

.10 FL2 and FL3 detect the loss of power on their monitor inputs and turn on the advance warning sign flashers.

TRAFFIC CONTROLLER ASSEMBLY MANUAL
VOLUME 1

Section 1000

Traffic Controller Assembly Operation at Intersections

Electrical and ITS Engineering

June 2019

1000 TRAFFIC CONTROLLER ASSEMBLY OPERATION AT MINISTRY INTERSECTIONS

LIST OF FIGURES

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1001 INTRODUCTION

This section describes the operation of the traffic controller assembly at common Ministry intersections.

The information presented in this section permits the reader to determine the status of the devices within the traffic controller assembly, at any given time. You will be required to do so at the time of installation, and during routine or corrective maintenance. This information includes the standard device interconnections, used by the Ministry, and how to interpret the displays and status indicators on each device.

Armed with an understanding of the basic theory of intersection configurations and the operation of the Ministry's traffic control devices, the reader is well equipped to tackle most situations likely to be encountered in the field.

1002 SIGNAL OUTPUT ASSIGNMENTS

1002.1 INTRODUCTION

.1 The Ministry has adopted a standard method of assigning controller unit phases, conflict monitor channels and load switches. The assignments of the common intersections, described in *Section 100*, are shown in *Tables 1 through 9*. *Tables 1 to 4* are for four-phase traffic controller assemblies, the remainder are for eight-phase. The standard assignment represents the factory configuration of new traffic controller assemblies.

1002.2 PHASE ASSIGNMENTS

.1 The controller unit phases and overlaps are shown in column 1 of each table. The second column shows the traffic movement assigned to the phase and the pre-emption output assignments. In the eight-phase traffic controller assembly, only the Red overlap outputs are pre-assigned.

.2 Information on the phase assignments at each intersection is contained on the intersection "timing sheet". A copy of this is kept in the traffic controller cabinet.

.3 *Table 3* shows an optional "dummy" phase assigned to phase 3. This is used to prevent a situation referred to as a "left-turn trap". A trap situation occurs when the traffic controller is in the Yellow interval, prior to servicing the left-turn movement, with no traffic on the cross street. In theory, only the ∅A2 traffic must be stopped to allow left-turn traffic to proceed. Operators of left-turning vehicles on the ∅A2 movement will see a yellow light and may assume that opposing through traffic will also be stopping. If this happens, they may turn left in front of oncoming traffic which they assume is about to stop.

.4 The LMD8000 controller unit has an all-red-clearance anti-trap feature which is normally used instead of the dummy phase. The controller unit internally times an all-red interval, before servicing the left turn, ensuring that highway traffic from both directions must stop. If internal all-red-clearance cannot be used, a dummy phase, which has no display in the field, is inserted before the left-turn movement creating the all-red interval.

1002.3 CONFLICT MONITOR CHANNEL ASSIGNMENTS

.1 Column 3 of each table shows the conflict monitor channel assigned to monitor the field outputs. Each conflict monitor channel has an input circuit for the Red, Yellow, Green and Walk outputs of each phase or overlap. However, in the eight-phase traffic controller assembly, only the Red overlap outputs are monitored by the Red input circuit of the assigned monitor channel. If a full overlap is used, OLD in *Table 7* for example, then the pre-assigned wiring must be changed. In this case, Channel 12 is used to monitor OLD. If phase 8 pre-emption is required, ∅B1 must be re-configured as a true phase (controller unit phase 4).

.2 The pre-emption White indicator outputs are monitored by the Walk circuit of the assigned conflict monitor channel. The load switch outputs for these signals are routed through an electro-mechanical relay called the "Monitor Inhibit Relay" (K9). K9 inhibits the monitoring of the white outputs during the initial flashing stage of the pre-emption sequence because the conflict monitor can not correctly monitor a signal flashing at this rate. K9 is energized by an output of the Pre-Emption Interface card during this interval.

.3 The pre-emption Blue indicator outputs are not monitored by the conflict monitor.

.4 All unassigned conflict monitor channels have their Red circuit inputs directly connected to 120 Vac line in the field terminal section of the traffic controller cabinet.

1002.4 LOAD SWITCH ASSIGNMENTS

.1 Columns 3 and 4 of each table show the standard load switch assignments. There are eight load switches in the four-phase traffic controller assembly, sixteen in the eight-phase. Although each cabinet comes pre-wired for all possible load switches, only those required at each intersection are currently installed.

.2 Each load switch has three input/output pairs. The controller unit phase and overlap vehicle outputs correspond to the load switches' Red, Yellow and Green inputs.

.3 The same type of load switch is used for the controller unit's pedestrian outputs. The load switch Green input/output is used for Walk, and the Yellow input/output for Don't Walk. In the four-phase traffic controller assembly, the Red input/output of the pedestrian load switches (LS4 and LS8) are used for the pre-emption White indicator outputs. In the eight-phase, the Red input/output of the pedestrian load switches (LS10, LS12, LS14 and LS16) is not used.

.4 In the eight-phase traffic controller assembly, the pre-emption and overlap outputs share the same load switches (LS9, LS11, LS13 and LS15). The load switch Red input/output is used for the Red overlap output, the Yellow input/output is used for the pre-emption Blue indicator, and the Green input/output is used for the pre-emption White indicator.

.5 The load switch outputs of all signals displayed during flashing operation are routed through the assigned flash transfer relay before being connected to the field terminals. Refer to *Figure 4* in *Chapter 803*. Load switch outputs of signals not displayed during flashing operation are directly routed to the field terminals.

C/U Phase	Movement/Function	Conflict Monitor Channel	Load Switch (R/Y/G)	Load Switch (W/DW)
1		1	LS1	
2	A (Highway)	2	LS3	LS4 (G/Y)
3		3	LS5	
4	B (Cross Street)	4	LS7	LS8 (G/Y)
OL A		5	LS2	
-	∅2 Pre-Emption White Indicator	9 (Walk)	LS4 (Red)	
-	∅4 Pre-Emption White Indicator	10 (Walk)	LS8 (Red)	
-	Pre-Emption Blue Indicators (All directions)	-	LS6	

Table 1. Simple Two-Phase Intersection

C/U Phase	Movement/Function	Conflict Monitor Channel	Load Switch (R/Y/G)	Load Switch (W/DW)
1		1	LS1	
2	A (Highway)	2	LS3	LS4 (G/Y)
3	B (Highway)	3	LS5	
4	C (Cross Street)	4	LS7	LS8 (G/Y)
OL A		5	LS2	
-	∅2 Pre-Emption White Indicator	9 (Walk)	LS4 (Red)	
-	∅4 Pre-Emption White Indicator	10 (Walk)	LS8 (Red)	
-	Pre-Emption Blue Indicators (All directions)	-	LS6	

Table 2. Three-Phase T-Intersection

C/U Phase	Movement/Function	Conflict Monitor Channel	Load Switch (R/Y/G)	Load Switch (W/DW)
1	A1-> (Highway - Left Turn)	1	LS1	
2	A2 (Highway)	2	LS3	LS4 (G/Y)
3	Optional “dummy” phase	3	LS5	
4	B (Cross Street)	4	LS7	LS8 (G/Y)
OL A	A1 (Highway)	5	LS2	
-	∅2 Pre-Emption White Indicator	9 (Walk)	LS4 (Red)	
-	∅4 Pre-Emption White Indicator	10 (Walk)	LS8 (Red)	
-	Pre-Emption Blue Indicators (All directions)	-	LS6	

Table 3. Three-Phase Intersection with Protected/Permissive Left Turn on the Highway

C/U Phase	Movement/Function	Conflict Monitor Channel	Load Switch (R/Y/G)	Load Switch (W/DW)
1		1	LS1	
2	A (Highway)	2	LS3	LS4 (G/Y)
3	B1-> (Cross Street - Left Turn)	3	LS5	
4	B2 (Cross Street)	4	LS7	LS8 (G/Y)
OL A	B1 (Cross Street)	5	LS2	
-	∅2 Pre-Emption White Indicator	9 (Walk)	LS4 (Red)	
-	∅4 Pre-Emption White Indicator	10 (Walk)	LS8 (Red)	
-	Pre-Emption Blue Indicators (All directions)	-	LS6	

Table 4. Three-Phase Intersection with Protected/Permissive Left Turn on the Cross Street

C/U Phase	Movement/Function	Conflict Monitor Channel	Load Switch (R/Y/G)	Load Switch (W/DW)
1	A2-> or Ay (Highway - Southbound Left Turn)	1	LS1	
2	A1 (Highway - Northbound)	2	LS2	LS10
3		3	LS3	
4	B (Cross Street)	4	LS4	LS12
5	A1-> or Ax (Highway - Northbound Left Turn)	5	LS5	
6	A2 (Highway - Southbound)	6	LS6	LS14
7		7	LS7	
8		8	LS8	LS16
OL A		9 (Red)	LS9 (Red)	
OL B		10 (Red)	LS11 (Red)	
OL C		11 (Red)	LS13 (Red)	
OL D		12 (Red)	LS15 (Red)	
-	∅2 Pre-Emption	9 (Walk)	LS9 (G/Y)	
-	∅4 Pre-Emption	10 (Walk)	LS11 (G/Y)	
-	∅6 Pre-Emption	11 (Walk)	LS13 (G/Y)	
-	∅8 Pre-Emption	12 (Walk)	LS15 (G/Y)	

Table 5. Five-Phase Intersection with Dual Left Turn on the Highway

C/U Phase	Movement/Function	Conflict Monitor Channel	Load Switch (R/Y/G)	Load Switch (W/DW)
1	A2-> or Ay (Highway - Southbound Left Turn)	1	LS1	
2	A1 (Highway - Northbound)	2	LS2	LS10
3	B (Cross Street - Eastbound)	3	LS3	
4	C (Cross Street - Westbound)	4	LS4	LS12
5	A1-> or Ax (Highway - Northbound Left Turn)	5	LS5	
6	A2 (Highway - Southbound)	6	LS6	LS14
7		7	LS7	
8		8	LS8	LS16
OL A		9 (Red)	LS9 (Red)	
OL B		10 (Red)	LS11 (Red)	
OL C		11 (Red)	LS13 (Red)	
OL D		12 (Red)	LS15 (Red)	
-	∅2 Pre-Emption	9 (Walk)	LS9 (G/Y)	
-	∅4 Pre-Emption	10 (Walk)	LS11 (G/Y)	
-	∅6 Pre-Emption	11 (Walk)	LS13 (G/Y)	
-	∅8 Pre-Emption	12 (Walk)	LS15 (G/Y)	

Table 6. Six-Phase Intersection with Dual Left Turn on the Highway and Split Cross Street

C/U Phase	Movement/Function	Conflict Monitor Channel	Load Switch (R/Y/G)	Load Switch (W/DW)
1	A2-> or Ay (Highway - Southbound Left Turn)	1	LS1	
2	A1 (Highway - Northbound)	2	LS2	LS10
3		3	LS3	
4		4	LS4	LS12
5	A1-> or Ax (Highway - Northbound Left Turn)	5	LS5	
6	A2 (Highway - Southbound)	6	LS6	LS14
7	B1->	7	LS7	
8	B2 (Cross Street - Westbound)	8	LS8	LS16
OL A		9 (Red)	LS9 (Red)	
OL B		10 (Red)	LS11 (Red)	
OL C		11 (Red)	LS13 (Red)	
OL D	B1 (Cross Street - Eastbound)	12	LS15	
-	∅2 Pre-Emption	9 (Walk)	LS9 (G/Y)	
-	∅4 Pre-Emption	10 (Walk)	LS11 (G/Y)	
-	∅6 Pre-Emption	11 (Walk)	LS13 (G/Y)	
-	∅8 Pre-Emption	-	-	

Table 7. Six-Phase Intersection with Dual Left Turn on the Highway and Protected/Permissive Left Turn on the Cross Street - ∅B1 As An Overlap

C/U Phase	Movement/Function	Conflict Monitor Channel	Load Switch (R/Y/G)	Load Switch (W/DW)
1	A2-> or Ay (Highway - Southbound Left Turn)	1	LS1	
2	A1 (Highway - Northbound)	2	LS2	LS10
3		3	LS3	
4	B1 (Cross Street - Eastbound)	4	LS4	LS12
5	A1-> or Ax (Highway - Northbound Left Turn)	5	LS5	
6	A2 (Highway - Southbound)	6	LS6	LS14
7	B1-> or Bx (Cross Street - Eastbound Left Turn)	7	LS7	
8	B2 (Cross Street - Westbound)	8	LS8	LS16
OL A		9 (Red)	LS9 (Red)	
OL B		10 (Red)	LS11 (Red)	
OL C		11 (Red)	LS13 (Red)	
OL D		12 (Red)	LS15 (Red)	
-	∅2 Pre-Emption	9 (Walk)	LS9 (G/Y)	
-	∅4 Pre-Emption	10 (Walk)	LS11 (G/Y)	
-	∅6 Pre-Emption	11 (Walk)	LS13 (G/Y)	
-	∅8 Pre-Emption	12 (Walk)	LS15 (G/Y)	

Table 8. Seven-Phase Intersection with Dual Left Turn on the Highway and Left Turn on the Cross Street

C/U Phase	Movement/Function	Conflict Monitor Channel	Load Switch (R/Y/G)	Load Switch (W/DW)
1	A2-> or Ay (Highway - Southbound Left Turn)	1	LS1	
2	A1 (Highway - Northbound)	2	LS2	LS10
3	B2-> or By (Cross Street - Westbound Left Turn)	3	LS3	
4	B1 (Cross Street - Eastbound)	4	LS4	LS12
5	A1-> or Ax (Highway - Northbound Left Turn)	5	LS5	
6	A2 (Highway - Southbound)	6	LS6	LS14
7	B1-> or Bx (Cross Street - Eastbound Left Turn)	7	LS7	
8	B2 (Cross Street - Westbound)	8	LS8	LS16
OL A		9 (Red)	LS9 (Red)	
OL B		10 (Red)	LS11 (Red)	
OL C		11 (Red)	LS13 (Red)	
OL D		12 (Red)	LS15 (Red)	
-	∅2 Pre-Emption	9 (Walk)	LS9 (G/Y)	
-	∅4 Pre-Emption	10 (Walk)	LS11 (G/Y)	
-	∅6 Pre-Emption	11 (Walk)	LS13 (G/Y)	
-	∅8 Pre-Emption	12 (Walk)	LS15 (G/Y)	

Table 9. Eight-Phase Quadruple Protected or Protected/Permissive Intersection

1003 LMD8000 CONTROLLER UNIT RUN-MODE DISPLAY

1003.1 INTRODUCTION

.1 The LMD8000 controller unit has a liquid crystal display (LCD) and keypad used to display status information and to view and edit programming data. The run-mode status display is one of the most useful tools for determining the current traffic controller assembly status.

.2 The instructions presented in this chapter describe only the methods of obtaining basic status information, used to assist in the location of traffic controller assembly faults.

.3 The data in the LMD8000 is organized in a menu system. Available menu options are accessed by using the adjacent key pad. The control keys operate as follows:

- .1 The "Run Status" key jumps to the basic run status display.
- .2 The "Main Menu" key jumps directly to the main menu display.
- .3 Menu options are selected by pressing the numbered key corresponding to the desired selection.
- .4 Page-up, "PgUp" and page-down, "PgDn" keys allow scrolling within a given menu option.
- .5 The Prior Menu key returns to the previous menu display.

.4 Two alternate run-mode displays can be accessed quickly by setting up a shortcut-key sequence. Access any desired run-mode display, then press the Enter key. Move to another run-mode display. You can now toggle between the two displays by pressing only the Enter key.

.5 *Figure 1* shows the menu structure for the run mode display option which is a small subset of the overall menu system. The following clauses describe the most important information found in run mode displays.

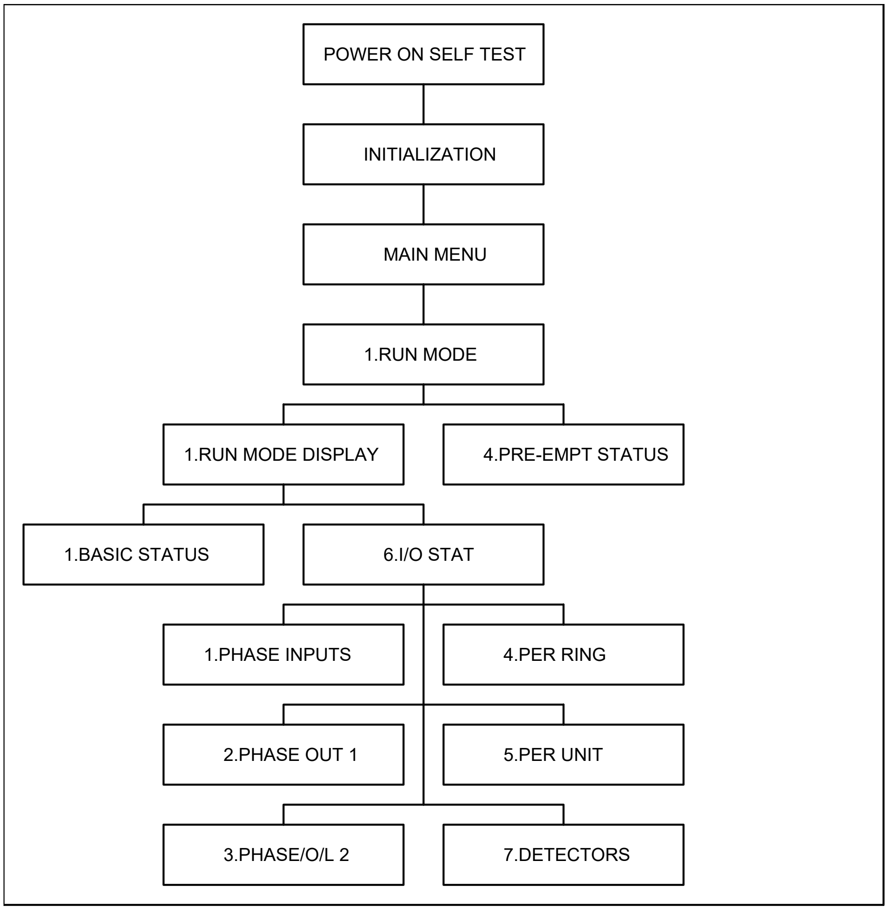

Figure 1. LMD8000 Run-Mode Display Menu Structure

1003.2 POWER ON SELF TEST AND INITIALIZATION DISPLAYS

.1 When power is first applied, the power on self test (POST) display is shown briefly, followed by the initialization display. To view the initialization display later, press the Main Menu key, followed by the Prior Menu key.

.2 The initialization display shows the following information:

  .1 The manufacturer's name.

  .2 The model type (LMD8000).

.3 The serial number, revision number and date of the firmware program.

.4 Copyright information.

.5 An optional user intersection name.

.3 To view the POST display later, press the Main Menu key, followed by the Prior Menu key, twice. The POST display provides the following information:

.1 BATTERY - shows the status (good/bad) of the RAM/clock backup battery.

.2 PROM - shows the status of the firmware program memory IC.

.3 RAM - shows the status of the read/write memory used to store non-programmed data.

.4 EEPROM - shows the status of the non-volatile memory used to store programmed timing and control data.

.5 RTC - shows the status of the internal real-time clock.

.6 The amount of RAM (Random Access Memory) installed.

1003.3 MAIN MENU AND BASIC STATUS MENU

.1 The main menu can be accessed at any time by pressing the Main Menu key.

.2 From the main menu, select 1.Run Mode to access the basic status menu.

.3 From the basic status menu, select 1.Run Mode Display to access the run mode menu.

1003.4 BASIC RUN STATUS

1003.4.1 General Description

.1 The most commonly viewed display is the basic run status. It indicates the status of each phase, vehicle inputs and interval times. Most of the required status information can be found here. A sample status screen is shown in *Figure 2*.

```
PHASE/OL   1.2 3 4 5.6 7 8 A B C D  | CYCLE
SP0         r G r r r G r r r r r r  | 1     0
MIN XX     WLK XX | MIN XX  WLK XX  | FREE
MX1 XX     PSG XX | MX1 XX  PSG XX  | OP
```

Figure 2. The Basic Run Status Display

.2 The basic run status display can be accessed at any time by pressing the Run Status key. An alternate method is to select 1.Basic Status from the run mode menu. (Main Menu-1-1-1)

.3 The following sub-clauses describe the information shown on the basic run status display.

1003.4.2 Per-Phase Status

.1 PHASE/OL - Phases 1 to 8 and overlaps A to D are always shown. A decimal in front of phase 1 to 8 indicates a vehicle call on that phase. Below each phase or overlap, any one of the following indications may appear:

- .1 **r** - phase is showing red while other phases are in service
- .2 **R** - phase is showing red while timing red clearance
- .3 **Y** - phase is showing yellow
- .4 **W** - phase is showing walk
- .5 **D** - phase is showing don’t walk
- .6 **G** - phase is showing green
- .7 **N** - this phase is next in the sequence

1003.4.3 Per-Unit Status

.1 CYCLE - "FREE OP" is displayed if the controller unit is not co-ordinating with another controller unit or master.

.2 SP0 - Indicates the active service plan, 1 to 8. Zero indicates that no service plan is in effect.

1003.4.4 Interval Status

.1 MIN XX - indicates minimum green timing is in effect where XX is the current timer value. Other possible indications in this area include:

- .1 EXTND'G - phase is extending
- .2 MAX REC - phase is on Max recall

.2 WLK XX - indicates walk timing is in effect where XX is the current timer value. Other possible indications include:

- .1 DW XX - Don't Walk timer is timing
- .2 WLK REST - phase is in Walk Rest
- .3 GRN REST - phase is in Green Rest
- .4 HOLD - phase has Hold applied
- .5 RED REST - phase is in Red Rest
- .6 STP TIME - Stop Time applied in that ring
- .7 MCE - Manual Control Enable is applied
- .8 FRC OFF - phase is being forced off
- .9 GAP OUT - phase has gapped out
- .10 MAX OUT - phase has Max'd out

.3 MX1 XX - indicates NEMA Max 1 timer is timing. Other indications in this area include:

- .1 MX2 XX - NEMA Max 2 timer is timing

.4 PSG XX - passage timer is timing. Other possible indications include:

- .1 YEL XX - Yellow clearance timer is timing
- .2 RED XX - Red clearance timer is timing

1003.5 INPUT/OUTPUT STATUS

.1 To access the I/O status displays menu, select 6.I/O STAT from the run mode menu. (Main Menu-1-1-6). Additional basic status information is found on six of the input/output (I/O) status display sub-menus.

.2 Phase Input Status Display - shows each phase indication as well as the status of the vehicle and pedestrian inputs for each phase. Active inputs are represented by an X, while calls stored in memory are represented by an M.

.3 Phase Output Status 1 Display - shows the current status of the per-phase outputs: Red, Yellow, Green, Don't Walk, Walk and Phase Next.

.4 Phases/Overlap Output Status 2 Display - shows additional per-phase outputs: current indication, Phase On, Phase Check and the current overlap outputs: Red, Yellow and Green.

.5 Per Ring Input Status Display - shows the active phase and indication for each ring, the interval name and current timer value; shows the status of the per-ring input modifiers.

.6 Per Unit Status Display - shows the status of the per-unit input modifiers: Interval Advance, Manual Control Enable, External Start, Minimum Recall, etc.; shows the status of the per-unit outputs: Flashing Logic Output (FLO) and CVM. Note that FLO should always be flashing and CVM should always be on steady.

.7 Detectors - this display shows the current input status of the 24 vehicle detector inputs. Note that per-phase vehicle call status is found on the phase input status display, described in *Paragraph .2* above. The detector number is shown at the top of the screen. Screen 1 shows detectors 1 to 8. The status of each detector is shown immediately below. Press the PgDn key to view detectors 9 to 16. Press PgDn again to view detectors 17 to 24.

1003.6 PRE-EMPTION STATUS

.1 The status of active pre-emption sequences and inputs can be seen on the pre-emption status display. To access this display, select 4.Pre-Empt Status from the basic status menu. (Main Menu-1-4)

.2 The pre-emption status display shows the current pre-empt sequence status (during pre-emption only) which includes the sequence number, current sequence program step, current phase, hold-on-input and active pre-emption outputs.

.3 Press the PgDn key to view the pre-emption input status. Next to the input number the input priority is shown. 1 is the highest priority, followed by 2, 3 and so on. Press PgDn again to view the low-priority pre-emption inputs.

1004 CONFLICT MONITOR DISPLAYS

1004.1 LSM12 AND LNM12E STATUS DISPLAYS

.1 The LSM12 and LNM12E conflict monitors have two LCD's to provide signal and fault status information.

.2 During normal operation, the displays indicate the currently active signals for the corresponding channel. Refer to *Clause 1002.3* for a definition of the standard Ministry channel assignments.

.3 During faults such as conflict, red failure, min clearance failure, CVM failure, etc. the display will indicate the signal conditions at the time of the fault, plus the specific failure mode.

.4 If power is interrupted while the monitor is in a latched failure mode, the monitor will immediately re-display the failure-display indications upon restoration of power.

.5 The LSM12 and LNM12E displays are shown in *Figure 3*. The upper display is for channels 1 to 6, the lower for channels 7 to 12. Failure mode status is displayed on the upper LCD only.

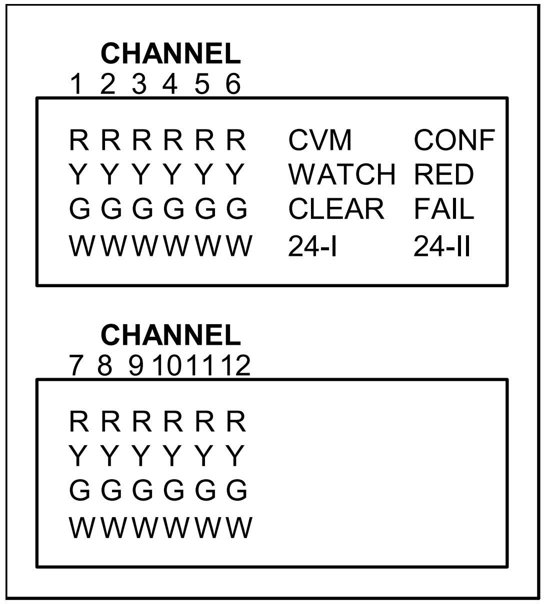

Figure 3. Conflict Monitor Status Displays

.6 The channel and failure mode status are displayed as follows:

- .1 During normal operation the display indicates the current active signal on the twelve channels.
- .2 During conflict, the display will indicate "CONF" plus the signals active at the time the conflict occurred.
- .3 During red failure, the display will indicate "RED FAIL" plus the signals active at the time the red failure occurred. The failing channel is identified by the fact that no signals are visible for that channel.
- .4 During voltage failure, the display will indicate "CVM", "24-I" or "24-II" plus the signals active at the time the failure occurred.
- .5 During a min. clearance timing failure, the display will indicate "CLEAR FAIL" plus the signals active at the time of failure, plus a flashing "R" on the channel being cleared.
- .6 During a watch dog failure, the display will indicate "WATCH FAIL" plus the signals active at the time of failure.
- .7 During an overlapping indication (on the same channel) failure, the display will indicate "FAIL" plus the signals active at the time of failure.

1004.2 LNM12E MESSAGE LOG DISPLAY

1004.2.1 General Description

.1 The LNM12E has an additional display, shown in *Figure 4*, used for time and date display, programming and for status and message log display. The message display is configured in a menu format, using two pushbuttons for commands to view data and change settings.

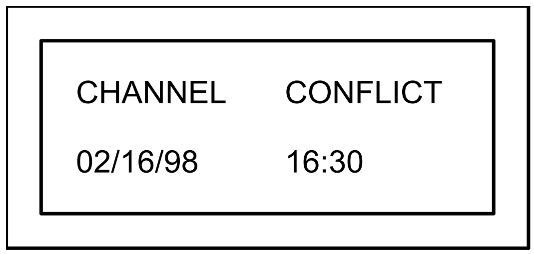

Figure 4. Conflict Monitor Message Log Display

.2 The normal display shows only the current date and time. During a failure, the display will show the last event saved in the LNM12E's message log.

1004.2.2 Viewing Saved Messages

.1 Previously saved messages can be viewed by accessing the display menu system using the two command pushbuttons, "SET" and "SELECT", located just above the LCD.

.2 To view the messages, execute the following sequence of commands:

- .1 Press the SELECT pushbutton once. The message count is displayed.
- .2 Press the SELECT pushbutton again. The main menu is displayed.
- .3 Press the SELECT pushbutton to move the cursor "*" next to the PROG/READ option. Press the SET pushbutton to enter this menu.
- .4 Press the SELECT pushbutton to move the cursor next to the DISP-MSG option. Press the SET pushbutton to enter this mode.
- .5 The most recent message is now displayed. Press the SELECT pushbutton to scroll through the saved messages.

.6 At any point, you may press the SET pushbutton to return to the PROG/READ menu.

.7 Press the SELECT pushbutton to move the cursor next to the PM (prior menu) option. Press the SET pushbutton to return to the main menu.

.8 Press the SELECT pushbutton to move the cursor next to the PM option. Press the SET pushbutton until the display returns to the current date and time.

.3 Current status information will not be shown while the message log is being viewed. Instead, the status displays will show the active signals and failure mode in effect at the time the corresponding message was saved. During this time, the monitor will continue to respond normally to any fault conditions.

1005 INPUT MODIFIER CARD INDICATORS

1005.1 PEDESTRIAN VEHICLE INTERFACE CARD

.1 The TEC-PV8 has three indicators for its ELB section: a red inhibit (INH) indicator, a green full-operating-point (FOP) indicator and a green solid-state relay enable (EN) indicator.

.2 The INH indicator is lit for 2.5 seconds on power-up, until the conflict monitor energizes its start delay relay. It will also be lit whenever the outside flash switch is in the flashing operation position.

.3 The FOP indicator is lit whenever the controller unit is at its full-operating point. It will continue to indicate the FOP interval, during flashing operation, if power is not removed from the controller unit and Power Supply card.

.4 The EN indicator is lit whenever the TEC-PV8 SSR-EN output is on. It will remain lit, during flashing operation, if the conflict monitor puts the intersection into flash and applies a stop-time signal. The EN indicator will turn off when the conflict monitor is reset.

.5 On the front panel there are also eight red indicators, one for each vehicle-call toggle switch. These indicators light only when the corresponding vehicle switch is operated.

1005.2 ADVANCE WARNING CARD

.1 There is a yellow indicator on the front panel of the TEC-AW2 for each channel. The indicator is lit whenever the TEC-AW2 turns on the flash control output for that channel.

.2 During flashing operation, if power is not removed from the controller unit and Power Supply card, the channel indicators will continue to show the status of the flash control outputs.

1005.3 PRE-EMPTION INTERFACE CARD

.1 There is a red indicator on the front panel of the TEC-DPE3 for each channel.

.2 During the initial portion of an emergency-vehicle or low-priority pre-emption sequence, the channel indicator will flash. The indicator will remain on steady when the controller unit's corresponding pre-emption output is on, until the completion of pre-emption operation.

.3 The indicator for a rail channel will remain on steady for as long as there is a valid external request signal, plus an additional delay of 5 seconds.

.4 If a channel is in fault mode, its front panel indicator will flash every three seconds, indicating the nature of the fault that has occurred: one flash for a contact fault, two flashes for a controller unit fault and three flashes for both.

1006 DETECTOR, LOAD SWITCH AND ADVANCE WARNING FLASHER INDICATORS

1006.1 LOOP DETECTOR INDICATORS

.1 Most detector units used by the Ministry have similar vehicle-detect indicators. At a minimum, each detector unit will have one indicator for each detection channel.

.2 During normal operation, the channel vehicle-detect indicator will be lit whenever a vehicle is detected.

.3 Some of the detectors used by the Ministry have additional indicators for loop faults. As their operation is not standardized, refer to the manufacturer's documentation for further details.

1006.2 LOAD SWITCH INDICATORS

.1 Each load switch is equipped with two sets of red, yellow and green indicators. One set shows the state of the low-voltage input which is controlled by the controller unit phase output or Pre-emption Interface card. The other set of indicators show the state of the corresponding high-voltage output, which is connected to the fuse block, flash transfer relay or monitor inhibit relay.

.2 The load switches for controller unit vehicle outputs are connected so that the indicator colours match the function of the outputs. On a pedestrian load switch, however, green indicates Walk and Yellow indicates Don't Walk. The connections of pre-emption outputs vary between the four and eight-phase traffic controller assemblies. Refer to *Clause 1002.4* for details.

.3 During normal operation, only one matching pair of indicators should be on. It is normal to observe two pairs of indicators on under some circumstances. For example, during pre-emption, the load switch Red may be on for Overlap X Red while the Yellow or Green will be on for the pre-emption indicator.

.4 During flashing operation, if power is not removed from the controller unit and Power Supply card, the input indicators will continue to show the status of the controller unit outputs. The output indicators, however, will remain off.

1006.3 ADVANCE WARNING FLASHER INDICATORS

.1 Each advance warning flasher has two red indicators and one green indicator for each channel. The green indicator is lit whenever the low-voltage flash control input, controlled by the Advance Warning card, is on. The red indicators will flash, alternately, whenever the high-voltage flasher outputs are on.

.2 During flashing operation, the green indicator will continue to show the status of the flash control input if power is not removed from the controller unit and Power Supply card. The output indicators will flash alternately throughout flashing operation.

1007 TROUBLESHOOTING

1007.1 STUDY THE INTERSECTION

.1 Troubleshooting a traffic controller assembly malfunction requires a logical and efficient approach. Since any malfunction can have a variety of causes, it is important to proceed methodically. Don't be tempted to start randomly changing devices or checking for loose connections.

.2 It is not possible to begin troubleshooting without a clear idea of the intersection configuration and phase assignments. Study the intersection before proceeding further.

1007.2 STUDY THE TRAFFIC CONTROLLER ASSEMBLY

.1 Take a few moments to study the traffic controller assembly. Make note of all the installed devices. See if advanced warning and/or pre-emption are used.

.2 Depending on the intersection configuration, it may be necessary to familiarize yourself with the intersection and cabinet electrical drawings and timing sheet.

1007.3 DEFINE THE PROBLEM

.1 Take time to examine the controller unit and conflict monitor displays and/or message logs. These displays will indicate the state of the traffic controller assembly at the time the fault occurred.

.2 Check the input modifier cards and load switch indicators to confirm the status indicated by the controller unit and conflict monitor.

.3 These observations will help to identify the areas of the traffic controller assembly where the fault may have occurred.

1007.4 LOCATE THE FAULT

.1 When the general location has been identified, use your knowledge of the standard device assignments and/or the electrical drawings to perform a check of the faulty circuit.

.2 Once again, it is important to remain focused and to proceed in a logical, step-by-step manner.

.3 Be sure to perform a thorough operational check of the traffic controller assembly after making any repairs.

.4 If the problem still exists after you have finished making repairs, carefully recheck your steps before proceeding further.

1007.5 DOCUMENTATION

.1 One of the most important troubleshooting steps is documentation. Be sure to fill out a log of your activities. This information will be important to the next person who works on the traffic controller assembly.

.2 Keep a central database of all corrective maintenance activities. This assists other Ministry personnel in their troubleshooting efforts and helps to identify and eliminate chronic problems.

British Columbia — Ministry of Transportation and Infrastructure

TRAFFIC CONTROLLER ASSEMBLY MANUAL

VOLUME 1

Section 1000

Traffic Controller Assembly Operation at Intersections

Electrical and ITS Engineering

June 2019

1100 COMMUNICATIONS

1101 TRAFFIC CONTROLLER ASSEMBLY COMMUNICATIONS

1101.1 INTRODUCTION

.1 Traffic controller assembly communications is becoming increasingly important at Ministry intersections. The term "communications" refers to the high-speed, electronic movement of data. Communication between traffic controller assemblies in a coordinated system, or between traffic controller assemblies and a central computer provides:

- .1 Improved efficiency in the movement of traffic.
- .2 The ability to remotely access real-time controller unit status information.
- .3 The ability to remotely recover traffic volume logs and other data.

1101.2 LMD8000 COMMUNICATION MODES

.1 The LMD8000 controller unit is capable of communication in a number of different modes:

- .1 Direct connection - two or more LMD8000's are connected together using modems. The LMD8000 has an internal modem that implements the BELL 202 communications standard. The modems are interconnected between adjacent intersections using a four-wire telephone circuit, fixed-wire link or some form of wireless communication. This mode is typically used for intersection coordination.
- .2 On-street master - two or more LMD8000's are connected in a daisy-chain fashion to a central on-street controller unit called the master. This method uses the internal LMD8000 modems and is also used for intersection coordination.
- .3 Direct-dial - the LMD8000 can communicate with a remote computer using a standard dial-up telephone circuit, cellular

telephone or other form of wireless communication. An external modem is used and is connected to one of the LMD8000 RS-232 ports. This mode is typically used for remote access to the LMD8000 volume logging data but can also be used to download new programming data to the controller unit. The LMD8000 can also be programmed to dial out to a central computer to automatically upload its data, or to send an alarm.

.4 PC interface - the LMD8000 can be directly connected to a personal computer using one of its RS-232 ports. This mode is used for programming in the shop and for program updates and data retrieval in the field.

.5 Conflict monitor interface - the LMD8000 can be connected to an LNM12E conflict monitor using one of its RS-232 ports. This allows conflict monitor settings and message logs to be uploaded to a PC via direct or remote connection to the controller unit.

1102 COORDINATION

1102.1 INTRODUCTION

.1 "Coordination" refers to the interconnection of traffic controllers in a manner that allows vehicles to travel a section of highway with minimal delays due to signalization.

.2 A basic form of coordination, called "time-based coordination" can be achieved without communication between traffic controller assemblies. Each controller unit generates internal commands independently, based on its own time clock. The clocks must be manually synchronized and no timing commands or data can pass between adjacent units. Time-based coordination is not as powerful or accurate as fully interconnected coordination.

.3 Communications facilitates coordination by allowing data, timing information and/or commands to be passed back and forth between traffic controllers.

1102.2 LMD8000 COORDINATION MODES

.1 The LMD8000 is capable of coordination in several modes. Where data communication between adjacent traffic controller assemblies does not exist, the Ministry uses time-based coordination.

.2 Where data communications exist, the Ministry may use a special type of controller unit called an MDM100 to control the "coordinated system" of intersections.

.3 The MDM100 is located in one of the traffic controller assemblies of the coordinated system. This device is referred to as an "on-street master". The MDM100 gathers traffic data from the LMD8000's at each of the system intersections. It in turn sends timing parameter commands allowing the controller units to adjust to varying traffic volumes on an ongoing basis. System coordination may be enabled during peak periods only, leaving each intersection to operate independently through the remainder of the day.

TRAFFIC CONTROLLER ASSEMBLY MANUAL
VOLUME 1

Traffic Control Glossary

Electrical and ITS Engineering

June 2019

TRAFFIC CONTROL GLOSSARY

Active Low	An electrical signal that is interpreted as "on" or "true" at the logic ground (0 Vdc) level.
Actuated Controller	A controller assembly that receives information from vehicle and/or pedestrian detectors and provides signal timing accordingly.
Actuation	The operation of any type of detector. The term operation refers to an output from the detector system to the controller unit.
Adaptive Split Control	A means of local intersection split selection based on vehicular activity.
Address	The identification of specific intersections for transmission of commands and/or receipt of data.
Adjustable Signal	A signal head having the signal faces mounted in the support hardware so that each face may be adjusted or "aimed", as required, to present the indication to approaching traffic.
Advance Warning	A safety feature that warns drivers that they should prepare to stop at the approaching intersection and that the light is either red, or is about to turn red.
Advance Warning Card	One of the Input Modifier Cards, it controls the operation of advance warning signs, located on the highway approaches to an intersection.
Advance Warning Flasher	A device which permits low-voltage signals from the controller unit or Advance Warning Card to control the operation of the advance warning sign flashers.

Advisory Detection	The detection of vehicles on one or more intersection approaches solely for the purpose of modifying the phase sequence and/or length for other approaches to the intersection.
Algorithm	A procedure, process or rule for the solution of a problem.
All-Red Interval	The display of red indications in all directions. See also "*Red Clearance Interval*".
Alternate	A coordination method whereby successive signals along an arterial do no give the same indication at the same time. Typically used in urban grid systems.
Alternating Current (ac)	An electric current which reverses direction at regular intervals. The rate of reversal (oscillation) is expressed in hertz (cycles per second).
Ampere	The unit expressing the rate of flow of an electrical current. One ampere is the current flowing through one ohm resistance with an applied voltage differential of one volt.
Amplifier	See "*Detector Amplifier*"
Analog Timing	A method of timing that measures continuous variables such as voltage or current.
ANSI	American National Standards Institute
Antenna	The radiating or receiving elements utilized in transmitting or receiving electromagnetic waves.
Area Detection	The continuous detection of vehicles over a length of roadway wherein the call of a vehicle in the detection area is intended to be held for as long as the vehicle remains in the area of detection (most detectors cannot hold the call indefinitely). Frequently referred to as large-area detectors, long-loop detectors or presence detectors.
Arterial	A major urban roadway, usually with coordinated signals along its length.

ASCII	American Standard Code for Information Interchange. A standard code for data communications.
ASTM	American Society for Testing and Materials
Asynchronous	A non-synchronized condition. Two systems operate or communicate without a common time reference.
Auto/Manual Switch	A switch that when operated, discontinues normal signal operation and permits manual operation. It is used in conjunction with the Interval Advance pushbutton switch. The Auto/Manual switch applies the Manual Control Enable signal when operated in the Manual position.
Auxiliary Equipment	Separate devices used to add supplementary features to a controller assembly.
Average	The offset and cycle lengths used in coordination during off-peak periods.
AVI	Automatic Vehicle Identification. A process for the automatic identification of vehicles while in motion, using specialized electronic equipment. This process facilitates the verification of vehicle permits or automatic toll collection without the need for the vehicle to stop.
AWG	American Wire Gauge. The standard measurement of wire size. It is based on the circular mil system: 1 Mil equals 0.001 inches.
Back Panel	A metal panel within the controller cabinet upon which are mounted field terminals, fuses or circuit breakers and other portions of the controller assembly not included in the controller unit or auxiliary equipment.
Background Cycle	The cycle length established by a master controller unit in a coordinated system. It takes precedence over the normal local controller unit cycle length.
Backing Rod	A thin styrofoam rod that is placed in a saw cut, above the loop wires, preventing the loop wires from rising to the surface within the encapsulation material.

Balance Adjuster — A device used in span-wire signal mount applications. It permits alignment of the point of suspension with respect to the centre of gravity of the signal head so that the signal will hang vertically.

Band — Through movement or green time elapsed between the first and last possible vehicle permitted through an intersection in a progressive coordination system.

Barrier — See "*Compatibility Line*"

Baud Rate — The rate of data transmission over a communications channel. Usually expressed in bits per second. E.g. 2400 baud = 2400 bits per second.

Bi-Directional Detector — A detector that is capable of being actuated by vehicles proceeding in either of two directions and of indicating in which of the directions the vehicles were moving.

Bit — Binary digit. The smallest unit of data.

Bracket Arm — A signal mounting bracket which complements a tubular bracket arm but is not of tubular construction.

Bracket Mount — A signal mounting arrangement where the signal head is mounted on the side of a pole, approximately parallel to the vertical axis of the pole.

Buffer — A device or computer program used to make two interconnected devices or systems compatible - either through voltage level translation or data synchronization.

Byte — A group of eight binary digits (bits) used to represent data. Often expressed as Kilobytes (one thousand bytes) or Megabytes (one million bytes).

Cabinet — See "*Traffic Controller Cabinet*"

Cable — A group of separately insulated conductors wrapped together and covered with an outer jacket.

Cable Entrance Adapter A signal mounting bracket of tubular construction, used between the span-wire hanger and the signal brackets, through which wiring can be passed to provide electrical connection of the signal.

Call A registration of a demand for right-of-way by traffic at a controller unit.

Call to Non-Actuated (CNA) A feature of an actuated controller whereby the active phase will always serve the walk and pedestrian clearance intervals regardless of demand.

Calling Detector A detector that is installed in a selected location to detect vehicles which may not otherwise be detected, and whose output may be modified by the controller unit. This has traditionally meant a small area detector near the stop line, used to detect vehicles entering the roadway from a driveway during the red or yellow signal. The detector is disconnected when the green signal is displayed so that extensions of the green time can only come from the appropriate Extension Detector.

Canadian Electrical Code A body of regulations pertaining to the application of electrical practices in Canada.

Capacitance The property of a system of conductors and dielectrics that permits the storage of electrical charges when potential differences exist between the conductors. Its value is expressed as the ratio of an electric charge to a potential difference. The unit of capacitance is the Farad, usually expressed in microfarads (uF), one millionth of a Farad.

Capacity The maximum number of vehicles that can pass over a given section of a lane or roadway, during a given time period, under prevailing traffic conditions.

Card-Rack Mounted Devices See "*Rack Mounted Devices*"

Carrier An electrical communication signal, of a single frequency, which is modulated to transmit data.

Carryover Output	The ability of a detector to maintain its output for a predetermined length of time following an actuation.
Central Processing Unit (CPU)	See "*Microprocessor*"
Centralized System	A computer-control system in which the master computer, communication facilities, console, keyboard and display equipment are all situated at a single, central location (often referred to as a Traffic Management Centre). From this location, the operating personnel coordinate and control traffic signals and related traffic-control functions throughout the region.
Chamfer	Diagonal saw cuts at the corners of square or rectangular loops to reduce the angle of bend of the loop wires.
Check	See "*Phase Check*".
Checksum	A computed sum used to check the validity of computer data.
Circuit	A closed conductive path followed by an electrical current.
Classification Detector	A detector that has the capability of differentiating among types of vehicles.
Clearance Interval	See "*Red Clearance Interval*"
Closed-Loop System	A control system in which the controlling device receives feedback from the devices or parameters under control. In a traffic control system, the controller unit operates the signals to control the flow of traffic and receives information back in the form of detector actuations. See also "*Feedback*".
Coil	A coiled conductor, wound on a form or core, that uses electro-magnetic induction to cause changes in a current.
Colour Sequence	The sequence of intervals and corresponding signal indications for an intersection.
Communications	The transmission of data between two or more devices or systems.

Compatibility Line A reference point in the preferred sequence of a dual-ring controller unit at which both rings are interlocked. The compatibility line assures that there will be no concurrent selection and timing of conflicting phases in different rings. Both rings cross the compatibility line simultaneously to select and time phases on the other side.

Concurrent Timing A mode of controller unit operation whereby a traffic phase can be selected and timed simultaneously and independently with another traffic phase.

Conditional Service A dual-ring controller unit feature that allows the re-servicing of an odd phase (left turn movement) once the opposing through phase has gapped out. The service is conditional upon sufficient time remaining in the adjacent through phase's MAX time.

Conductivity The measure of a material's ability to conduct electricity.

Conductor A medium for transmitting electrical current; a material which conducts electricity; a wire.

Conduit A tube for protecting electrical wires or cables.

Conflict The occurrence of conflicting or incompatible signal indications as detected by the conflict monitor.

Conflict Monitor A device used to continually check for the presence of overlapping or conflicting signal indications and monitor controller assembly voltage levels. Places the intersection into flash if a conflict or fault occurs.

Conflicting Call See "*Serviceable Conflicting Call*"

Conflicting Phases Two or more traffic phases that will cause interfering traffic movements if operated concurrently.

Continuous Presence Mode See "*Presence Mode*"

Contoured Visor See "*Cutaway Visor*"

Controller A term that refers to either a controller assembly or a controller unit.

Controller Assembly A complete electrical system, mounted in a cabinet, for controlling the operation of a signalized intersection.

Controller Unit The portion of a controller assembly devoted to the selection and timing of signal displays, commonly referred to as a "mainframe".

Coordinated Phase The traffic phase which constitutes the main arterial in a coordinated system.

Coordination A manner of interconnecting traffic controllers along an arterial or grid to minimize delays due to signalization.

Coordinator A device used to synchronize the timing of one controller unit to another.

Critical Intersection A selected, heavily traveled intersection within a coordinated arterial used as a reference to dynamically control the split at other intersections, based on demand.

Cross Street A secondary roadway that intersects an arterial.

Crosstalk The adverse interaction of any detector channel with another. It is the mutual coupling of magnetic fields that produces interaction between two or more detector units in the same controller assembly when the units are operating at similar frequencies. Crosstalk results in a detector outputting a false actuation in the absence of a vehicle.

CSA Canadian Standards Association. An organization that operates laboratories for the examination and testing of devices, systems and materials for the purpose of fire and casualty prevention and ensuring compliance with standards and regulations.

CSA Approved A product that has been tested and approved by the Canadian Standards Association. The product or device carries a label denoting approval.

Current The rate of flow of electrical charge. The unit of current is the Ampere.

Cutaway Visor — A signal visor that encircles approximately 300 degrees around the lens, the lower half of which may be cut away and contoured.

CVM — Controller Voltage Monitor. A controller unit output that is maintained in the true state as long as the controller unit is functioning normally. This output is monitored by the conflict monitor, which puts the intersection into flash if the controller unit fails.

Cycle — A complete sequence of signal indications. In an actuated controller unit, a complete cycle is dependent on the presence of calls on all phases.

Cycle Length — The time period in seconds required for one complete cycle.

Cycle Zero Point — See "*Time Reference Point*"

Data Base — A collection of data constants and parameters used by a computer algorithm in the execution of traffic control. This normally includes timing parameters, adjustment coefficients, algorithm coefficients and limit parameters.

Delayed Call Detector — A detector that does not issue a call until the detection zone has been occupied for a pre-determined length of time. See also "*Delayed Output*".

Delayed Output — The ability of a detector to delay turning on its output for a pre-determined length of time, during an extended actuation.

Demand — The request for right-of-way by vehicles or pedestrians.

Demand Operation — A mode of coordinated operation whereby the service provided at an intersection reflects the presence of demand, without regard to background cycles.

Density — A measure of the concentration of vehicles, stated as the number of vehicles per kilometer per lane.

Density Controller — An actuated controller assembly that has timing adjustments for the selection of the allowable gap, independent of the passage time.

Design Speed — The speed, under free traffic flow conditions, used in the design of the detector/controller system.

Detection — The process of identifying the presence or passage of a vehicle at a specific point or the presence of one or more vehicles within a specific area.

Detection Zone — That area of the roadway within which a vehicle will be detected by a specific detector. Also called the "Zone of Detection", "Effective Loop Area" or "Sensing Zone".

Detector — A device for indicating the presence or passage of vehicles or pedestrians. This general term is usually supplemented with a modifier indicating the type (e.g. *loop* detector), operation (e.g. *presence* detector) or function (e.g. *extension* detector).

Detector Actuation — The operation of any type of detector in response to the detection of a vehicle or pedestrian.

Detector Amplifier — A device that intensifies the electrical signal produced by a detector.

Detector Failures — The occurrence of detector malfunctions including non-operation, chattering or erroneous detections.

Detector Memory — The retention of an actuation by the controller unit for future utilization. The memory is within the controller unit, not the detector.

Detector Mode — A term that describes the operation of a detector channel output when an actuation occurs. See also "*Presence Mode*" and "*Pulse Mode*".

Detector Setback — The longitudinal distance between the stop line and the detector sensor.

Detector System	The complete sensing and indicating apparatus consisting of the detector unit, the lead-in cable, the lead-in wires and the sensor.
Detector Unit	The portion of a detector system which is an electronic assembly, excluding the lead-in cable, lead-in wires and sensor. Commonly referred to as a "detector".
Diagnostics	A program that facilitates the maintenance of a device by detection and isolation of malfunctions and/or verification of correct operation.
Dielectric	Any material that does not conduct electricity.
Digital Controller Unit	A controller unit wherein timing is based upon a defined frequency source such as a 60 hertz alternating current source.
Digital Timing	A method of timing that operates by counting discrete units.
Dilemma Zone	A distance or time period related to the onset of the yellow change interval. It describes the portion of the roadway in advance of the intersection, within which an operator is indecisive about stopping or proceeding through the intersection.
Dilemma Zone Protection	Any method or procedure that attempts to control the end of the green interval so that no vehicle will be in the dilemma zone when the signal turns yellow.
Dimming	A feature that allows selected signal indications to be dimmed during nighttime operation.
Direct Current (DC)	An electrical current which moves uniformly in one direction.
Directional Detector	A detector that is only capable of being actuated by vehicles proceeding in one direction.

Disconnect Hanger (Jack Box)	A signal mounting device for a span-wire or mast-arm mount that contains a terminal block for a plug and socket and a means of readily attaching or detaching the signal head.
Disk Operating System (DOS)	A program that controls the basic operation of a computer including file management, input/output procedures, memory management, printing, etc.
Distributed System	A traffic control system in which individual master computers are installed in each of the major control areas of the overall system. A supervising master computer is used to provide an interface between the different areas and to make decisions on timing patterns that affect two or more areas.
Downstream	The portion of the roadway extending from the stop line across the intersection and beyond.
Drift	A change in the electrical properties of a detector system due to environmental changes, particularly temperature and moisture.
Dual Entry	A mode of operation of a dual-ring controller unit in which one phase in each ring must be in service. If a call does not exist in a ring when it crosses the compatibility line, a phase is automatically selected in that ring for service.
Dual-Ring Controller Unit	A controller unit in which phases are assigned to two interlocked rings, arranged to time in a preferred sequence. Concurrent timing of one phase from each ring is allowed. Only one phase in each ring may be on at one time.
Duplex	Two-way communication over a single communication link. Communication can occur simultaneously in both directions, but not necessarily at the same rate in both directions. See also "*Half Duplex*" and "*Full Duplex*".
Dwell	See "*Rest*"

Eddy Current An electric current induced within the body of a conductor when the conductor moves through a non-uniform magnetic field.

EEPROM Electrically Erasable Programmable Read-Only Memory. A memory storage device which can be written to (programmed) and read from by a microprocessor, in circuit, during the course of normal operation. EEPROM devices do not require a special process to erase existing data before new data can be stored.

Effective Loop Area See "*Detection Zone*"

Electrical Safety Branch A department of the government of British Columbia responsible for the inspection and approval of electrical installations and special electrical devices.

Electro-Mechanical Device A device that is characterized by electrical circuits utilizing relays, step switches, motors, etc.

Electronic Device A device that is characterized by electrical circuits utilizing solid-state, integrated-circuit components, resistors, capacitors, inductors, transistors and which may also include electro-mechanical devices.

Elevator Mast-Arm Mount A mast-arm signal mount where the signal head is supported on the mast arm by a bracket between the sections, placing one or more of the sections above the arm.

EMR External MIN Recall. A controller unit input that places a MIN recall on all vehicle phases.

Encapsulation The process of filling a saw cut with sealant to surround the loop wires in the slot.

Encasement A process whereby the loop wire is encased in a polyvinyl or polyethylene tube to provide protection for the wire.

Enhanced Ped An LMD8000 CNA related feature whereby the walk time will be equal to the MAX I value.

Epoxy A resin used in bonding.

EPROM Erasable Programmable Read-Only Memory. A memory storage device which can be read from by a microprocessor. Before new data can be programmed, the EPROM must be removed from the circuit and erased by exposure to ultra-violet light. New data is programmed into the device before re-insertion into the circuit.

Exception Days A traffic pattern timing routine stored in controller unit memory, activated to compensate for unusual traffic flow caused by a special event.

Exclusive Pedestrian Phase A traffic phase allocated to pedestrian traffic only that provides a right-of-way pedestrian indication to the exclusion of all vehicular phases (all red). See also "*Pedestrian Signal*".

Extended Call Detector A type of detector that can optionally extend its output for a pre-determined length of time after the vehicle departs the detection zone. See also "*Carryover Output*".

Extendible Recall A form of recall whereby the associated phase will always serve MIN green plus additional green time subject to detector actuation.

Extensible Portion That portion of the green interval of an actuated phase, following the initial portion, which may be extended, e.g. by traffic actuation.

Extension The timing interval during the extensible portion of a phase that is resettable by each detector actuation. The green right-of-way of the phase may terminate on expiration of the extension time.

Extension Detector A detector that is arranged to register actuations at the controller only during the green interval for that approach so as to extend the green time for the actuating vehicles.

Extension Limit The maximum time of the extensible portion of a phase.

External Start — A controller unit input that is activated by the conflict monitor start delay relay for 2.5 seconds upon power-up of the controller assembly. Activation of this input causes the controller unit to revert to its initialization interval. See also "*Start Delay Relay*" and "*System Reset*".

Failsafe — A type of detector output relay design that produces a continuous output in the event of a detector unit failure.

Farad — The unit of capacitance, usually expressed in microfarads (uF), one millionth of a farad.

Feedback — A system or circuit path which is provided to verify or limit the response to a command. See also "*Closed Loop System*".

Feeder Cable — See "*Lead-in Cable*"

Field of Influence — See "*Detection Zone*"

Field Terminals — Devices for connecting wires entering the controller assembly.

Firmware — Logic or program memory contained in read-only-memory (e.g. EPROM). Typically describes a "software" program stored in an integrated circuit device that may be easily changed to facilitate program upgrades.

Fixed-Face Signal — See "*Non-Adjustable Signal*"

Fixed-Time Controller Assembly — A controller assembly for the operation of traffic signals with predetermined cycle length, interval duration and interval sequence; a controller assembly that is completely non-actuated.

Flash Control Circuit — A system of auxiliary devices within Ministry controller assemblies, used to control the transfer of the intersection from flashing to three-colour operation.

Flash Control Relay — An electro-mechanical relay used in Ministry controller assemblies to control the operation of the flash transfer relays. The flash control relay is energized by the solid state relay.

Flash Control Switch A device that, when operated, discontinues normal signal operation and causes the flashing of any predetermined combination of signal indications. In Ministry traffic controllers there are two flash control switches: the Inside Flash Switch and the Outside Flash Switch.

Flash Transfer Relay A two-pole electro-mechanical relay used in Ministry controller assemblies to control the supply of 120 Vac power to signals that have indications during both three-colour and flashing operation. During three-colour operation, the flash transfer relay supplies power to the signal from the appropriate load switch. During flashing operation it supplies power to the signal from the intersection flasher.

Flasher A device used to open and close signal circuits at a repetitive rate.

Flasher Controller Assembly A complete electrical mechanism for flashing a traffic signal or beacon.

Flashing Bus A 120 Vac flasher output supplying signal power via the flash-transfer relays during flashing operation.

Flashing Operation Intersection operation upon initial power-up of the controller assembly or after a conflict or other fault condition has occurred. Normally during flashing operation, all traffic movements are given a flashing red indication except the highway through movements, which may be given a flashing yellow indication. This condition is also referred to as "in flash".

Flexible Mast-Arm Mount A mast-arm signal mount where the signal head is attached to the mast arm with a flexible joint and connector to permit free swinging of the signal head.

FOP Full Operating Point. A selectable interval at which the intersection is allowed to transfer from flashing to three-colour operation. The FOP is detected by the Pedestrian Vehicle Interface Card.

Force Off	A controller unit input that forces the start of termination of the current right-of-way. Used in pre-emption and coordination.
Freeway Surveillance	Process or method of monitoring freeway traffic performance and control system operation.
Frequency	The rate of oscillation of an electrical signal.
FSK	Frequency Shift Keying. A form of digital frequency modulation employing discrete frequencies for specific signals. The modem transmitter is changed (keyed) from one frequency to another to transmit data.
Full Duplex	Simultaneous communication in two directions over a single communication link. The data rate is the same in both directions.
Full-Circle Tunnel Visor	A signal visor which encircles the entire lens.
Full-Traffic-Actuated Controller Assembly	A type of traffic-actuated controller assembly in which means are provided for traffic actuation on all approaches to the intersection.
Fully-Actuated Controller Assembly	See "Full-Traffic-Actuated Controller Assembly"
Gap	The time interval between the end of one vehicle detector actuation and the beginning of the next.
Gap Out	The termination of a phase's green interval due to an excessive time between vehicle calls on that phase.
Gap Reduction	A dynamic reduction of the extension or allowed time spacing between successive vehicle actuations in the extensible portion of a phase.
GPS	Global Positioning System. A satellite-based system allowing the precise location of a terrestrial GPS receiver to be determined. GPS also provides extremely accurate world time standard synchronization.
Green Band	See "*Band*"

Green Extension System A hardware assembly of extended-call detectors and auxiliary logic. The logic can monitor the signal display, enable or disable the selected detectors and hold the controller in highway green.

Grid A group of coordinated thoroughfares covering a large area with movements in several directions. The entire area is controlled in a synchronized manner to minimize delays. Master control is usually centralized.

Ground (Chassis Ground) An electrical connection between a circuit or piece of equipment and the earth.

Half Duplex Communication in two directions over a single communication link. Communication cannot occur simultaneously in both directions so each side is forced to wait while the other is transmitting.

Hand Hole An opening in a traffic pole or arm to facilitate the installation of conductors.

Hand Hole Cover A metal plate that covers the opening of a hand hole.

Hard Copy Data permanently recorded on paper or other tangible media for later reference.

Headway The time separation between successive vehicles approaching an intersection.

Henry The unit of inductance, usually expressed in microhenrys (uH), one millionth of a Henry.

Hertz (Hz) The unit of frequency, meaning cycles-per-second. Often expressed in kilohertz (kHz), thousands of cycles-per-second or megahertz (MHz), millions of cycles-per-second.

Highway Traffic Signal Any power-operated traffic-control device (except a sign, barricade warning light or steady-burning electric light) by which traffic is warned or is directed to take specific action.

Hold	A controller unit input that retains the existing right-of-way even in the presence of conflicting calls. A momentary release of the hold command allows the controller unit to yield to other conflicting phases requesting service (often referred to as the yield command or yield point).
HOV	High Occupancy Vehicle. A transit vehicle or commuter vehicle carrying the minimum required number of passengers.
HOV Lane	A special lane whose use is restricted to high occupancy vehicles only.
I/O	Input/Output. A general term describing the flow of data to/from a device or system.
IEEE	Institute of Electrical and Electronics Engineers
IMSA	International Municipal Signal Association
Inbound	The condition where an imbalance exists in traffic with a heavier flow towards central points. Also described as the a.m. peak period or a.m. rush hour.
Inductance	The property of an electric circuit or of two neighbouring circuits whereby an electromotive force is generated in one circuit by a change of current in itself or in the other. The unit of inductance is the henry, defined as the electromotive force of 1 volt generated when the current changes at a rate of 1 ampere per second.
Inductive Loop Detector	A detector that senses a decrease in inductance of its sensor loop(s) caused by the passage or presence of a vehicle in its detection zone.
Infrared Detector	A detector that senses radiation in the infrared spectrum.
Inhibit	An action or signal which prevents a normal change in the operating sequence of a controller. It is used to achieve coordination or other special conditions upon command from an external source.

Initial Portion The first timed portion of the green interval in an actuated controller unit. 1) Fixed initial portion: a preset initial portion that does not change. 2) Computed initial portion: an initial portion that is traffic adjusted. 3) Maximum initial portion: the limit of the computed initial portion. 4) Minimum initial portion: see "Fixed initial portion". 5) Added initial portion: an increment of time added to the minimum initial portion in response to vehicle actuations.

Initialization Interval A pre-determined phase and interval in which the controller unit begins its operation when power is first applied.

Input Modifier Cards A series of electronic devices, developed by the Ministry, to perform a variety of specific interfacing requirements within the traffic controller assembly. These include the Pedestrian Vehicle Interface Card, the Advance Warning Card, the Pre-Emption Interface Card and the Relay Interface Card.

Inside Flash Switch A four-pole switch, located inside Ministry traffic controller cabinets, used to manually place the intersection into flashing operation.

Interconnection A communication link between adjacent intersections for the purpose of coordination.

Interface A device which connects one portion of a system to another. It may include electrical isolation as well as timing synchronization, current and/or voltage level translation.

Intersection Two or more roadways that intersect.

Intersection Flasher A two-pole flasher whose outputs flash at a rate of 60 flashes per minute. The intersection flasher supplies 120 Vac power to the signal indications seen during flashing operation.

Interval The time period allotted to a specific control function. The signal indications may or may not change from one interval to the next.

Interval Advance — A controller unit input which causes the immediate termination of the current timing interval. Usually activated by a manual pushbutton, called the Interval Advance switch. It is used in conjunction with the Manual Control Enable feature.

Interval Portion — A discrete subdivision of an interval during which the signals do not change.

Interval Sequence — The order of appearance of signal indications during successive intervals of a cycle.

Isolated Controller Assembly — A controller assembly for operating traffic signals that are not under master supervision.

ITE — Institute of Transportation Engineers

ITS — Intelligent Transportation Systems

IVHS — Intelligent Vehicle Highway System. Now superceded by the term ITS.

Junction Box — A container that is placed underground with a removable lid level with the surface of the ground, or mounted on the exterior of a pole or enclosure. Provides access to conduits, cables, wire and splices and can be used for the storage of excess or spare wire.

Junction Well — See "*Junction Box*"

Lane — A standard width subdivision of a roadway sufficient for the passage of a single vehicle.

Lane-Use Control Signal — A highway traffic signal that is erected to control the direction of vehicular traffic movement in an individual lane.

Large Area Detector — A detector or series of detectors wired together in series, parallel or series/parallel covering an area in the approach to an intersection.

Last Car Passage — A selected feature of a density controller which, upon gap out, will cause the controller unit to complete the timing of the passage time. The last vehicle to have been detected, known as the "last car", will therefore retain the green signal until it reaches the stop line. Thus, it is assured of avoiding the dilemma zone problem.

Lead/Lag Operation — A feature that allows the reversal of the normal phase sequence on a phase-pair basis (1-2, 3-4, 5-6 and 7-8). When reversed, the odd phase will lag the even phase instead of leading. Also refers to the situation where one direction of protected left turn is programmed to occur after the termination of the opposing through movement. This is normally done when the turning path of opposing left-turning vehicles would overlap if allowed to occur simultaneously.

Lead-In Cable — The electrical cable which serves to connect the sensor loop(s) to the loop detector.

Lead-In Wire — That portion of the loop wire that is between the physical edge of the loop and the junction box where the loop wire is connected to the lead-in cable.

Light-Sensitive Detector — A detector that utilizes a light-sensitive device for sensing the passage of an object interrupting a beam of light directed at the sensor.

Link — The length of roadway or one-way traffic movement between two signalized locations (nodes).

Load Switch — A device used to permit low-voltage signals (e.g. controller unit outputs) to switch 120 Vac power to the signal lamps.

Local Controller Assembly — See "*Secondary Controller Assembly*"

Local Offset Unit — An auxiliary synchronous device used to keep a non-synchronous controller unit in step with a control frequency such as the AC power line.

Locking (Section or Group) A method of coordinated system control whereby one section selects the timing pattern for one or more other sections.

Locking Detection Memory A selectable feature of a controller unit phase whereby a vehicle call arriving during the red or yellow interval is remembered or held by the controller unit until that phase returns to a green interval. When enabled, the call is held in memory even if the actuation is removed before the controller unit returns to service it.

Logic Ground A voltage reference common point and current return path for logic circuits.

Loop Detector See "*Inductive Loop Detector*"

Loop System A combination of loops of wire connected through lead-in cable to the detector input terminals.

Magnetic Detector A detector that senses changes in the earth's magnetic field caused by the movement of a vehicle near its sensor.

Mainframe A controller unit.

Manual Control Enable A controller unit input used for manual operation. Vehicle and pedestrian calls are placed on all phases, and timing in all intervals is stopped except vehicle clearances. In Ministry controllers, this input is applied when the Auto/Manual switch is operated in the Manual position. This input is used in conjunction with the Interval Advance pushbutton.

Manual Operation The operation of a controller assembly by means of a hand-operated device, e.g. pushbutton switch.

Manual Reset A controller reset command by which it is possible to manually establish the offset. See also "*Offset Seeking*".

Mast-Arm Mount A signal mounting method where the signal heads are mounted on a rigid arm extended over the roadway.

Master Controller Assembly	A controller assembly for supervising a system of secondary (local) controller assemblies.
Master-Secondary Controller Assembly	A controller assembly which is both operating traffic signals and providing supervision of other secondary controller assemblies.
Max Out	The termination of a phase's green interval due to the expiration of its MAX timer.
MAX Recall	A form of recall whereby the associated phase or phases will always serve the MAX time regardless of demand.
Maximum I (MAX I)	The normal maximum allowable green time of a phase after a serviceable conflicting call is registered.
Maximum II (MAX II)	An optional maximum green time usually associated with coordination.
Maximum Variable Initial Interval	The maximum extension to the MIN green interval of a phase. See also "*Variable Initial Interval*" and "*Seconds per Actuation*".
Megger	A device that measures very high resistance to earth ground, used to test the state of loop installations.
Memory Off	See "*Non-Locking Detection Memory*"
Mercury Contactor	An electro-mechanical device that supplies power to the load switches during three-colour operation. The mercury contactor is energized by the output of the solid state relay.
Microcontroller	A special-purpose microprocessor designed to be used in stand-alone applications. Usually contains features normally performed by peripheral devices in a standard microprocessor system.
Microprocessor	An integrated-circuit component of a computer device which performs the execution of instructions.
Microwave Detector	A detector that is capable of sensing the passage of a vehicle through its field of emitted microwave energy.

Mid-Mast-Arm Mount A signal head mounted at a point between the end of the mast arm and the pole.

Min Clear A conflict monitor feature that ensures that a green signal is followed by a yellow and red indication.

Min Flash A conflict monitor feature that prevents the intersection from going into three-colour operation for a selectable period of time after power is first applied to the controller assembly. The monitor achieves this feature by delaying the energizing of its output relay over a range of 0 to 15 seconds (the Ministry standard is 5 seconds).

MIN Gap During the process of gap reduction, it is the shortest time to which the passage timer will reduce. See also "*Gap Reduction*".

MIN Green See "*Minimum Green Interval*"

MIN Recall A form of recall whereby the associated phase or phases will always serve the MIN green time regardless of demand.

Minimum Green Interval The shortest green time of a phase. If a time setting control is designated as "minimum green", the actual green time of the phase shall not be less that that setting.

Minimum Red Indication (Red Revert) Provision within the controller unit to assure a minimum Red signal indication in a phase following the Yellow Change interval of that phase.

Minimum Vehicle Standard A test unit that produces the minimum change in input for which a detector system must sense and indicate the passage or presence of a vehicle. NEMA specifies a Class 1 vehicle (a small motorcycle).

Minor Movement Controller Unit A device that can be added to a controller assembly to provide subordinate phase timing.

MIST Management Information System for Traffic

Modem	Modulator-demodulator. A device which provides data communication between two or more other devices. A single-frequency carrier signal is modulated (changed) to transmit the outgoing data and the received signal is demodulated to extract the incoming data.
Modular Design	A design concept such that functions are sectioned into plug-in units which can be readily exchanged with similar units.
MOE	Measures of Effectiveness. A data record measuring the effectiveness of the control system in improving traffic flow. Common bases for comparison include volume, occupancy, delays and speed.
Motion Detector	A detector that detects the motion of a vehicle passing through the detection zone at some minimum speed, usually 3.2 to 4.8 kph (2 to 3 mph). Vehicles travelling slower than the minimum speed, or stopped in the zone, are not detected.
Mounting Brackets	A system of parts used to fix a signal head in its operating position.
MOV	Metal Oxide Varister. A semi-conductor component which is used to protect sensitive equipment from transient voltages. The MOV remains in a high-impedance state during normal operation. When a higher-than-rated voltage is applied, the MOV conducts, shorting the transient to ground.
Movement	A single direction of travel and approach to an intersection.
MS	Mil-Spec. A general term referring to components or devices which have been designed to meet the specifications of the U.S. Military. These components typically have higher environmental tolerances and are more rigorously tested than standard commercial components. This term describes components that have been adopted for traffic control usage, e.g. NEMA controller unit connectors, MS-A, MS-B etc.

MSG	Main Street Green. A signal from a local controller unit to the central computer during the period when the local controller is displaying green for the coordinated phase.
Multi-Drop	A method of interconnection of devices whereby more than two devices communicate over the same communications channel. Normally two wires are used for the transmit function and two wires are used for the receive function.
NEMA	National Electrical Manufacturers Association
Network	A series of intersecting arterials or streets that are part of a coordinated signal system.
Node	Each signalized intersection in a traffic signal system.
Nominal Inductance	A design value of loop system inductance where the actual value can vary within a range that permits satisfactory detector system operation.
Non-Actuated	Generally refers to a "*Fixed-Time Controller Assembly*" but may also refer to a specific non-actuated phase within an otherwise actuated controller.
Non-Adjustable Signal	A signal in which the faces are mounted in a framework such that the indications are presented at a fixed angle.
Non-Conflicting Phases	Two or more traffic phases that will not cause interfering traffic movements if operated concurrently.
Non-Directional Detector	A detector that is capable of being actuated by vehicles proceeding in any direction.
Non-Locking Detection Memory	A mode of actuated controller unit operation in which the controller unit drops a vehicle call that terminates during the red or yellow interval of a phase.
Non-Volatile	A feature of memory storage devices whereby the stored data is retained when power is removed from the device.
Occupancy	The proportion of time a detector is occupied. Occupancy is a pseudo-measure of density on a roadway.

Occupancy Controller Assembly A traffic-actuated controller which responds to the presence of vehicles within an extended zone of detection.

Offset The distance relationship, expressed in seconds or percentage of cycle length, between two or more intersections in a coordinated system. Vehicles starting at a reference point may proceed along the arterial at a pre-determined speed without stopping. See also "*Progression*".

Offset Interrupter A method of offset seeking which distributes large offset changes over two or more cycle lengths.

Offset Seeking A process performed by a local controller to get in step (in sync) with the master controller. When in sync, the local controller's cycle zero point is offset from the master's sync pulse by a programmable value determined by the current offset.

Ohm The unit of electrical resistance. One ohm is defined as the resistance through which a current of 1 ampere will flow when a potential difference of 1 volt is applied across it.

Open-Bottom Tunnel Visor A visor that encircles the entire lens except a segment at the bottom.

Optical Unit Within a signal, an assembly of a lens, reflector, light source (signal lamp) and other components.

Outbound The condition where an imbalance exists in traffic with a heavier flow away from central points. Also described as the p.m. peak period or p.m. rush hour.

Output Relay An electro-mechanical relay within the conflict monitor which supplies 120 Vac power to the solid state relay. The relay remains de-energized for a selectable time (Ministry standard 5 seconds) upon power-up of the controller assembly. The relay is de-energized by the conflict monitor in response to a conflict or fault condition, putting the intersection into flash.

Outside Flash Switch A two-pole switch, accessible from the exterior of a traffic controller cabinet, used to manually place the intersection into flashing operation. It is used by emergency services in the event of a motor vehicle accident, etc. This switch is also referred to as the "police switch".

Overlap A traffic movement that is conditionally serviced at same time as another phase or phases (called "parent phases").

Parent Phase A traffic movement to which the conditional service of an overlap is linked.

Passage Detection The ability of a vehicle detector to detect the passage of a vehicle moving through the detection zone and to ignore the presence of a vehicle stopped within the detection zone.

Passage Detector A detector with passage detection capability.

Passage Period The time allowed for a vehicle to travel at a selected speed from the detector to the nearest point of conflicting traffic.

Passage Time A selectable timer within the controller unit that operates during the extensible portion of a green interval. The passage timer counts down from its preset limit between each successive actuation and is reset by each detector actuation. The expiration of the passage timer after the minimum green portion is referred to as "gapping out".

Pattern A unique set of timing parameters (cycle, split and offset) associated with each intersection within a pre-defined section.

Pattern Matching A technique used to select a pattern based on comparing measured traffic data with stored data.

Pattern Selection Choosing one of several stored patterns from a library, either manually or automatically, as a function of time-of-day or traffic demand.

Pedestal Mount See "*Post Mount*"

Pedestrian Clearance Interval
The first clearance interval following the pedestrian Walk indication, normally flashing Don't Walk - allows pedestrians to clear the intersection.

Pedestrian Detector
A detector that is responsive to operation by or the presence of pedestrians. This is normally in the form of a hand-operated pushbutton installed near the pedestrian crossing.

Pedestrian Phase
A traffic phase allocated to pedestrian traffic that may provide a right-of-way pedestrian indication either concurrently with one or more vehicular phases, or to the exclusion of all vehicular phases.

Pedestrian Recall
A controller unit input which guarantees the timing of pedestrian Walk and clearance intervals regardless of demand.

Pedestrian Recycle
A controller unit input which allows the re-service of pedestrian demand within the green time of the associated phase.

Pedestrian Signal
A traffic control signal that is erected for the exclusive purpose of directing pedestrian traffic at signalized locations.

Pedestrian Vehicle Interface Card
One of the Input Modifier Cards, it provides an electrical interface between the pedestrian pushbuttons in the field and the controller unit. It provides test switches allowing pedestrian and vehicle calls to be simulated on all controller unit phases. It provides logic circuitry to ensure a safe transition of the intersection from flashing to three-colour operation.

Pedestrian-Actuated Controller Assembly
A controller assembly in which intervals, such as pedestrian Walk and clearance intervals, can be added to or included in the controller cycle by the actuation of a pedestrian detector.

Percentile Speed Information regarding vehicle speeds in an intersection approach. For example, the 80th percentile speed is the speed above which 80% of the speeds occurred and below which 20% of the speeds occurred.

Permissive Period Selected periods during the cycle of a coordinated controller during which calls from opposing phases may be serviced.

Phase A unique traffic movement or group of controller unit parameters assigned to control it.

Phase Check A controller unit output that indicates the existence of an unanswered call on the associated phase.

Phase Next A controller unit output indicating that the associated phase is committed to be next in the sequence. The decision for which phase is to be serviced next is taken at the end of the green interval of the terminating phase. The output will remain on until the phase becomes active.

Phase Omit A controller unit input that causes the omission of the associated phase.

Phase Sequence A predetermined order in which the phases of a cycle occur.

Platoon A group of vehicles in motion.

Pneumatic Detector A pressure-sensitive detector that uses a pneumatic tube as a sensor.

Point-to-Point A method of interconnection of devices whereby exactly two devices communicate over a communications channel.

Police Door A covered compartment, accessible from the exterior of a traffic controller cabinet, in which the outside flash switch (police switch) is located.

Police Switch See "*Outside Flash Switch*"

Polychloroprene The chemical name for neoprene. Used for jacketing wire and cable that will be subject to rough usage, moisture, oil, greases, solvents and/or chemicals. May also be used as a low-voltage insulating material.

Polyethylene A family of insulating materials derived from the polymerization of ethylene gas. All members of the family are excellent dielectrics. It has high insulation resistance, high dielectric strength and good abrasion resistance. It is widely used for insulation of signal and detector wire and cable and is suitable for direct burial.

Polyolefins A family of plastics including cross-linked polyethylene and various ethylene copolymers which shrinks when heat is applied. Commonly used in splicing.

Polypropylene A thermoplastic with good electrical characteristics, high tensile strength and resistance to heat.

Polyurethane An enamel that has excellent moisture resistance and excellent winding properties.

Polyvinyl Chloride (PVC) A family of insulating compounds whose basic ingredient is either polyvinyl chloride or its copolymer with vinyl acetate. It can be either rigid as used in conduit or flexible as used in the manufacture of pre-formed loops. It is also widely used as a jacketing and insulation material.

Post Mount A signal head mounted on top of a post.

Posted Speed The legal maximum speed limit in force over a particular section of roadway.

Power Line Switch (Disconnect Switch) A manual switch for disconnecting power to the controller assembly and traffic control signals.

Pre-Empt Sequence A special set of instructions that tell a controller unit how to operate when pre-emption is required.

Pre-Emption
The transfer of the normal control of signals to a special control mode. This mode of operation is most commonly required for emergency vehicles and railroad crossings. Pre-emption is also used for transit or HOV's and for other special needs that are not within the normal operation of the controller.

Pre-Emption Interface Card
One of the Input Modifier Cards, it provides an electrical interface between external pre-emption request devices and the controller unit. It enforces the relative priority of external devices to ensure that the controller unit receives only one request at a time. It controls lights in the intersection that signal to approaching emergency vehicles.

Pre-Emptor
A device which provides pre-emption.

Preferred Sequence
The normal order of phase selection within a ring having calls on all phases.

Pre-Formed Loop
A process whereby an encased loop is laid in place in the roadway prior to the final layer or "lift" of pavement being poured.

Presence Detection
The ability of a vehicle detector to sense that a vehicle, whether moving or stopped, has appeared in the detection zone. The sensor may cover a large area or be a series of small sensors wired together.

Presence Detector
A vehicle detector that can detect the presence or absence of a vehicle within its detection zone.

Presence Holding Time
The time that a detector unit will continue to indicate the presence of a vehicle in its detection zone without adjustment. Upon making an adjustment, the actuation is terminated. NEMA requires that a Class 2 vehicle (large motorcycle) be detected for a minimum of 3 minutes.

Presence Mode — The operation of a vehicle detector whereby the detector produces a continuous output when detection occurs, as long as a vehicle remains within the detection zone. This definition does not imply that the use of this mode guarantees that the output will continue indefinitely. Most detectors are incapable of maintaining a call beyond a finite interval.

Pressure-Sensitive Detector — A detector that is capable of sensing the pressure of a vehicle passing over the surface of its sensor.

Pre-Timed Controller Assembly — See "*Fixed-time Controller Assembly*"

Primary Feed — The 120 Vac single-phase input to the controller assembly from the local power distribution system. The primary feed includes the neutral conductor.

Priority-Traffic Phase Selection — A means by which, upon demand from priority traffic, the right-of-way for such traffic is obtained or modified.

Probe — The form of sensor that is commonly used with a magnetic type detector.

Processor — See "*Microprocessor*"

Programmable Signal Head — See "*Adjustable Signal*"

Progression — A coordination method based on offsets between intersections along an arterial.

Progressive Flow — Coordinated movement along an arterial at a given speed.

Protected Left Turn — A traffic movement for left-turning vehicles that has its own separate red, yellow and green indications. The green indication is in the form of a solid green arrow. Left turns are only permitted during the green interval of the left-turn movement. The green interval occurs either with an opposing protected left-turn movement or with the adjacent through movement.

Protected/Permissive Left Turn A traffic movement for left-turning vehicles that has a separate yellow and green indication but no red indication. The green indication is in the form of a flashing green arrow and the yellow indication is in the form of a solid yellow arrow. Left turns are permitted during the left-turn green interval and during the green interval of the adjacent through movement. The green interval occurs either with an opposing protected/permissive left-turn movement or with the adjacent through movement.

Pull Box See "*Junction Box*"

Pulse Mode The operation of a vehicle detector whereby the detector produces a short output pulse when detection occurs, regardless of the length of time the vehicle occupies the detection zone.

Quadrupole A loop geometry that includes an additional longitudinal saw cut along the centre of the rectangle so that wire can be installed in a figure-eight pattern. The design improves the sensitivity to small vehicles.

Quality Factor (Q) A numerical index for rating the quality of a resonant circuit. A higher number indicates fewer losses and increased detection sensitivity in a resonant-type (inductive) detector system.

Queue A platoon, or group of vehicles waiting at an intersection.

Queue Detector A component of a traffic control system that senses the presence or number of vehicles waiting in a queue at an intersection or freeway ramp.

Queue Length The number of vehicles that are stopped or slowly moving in a line.

Rack Mounted Devices Electrical devices that have no enclosure and must therefore be placed in the controller assembly by insertion into a rack or cage.

Radar Detector A vehicle detector capable of being activated by the passage of a vehicle through its field of emitted microwave energy.

Radio Frequency Detector A vehicle detector consisting of an antenna embedded in the roadway that receives signals from a vehicle-mounted transmitter.

Radio Frequency Interference Filter A device inserted in the power line of the controller assembly that minimizes the transmission of radio frequency interference from the power line into electronic devices within the controller assembly.

RAM Random Access Memory. A memory storage device with both read and write capabilities. Any memory location can be randomly accessed without the need to sequentially read through all prior memory locations. RAM devices are typically used only during the operation of the system in which they are installed, and all data is lost when power is removed. Special devices called "Battery-Backed-Up" RAM can be used for semi-permanent storage of data and will retain data when primary power is removed.

Real-Time Clock A timing device which measures real-world timing parameters (year, month, day, hour and second).

Recall An operating mode of an actuated controller whereby a phase is serviced during each cycle whether or not an actual demand exists for that phase.

Recall Switch A manual switch that, when operated, causes the automatic return of the right-of-way to its associated phase.

Receiver The portion of a detector which receives signals from a sensor.

Red Clearance Interval A clearance interval that may follow the yellow interval during which both the terminating phase and the next right-of-way phase display red - allows vehicles to clear the intersection.

Rejection The ability of a detector to avoid unwanted actuation caused by a vehicle in an area adjacent to its detection zone.

Relay Interface Card — One of the Input Modifier Cards, it is a general-purpose device for special interfacing or control applications. It is used when functions are required that are not provided by the controller unit or any of the other Input Modifier Cards.

Remote Flash — A controller unit input which manually places the intersection into flashing operation.

Rephase — The process of detector resetting, after a pulse actuation, to enable another pulse actuation to occur.

Resin — An organic substance that is non-conductive and is commonly used for insulation and encapsulation of loops.

Resistance — The opposition that a device or material offers to the flow of electrical current. The unit of resistance is ohms, often expressed in kilohms (Kohms), thousands of ohms or megohms (Mohms), millions of ohms.

Resonant Frequency — The natural oscillation frequency of a loop system and the detector circuitry.

Response Time — The time required for a detector to sense a vehicle in its detection zone and produce an actuation.

Rest — The interval portion of a phase when present timing requirements have been completed.

Rest In Red — A controller unit operational mode whereby all directions are given a red signal in the absence of any demand.

Rigid Mast-Arm Mount — A mast-arm signal mount where the signal head is fixed, preventing any movement of the signal head relative to the mast arm.

Ring — A group of two or more sequentially timed and individually selected conflicting phases arranged to occur in an established order.

ROM	Read Only Memory. A memory storage device that, when programmed with data, can be read from by a microprocessor. See also "*EPROM*".
RS-232	An electrical specification for the point-to-point connection of two devices for serial communication. Typically used over short distances such as between a computer and a modem.
RS-485	An electrical specification for the multi-drop connection of two or more devices for serial communication. Typically used over long distances.
Sample Rate	The rate at which measurements of electrical signals or physical quantities are made.
Sampling Detector	Any type of vehicle detector used to obtain representative traffic flow information but not used for controller unit actuation.
Sampling Period	The length of time between successive samples.
Saw Cut (Slot)	A thin cutting in the road surface into which loop wire may be placed.
Scanning Detector	A multi-channel detector in which the loop(s) of each channel are sequentially energized.
Sealant	The material used in a saw cut of a loop to seal the wires in place.
Secondary Controller Assembly (Slave)	A controller assembly that operates traffic signals under the supervision of a master controller assembly.
Seconds per Actuation (S/A)	An actuated controller setting associated with variable initial interval. Each time a vehicle actuation occurs, the S/A value is successively added to itself until the total exceeds the MIN green time of the phase. The total becomes the new MIN green time up to the maximum variable initial interval.

Section Blank Door	A covering which closes the face of a signal section housing in which no optical unit is installed.
Section Door	A covering which closes the face of a signal section housing and supports the lens.
Section Housing	The part of a signal section that encloses, protects and supports the optical unit.
Self-powered Vehicle Detector	A detector buried in the pavement that uses a self-contained battery for power and remotely transmits vehicle actuations to the controller unit.
Self-Tracking Detector	A loop detector, not necessarily self-tuning, that can automatically compensate for environmental drift (e.g. temperature change).
Self-Tuning Detector	A loop detector that can automatically adapt its operation to the resonant frequency of the loop system.
Semi-Actuated Controller Assembly	See "Semi-Traffic-Actuated Controller Assembly"
Semi-Traffic-Actuated Controller Assembly	A type of traffic-actuated controller assembly in which traffic actuation is provided on one or more but not all approaches.
Sensing Zone	See "*Detection Zone*"
Sensitivity	As it relates to a loop system, sensitivity is the change in total inductance of the system due to a minimum vehicle presence in one loop, expressed as a percentage of the total loop system inductance. As it relates to a detector, sensitivity is the minimum inductance change, expressed in percent, resulting in an actuation.
Sensor	Traffic detection devices that permit the system master or local controller to obtain traffic flow information. Or, the sensing element of a detector.
Sensor Loop	An electrical conductor arranged to encompass a portion of the roadway to provide a detection zone.

Serviceable Conflicting Call A call which: occurs on a conflicting phase not having the right-of-way at the time the call is placed; occurs on a conflicting phase which is capable of responding to a call; when occurring on a conflicting phase operating in an occupancy mode, remains present until given its right-of-way.

Sheath The outer covering or jacket over the insulated conductors of a cable.

Shelf Mounted Devices Electrical devices that have an enclosing case and can be located in a controller assembly by placing them on a shelf.

Shield A conductive material surrounding the conductors (individually or overall) in a cable to reduce or eliminate the effect of external electrical interference.

Side Mount See "*Bracket Mount*"

Side-Fire Detector A vehicle detector with its sensor located to one side of the roadway.

Signal An optical device, electrically operated by a controller assembly, which communicates a prescribed action (or actions) to traffic.

Signal Backplate A thin strip of material that surrounds a traffic signal housing to provide a suitable background and contrast for the signal indications.

Signal Bus The 120 Vac power supply to the signal load switches. See also "*Flashing Bus*" and "*Three-Colour Bus*".

Signal Face A signal section or combination of signal sections, each capable of displaying its indication in one direction.

Signal Focal Point The point, within the optical unit, from which emitted light will be redirected by the reflector into a prescribed pattern. Typically the location of the signal lamp.

Signal Hardware A system of parts used to fix signal faces or sections in relation to each other to form a signal head.

Signal Head	An assembly containing one or more signal faces/sections.
Signal Indication	The illumination of a signal whereby the movement of vehicular or pedestrian traffic is controlled.
Signal Installation	All of the equipment and material involved in the control of traffic at one or more intersections operated by a single controller assembly.
Signal Lamp	That part of the optical unit which, when energized, provides the light source.
Signal Lens	That part of the optical unit through which light passes and is redirected into a prescribed pattern and filtered to a prescribed colour.
Signal Load Switch	See "*Load Switch*"
Signal Reflector	A contoured reflective surface that redirects the light from the light source (signal lamp) toward the lens.
Signal Section	The optical unit and section housing of a signal capable of displaying one unique indication.
Signal Shut-Down Switch	A manual switch to disconnect the operation of traffic control signals without affecting the power supply to other components in the controller assembly.
Simultaneous	A coordination method whereby all signals along an arterial give the same indications to a given roadway at a given time.
Simultaneous Gap-Out Inhibit	A controller unit feature that prevents a phase's passage timer from restarting once it has timed out. In normal dual-ring operation, the active phases in both rings must simultaneously gap-out before the controller can cross the barrier.
Single Entry	A mode of operation of a dual-ring controller unit in which one phase from a single ring may be serviced and timed alone if there is no demand for service in the other ring.
Single-Ring Controller Unit	A controller unit in which phases are selected and individually serviced in an established sequential order.

Slipfitter	A signal mounting bracket which facilitates the mounting of a signal head to the top of a post.
Small Area Detector	A detector system intended to detect vehicles at a spot location upstream of the stop line.
Socket	The part of a signal optical unit which supports the lamp and fixes the position of the light source (signal lamp) with respect to the focal point of the reflector.
Soft Recall	A form of extendable recall in which the associated phase is only serviced if no actual serviceable conflicting calls exist.
Software	A general term for computer programs.
Solid Spreader	A signal mounting bracket having solid arms radiating from a hub.
Solid-State Device	A device that is characterized by electrical circuits, the active components of which are semi-conductors, to the exclusion of electro-mechanical devices or tubes.
Sound-Sensitive Vehicle Detector	A detector that is actuated by the sound waves generated by the passage of a vehicle near its sensor.
Span Wire	A cable hung over the roadway between two poles from which signal heads may be suspended.
Span-Wire Hanger	A mounting bracket for supporting a signal head by clamping onto a span wire.
Span-Wire Mount	A signal head suspended over the roadway on cable.
Special Event Programming	See "*Exception Days*"
Speed Analysis System	A system composed of vehicle detectors and auxiliary logic that is used to compute the speed of vehicles in a lane(s) based on the time interval between the actuation of successive sensors.
Speed Trap	See "*Speed Analysis System*"

Splashover An unwanted detector actuation caused by a vehicle in an adjacent lane.

Splice Box See "*Junction Box*"

Split A division of the cycle length of a controller unit, normally expressed in percent, allocated to each of the various phases.

Split Selection See "*Adaptive Split Control*"

SSR Solid State Relay. A relay used in Ministry controller assemblies to control the operation of the mercury contactor and flash control relay. The SSR is energized by an output of the Pedestrian Vehicle Interface Card.

Standard Visor See "*Cutaway Visor*"

Start Delay Relay An electro-mechanical relay within the conflict monitor that applies a reset signal to the controller unit and Input Modifier Cards. The relay remains de-energized for 2.5 seconds upon power-up of the controller assembly. The reset signal is removed when the relay energizes. See also "*System Reset*" and "*External Start*".

Stop Bar See "*Stop Line*"

Stop Line A painted line across a roadway indicating the place where vehicles should stop at a red light.

Stop Timing A controller unit input which causes the suspension of timing of the current interval. The timing resumes from the same point when the input is turned off.

Storage Area The area, expressed in number of vehicles, between the stop line and an upstream detector.

Stretch Detector See "*Extended Call Detector*"

Subordinate Phase A traffic phase in which the right-of-way is dependent on the related operation (leading or lagging) of a specific independent phase. A subordinate phase cannot occur independently of its associated phase (parent phase).

Sync Pulse	An electrical signal generated by a master controller or external time clock for synchronization of a controller unit or units.
Synchronous	A synchronized condition. Two systems operate or communicate with a common time reference.
Synchronous Controller Unit	A controller unit in which the timing mechanism is controlled by and dependent on a suitable frequency standard such as the frequency of the alternating current source.
Synchronous-Motor Controller Unit	A controller unit operated by a synchronous motor that maintains a constant speed determined by the frequency of the power supply circuit.
System Detector	A detector located to provide information to a system master on the flow of traffic between coordinated intersections.
System Loops	See "*System Detector*"
System Reset	A reset signal to the controller unit and Input Modifier Cards that is applied by the conflict monitor start delay relay for 2.5 seconds upon power-up of the controller assembly. See also "*Start Delay Relay*" and "*External Start*".
Tapeswitch	A temporary detector sensor consisting of two strips of metal encased in a flat ribbon affixed to the roadway. The two strips of metal form a circuit when crossed by a vehicle.
TBR	Time Before Reduction. The time period before gap reduction takes place. See also "*Gap Reduction*".
TDM	Time Division Multiplexing. A technique for simultaneously transmitting several different signals over one communications channel by alternately transmitting a portion of each signal.

Terminal Compartment	A compartment having a terminal block for connecting signal-control wiring and which may support the signal face.
Terminals (Terminal Block)	An electrically conductive device serving as a point of connection between two or more conductors.
Three-Colour Bus	The output of the mercury contactor supplying 120 Vac power to the load switches during three-colour operation.
Three-Colour Operation	Intersection operation where normal signal indications are seen.
Threshold	A minimum level of percent change in inductance causing a detector actuation.
Through Band	See "*Band*"
Through Movement	A traffic movement which continues through the intersection in a straight line. I.e. not a turn.
Time Clock	An internal controller unit "circuit" for the automatic selection of modes of operation of traffic signals in a manner prescribed by a predetermined time schedule; an auxiliary device that provides a time synchronization signal to the controller unit, based on an external signal such as GPS or the universal time standard.
Time Reference Point	A time to which all intersection offsets are referenced. The beginning of the cycle, usually the start of arterial green, of a chosen intersection.
Time-Based Coordination	Coordinated operation in response to internally generated time clock commands (rather than synchronized to a master) to select cycle, split and offset.
Time-of-Day Patterns	Signal timing parameters selected according to the time of day (and/or day of the week).
Timing Plan	A specific set of phase-timing parameters that can be implemented based on some pre-determined criteria, e.g. time-of-day.

TN This Phase Next. See "*Phase Next*".

Traffic Controller Cabinet An outdoor enclosure designed for base, pedestal or pole mounting, providing protection, support, ventilation and security for the controller unit and associated equipment. In some cases, this term is understood to mean "controller assembly".

Traffic Phase Those right-of-way, change and clearance intervals in a cycle assigned to any independent movement(s) of traffic.

Traffic-Actuated Controller Assembly A controller assembly for supervising the operation of traffic control signals in accordance with varying traffic demands.

Trailing Car The vehicle behind the "last car" upon gap out in a density controller. Gap out occurs because the headway between the last car and the trailing car exceeds the allowable gap imposed by the controller.

Train Approach Signal A highway traffic signal that indicates the approach and passage of trains at a level crossing.

Transducer A sensor which transmits energy to the detection zone and receives a signal from the detection zone.

Transmitter The portion of a detector which transmits energy to a sensor.

TTR Time To Reduce. The total time for a gap reduction process to take place.

Tubular Bracket Arm A signal mounting bracket, of tubular construction, through which wiring can be passed to provide electrical connection of the signal.

Tubular Spreader A signal mounting bracket having tubular arms radiating from a hub through which wiring can be passed to provide electrical connection of the signal.

Twisted Pair Two insulated conductors twisted together, usually with one or more other twisted pairs in a cable. The use of twisted-pair cable reduces the effect of external electrical interference.

UL Underwriters' Laboratories. An organization that operates laboratories for the examination and testing of devices, systems and materials for the purpose of fire and casualty prevention and ensuring compliance with standards and regulations.

UL Approved A product that has been tested and approved by Underwriter's Laboratories. The product or device carries a label denoting approval. A special "ULC" approval is required for devices used in Canada.

Ultrasonic Detector A detector that is capable of sensing the passage or presence of a vehicle through its field of emitted ultrasonic energy.

Upstream The portion of roadway preceding the stop line.

Variable Initial Interval A controller unit feature which adjusts the duration of the initial interval for the number of vehicles in the queue. See also "*Maximum Variable Initial Interval*" and "*Seconds per Actuation*".

Vehicle Detector System A system for indicating the presence or passage of vehicles.

Vehicular Phase A phase that is allocated to vehicular traffic movement as timed by the controller unit.

Video Detection Systems A detection system that analyzes a video image of an intersection or approach and identifies vehicles in multiple defined detection zones.

Visor The part of a signal section that protects the lens from direct ambient light.

Volume Density Controller An actuated controller that has a gap-reduction factor based on opposing phase vehicle waiting time.

Warrants The results of a survey made at an intersection to determine if signalization is needed or requires change.

Waterblocked Cable jacket which is impervious to water entrance and migration.

Week Program A controller unit feature used to determine the type of operation according to a weekly schedule, which may vary from day to day.

Weigh In Motion (WIM) A system of detectors and weighing devices that can weigh and classify vehicles while in motion.

Yellow Change Interval The first interval following the green right-of-way interval in which the signal indication for that phase is yellow.

Yield Point A point in the cycle of a coordinated controller where the right-of-way may be given to opposing phases.

Zone of Detection See "*Detection Zone*"