BRITISH COLUMBIA

Ministry of Transportation and Infrastructure

TRAFFIC CONTROLLER ASSEMBLY MANUAL
VOLUME 2

Electrical and ITS Engineering

June 2019

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PREFACE

This manual will be distributed to the participants in the TS2 Traffic Controller Assembly course presented on behalf of the BC Ministry of Transportation and Infrastructure's Electrical and ITS Engineering.

This 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 activities.
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 NEMA TS2 Controller Assemblies.
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. Repairs to faulty electronic components are not typically conducted by Electrical Maintenance Personnel. Controller assembly components are therefore 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 personnel to identify faulty components in the event of a traffic controller assembly malfunction.
4. 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 is journeymen electricians or senior apprentices performing maintenance activities on behalf of the Ministry of Transportation and Infrastructure.

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.

British Columbia
Ministry of Transportation and Infrastructure

TRAFFIC CONTROLLER ASSEMBLY MANUAL
VOLUME 2

Section 100

Configuration of Common Ministry Intersections

Electrical and ITS Engineering

June 2019

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 typical controller operation, 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 Traffic movement diagrams are used to describe the operation of a traffic signal (*Figs. 2 and 3*). Study carefully *Figure 1* and the following explanations of the symbols used in these diagrams.

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

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

.1 A left turn movement designation with an arrow above it in a circle (e.g. $\overrightarrow{A1}$, $\overrightarrow{A2}$, $\overrightarrow{B1}$ or $\overrightarrow{B2}$) 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 (the protected portion of the movement), followed by a solid yellow arrow (*Fig. 2*). 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. After the arrow signal terminates, traffic may continue to turn left throughout the green portion of the adjacent through movement when breaks in traffic occur (the permissive portion of the movement). Left turn traffic is halted by the yellow and red signals of the adjacent through movement.

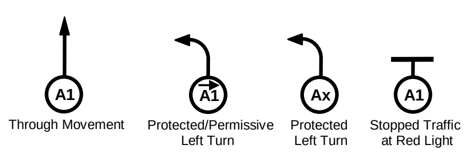


Figure 1. Legend of Traffic Movement Symbols

.2 A left turn movement 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 2 and 3*.

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 2 and 3* show the phase assignments for a north-south and east-west highway.

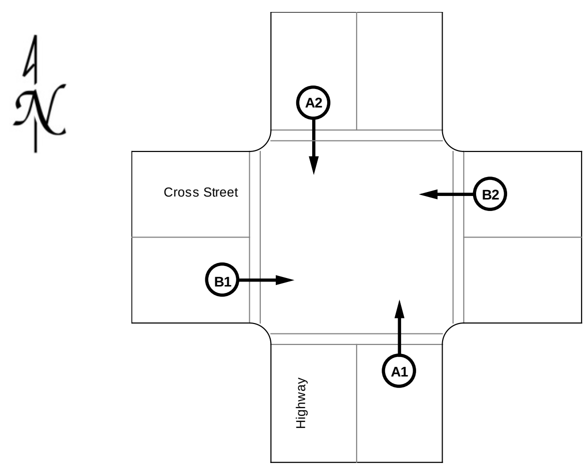


Figure 2. Direction Assignments for a North-South Highway

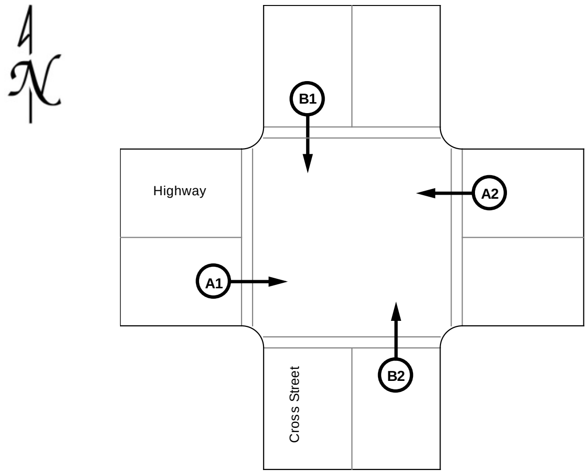


Figure 3. Direction Assignments for an East-West Highway

.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**.

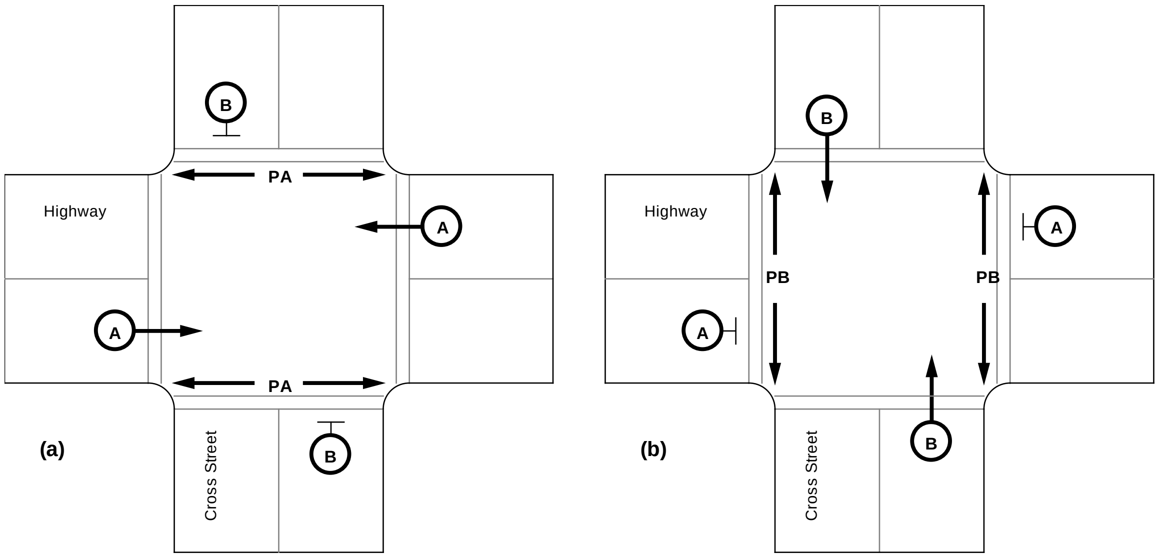


Figure 4. Transfer of Right-of-Way at a Two-Phase Intersection

.2 A single transfer of right-of-way is shown in *Figure 4*. In *Figure 4 (a)* the ∅A traffic (with associated pedestrian movement) has a green light, while ∅B traffic is halted by a red light. In *Figure 4 (b)*, the signal displays are reversed. Detailed site plan (TE) drawings of the intersection are found at Electrical and ITS Engineering and inside the traffic controller assembly. The TE drawings include a Signal Display Diagram similar to the figures 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 5 (a) and (b)* show the two phases of traffic movement at a T-intersection. In this case, vehicles approaching from the cross street must turn either 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 5 (c)*.

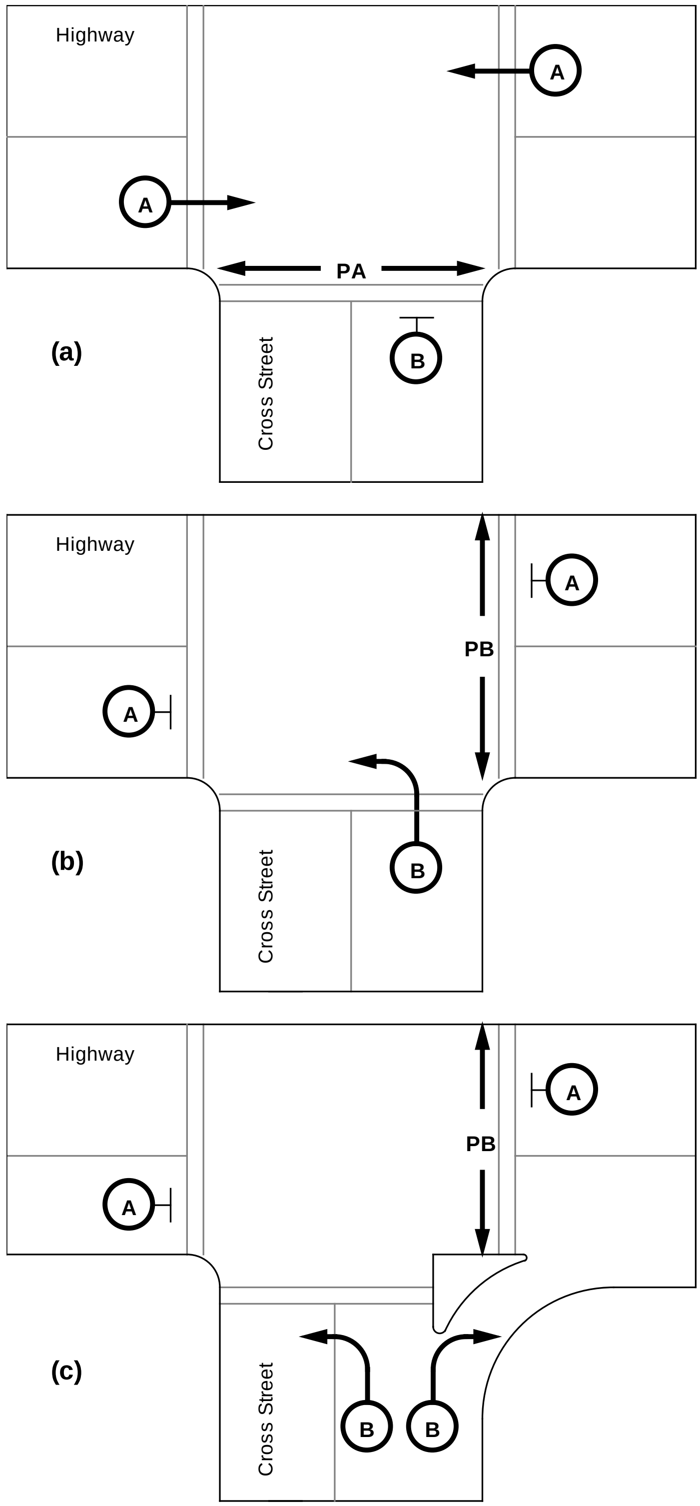


Figure 5. Transfer of Right-of-Way at a Two-Phase T-Intersection

103 INTERVALS AND COLOUR SEQUENCES

103.1 INTERVALS AND COLOUR SEQUENCES

.1 The signals at an intersection are in a fixed colour state at any given instant in time. The period of time during which any state prevails is referred to as an interval. Intervals and colour sequences are illustrated in *Figure 6* as follows:

.1 **Interval 1.** Suppose that traffic on the main highway has the right-of-way. This condition would prevail over a certain period of time – in other words, for a given interval. During this interval, the lights facing the highway traffic would be green, while those directed towards the cross-street would be red. That combination of colour for this interval is shown in the table shown in *Figure 6 (a).*

.2 **Interval 2.** Now in order to transfer the right-of-way to phase B traffic safely, the drivers of phase A vehicles must be warned that the transfer is about to occur so they can stop. The signals therefore must change for a second interval in which a yellow light is displayed to traffic on the highway while phase B traffic is still halted by a red light. The colour sequence table now shows two intervals in *Figure 6 (b).*

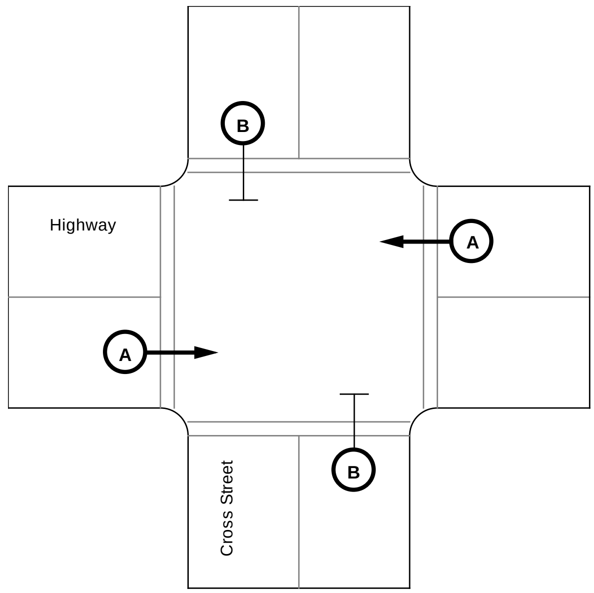
.3 **Interval 3.** In the third interval, the signals turn red for the highway and remain red for the cross-street. This all red clearance provides safe clearance for traffic still waiting to turn left in the middle of the intersection. This red time is only cautionary, as the yellow light should provide adequate clearance for highway traffic to stop. *Figure 6 (c)* shows the all red interval added to the colour sequence table.

.4 **Interval 4.** In the fourth interval the signals remain red for highway traffic and turn green for cross-street traffic. At this point the right-of-way has been transferred from phase A to B vehicles. Refer to *Figure 6 (d).*

.5 **Interval 5.** To reverse the transfer of right-of-way a fifth interval is needed with the highway traffic red and the cross-street yellow. Refer to *Figure 6 (e).*

.6 **Interval 6.** This would then be followed by another interval in which both traffic directions display all red again. *See Figure 6 (f).*

.7 The entire sequence of signals is now completed when the lights turn red for phase B traffic and green for phase A vehicles. In our colour sequence chart the colours have now returned to Interval 1.



Phase	Interval	
	1	
A	G	
B	R	

(a)

Phase	Interval		
	1	**2**	
A	G	Y	
B	R	R	

(b)

Phase	Interval			
	1	**2**	**3**	
A	G	Y	R	
B	R	R	R	

(c)

Phase	Interval				
	1	**2**	**3**	**4**	
A	G	Y	R	R	
B	R	R	R	G	

(d)

Phase	Interval					
	1	**2**	**3**	**4**	5	
A	G	Y	R	R	R	
B	R	R	R	G	Y	

(e)

Phase	Interval					
	1	**2**	**3**	**4**	5	**6**
A	G	Y	R	R	R	R
B	R	R	R	G	Y	R

(f)

Figure 6. Intervals and Colour Sequence Chart

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 coordinated. 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 500* 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 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 still favouring highway traffic.

.2 Intersections such as the one just described were once 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 then 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 Fully-actuated signalized intersections are now the standard and therefore the most common type of Ministry traffic controller assembly.

.2 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.

.3 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 7* 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 1* shows the colour sequence.

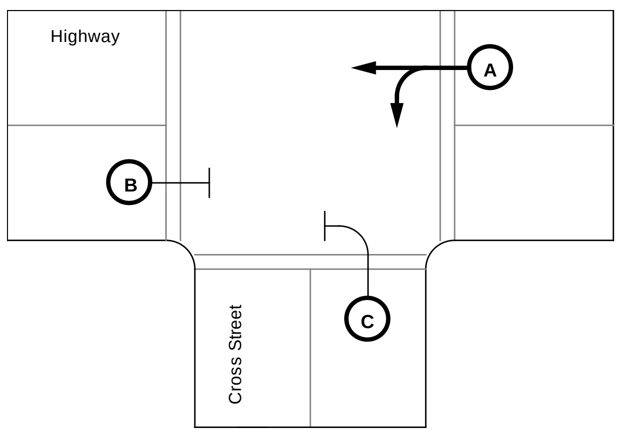


Figure 7. Three-Phase T-Intersection

Table 1. Colour Sequence for a 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

106.2 PROTECTED/PERMISSIVE LEFT TURN ON THE HIGHWAY

.1 Refer to the intersection shown in *Figure 8 (a) to (c)* where there are three true traffic phases: $\overrightarrow{A1}$, A2 and B. The remaining A1 movement which can be on (i.e. green) with either ∅$\overrightarrow{A1}$ or ∅A2 is referred to as an **overlap** rather than a phase because it does not have a fixed place in the signal cycle, nor does it have vehicle detection to call it. Its green output simply overlaps (is on with) the green of its parent phases (∅$\overrightarrow{A1}$ or ∅A2). These three movements share a common alphabetical label **A** to indicate their concurrency (i.e. grouping) since the ∅A1 overlap green signal is always on when ∅A2 is green or when ∅$\overrightarrow{A1}$ 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 a protected/permissive left turn (∅ $\overrightarrow{A1}$) on the highway.

.2 Let us assume that traffic demands are equal and continuous from all directions. Refer to *Figure 8 (a) to (c)* and *Table 2* for the following description of how the intersection operates:

.1 During Interval 1, the right-of-way remains with ∅A1 and ∅A2 traffic. ∅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 h**a**lted 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 ∅$\overrightarrow{A1}$ 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.

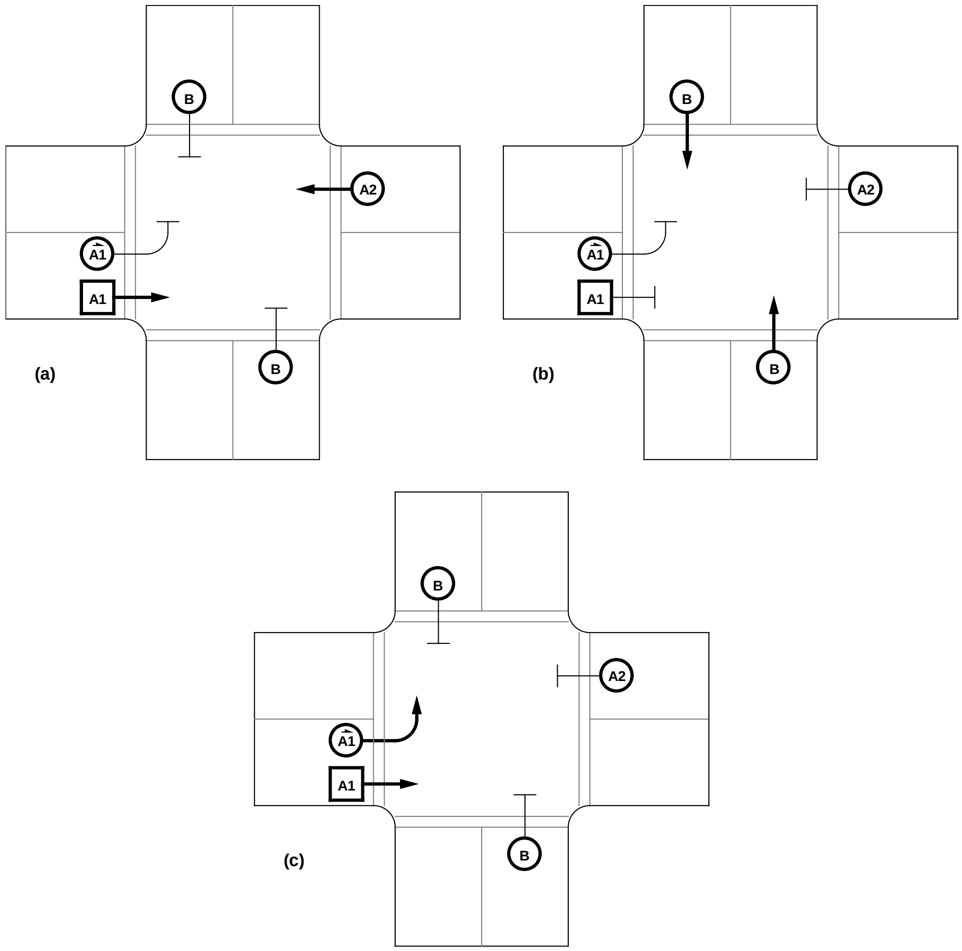


Figure 8. Three-Phase Intersection with Protected/Permissive Left Turn on the Highway

Table 2. Colour Sequence for a Three-Phase Intersection with Protected/Permissive Left Turn on the Highway

Interval	∅A1	∅A2	∅B	∅$\overrightarrow{A1}$
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	-

.7 At the end of the advance left turn time, the $\varnothing\overrightarrow{\text{A1}}$ first turns to a solid yellow arrow during Interval 8, followed by blank in Interval 9. Note that $\varnothing\overrightarrow{\text{A1}}$ is blank in all intervals except Intervals 7 and 8, even though it is technically 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 *Figure 9* the protected/permissive left turn arrow is provided for one direction of the cross street rather than 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, $\varnothing\overrightarrow{\text{B1}}$ and ∅B2. Assuming demand for all cross street movements, when the right-of-way is transferred from the highway to the cross street the $\varnothing\overrightarrow{\text{B1}}$ green arrow will flash and the ∅B1 overlap will be a solid green light. In this interval ∅B2 traffic remains stopped at a red light. Once the $\varnothing\overrightarrow{\text{B1}}$ yellow arrow and red clearance have terminated, both ∅B2 and ∅B1 are solid green. After the ∅B2 and ∅B1 yellow and red clearances terminate the right-of-way returns to the highway ∅A traffic. The intersection rests in this Interval 1 until there is again demand from cross-street traffic.

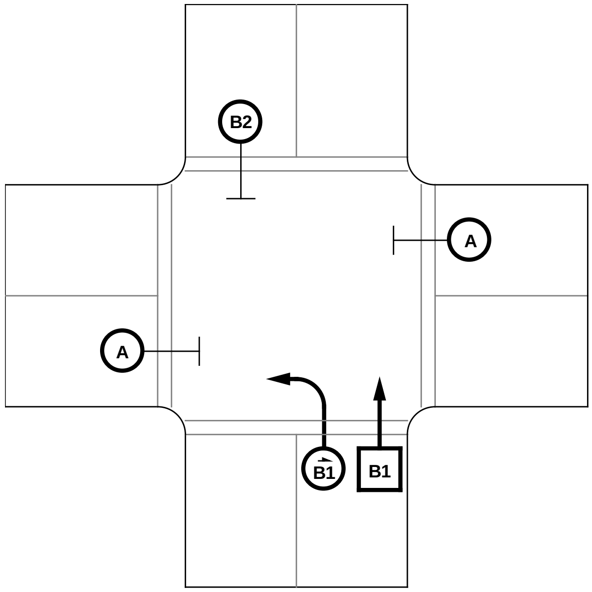


Figure 9. Three-Phase Intersection with Protected/Permissive Left Turn on the Cross Street

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

Interval	∅A	$\varnothing\overrightarrow{B1}$	∅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

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 10* shows an example of such an intersection.

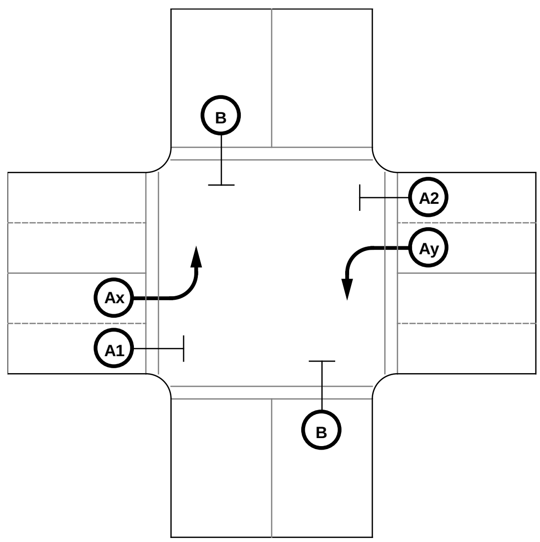


Figure 10. Five-Phase Dual Left Turn Intersection

Table 4. Colour Sequence for a 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

.2 This intersection is configured to the NEMA Dual Ring standard. A ring refers to a group of phases that are serviced sequentially. There are two rings of four phases each. However not all phases must be used at an intersection. *Figure 11* shows the NEMA Dual Ring structure and how phases for this intersection fit within it. It is quite simple to understand how an intersection operates in a NEMA Dual Ring structure once you know the rules:

.1 Only one phase from each ring may be green at the same time.

.2 Phases that are green at the same time must be on the same side of the Barrier (left side or right side).

.3 The phase sequence for each ring is from left to right (lowest to highest).

.4 Once you reach the end of a ring you return back to its beginning.

		Barrier →		
RING 1 →	∅1 = ∅Ax	∅2 = ∅A1	∅3 = Not Used	∅4 = ∅B
RING 2 →	∅5 = ∅Ay	∅6 = ∅A2	∅7 = Not Used	∅8 = Not Used
			← Barrier	

Figure 11. NEMA Dual Ring Structure of a Five-Phase Dual Left Turn Intersection

.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 12 and 13*. 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 similarly heavy left-turn demand from eacch side of the cross street, two entirely independent phases, B and C are used as shown in *Fig. 12*. This is done to maximize the cross-street left-turn time by allowing it to be on throughout the adjacent through movement. This method is used when normal advance left turn time cannot be suitably increased without adversely affecting the traffic flow on the highway. It is also used when there are geometric conflicts between opposing left turns.

.2 Traffic from one cross-street direction remains stopped while vehicles from the opposing direction are allowed to proceed through and 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.

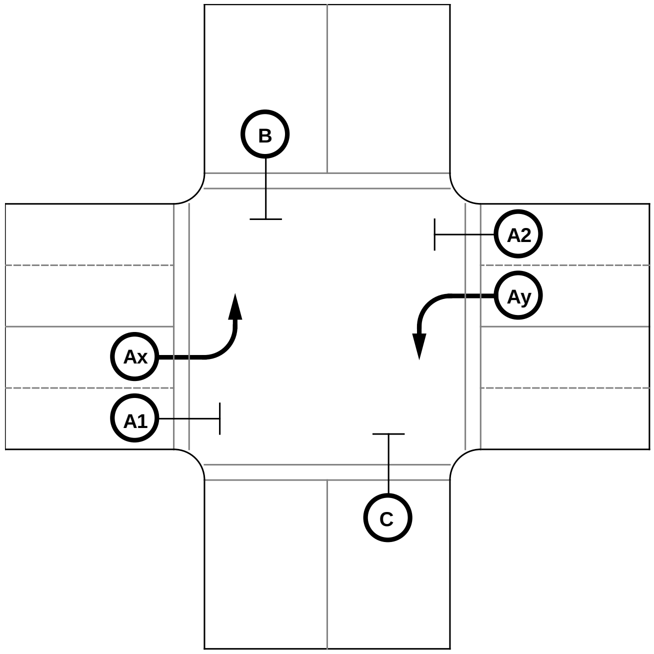


Figure 12. Six-Phase Dual Left Turn with Split Cross Street

Table 5. Colour Sequence for a 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

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, ∅$\overrightarrow{\text{B1}}$, on the B movement is used as shown in *Fig. 13*. Cross street through traffic is split into ∅B1 overlap and ∅B2. If, unlike this case, one of the through movements is not programmed as an overlap, a seven-phase configuration results. Refer to *Section 108.2* for seven-phase intersections.

.2 The ∅B1 overlap signal is green and ∅$\overrightarrow{\text{B1}}$ traffic is given a flashing green arrow while the ∅B2 traffic remains halted (Interval 7). Following the yellow arrow and red clearance of ∅$\overrightarrow{\text{B1}}$, ∅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.

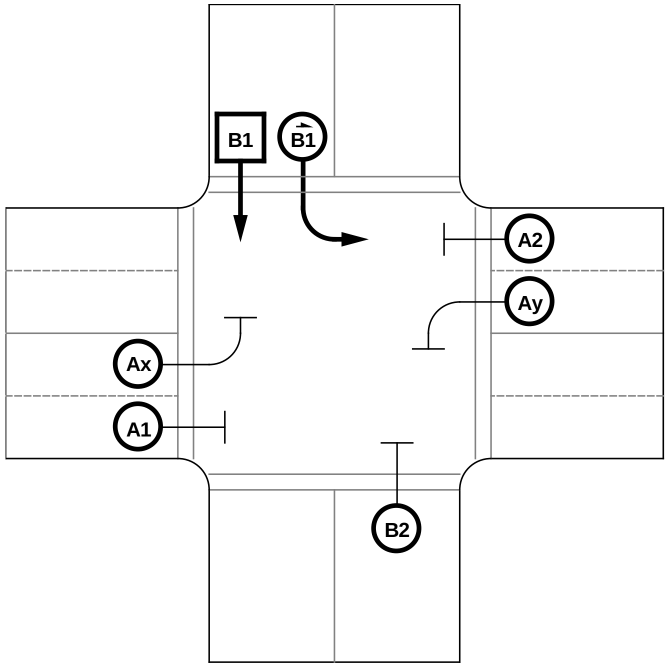


Figure 13. Six-Phase Dual Left Turn with Protected/Permissive on the Cross Street

Table 6. Colour Sequence for a Six-Phase Dual Left Turn with Protected/Permissive on the Cross Street

Interval	∅Ax	∅Ay	∅A1	∅A2	∅$\overrightarrow{B1}$	∅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

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. However, in this case the through movement with the protected/permissive left turn is programmed as a true phase, instead of an overlap. This results in the seven-phase configuration shown in *Figure 14*. The protected/permissive left turn is shown on ∅B2 in this example.

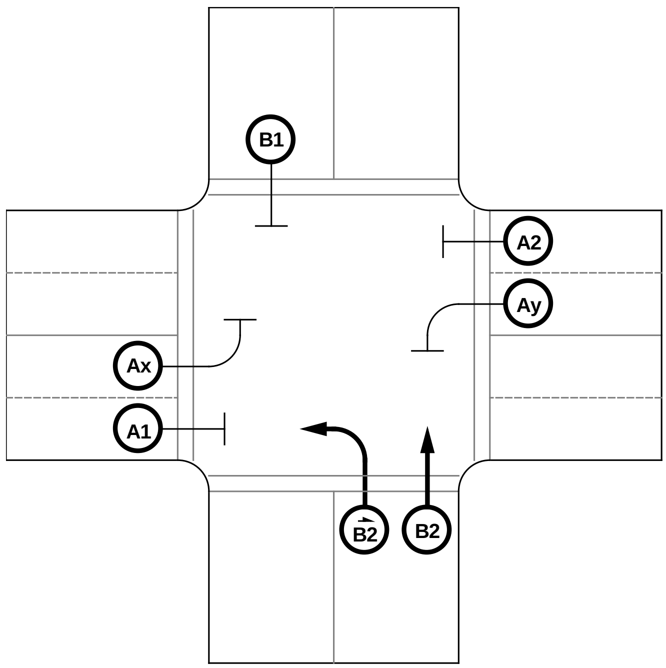


Figure 14. Seven-Phase Dual Left Turn with Protected/Permissive on the Cross Street

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 15* and *Table 7*. This is a NEMA 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 left-turn green arrow.

109.2 QUADRUPLE PROTECTED/PERMISSIVE LEFT TURN

.1 The eight phase, quadruple protected/permissive left turn configuration is similar to the previous eight phase 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 16* and *Table 8*.

.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.

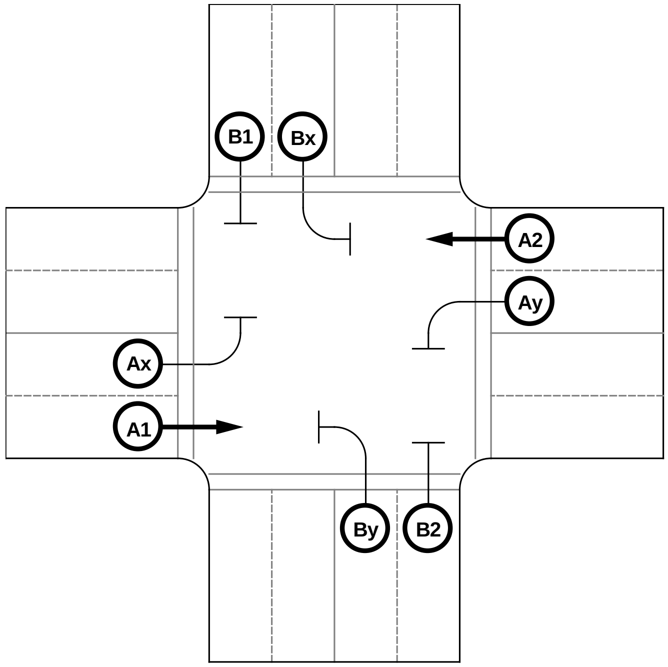


Figure 15. Eight-Phase Quadruple Protected Left Turn

Table 7. Colour Sequence for an 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

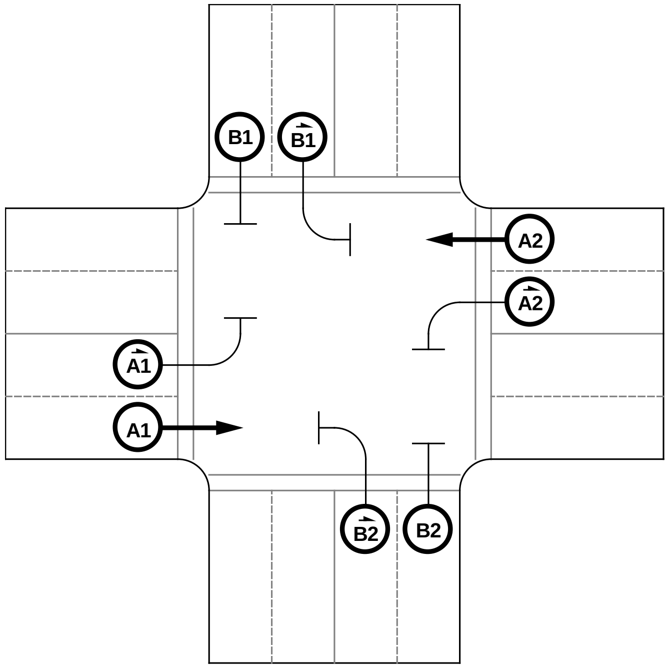


Figure 16. Eight-Phase Quadruple Protected/Permissive Left Turn

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

Interval	∅$\overrightarrow{A1}$	∅$\overrightarrow{A2}$	∅A1	∅A2	∅$\overrightarrow{B1}$	$\overrightarrow{B2}$	∅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

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 17*, 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.

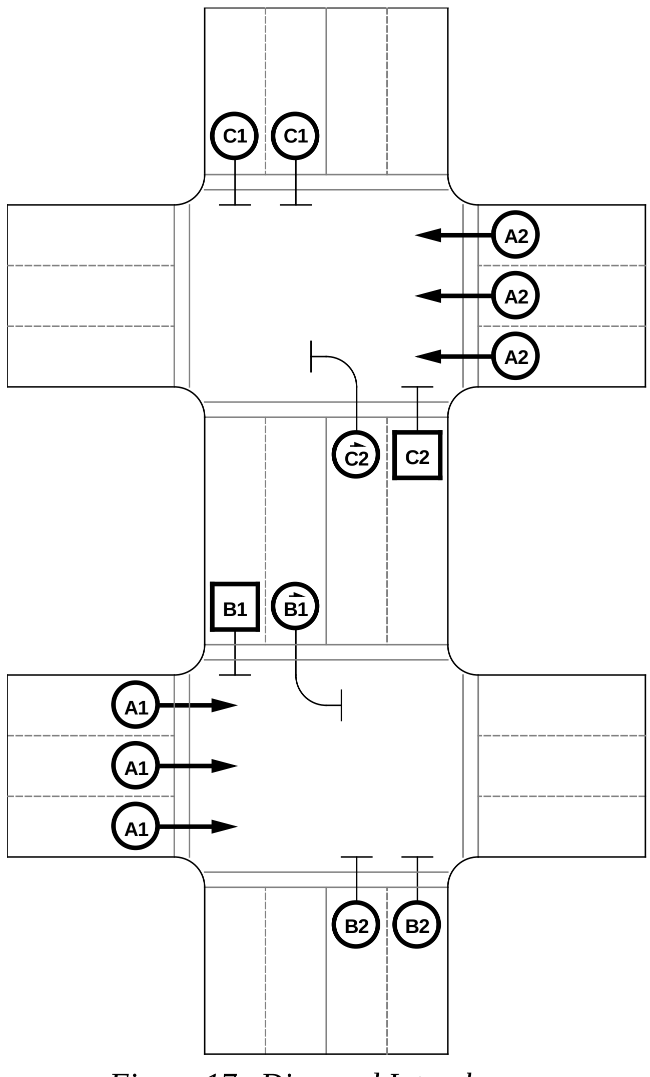


Figure 17. Diamond Interchange

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 its associated 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 travelling at the speed limit 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 703.*

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), off-ramp congestion, and for other special needs that are not within the normal operation of the traffic controller assembly.

.2 A special set of instructions called a Pre-Emption 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-emption 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. However, pre-emption operation typically remains in effect as long as the request for pre-emption prevails, i.e. until the train, ambulance or fire engine has passed by. Unlike rail pre-emption, emergency pre-emption is typically programmed with a maximum pre-emption call time of 180s. After 3 minutes of a constant call from an ambulance or fire engine it is assumed that there is a malfunction in the pre-emption equipment and normal signal operation is allowed to resume.

.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-emption sequence program the traffic controller assembly returns to normal operation. For more information on pre-emption, refer to *Chapter 704*.

TRAFFIC CONTROLLER ASSEMBLY MANUAL

VOLUME 2

Section 200

TS2 Traffic Controller Assembly

Electrical and ITS Engineering

June 2019

201 INTRODUCTION

201.1 GENERAL DESCRIPTION

.1 The TS2 traffic controller assembly is housed in a double-door pad-mounted enclosure containing all of the devices and circuitry necessary for the control of an intersection. The Ministry has standardized the manufacture of a single TS2 traffic controller assembly. Although there may be some minor variations between manufacturers, the general layout and function of the TS2 controller assembly is maintained. The Ministry uses a letter and number designation to identify all its traffic controller assembly models. The current TS2 traffic controller assembly has been assigned the designation **P6**.

.2 With legacy **M** & **S** TS1 controller assemblies, the type of control required at a given intersection determined the choice of traffic controller assembly used. The P6 controller assembly is the only TS2 assembly used and can be configured to control any typical Ministry signal regardless of the number of phases or special features required.

.3 This section describes the location and purpose of the devices within the P6 TS2 traffic controller assembly. 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 P6 traffic controller assembly. *Sections 300 to 700* of this document describe the different groups of equipment which make up the P6 assembly.

201.2 TS2 AND TS1 DIFFERENCES

.1 TS1 cabinets use a parallel systems architecture. That is, all controller unit, detectors, input modifier cards, load switches and other component inputs and outputs (I/Os) are wired to their own terminals on the backboard. Connections between the TS1 assembly components are then made with additional wiring between these terminals in a switchboard fashion. The downside of this architecture is that troubleshooting can be difficult with all the terminals and conductors present in the cabinet.

.2 TS2 cabinets use a serial systems architecture. Rather than all I/Os having their own terminals as with the TS1, the state of all I/Os are transmitted to all critical components via the Synchronous Data Link Control (SDLC) communication bus. This reduces the number of conductors in the cabinet which eases troubleshooting operational problems. In the TS2 architecture the Controller Unit and Malfunction Management Unit have their own SDLC ports on their front panels. To interface the parallel I/Os of vehicle detectors and load switches to the TS2 assembly a Bus Interface Unit (BIU) is required. BIUs communicate on the SDLC bus and constantly update the Controller Unit inputs with the current state of the detector inputs. They also constantly update the load switch inputs with the current Controller Unit output states. A BIU is required for each vehicle detector rack and for each row of load switches.

201.3 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 (from the controller unit) to control high-voltage signals (to the field signals).

.3 Electronic devices within the traffic controller assembly such as the Controller Unit, Malfunction Management Unit and any rack-installed cards all use low-voltage, 24 VDC signals. The Power Supply Unit 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 inputs and outputs within the traffic controller assembly are typically Active-Low signals. Therefore 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 THE P6 TRAFFIC CONTROLLER ASSEMBLY

202.1 INTRODUCTION

.1 The standard TS2 traffic controller assembly, shown in *Figure 18*, is designed for use at all intersections.

.2 The base-mounted P6 assembly is the current standard TS2 model used by the Ministry of Transportation and Infrastructure.

202.2 GENERAL DESCRIPTION

.1 The P6 traffic controller assembly consists of an aluminum enclosure measuring approximately 56 high by 44 wide by 26 deep.

.2 It has two front doors for all 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 louvers in the doors and exhausts through a vent in the soffit of the enclosure roof.

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

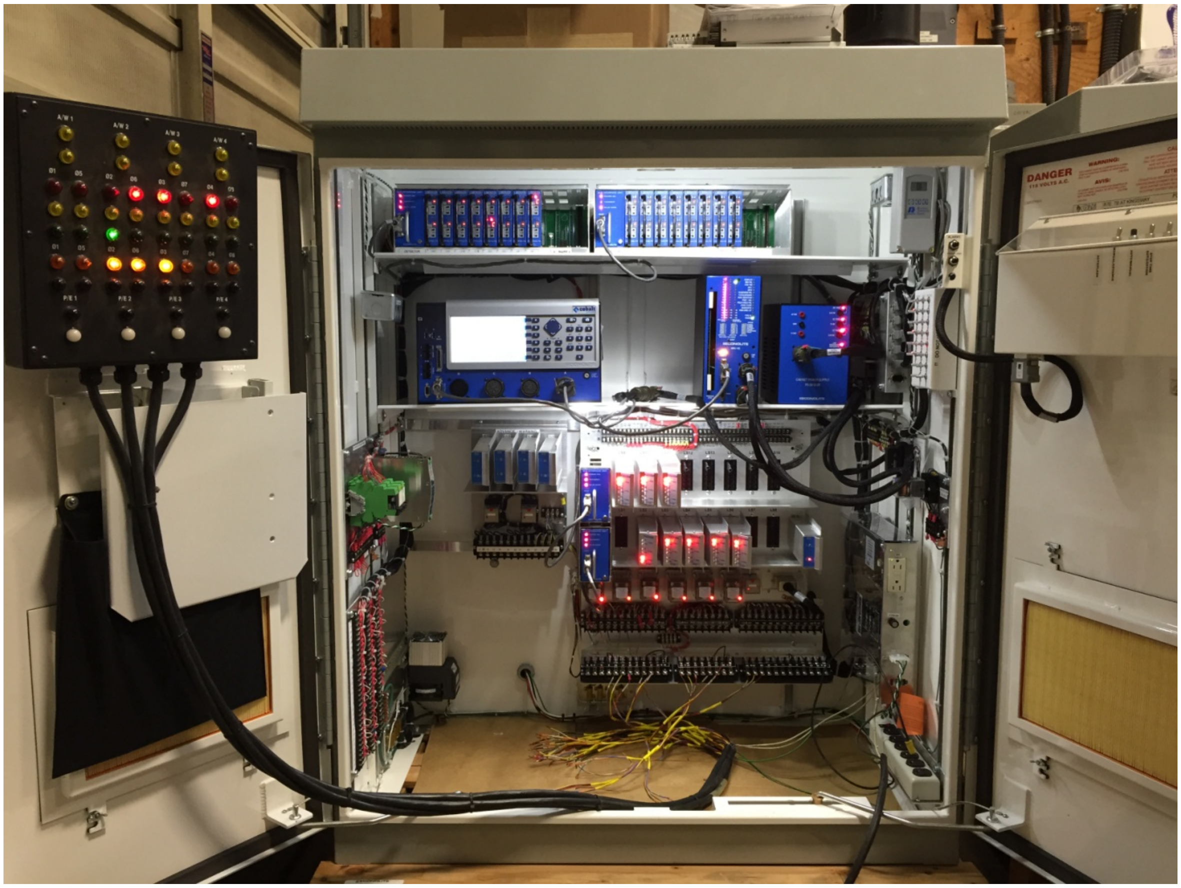


Figure 18. The P6 TS2 Traffic Controller Assembly

202.3 EQUIPMENT LAYOUT

202.3.1 Enclosure Interior

.1 All equipment in the P6 traffic controller assembly is mounted on the interior walls of the enclosure. Two shelves are installed in the top of the enclosure. *Figure 19* shows the equipment on the P6 shelves.

.2 The top shelf accommodates the two Vehicle Detector Racks which house the Vehicle Detector Cards. Each rack requires a Bus Interface Unit (BIU) in the left slot to interface the rack I/Os with the serial SDLC communications bus. Refer to *Section 500* for more detail.

.3 The bottom shelf accommodates the Controller Unit (CU), the Malfunction Management Unit (MMU) and the Power Supply Unit (PSU).

Each of these devices sits free on the shelf. Electrical connections to these devices are made by wiring harnesses which connect to their front panels. The wiring harnesses are referred to by the names:

- MS-A and SDLC for the CU,
- MMA, MMB and SDLC for the MMU and
- PS-P1 for the PSU.

The other ends of the SDLC cables are connected to the Power Bus Panel (PBP) which receives power from the PSU and distributes SDLC communications throughout the enclosure. The PBP also distributes power to each shelf mounted device via their front panel circular connector(s). Refer to *Sections 300, 400 and 600* for more detail on the CU, MMU and PSU respectively.

.4 Below the bottom shelf on the back wall of the cabinet (*Fig. 20*) is a fuse panel with eight 10A fuses protecting the 120VAC inputs of the load switches. Refer to *Section 702* for more detail.

.5 Adjacent to the fuse panel is the Advance Warning Interface. This panel interfaces the controller unit's 24VDC phase outputs and translates them into 120VAC flashing outputs for the Advance Warning Signs in the field. Refer to *Section 703* for more detail.

.6 Below the fuse panel are two terminal strips connected to a limited set of the CU Inputs & Outputs. These I/Os can be used at the electrician's discretion *e.g.* to interface phase outputs with the Advance Warning Interface or to create a ramp congestion pre-emption sequence from the output of a vehicle detector. *Section 303* describes the available I/Os in more detail.

.7 Below the CU I/O terminals are the Load Switches which interface the 24VDC control signals to the 120VAC outputs to signals in the field. Each row of Load Switches requires a BIU to interface CU control signals on the SDLC communications bus with the 24VDC control of the Load Switches. *Section 702* covers load switches and the field outputs in further detail.

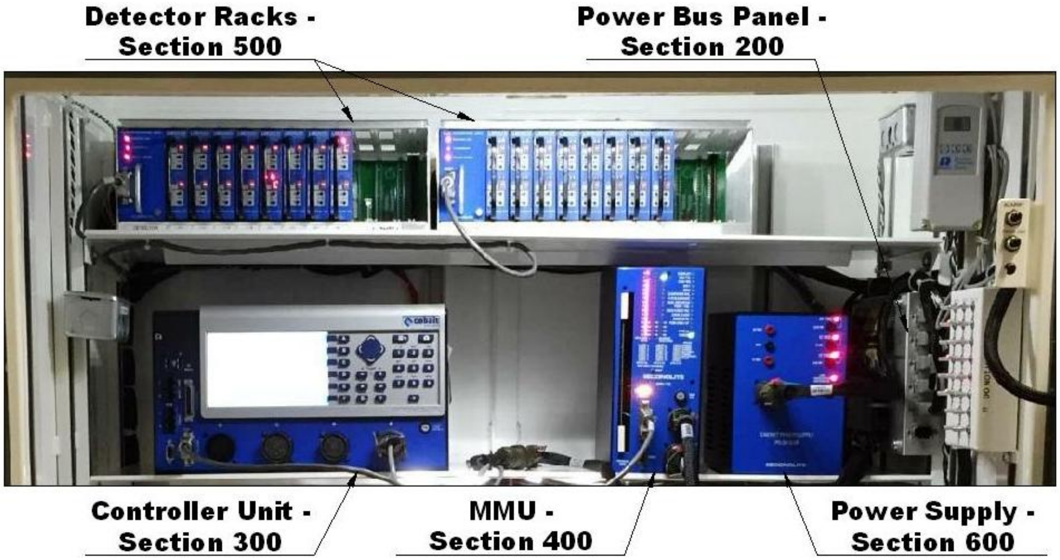


Figure 19. The P6 TS2 Traffic Controller Shelf Equipment

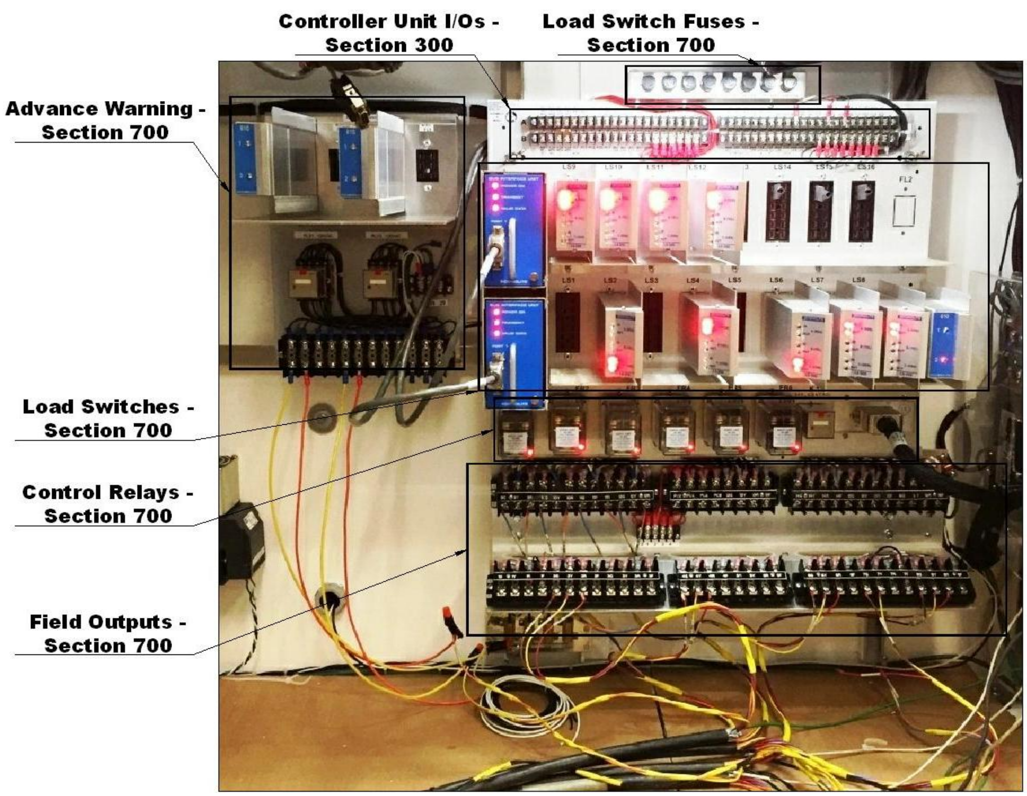


Figure 20. The P6 TS2 Traffic Controller Back Wall Equipment

Figure 21. The P6 TS2 Traffic Controller Left Wall Equipment

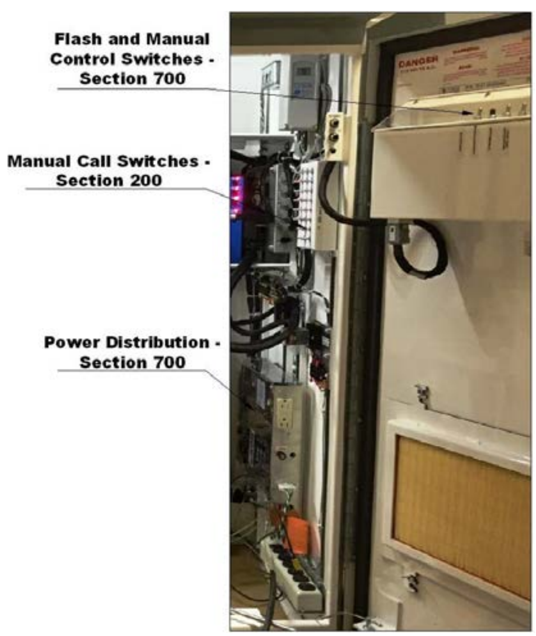


Figure 22. The P6 TS2 Traffic Controller Right Wall Equipment

.8 At the bottom-rear of the enclosure are two 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 bottom row of terminal blocks which are used for the field connections to the signals. The Malfunction Management Unit channel inputs are connected here as well.

.9 The Pre-Emption Interface panel is located on the left side of the enclosure (*Fig. 21*). All pre-emption inputs from the field are terminated on this panel. The pre-emption interface is detailed in *Section 704*.

.10 Below the Pre-Emption Interface on the left side are the terminals used for the field connections to detector loops and pedestrian pushbuttons.

.11 A manual-call panel is mounted on the right side of the enclosure (*Fig. 22*). The switches on this panel can be turned on to place momentary or fixed calls to vehicle and pedestrian phases.

.12 Below the manual-call 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. Cabinet power distribution is described in *Section 701*.

.13 The top right corner of the enclosure is where the thermostat is located to control the cabinet heater and fan temperature set points.

TRAFFIC CONTROLLER ASSEMBLY MANUAL

VOLUME 2

Section 300

Controller Unit

Electrical and ITS Engineering

June 2019

301 ECONOLITE COBALT TRAFFIC CONTROLLER UNIT

301.1 GENERAL SPECIFICATIONS

.1 At the heart of any traffic signal control system is the Controller Unit. This device is also called the mainframe. The Econolite Cobalt (*Fig. 23*) is one of two TS2 Type 2 Controller Units approved for use by the Ministry.

Figure 23. 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 The Cobalt allows the control of 16 vehicle phases, and 16 pedestrian phases which can be configured as overlaps.

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

.6 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.

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

.8 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.

.9 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.

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

.11 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.

.12 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.

.13 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.

301.3 CONTROLLER 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.

301.4 MENU SYSTEM

.1 Due to the complexity of the Cobalt's graphical mode this manual will refer only to the 'classic' mode menu system on the Cobalt. The 'classic' mode offers the same menu displays and menu system as the 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 900* for details.

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

301.5 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.

301.6 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.

302 TRAFFICWARE/NAZTEC 980

302.1 GENERAL SPECIFICATIONS

.1 The Trafficware/Naztec 980 (*Fig. 24*) is one of two TS2 Type 2 Controller Units approved for use by the Ministry.

Figure 24. 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 The Naztec 980 allows the control of 16 vehicle phases, and 16 overlaps.

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

.6 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.

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

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

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

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

.11 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.

302.2 CONTROLLER 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.

302.3 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 900* for details.

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

302.4 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.

302.5 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.

303 CONTROLLER UNIT INPUTS AND OUTPUTS

303.1 INTRODUCTION

In a NEMA TS1 cabinet, all Controller Unit and Input Card I/Os are terminated at their own terminals on the back panel. This allows for easy access to monitor controller outputs or affect controller inputs.

In a NEMA TS2 cabinet all the Controller Unit I/O statuses are 'hidden away' in the SDLC serial communications bus. However a select number of Controller Unit and detector I/Os have been terminated at terminal blocks in the cabinet and can be accessed if needed. These I/Os are provided by Bus Interface Units (BIUs) #1 & #2. The I/Os are grouped in two rows: 'A' terminals and 'B' terminals. Some MMU I/Os from the MMA and MMB harnesses are also located at these terminals.

The scope of this document does not permit a complete discussion of all of the many controller unit inputs and outputs for both the Econolite Cobalt and Naztec 980. Instead, an overview of the terminal block I/Os available in the P6 cabinet is provided.

For reference, a full listing of all Cobalt and Naztec 980 I/Os can be found in their Operation Manuals. It is strongly recommended that you understand the overall effect of any of these I/Os on the traffic signal operation before attempting to affect them.

303.2 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 All inputs to the controller unit use 'active-low' 24 VDC logic. All True or On signals are at the Logic Ground level (0VDC). All False or Off signals are at the +24 VDC level. Control of these signals is provided by external devices.

303.3 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 All outputs from the controller unit use ‘active-low’ 24 VDC logic. All True or On signals are at the Logic Ground level (0VDC). All False or Off signals are at the +24 VDC level. Control of these signals is provided by the controller unit.

303.3.2 P6 Cabinet I/O Terminals

.1 Table 9 describes the I/O terminals provided in the P6 cabinet. Each table entry provides: the name of the I/O, whether it is an input or output and a brief description of its function.

.2 The spare terminals can have any controller I/O mapped to them if you need one that is not already provided.

Table 9. P6 Cabinet I/O Terminals

TERMINAL	TYPE	NAME	FUNCTION
A-1	Input	Ring 1 Inhibit Max	Inhibits the Max timers on all phases on Ring 1.
A-2	Input	Ring 2 Inhibit Max	Inhibits the Max timers on all phases on Ring 2.
A-3	Input	Ring 1 Force Off	Terminates the current Ring 1 phase green timing if there is a serviceable call on another phase. Force off is not effective during the minimum green, walk or pedestrian clearance timing.
A-4	Input	Ring 2 Force Off	Terminates the current Ring 2 phase green timing if there is a serviceable call on another phase. Force off is not effective during the minimum green, walk or pedestrian clearance timing.
A-5	Input	Ring 1 Max 2 Select	Selects Max 2 green times for all phases in Ring 1. Selects Max 1 if no Max 2 times are programmed.
A-6	Input	Ring 2 Max 2 Select	Selects Max 2 green times for all phases in Ring 2. Selects Max 1 if no Max 2 times are programmed.
A-7	Input	Call To Non-Actuation 1	Sets phases programmed for CAN to run in a non-actuated mode on Ring 1.
A-8	Input	Call To Non-Actuation 2	Sets phases programmed for CAN to run in a non-actuated mode on Ring 2.
A-9	Input	Walk Rest Modifier	Allows phases to rest with their pedestrian signals in Walk.

TERMINAL	TYPE	NAME	FUNCTION
A-10	Input	External Min Recall	When active the controller cycles through all active phases. The phases are on for only their Min timer value.
A-11	Input	External Start	Input used to send the controller unit to its initialization phase and interval. Timing of the interval will not begin until the input is turned off.
A-12	Input	Test Input A	User programmable input.
A-13	Input	Test Input B	User programmable input.
A-14	Input	Test Input C	User programmable input.
A-15	Output	TBC Online	Active when Time Based Coordination is active.
A-16	Output	TBC Auxiliary 1	Auxiliary output than can be activated via Time Base programming.
A-17	Output	TBC Auxiliary 2	Auxiliary output than can be activated via Time Base programming.
A-18	Output	TBC Auxiliary 3	Auxiliary output than can be activated via Time Base programming.
A-19	Output	Coord. Status Out	Active if the Controller Unit is running coordination.
A-20	Output	Logic Ground	Logic ground supply.
A-21	Output	Pre-Empt. 1 Active	Active when pre-empt. 1 sequence is in its dwell phases.
A-22	Output	Pre-Empt. 2 Active	Active when pre-empt. 2 sequence is in its dwell phases.
A-23	Output	Pre-Empt. 3 Active	Active when pre-empt. 3 sequence is in its dwell phases.
A-24	Output	Pre-Empt. 4 Active	Active when pre-empt. 4 sequence is in its dwell phases.
A-25	Output	Pre-Empt. 5 Active	Active when pre-empt. 5 sequence is in its dwell phases.
A-26	Output	Pre-Empt. 6 Active	Active when pre-empt. 6 sequence is in its dwell phases.
A-27	Output	Logic Ground	Logic ground supply.
A-28	Output	Logic Ground	Logic ground supply.
A-29	Output	Logic Ground	Logic ground supply.
A-30	Input	Stop Timing 1 & 2	Input to apply stop time to Ring 1 & Ring 2.
A-31	Output	MMU Stop Timing	Active when the MMU has applied stop time to the Controller Unit during a fault.
A-32	Output	Local Flash Status	Input to apply local flash to MMU.
A-33	Output	Alarm 1	If alarms have been programmed this will activate when the alarm conditions are met.
A-34	Output	Alarm 2	If alarms have been programmed this will activate when the alarm conditions are met.

TERMINAL	TYPE	NAME	FUNCTION
A-35	Output	Logic Ground	Logic ground supply.
A-36	Input	Dim. Enable	Used to enable dimming if programmed. Never used due to LED field signals.
A-37	Input	Auto Flash	If active it puts the controller into auto flash if auto flash is enabled via programming.
A-38	Input	Coord. Free	Forces the controller to run in free Max timing when coordination is active.
A-39	Input	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.
A-40	Input	Interval Advance	Advances to the next interval when Manual Control Enable is active.
B-1	Input	MMU Reset	Resets the MMU when active.
B-2	Input	24V Monitor Inhibit	Inhibits the MMU from monitoring 24V when active.
B-3	Input	MMU +24V Monitor 2	Input of MMU to monitor status of 24V supply.
B-4	Input	MMU +24V Monitor 1	Input of MMU to monitor status of 24V supply.
B-5	Input	Fault Monitor	Controller Voltage Monitor (CVM) input of MMU.
B-6	Input	Pedestrian Detector 1	Input for phase 1 pedestrian call.
B-7	Input	Pedestrian Detector 3	Input for phase 3 pedestrian call.
B-8	Input	Pedestrian Detector 5	Input for phase 5 pedestrian call.
B-9	Input	Pedestrian Detector 7	Input for phase 7 pedestrian call.
B-10	-	BIU Spare 1	Spare I/O.
B-11	-	BIU Spare 2	Spare I/O.
B-12	-	BIU Spare 3	Spare I/O.
B-13	-	BIU Spare 4	Spare I/O.
B-14	Output	Logic Ground	Logic ground supply.
B-15	Input	Pre-Empt. Call 1	Activates pre-emption sequence for PE input 1.
B-16	Input	Pre-Empt. Call 2	Activates pre-emption sequence for PE input 2.
B-17	Input	Pre-Empt. Call 3	Activates pre-emption sequence for PE input 3.
B-18	Input	Pre-Empt. Call 4	Activates pre-emption sequence for PE input 4.
B-19	Input	Pre-Empt. Call 5	Activates pre-emption sequence for PE input 5.
B-20	Input	Pre-Empt. Call 6	Activates pre-emption sequence for PE input 6.
B-21	Input	MMA AC+ I Input	Power input for MMU.
B-22	Output	OR1 Open	Normally open contact from MMU Output Relay 1.
B-23	Output	OR2 Closed	Normally closed contact from MMU Output Relay 1.
B-24	Output	MMA Spare 1	Spare MMU output.

TERMINAL	TYPE	NAME	FUNCTION
B-25	Output	Cabinet Interlock A	Can be used to create a cabinet interlock circuit to prevent the cabinet from operating when the MMU is not present.
B-26	Output	Cabinet Interlock B	Can be used to create a cabinet interlock circuit to prevent the cabinet from operating when the MMU is not present.
B-27	Output	MMA Spare 2	Spare MMU output.
B-28	Output	SDR Open	Normally open contact of the MMU start delay
B-29	Output	MMB Spare 1	Spare MMU output.
B-30	Output	MMB Spare 2	Spare MMU output.
B-31	Output	MMB Spare 3	Spare MMU output.
B-32	Output	Detector Output 25	Channel 1 output of detector in slot 6 of Detector Rack 2.
B-33	Output	Detector Output 26	Channel 2 output of detector in slot 6 of Detector Rack 2.
B-34	Output	Detector Output 27	Channel 1 output of detector in slot 5 of Detector Rack 2.
B-35	Output	Detector Output 28	Channel 2 output of detector in slot 5 of Detector Rack 2.
B-36	Output	Detector Output 29	Channel 1 output of detector in slot 8 of Detector Rack 2.
B-37	Output	Detector Output 30	Channel 2 output of detector in slot 8 of Detector Rack 2.
B-38	Output	Detector Output 31	Channel 1 output of detector in slot 7 of Detector Rack 2.
B-39	Output	Detector Output 32	Channel 2 output of detector in slot 7 of Detector Rack 2.
B-40	N/C	N/C	Not connected.

TRAFFIC CONTROLLER ASSEMBLY MANUAL

VOLUME 2

Section 400

Malfunction Management Units

Electrical and ITS Engineering

June 2019

401 MMU 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 Malfunction Management Unit (MMU).

.2 An MMU is installed in every Ministry intersection and is so integral to the traffic controller assembly that it cannot operate without one. The MMU enables the display of normal signals in the intersection. The MMU 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 MMUs are exchanged annually and must go through a complete re-certification process before going back into use.

.4 The MMU fulfils four main functions critical to the safe operation of a signalized intersection:

- .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 MMUs 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 MMUs: Econolite/EDI MMU-16E, Reno A&E MMU-1600D and Peek Traffic Double-Diamond. Each of these MMUs provides all basic NEMA functions, as well as additional non-NEMA-specified features described in subsequent sections.

401.2 MMU VERSUS CMU

.1 MMUs are very similar to TS1 Conflict Monitor Units (CMU). In fact an MMU is backwards compatible into a TS1 assembly. If an MMU is installed in a TS1 cabinet, it will enter into a 'Type 12' mode. This means that the MMU will operate as a 12 channel CMU. In this mode the pedestrian movements will no longer have their own channels and the pedestrian indications will be monitored on channels 1-12.

.2 An MMU does not require a Port 1 SDLC connection in Type 12 mode. However if an MMU is used in a TS1 assembly, ensure all MMU channel monitoring inputs are connected to the correct field outputs.

.3 A CMU is not compatible with a TS2 controller assembly.

401.3 GENERAL OPERATION

.1 All current Ministry MMUs have sixteen input channels. Each channel has an input for a green, yellow and red signal. This gives 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 902* for details.

.2 The MMUs 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.

.3 The compatibilities set on the MMU Program Card (*Fig. 25*) must match the compatibilities programmed into the Controller Unit in a TS2 assembly. The MMU will check the CU program via SDLC communications. If the programmed compatibilities do not match those on the MMU Compatibility Card the signal will not remain in three-colour operation.

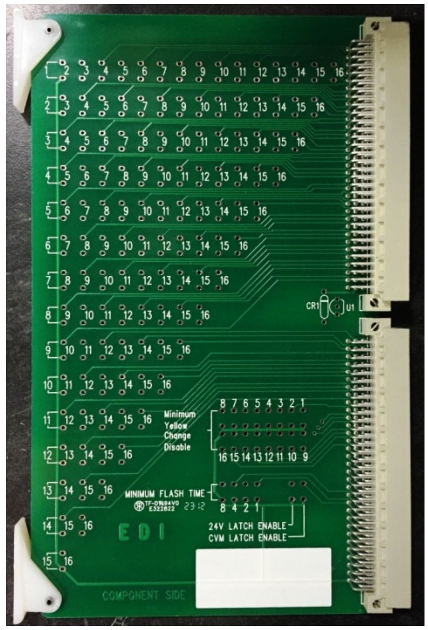


Figure 25. MMU Program Card

.4 The MMU has three electro-mechanical relays to control the operation of the intersection. These relays are called the Start-Delay Relay, Output Relay 1 and the Output Relay 2.

.5 The Start-Delay Relay 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.

.6 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.

.7 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 MMU Output Relays, along with other devices, determines flash control circuit operation. *Refer to Sections 705 and Section 800* for details.

.8 In the event of a fault, the MMU de-energizes its Output Relays, putting the intersection into flash.

.9 When the Output Relays are 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 last known signal conditions at the time the fault occurred. Stop-time is removed when the fault is corrected and the MMU is reset.

401.4 FAULT MONITORING

401.4.1 Conflicts

.1 The MMU detects conflicting signal indications between all monitored field outputs. Only red signals are considered 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 the Program Card is used. The Program 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 compatible channels to be on at the same time as each other. The compatibilities programmed on the card must match those in the CU program or the signal will not operate in three-colour.

.3 The MMU continuously observes the signal indications on all sixteen 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 considered on when its voltage is at 70VAC or greater. A green, yellow or walk signal is considered on when its voltage is at 25VAC or greater. Conflicts are typically deemed to occur after a concurrent signal display of 350 milliseconds.

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

401.4.2 Red Failure

.1 In addition to monitoring for conflicting displays, the MMU 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 MMU 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. This is typically done by plugging a jumper between the 120VAC input and the red output of an unused load switch socket.

.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 850ms.

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

401.4.3 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. CVM faults are typically detected after 150ms.

401.4.4 +24 Volt Monitor

.1 The MMU has 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 Unit via the 24VDC Control Relay. Refer to *Section 705* for details.

.2 +24 Volt **I** monitors the voltage output of the Power Supply Unit at its point of its distribution to the cabinet from the 24VDC Control Relay.

+24 Volt **II** is tied directly to the +24 Volt I input at the cabinet I/O terminals. These inputs are True at +22 VDC or greater.

.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 MMU will automatically allow the intersection to come out of flash if no other faults are present.

401.4.5 Power Interruption Monitoring

.1 The MMU continually observes the traffic controller assembly 120 VAC distribution. The MMU will put the intersection into flash if the supply level drops below 89VAC for longer than 475ms.

.2 Power interruption faults are non-latching. Once the supply returns to 98VAC or greater, the MMU will allow the intersection to come out of flash if no other faults are present.

401.5 ADDITIONAL MONITORING FEATURES

.1 The following additional features are provided on the MMU-16E, MMU-1600D and Double-Diamond MMUs.

401.5.2 Minimum Flash

.1 A safety feature called Minimum Flash or Min Flash ensures a user-selectable minimum delay from power up, until the MMU energizes its Output Relays (*Section 802*), allowing the intersection to come out of flash. The range of delay time is selectable between 0 and 15 seconds. The Ministry standard is 5 seconds. This is programmed on the MMU Program Card by soldering the ‘4s’ and ‘1s’ jumpers in the Minimum Flash Time area.

401.5.3 Minimum Clearance

.1 The Minimum Yellow + Red Clearance feature is used to verify that a period of at least 2.7 seconds exists between any two consecutive green/walk signals on a channel.

.2 The Minimum Yellow Clearance feature is used to detect a short or missing yellow interval on a channel. A pedestrian channel will violate this rule as it moves immediately from Walk (green) to Pedestrian Clearance (yellow) plus flashing Don't Walk (red). Therefore this feature will need to be disabled for any pedestrian channels. This is disabled by soldering jumpers for each used pedestrian phase on the MMU Compatibility Program Card in the 'Minimum Yellow Change Disable' area.

401.5.4 Watchdog

.1 The Watchdog input of the MMU detects 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.

401.5.5 Dual Indication

.1 The Dual Indication feature checks if there are multiple active inputs on a channel i.e. a green and red on simultaneously for the same channel. This is a latched failure and requires a manual reset to clear.

401.6 OPTION SWITCHES

.1 Use of the various features and options provided by the MMU-16E and MMU-1600D are user-selected by means of the 'Field Check/Dual Enable' and 'Options' DIP switches mounted on the unit front panel.

.2 The Peek Double Diamond MMU options are set through its menu system, keypad and LCD display.

402 THE MMU-16E MALFUNCTION MANAGEMENT UNIT

Figure 26. The MMU-16E Malfunction Management Unit

402.1 GENERAL DESCRIPTION

.1 The MMU-16E provides all basic NEMA functions plus some additional features.

.2 The MMU-16E is a sixteen-channel monitor. The sixteen input channels are assigned to vehicle phases, pedestrian phases and overlaps. Each channel is capable of monitoring a Red, Yellow, and Green signal.

.3 The MMU-16E has user configuration DIP switches mounted on the front panel.

.4 The MMU-16E front panel has LED indicators showing fault conditions and the current status of inputs on each of the sixteen channels.

.5 The MMU-16E has a built-in power supply which is fed from the traffic controller assembly's 120 VAC distribution system.

402.2 DIP SWITCHES

.1 The sixteen 'FIELD CHECK/DUAL ENABLE' (1-16) switches allow each channel to be individually included or excluded from monitoring as well as the unit-wide OPTIONS. 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. All vehicle channels typically have their FIELD CHECK/DUAL ENABLE switches set to ON. All pedestrian channels typically have their FIELD CHECK/DUAL ENABLE switches set to OFF because the PEDESTRIAN CLEARANCE (Yellow) signal will be active at the same time as the DON'T WALK (Red) signal.

.2 Typically channels 9-12 are used for pedestrian phases 2, 4, 6 & 8 respectively. The FIELD CHECK switches for these channels should be OFF for all pedestrian phases in use. Additionally, the Minimum Yellow Clearance checks on pedestrian channels must be suppressed. This is necessary because a pedestrian channel will go from WALK (Green MMU input) immediately to PED CLEARANCE (Yellow MMU input) and a flashing DON'T WALK (Red MMU input). Therefore solder the 'MINIMUM YELLOW CHANGE DISABLE' jumpers for all used pedestrian channels on the MMU Compatibility Program Card.

.3 The eight 'OPTIONS' DIP switches on the MMU-16E are used to enable additional MMU features: Green-Yellow Dual Indication, Recurrent Pulse Detection, External Watchdog Enable, Walk Disable, Configuration Change Fault Enable, CVM Log Function Disable and the LEDguard Enable. Table 11 lists the standard Ministry OPTIONS switch settings for the MMU-16E.

Table 10. MMU-16E Option Switch Settings

OPTION SWITCH	NORMAL STATE	FUNCTION
1	ON	GY ENABLE – Enables dual indication monitoring for Green and Yellow inputs on the same channel.
2	ON	RP DISABLE – Disables the MMU's Recurrent Pulse detection used to detect a pulsing failing output that stays under the fault detection timings. This is disabled as it can conflict with flashing arrow indications.
3	OFF	WD ENABLE – The P6 TS2 Assembly does not require the monitoring of an external Watchdog signal. Therefore this is disabled.
4	OFF	WALK DISABLE – Only applicable if the MMU is retrofit into a TS1 cabinet and therefore running in its 'TYPE 12' mode.
5	OFF	CF ENABLE – This feature periodically compares the Program Card jumpers and DIP Switch settings recorded at startup to the current settings. If the settings have changed since power-up and this feature is enabled it will cause a fault. For Ministry purposes this shall remain OFF.
6	OFF	CVM LOG DISABLE – If a signal has routine CVM events such as going into Time of Day flash, the logging of these events can be disabled. However for Ministry purposes this shall remain OFF.
7	OFF	LEDguard ENABLE – This is a special feature that can be used to characterize current LED loads and cause a fault if the load characteristics change. For Ministry purposes this feature shall remain OFF.
8	OFF	Not used.

402.3 INPUTS AND OUTPUTS

.1 The MMU-16E has a Port 1 SDLC which must be connected to the MMU SDLC cable in the P6 cabinet.

.2 The MMU-16E Program Card must be installed correctly. Otherwise the 'PGM CARD/CF' LED will be active on the front panel and the signal will not be allowed to enter 3-colour operation.

.3 The P6 Cabinet Assembly has an MMA and MMB harness which must be connected to the two circular connectors on the front of the MMU-16E.

403 THE MMU-1600D MALFUNCTION MANAGEMENT UNIT

Figure 27. The MMU-1600D Malfunction Management Unit

403.1 GENERAL DESCRIPTION

.1 The MMU-1600D provides all basic NEMA functions plus some additional features.

.2 The MMU-1600D is a sixteen-channel monitor. The sixteen input channels are assigned to vehicle phases, pedestrian phases and overlaps. Each channel is capable of monitoring a Red, Yellow, and Green signal.

.3 The MMU-1600D has user configuration DIP switches mounted on the front panel.

.4 The MMU-1600D front panel has LED indicators showing fault conditions and the current status of inputs on each of the sixteen channels.

.5 The MMU-1600D has a built-in power supply which is fed from the traffic controller assembly's 120 VAC distribution system.

403.2 DIP SWITCHES

.1 The sixteen 'FIELD CHECK/DUAL ENABLE' (1-16) switches allow each channel to be individually included or excluded from monitoring as well as the unit-wide OPTIONS. 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. All vehicle channels typically have their FIELD CHECK/DUAL ENABLE switches set to ON. All pedestrian channels typically have their FIELD CHECK/DUAL ENABLE switches set to OFF because the PEDESTRIAN CLEARANCE (Yellow) signal will be active at the same time as the DON'T WALK (Red) signal.

.2 Typically channels 9-12 are used for pedestrian phases 2, 4, 6 & 8 respectively. The FIELD CHECK switches for these channels should be OFF for all pedestrian phases in use. Additionally, the Minimum Yellow Clearance checks on pedestrian channels must be suppressed. This is necessary because a pedestrian channel will go from WALK (Green MMU input) immediately to PED CLEARANCE (Yellow MMU input) and a flashing DON'T WALK (Red MMU input). Therefore solder the 'MINIMUM YELLOW CHANGE DISABLE' jumpers for all used pedestrian channels on the MMU Compatibility Program Card.

.3 The twelve 'OPTIONS' DIP switches on the MMU-16E are used to enable additional MMU features: Green-Yellow Dual Indication, Recurrent Pulse Detection, External Watchdog Enable, Walk Disable, Configuration Change Fault Enable, CVM Log Function Disable and the LEDguard Enable. Table 11 lists the standard Ministry OPTIONS switch settings for the MMU-16E.

Table 11. MMU-1600D Option Switch Settings

OPTION SWITCH	NORMAL STATE	FUNCTION
1	OFF	<u>CONVERT 24V-2 TO 12VDC</u> – Changes 24V-II input thresholds to monitor 12VDC. For Ministry purposes this is set to OFF.

OPTION SWITCH	NORMAL STATE	FUNCTION
2	OFF	PER CHAN RED ENABLE – If enabled the MMU will only perform Red Fail and Field Check monitoring for the selected channels (selected in MMU software). For Ministry purposes this is set to OFF.
3	OFF	DISABLE LOCAL FLASH – When enabled, the MMU will ignore the LOCAL FLASH input. For Ministry purposes this is set to OFF.
4	OFF	MODIFIED CVM LATCH – When enabled and the CVM Latch Enable jumper is in place on the Program Card, the MMU will not latch a CVM fault unless it is valid for more than 175ms first. For Ministry purposes this is set to OFF.
5	ON	GY ENABLE – Enables dual indication monitoring for Green and Yellow inputs on the same channel.
6	OFF	WD ENABLE – The P6 TS2 Assembly does not require the monitoring of an external Watchdog signal. Therefore this is disabled.
7	OFF	FLASH DW ENABLE – When enabled the MMU will monitor flashing DON'T WALK signals to not conflict with other green, yellow or walk signals. For Ministry purposes this is set to OFF.
8	OFF	TYPE 16 ONLY – When enabled the MMU will ignore the TYPE SELECT input pin and force the MMU to always operate in the 16 channel mode whether it is installed in a TS2 or TS1 cabinet. For Ministry purposes this is set to OFF.
9	OFF	LED THRESHOLDS – If enabled the monitor will use the enhanced LED field display thresholds rather than the standard incandescent display thresholds. For Ministry purposes this is set to OFF.
10	OFF	FYA ENABLE – If enabled the MMU will activate special logic to properly monitor a channel with a Flashing Yellow Arrow Protected/Permissive Left Turn. For Ministry purposes this is set to OFF.

OPTION SWITCH	NORMAL STATE	FUNCTION
11	OFF	OPTION 3 – Not used.
12	OFF	OPTION 4 – Not used.

403.3 INPUTS AND OUTPUTS

.1 The MMU-1600D has a Port 1 SDLC which must be connected to the MMU SDLC cable in the P6 cabinet.

.2 The MMU-1600D Program Card must be installed correctly. Otherwise the ‘PGM CARD/CF’ LED will be active on the front panel and the signal will not be allowed to enter 3-colour operation.

.3 The P6 Cabinet Assembly has an MMA and MMB harness which must be connected to the two circular connectors on the front of the MMU-1600D.

404 THE PEEK DOUBLE DIAMOND MALFUNCTION MANAGEMENT UNIT

Figure 28. The Peek Traffic Double Diamond Malfunction Management Unit

404.1 GENERAL DESCRIPTION

.1 The Double Diamond provides all basic NEMA functions plus some additional features.

.2 The Double Diamond is a sixteen-channel monitor. The sixteen input channels are assigned to vehicle phases, pedestrian phases and overlaps. Each channel is capable of monitoring a Red, Yellow, and Green signal.

.3 The Double Diamond uses an LCD display and keypad to program the MMU via its menu system.

.4 The Double Diamond front panel has an LCD display showing fault conditions and the current status of inputs on each of the sixteen channels.

.5 The Double Diamond has a built-in power supply which is fed from the traffic controller assembly's 120 VAC distribution system.

404.2 MMU SETTINGS

.1 Unlike the other MMUs discussed, the Double Diamond does not make use of front panel DIP switches to configure output monitoring. In the Double Diamond all output monitoring settings are configured via its menu system. To access these settings first press the **MENU** button to go to the **Main Menu**. Then using the arrow buttons and the **ENTER** button select the **Config** menu followed by the **Monitor** menu. In this menu there are two options for setting MMU monitoring settings: **Per Unit** for global settings and **Per Channel** for channel-by-channel monitoring configuration.

.2 The **Per Unit** settings are broken into 5 screens which can be navigated using the Page-Up (**PGUP**) and Page-Down (**PGDN**) buttons. Table 12 lists the standard Ministry settings for each of these screens.

Table 12. Peek Double Diamond MMU Unit Settings

SCREEN/ PAGE	TYPICAL SETTINGS	FUNCTION
1	**'110'**	This screen contains three single-digit numerical codes that set the following three parameters. Everything else on this screen other than those three numbers is just explanatory text. **Field Check** - The first of the three numbers defines whether the Field Check option is enabled or not. 0 = Disabled, **1 = Enabled**. To use Field Check, this must be enabled and the per channel field check settings must also be enabled. **Red Fail RYG Only** - The second of the three numerical codes defines whether the Red Fail RYG Only option is enabled or disabled. 0 = Disable, **1 = Enable**. When this is enabled, a Walk signal cannot prevent a Red Failure fault.

SCREEN/ PAGE	TYPICAL SETTINGS	FUNCTION
		Fault Re-initialize Mode - The third of the three numerical codes defines the way that the MMU handles fault reinitialization. The possible fault reinitialization methods are: **0 = Disable** 1 = Fault re-initialize after all faults--self heal or reset 2 = Fault re-initialize after self-heal faults but not after a reset (by input or button).
2	**'011'**	Again, the parameters are defined on this screen by setting the three single-digit number codes. **Watchdog Enable** - The MMU Watchdog monitoring mode can be enabled and disabled using the first of the three single-digit codes. Setting it to **0 = Disable**, 1 = Enable. When enabled, pin S on Port B must toggle on and off at regular intervals, or the MMU will assume that the controller has become frozen. (This Watchdog signal is usually driven by the controller's FL logic output.) **24V/CVM Latch** - These two settings are specified by the second and third of the single-digit codes on this screen, but only for TS 1 environments. In a TS 2 cabinet, the TS 2 Programming Card has jumpers that define these settings. Those values will override the values defined on this screen. The two values possible are: 0 = Disable, or **1 = Enable**. When these parameters are set to 'enabled', the 24V and CVM faults (respectively) become latched failures.
3	**'5'**	**Min Flash** - This setting determines the minimum time allowed by the MMU for a controller flash period on startup or after a fault. It can be any value between 4 and 10 seconds. Use the up and down arrow keys to change the value. This value is only used if the MMU is running in TS 1 mode, since the TS 2 programming card has an overriding jumper setting for this value.
4	**'1'**	**Fast Flash Enable** - This setting is used for fast flash left turns with Canadian controllers. When enabled, the conflict recognition time is lowered so that a signal flashing at a rate of up to 180 fpm will be recognized. Recognition requires approximately 133 ms when this option is enabled. (At a

SCREEN/ PAGE	TYPICAL SETTINGS	FUNCTION
		180 fpm rate, each ON flash lasts approximately 166 ms, so it will be detected by the MMU with the lower recognition time.) When disabled, the normal NEMA recognition time is used, which detects signals that are longer than approximately 267 ms. 0 = Disable, or **1 = Enable**.
5	**'0'**	The one single-digit option code on this screen tells the MMU what type of status mode output to use. This depends on whether the MMU is operating in normal operation, or if the front-circuit board DC jumpers have been modified so that the unit is running in ELRA-compatible mode. If the jumpers have been modified in this way, then the DC-coded status bits A, B, and C will change. The output mode of these bits can be set to one of two methods depending on the type of unit the Double Diamond needs to emulate. **0 = status bits compatible with LSM, LNM, and ELRB type monitors.** 1 = status bits compatible with an ELRA monitor.

.3 The **Per Channel** settings are broken into 8 screens which can be navigated using the Page-Up (**PGUP**) and Page-Down (**PGDN**) buttons. Each of these screens allows you to assign output monitoring settings by channel. Table 13 lists the standard Ministry settings for each of these screens.

Table 13. Peek Double Diamond MMU Channel Settings

SCREEN NAME	NORMAL STATE	FUNCTION
GWY vs. R	ON for Vehicle Channels	**Green, Walk or Yellow vs. Red** – First part of the setup for multiple-indications monitoring. When enabled, green, walk or yellow cannot be on with the red of the same channel for more than 1000ms. Set this to '1' (ON) for all channels monitoring used vehicle phases. Typically channels 1-8 and 13-16. Set this to '0' (OFF) for all channels monitoring pedestrian phases. Typically channels 9-12.

SCREEN NAME	NORMAL STATE	FUNCTION
GW vs. Y	ON for Vehicle Channels	**<u>Green or Walk vs. Yellow</u>** – Second part of the setup for multiple-indications monitoring. When enabled, green or walk cannot be on with the yellow of the same channel for more than 1000ms. Set this to '1' (ON) for all channels monitoring used vehicle phases. Typically channels 1-8 and 13-16. Set this to '0' (OFF) for all channels monitoring pedestrian phases. Typically channels 9-12.
CHN = WLK	OFF	**<u>Display Green as Walk</u>** – When enabled, the MMU will display 'W' instead of 'G' when the channel green input is active. This affects the display only and does not change the way the MMU monitor outputs.
FIELD CHK	OFF	**<u>Field Check Enables</u>** – This is a Port 1 (SDLC) MMU feature where the monitored outputs are compared to messages from the Controller Unit to determine that the field is displaying the intentions of the CU.
MIN YEL	'1'	**<u>Min Yellow Clearance Disables</u>** – This option is applicable when a TS1 style compatibility jumper card is inserted and there is no min yellow disable jumper programming. The TS2 jumper card provides this programming and is therefore not necessary to program here. **The Program Card will take precedence over keyboard programming when the TS2 card is inserted.**
RYG ONLY	ON	This screen is the per channel portion of the RYG only feature. Note that for the feature to occur, it must be enabled at the unit level as well as for the desired channels. The factory ship defaults are OFF at the per unit level and ON for ALL CHANNELS at the per channel level. In this way the feature can be turned on unit wide at the per unit level (unless the above have been changed).
GG INHIB	OFF	**<u>Green to Conflicting Green Monitoring Inhibit</u>** – Allows you to prevent the triggering of clearance failures by channel when a green to conflicting green sequence occurs.
BLINK LOG	OFF	By default, blink events, meaning times where a signal turns on and off for a fraction of a second (but not long enough to cause a more serious fault condition) are

SCREEN NAME	NORMAL STATE	FUNCTION
		NOT logged in the Double Diamond MMU's blink log or event log. Setting a channel to ON will enable blink monitoring for that channel.

404.3 INPUTS AND OUTPUTS

.1 The Double Diamond has a Port 1 SDLC which must be connected to the MMU SDLC cable in the P6 cabinet.

.2 The Double Diamond Program Card must be installed correctly. Otherwise the 'FAULT' LED will be active on the front panel and the signal will not be allowed to enter 3-colour operation.

.3 The P6 Cabinet Assembly has an MMA and MMB harness which must be connected to the two circular connectors on the front of the Double Diamond.

TRAFFIC CONTROLLER ASSEMBLY MANUAL
VOLUME 2

Section 500

Vehicle Detectors

Electrical and ITS Engineering

June 2019

501 INTRODUCTION

501.1 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.

.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 other forms of vehicle detectors such as video detection.

502 DETECTOR RACK

Figure 29. TS2 Detector Rack

502.1 GENERAL DESCRIPTION

.1 The P6 detector racks ‘DR1’ and ‘DR2’ (*Fig. 29*) house all vehicle detector cards. These are typically inductive-loop vehicle detectors.

.2 The left-most slot of the rack is reserved for the Bus Interface Unit (BIU). The BIU monitors all card I/Os in the rack and communicates them to the Controller Unit via the SDLC communications bus.

.3 The detector rack consists of an aluminum frame with plastic card guides top and bottom to hold the vehicle detector cards. The front panels of the detector cards and BIU are accessible from the front of the assembly when inserted.

.4 Each detector rack can hold up to 8 vehicle detector cards.

502.2 BUS INTERFACE UNIT (BIU)

Figure 30. Bus Interface Unit (BIU)

.1 The leftmost card slot on the detector rack is reserved for the Bus Interface Unit (*Fig. 30*).

.2 The BIU monitors the detector card I/Os and relays them to the Controller Unit via the SDLC communications bus.

.3 The BIU has a single SDLC port on its front and LEDs indicating the BIU has power and that SDLC communications are present.

.4 The BIU in detector racks DR1 and DR2 can be connected to either of the detector SDLC cables.

.5 If no BIU is present or the SDLC cable is not correctly connected to a BIU the controller unit will detect the fault. As a failsafe the controller unit will place calls on all its detector inputs that are affected by the non-communicating detector cards.

502.3 DETECTOR RACK ADDRESS

.1 Each detector rack has a unique address which is correctly setup and tested at the time of manufacture. The correct address is critical for each Detector Rack to function correctly within the TS2 Assembly.

.2 The address is typically set via jumpers on the Detector Rack printed circuit board.

.3 Refer to the manufacturer’s cabinet drawings for the correct address of each Detector Rack.

502.4 DETECTOR CARDS

.1 A Detector Rack accommodates up to 8 detectors. Each Detector Rack has a rear circuit board called the detector back plane containing card-edge connectors that mate with the circuit board of each detector card.

.2 All of the card-edge connectors on the detector back plane connect to the BIU via traces on the back plane. The BIU continuously updates the Controller Unit on the status of all detector I/Os.

.3 Detectors can be installed in any slot in the section, as all positions are electrically identical.

503 LOOP DETECTORS

503.1 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. The most common one shipped with Ministry TS2 cabinets is shown in *Figure 31*.

Figure 31. Typical Ministry Loop Detector

.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 fixed capacitor in the loop detector unit causes the output to oscillate at a specific frequency known as the 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 vehicle chassis (or other mass of metal) in proximity to the loop, reduces the loop's magnetic field which reduces its overall inductance. A reduction of inductance in this type of circuit translates to a reduction in the resonant frequency. The reduction of the output frequency 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 P6 controller assembly can accommodate up to sixteen detector units (8 per rack). This means the P6 assembly can accommodate unique detector inputs from as many as thirty-two detection loops in the field.

.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 BIU input. When a vehicle is detected, the relay is energized, placing a vehicle call to the controller unit for the associated phase via the BIU.

.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. Typically the Ministry uses detectors set for presence.

.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 controller unit has similar programming capability for its inputs, preventing the necessity to use detector card delay and extension.

.9 Occasionally, the outputs of two or more detector channels are physically connected in parallel. 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. Alternately, this function may also be accomplished by programming.

.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 occasionally used for detection of transit vehicles.

503.2 FREQUENCY SELECTION AND SENSITIVITY

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

.2 Normally, each channel has several available frequency settings and 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, mid-range sensitivity is used. The sensitivity may be adjusted to ensure accurate detection is achieved.

503.3 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. Typically a loop-to-lead-in inductance ratio of at least 2:1 is considered adequate.

.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 interaction with the vehicle's metallic chassis.

.5 Loops can be formed in a variety of shapes. The standard shape now used by the Ministry is a 1.8m diameter circular loop.

.6 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.

503.4 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. A failed detector card is detected by the controller unit and a failsafe call will be automatically placed on the controller inputs that card affects.

.2 Loop detectors have the capability to perform self-diagnosis on a continuous basis. Typically a loop detector channel will continuously place a call if the loop has failed. This is considered a 'fail-safe' to accommodate a vehicle on the failed loop that would otherwise not be detected. The detector will return to normal operation if the loop problem is corrected. Loop detectors also provide a visible fault indication. This allows service personnel to easily determine that faults exist, even if they are intermittent.

.3 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 10-20 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.

504 OTHER VEHICLE DETECTORS

504.1 OTHER VEHICLE DETECTION

.1 Although inductive loop vehicle detection is the standard for Ministry traffic signals other vehicle detection technologies can be used in the P6 Assembly.

.2 The Detector Rack can accept any TS2 standard detector card regardless of its detection technology. The outputs of the detector card can be assigned to any Controller Unit input just as it is for loop detectors.

.3 Currently the only type of vehicle detection approved by the Ministry other than loop detection is video detection.

504.2 VIDEO DETECTION

.1 Video detectors use video cameras, mounted on signal poles, to generate real-time images of the intersection. Software within the detector card is used to process these images to achieve vehicle recognition.

.2 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 video monitor.

.3 Once the detection zones are defined, the detector card responds to the changing video images and generates vehicle calls for each area, or areas defined.

.4 Video detection allows the user to manipulate a variety of parameters to customize and optimize the system's operation.

.5 Video detectors have the advantage that the whole intersection can often be viewed from about four camera locations. However this can also be a disadvantage should any camera fail.

TRAFFIC CONTROLLER ASSEMBLY MANUAL

VOLUME 2

Section 600

Power Supply Unit

Electrical and ITS Engineering

June 2019

601 GENERAL DESCRIPTION

.1 The P6 TS2 assembly uses the shelf-mount PS-2412-5A power to supply power to the traffic controller assembly. The PS-2412-5A is shown in *Figure 32*.

Figure 32. PS-2412-5A Shelf Mount Power Supply

.2 The PS-2412-5A is supplied with 120 VAC from the traffic controller assembly's power distribution panel. It in turn supplies 24VDC, 12VDC, 12VAC and a 60Hz line reference to the controller assembly.

.3 The +24 VDC output of the PS-2412-5A supplies load switches, BIUs and detector cards. This voltage is monitored by the MMU.

.4 The 12 VAC output provides a safe voltage for the pedestrian pushbuttons.

.5 The 60Hz AC line reference is a 24V square wave used to synchronize all BIU outputs.

.6 The PS-2412-5A is mounted on the bottom shelf by the left interior wall.

602 ELECTRICAL SPECIFICATIONS

.1 Table 14 lists the PS-2412-5A specifications:

Table 14. Power Supply Electrical Specifications

Power	Outputs	24 VDC ± 2VDC at 2.0 A Regulated. 12 VAC at 0.25 A Unregulated.
	Inputs	89 VAC to 135 VAC full load
	Frequency	60 Hertz
	Power Factor	0.8
Fusing	120 Volt	2.0 A Slow Blow

.2 Table 15 lists the I/O pin-out for the PS-2412-5A MS3106-18-1SW circular connector:

Table 15. Power Supply Circular Connector Pin-Out

Pin	Purpose
A	AC Neutral
B	Line Frequency Reference
C	AC Line
D	+12VDC Output
E	+24VDC Output
F	Reserved
G	Logic Ground
H	Earth Ground
I	12VAC Output
J	Reserved

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TRAFFIC CONTROLLER ASSEMBLY MANUAL
VOLUME 2

Section 700

Power Distribution Panel

Electrical and ITS Engineering

June 2019

701 POWER DISTRIBUTION PANEL

701.1 GENERAL DESCRIPTION

.1 The power distribution panel in the P6 controller assembly is mounted on the lower right-hand side and is covered by a protective Plexiglas screen. The screen has a cut-out for access to the three circuit breakers, two GFI 120VAC receptacles, and distribution fusing.

701.2 POWER DISTRIBUTION

.1 *Figure 33* is a schematic diagram of the power distribution system in the P6 traffic controller assembly.

.2 The 120 VAC Line is connected to the AC+ input terminal where it is distributed to the input breakers CB1 & CB2. The incoming Neutral is connected to the AC- input terminal where it is distributed to the neutral bus GB1. The incoming Ground (Bond) is directly connected to the Earth-Ground bus GB2.

.3 The CB1 breaker output is connected to the transient suppression line filter (LF) input and is also distributed to the two utility receptacle boxes at the top of the cabinet. The distribution to these utility receptacles is fused at 4A.

.4 The output of the line filter is distributed to: the input of the cabinet RFI filter (RFI), the energized-side of the Solid State Relay (SSR), the System Flasher (FL) and the input of Circuit Breaker 3 (CB3).

.5 The RFI filtered output power is connected to the Power Bus Panel where it is distributed to control equipment throughout the controller assembly including the CU, MMU and Power Supply Unit.

.6 The CB2 breaker supplies power to the: cabinet light, thermostat/fan/heater, and the GFI on the Power Distribution Panel.

.7 The CB3 breaker supplies power to the communication interface panel power bus and the pre-emption panel power supply (via a 4A fuse).

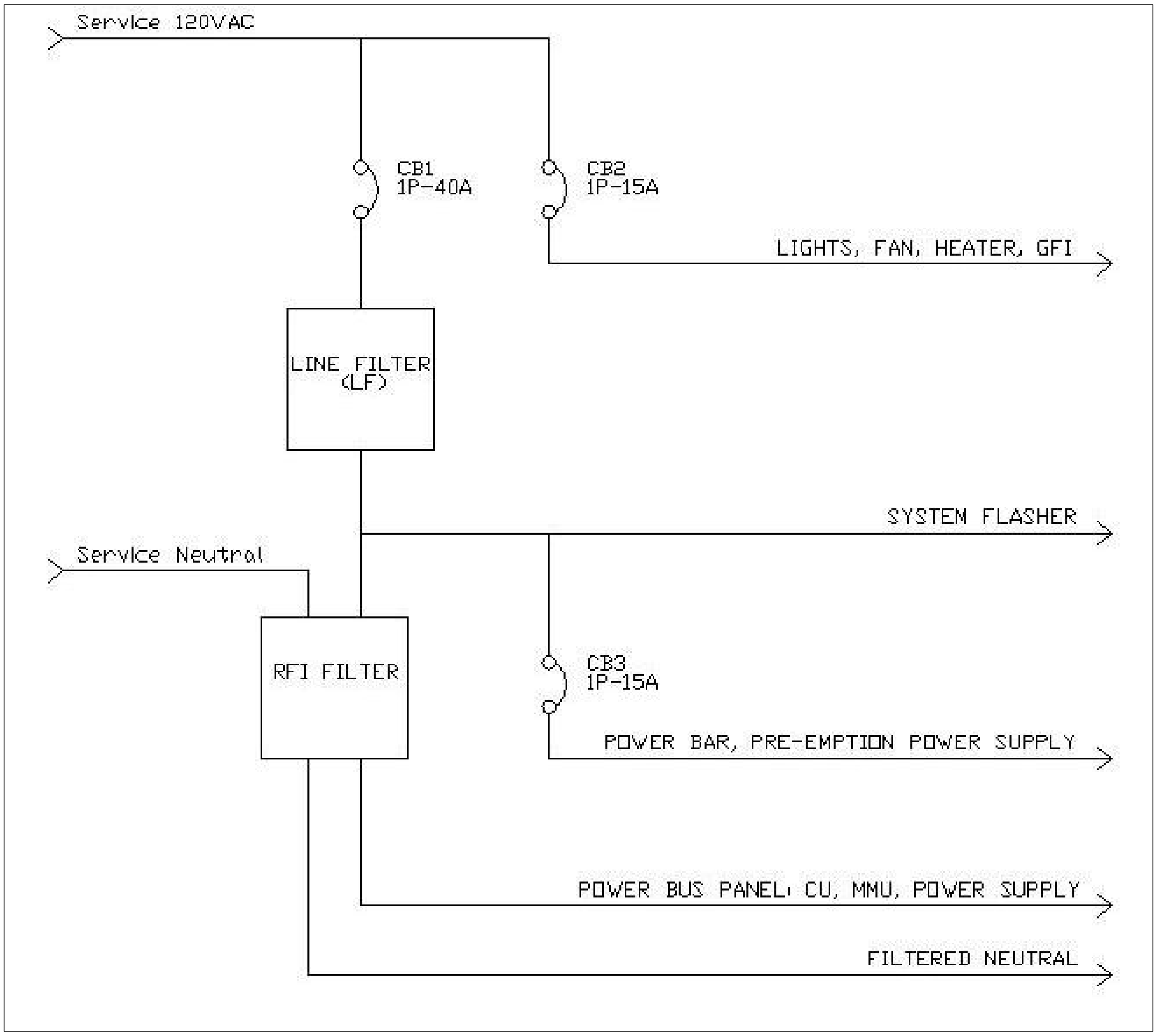


Figure 33. Typical P6 Assembly Power Distribution Schematic

702 FIELD OUTPUTS

702.1 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.

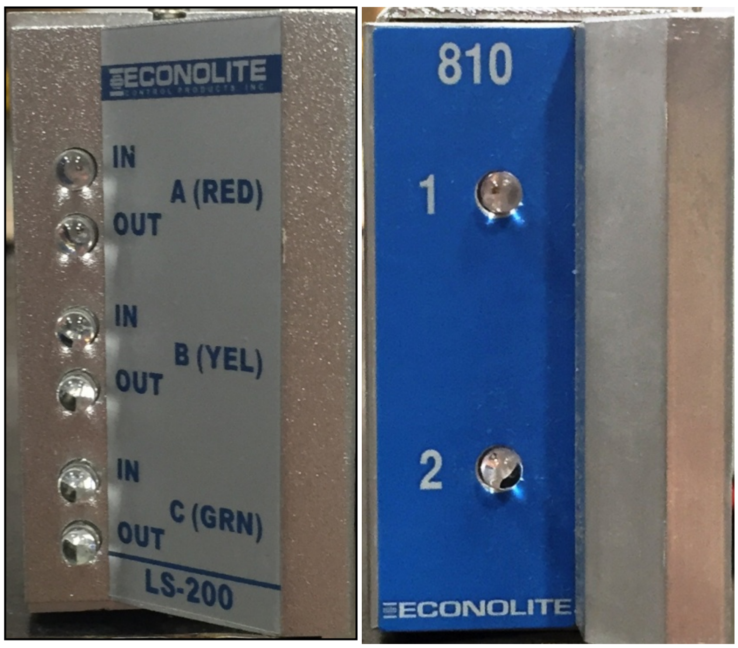
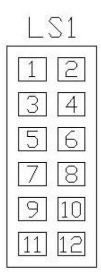


Figure 34. LS-200 Load Switch, and 810 Flasher



LOAD SWITCH	
PIN	FUNCTION
1	115 VAC
2	CHASSIS GND
3	RED/DW OUTPUT
4	-------------
5	YEL OUTPUT
6	RED/DW INPUT
7	GRN/W OUTPUT
8	YEL INPUT
9	+24 VDC
10	GRN/W INPUT
11	AC COMMON
12	-------------

Figure 35. TS2 Load Switch Socket Front View and Pin-Out Table

702.2 LOAD SWITCHES

.1 During three-colour operation, all signals in the intersection are controlled by the controller unit. The controller unit uses low-voltage or 24 VDC logic which is not designed to supply power to the signal lights. High-voltage (120 VAC) power is supplied to the signals by devices called load switches. Typical load switches shipped with Ministry TS2 cabinets are shown in *Figure 34*. The pin-out of these load switches is given in *Figure 35*.

.2 Load switches in the P6 assembly are arranged in two files. The lower file load switches LS1 through LS8 are typically used to drive the signals for phases 1 through 8 in the field. The upper file load switches LS9 through LS12 are typically used to drive pedestrian signals for phases 2, 4, 6 & 8 respectively. The upper file load switches LS 13 through LS 16 are typically used to drive the signals for overlaps A to D respectively.

.3 Each load switch file must have a Bus Interface Unit (BIU) installed in the slot immediately to the left of the file. The BIU receives the current state of the Controller Unit's outputs via the SDLC communications bus and conveys the low-voltage control outputs to the inputs of the appropriate load switch in its file.

.4 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 supply 120 VAC power to the signal lights when the controller unit (via the BIU) applies a Logic Ground signal to the low-voltage input.

.5 Each of a load switch's three circuits typically corresponds to the green, yellow and red signals for a particular phase. Therefore one load switch is required for each assigned controller unit vehicle phase. Additionally, a separate load switch is required for each phase's pedestrian movement outputs. Load switches 9-12 are reserved for pedestrian outputs. For a pedestrian movement the Walk and Don't Walk signals are controlled by the load switch's green and red circuits respectively. The yellow circuit is not used for any pedestrian field signals.

.6 The load switch has two LED indicators on the front per circuit. One LED is active if the low-voltage input is active and the other if the output is active. The indicators' colour corresponds to the controller unit phase output (red, yellow or green) or pedestrian outputs (green for walk, red for don't walk). In normal operation, only one input/output pair is on at a time.

702.3 LOAD SWITCH FLOATING OUTPUTS

.1 Unlike the Ministry's load switches for its TS1 controller assemblies, the TS2 load switches do not have a built in shunt resistance between the output 120VAC and neutral. The solid-state relays within a load switch require a suitable load if 120VAC is to be present at the load switch output. If there is no load, a solid-state relay's output can vary or 'float', even if the relay is energized. This can be problematic as the MMU monitors the controller assembly field voltages. If an unused red output floats too low for a protected/permissive left turn when the green and yellow arrows are not active, the MMU will put the controller into flash due to a perceived red failure.

.2 To ensure potentially unused colour circuits do not float, load resistances have been manufacturer-installed at locations where floating is likely to occur:

  .1 Pedestrian load switch (LS9-12) yellow outputs have a 2.2kΩ 10W shunt resistor as only the green (Walk) and red (Don't Walk) outputs have loads in the field. This resistor is soldered directly between these load switch's socket terminals.

  .2 The red output terminals for odd vehicle phases (1, 3, 5, & 7) are connected by default to shunt resistors. This is in case they will be used as protected/permissive left turns where only the green and yellow outputs have field loads. These resistors are located below the bottom field terminal row as seen in Figure 36.

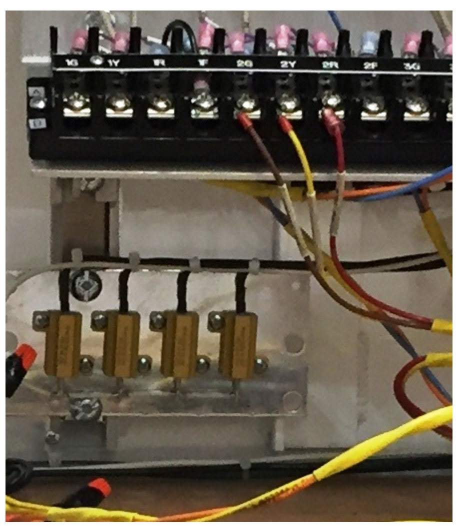


Figure 36. Load Resistors Beneath the Field Output Terminals

.3 Note that these resistances will not adversely affect the load switch output circuit if it is also connected to a field load.

.4 If a design calls for using only a portion of the load switch outputs (e.g. activating a ‘No Left Turn’ rail sign) you can connect the unused load switch outputs to the shunt resistor network beneath the field terminals.

702.4 FLASHER MODULE

.1 A special device, similar to a load switch, is used for the control of the P6 assembly’s flash circuit and advance warning sign lights. This device, shown in *Figure 34*, is called a flasher module.

.2 The flasher module is a 120VAC device. When it is supplied 120VAC at its inputs, its two outputs flash at approximately 60fpm with a 50% duty. Therefore when on, there will always be one output active at any given time.

.3 There is an LED indicator on the front of the flasher unit for each output. An active LED indicates that output is currently active.

.4 Each output is rated for 15A max load current.

702.5 PROTECTIVE FUSING AND FIELD TERMINALS

.1 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 Fuses 1-8 protect the load switches from faults in the field. These fuses are located immediately above the top load switch file. Each fuse is a 10A slow-blow.

.3 Each fuse protects two load switches. Table 16 shows which fuses protect which load switches.

Table 16. Load Switch Fusing

Fuse	Load Switches Protected
F1	LS1 & LS5
F2	LS2 & LS9
F3	LS3 & LS7
F4	LS4 & LS10
F5	LS6 & LS11
F6	LS8 & LS12
F7	LS13 & LS15
F8	LS14 & LS16

.4 Each load switch 120VAC output is connected to a field terminal in the bottom of the enclosure. There is one field terminal per phase output colour including pedestrian outputs (green is Walk, red is Don't Walk). However each field terminal typically supplies more than one signal load in the intersection. There are normally at least two sets of signal heads for each phase. All signals of the same colour, for the same phase are controlled by one output/terminal.

.5 Adjacent to the field terminals, there is a neutral bus (GB1) at the bottom of the Power Distribution Panel for terminating the neutral wires from the field.

703 ADVANCE WARNING

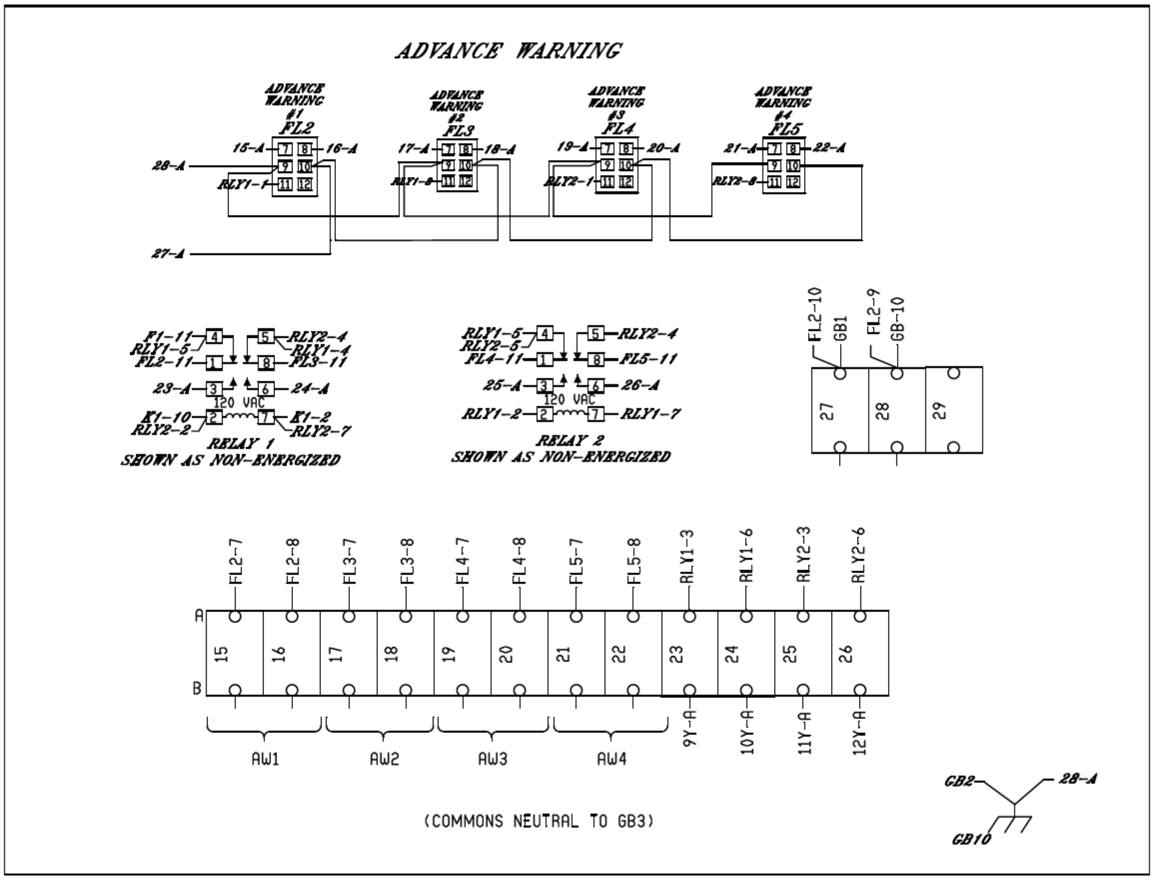


Figure 37. Advance Warning Sub-Panel Schematic

703.1 ADVANCE WARNING OPERATION

.1 Advance Warning notifies drivers approaching an intersection when the signal is or is about to turn red and stop traffic. Advance Warning signs are installed on any intersection approach where the speed limit is greater than 60km/h. It is also installed at locations where sight lines are limited when approaching an intersection.

.2 The P6 controller assembly has a sub-panel dedicated to Advance Warning signals. This AW sub-panel is shown in *Figure 37*.

.3 The AW sub-panel has 8 output terminals (15-22) and 4 input terminals (23-26). Output terminal pairs 15/16, 17/18, 19/20 & 21/22 are connected to the pair of amber signals of their respective Advance Warning sign (AW1-4) in the field. The 4 input terminals are connected to the yellow outputs of load switches 9 to12.

.4 The AW sub-panel has 4 flasher modules. Each module is connected to the output terminals such that one flasher module will drive one Advance Warning Sign in the field. This ensures each sign 'wig-wags' its amber signals in the proper 60fpm alternating fashion when advance warning is active.

.5 The AW sub-panel has two flash control relays 1 & 2. When the controller assembly is in flash, these relays disconnect the AW sub-panel inputs 23-26 from the inputs of the flasher modules. In this state the relays switch the 120VAC control of the assembly system flasher directly to the inputs of the 4 flasher modules. This makes all the advance warning signs flash when the intersection is in flash.

.6 **3 Colour Operation** – When the assembly is in 3-colour operation Relays 1 & 2 are energized and inputs 23-26 are connected to the inputs of flasher modules 1-4 respectively. When any of these inputs are active (120VAC) their respective flasher module is active which activates the warning sign in the field.

.7 **Advance Warning Control** – The AW sub-panel inputs 23 to 26 are connected to the unused yellow circuits for pedestrian load switches 9 to 12 respectively. As these yellow circuits are not used on pedestrian output channels, some programming must be entered in the Controller Unit to ensure these yellow circuits turn on and off at the correct times in the signal cycle. The way to this is dependent on the type of CU:

.1 Econolite Cobalt – A statement for each Advance Warning Sign must be entered and enabled in the Cobalt's Logic Processor. The statement should look like:

IF (AW PHASE RED) IS ON

THEN (PED PHASE YELLOW) IS ON

ELSE (PED PHASE YELLOW) IS OFF

The above statement is meant to illustrate the necessary logic but is not in the correct logic processor syntax. Refer to the Cobalt programming manual and the Cobalt help files on proper syntax.

.2 Naztec 980 – This controller does not have a logic processor so the controller I/Os will need to be remapped such that the Advance

Warning phase red output in the Controller Unit is mapped to the appropriate pedestrian load switch yellow output. Refer to the Naztec 980 Operator's Manual on how to re-map outputs.

Regardless of the controller used the above two examples will activate an Advance Warning sign by allowing the Advance Warning phase red to control when its Advance Warning Sign is active.

704 SIGNAL PRE-EMPTION

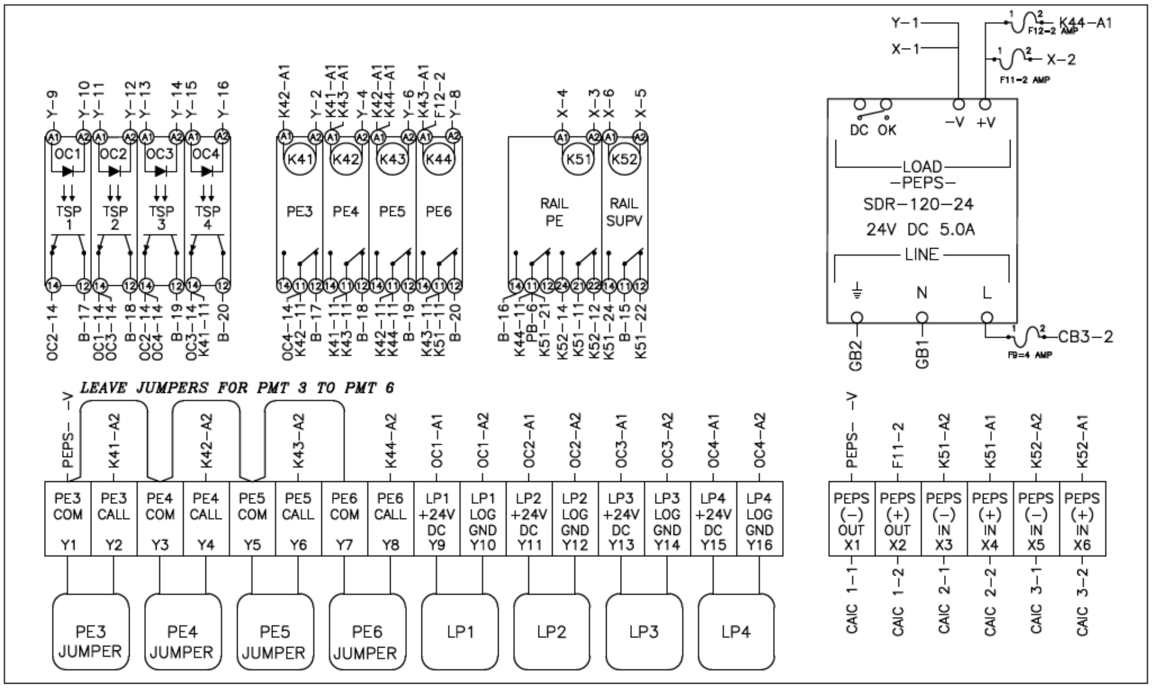


Figure 38. The Pre-Emption Sub-Panel Schematic

704.1 SIGNAL PRE-EMPTION OPERATION

.1 Traffic Signal Pre-Emption allows external equipment to force the traffic signal into a particular signal phase or sub-set of phases. From highest to lowest priority the types of pre-emption inputs are:

.1 <u>Rail Pre-Emption</u> – pre-emption allows a track-clearance phase to clear traffic away from the tracks. This is followed by the traffic signal only servicing those phases that do not conflict with the train. A rail pre-emption call is a steady call which clears only after the train has passed. Rail pre-emption calls are made using input terminals X1 to X6 in *Figure 38.*

.2 <u>Emergency Pre-Emption</u> – pre-emption allows the controller to service a particular phase or phases to ease the passage of an emergency vehicle (ambulance or fire engine) through the intersection. An emergency pre-emption call is a steady call which clears only after the emergency vehicle has passed. Emergency pre-emption calls are made using input terminals Y1 to Y8 in *Figure 38*.

.3 Low-Priority Pre-Emption – typically used for Transit Signal Priority (TSP) where the Controller Unit will attempt to allow an approaching Transit Vehicle to pass through the intersection with as little delay as possible. A low-priority call is made using a 6.25Hz input pulse. Low-priority pre-emption calls are made using input terminals Y9 to Y16.

.2 The Pre-Emption Sub-Panel shown in Figure X serves two purposes: to provide an interface for external pre-emption detection equipment and to isolate the Controller Unit's pre-emption inputs from potentially hazardous voltages in the field.

.3 The sub-panel has its own 24VDC 'pre-emption power supply' (PEPS) isolated from the controller power supply. This power supply connects directly to the pre-emption detection equipment in the field. If there was a fault in the field it would only affect this isolated supply and not the basic operation of the traffic controller assembly. The pre-emption power supply is sourced by Circuit Breaker 3 (CB3) in the Power Distribution Panel. Its line input is fused at 4A (F9) and it's +24VDC outputs are fused at 2A (F11 & F12).

.4 The sub-panel uses relays to isolate field inputs at the terminals from the Controller Unit inputs. The rail pre-emption and rail supervisory mechanical relays are used to interface rail pre-emption. Mechanical relays PE3 to PE6 are used for the emergency pre-emption interface. The opto-isolated solid-state relays TSP1 to TSP4 interface with low-priority pre-emption inputs.

.5 Rail Pre-Emption Operation - The current rail pre-emption interface has been standardized to a 6-wire interconnect between the controller assembly and the rail authority. A schematic of this interconnect is shown in *Figure 39*. The PEPS power supply outputs are sent out to the rail pre-emption detection field equipment where it is passed through their relay contacts and fed back to the rail pre-emption and supervisory relays via the interconnect. This dual-relay interface provides added protection as it can detect if there is a malfunction with the rail authority or interconnect equipment. If there is a malfunction the traffic controller will clear the tracks and then go into flash. To avoid going into flash the Rail Pre-Emption relay and Rail Supervisory relay cannot be on or off at the same time. For more details on the 6-wire rail interconnect refer to Ministry Technical Bulletin 2007-02. These relays affect the Controller Unit pre-emption inputs 1 & 2 which are the highest priority pre-emption inputs.

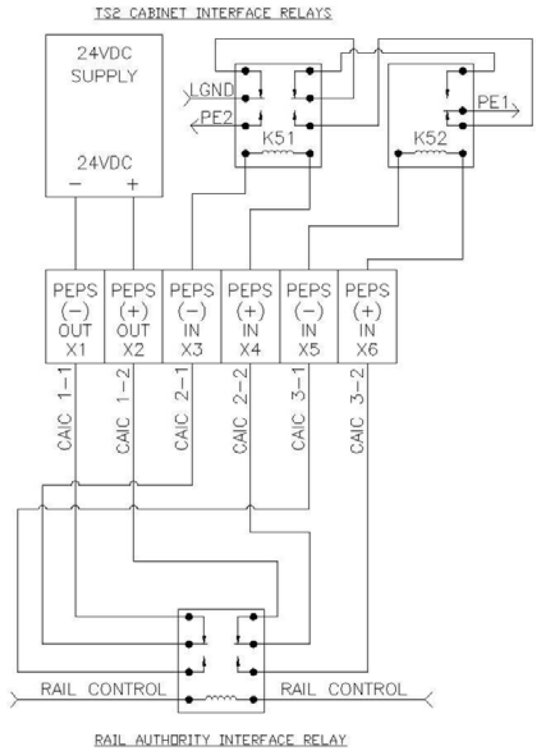


Figure 39. Rail Interconnect State When No Train is Present

.6 <u>Emergency Pre-Emption Operation</u> – each emergency pre-emption call requires a single-pair interconnect between the pre-emption panel and the pre-emption detection equipment in the field. A schematic of this interconnect is shown in Figure 40 for just pre-emption input 3. The interconnect must have one connection to the pre-emption 'Common' terminal and another to the 'Call' terminal. All of the 'Common' terminals are directly connected to the Logic Ground of the PEPS isolated pre-emption power supply. All of the emergency pre-emption relays PE3 to PE6 have one side of their coils directly connected to the 24VDC of the PEPS supply. By standard, the pre-emption detection equipment is meant to short the interconnect conductors with active-closed mechanical relay contacts when there is no pre-emption call. In this state the PEPS Logic Ground is looped-back to the Call terminal which energizes the PE relay. When a PE relay is energized it is not placing a pre-emption call. When the pre-emption field equipment makes a call it opens its interface relay contacts and de-energizes the PE relay in the P6 cabinet. This makes the pre-emption call to the Controller Unit which will attempt to enter the pre-emption input's associated pre-emption sequence as soon as possible. The PE relays affect the Controller Unit pre-emption inputs 3-6 which are the second-highest priority pre-emption inputs.

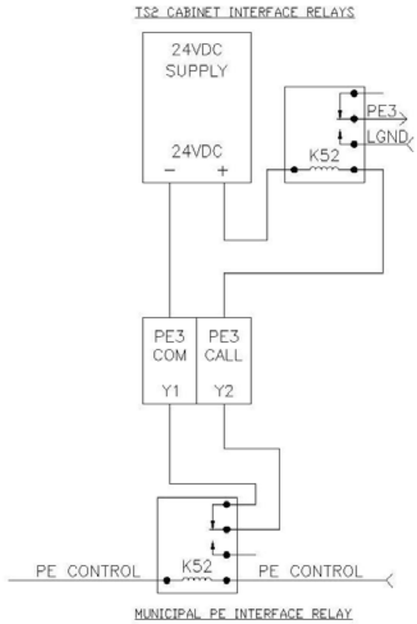


Figure 40. Emergency Pre-Emption Circuit When No Emergency Vehicle is Present

.7 Low-Priority Pre-Emption Operation – similar to emergency pre-emption each low-priority pre-emption input requires a single-pair interconnect. However, the PEPS supply is not used to energize the solid-state relays TSP1 to TSP4. Instead the field equipment making the low-priority call is responsible for generating the 6.25Hz 24VDC pulse sequence necessary to make the call. The TSP relays affect the same Controller Unit pre-emption inputs 3-6 that emergency pre-emption does. However, the controller unit interprets a steady call on these inputs as an emergency pre-emption call and a 6.25Hz pulse input as a low-priority pre-emption call.

704.2 SIGNAL OPERATION WITH NO EMERGENCY PRE-EMPTION

.1 As noted in *704.1.6*, the connection between an emergency pre-emption's 'Common' terminal and 'Call' terminal is maintained by the pre-emption detection in the field to indicate there is no pre-emption call. Therefore any unused pre-emption inputs must have a jumper installed between these terminals or there will be a constant call on that input which will affect normal controller assembly operation.

704.3 SIGNAL STARTUP WITH NO RAIL PRE-EMPTION

.1 As noted in *704.1.5* the Rail PE relay and Rail Supervisory relay cannot be on or off at the same time or the intersection will enter flash. A proper 6-wire interconnect to the rail authority will prevent this from happening. However intersections that do not have rail pre-emption will not have an interconnect to keep these relays from putting the intersection in flash. In fact, without an interconnect, an 'out-of-the-box' P6 assembly will not even enter 3-colour operation until the state of these rail relays is managed.

.2 At intersections with no rail pre-emption one of the relays must be 'hard-wired' on while the other is off. To do this install a jumper between terminals X1 and X5 as this will apply logic ground to one side of the Supervisory Relay coil. Then install a jumper between terminals X2 and X6 as this will apply 24VDC to the other side of the Supervisory Relay coil. Now the Supervisory Relay will be energized and the Rail PE Relay will be off, preventing a rail pre-emption call and stopping the controller assembly from staying in flash.

704.4 PRE-EMPTION INDICATOR LIGHTS

.1 In the Ministry legacy TS1 controller assemblies, blue and white lights were sometimes used in conjunction with emergency pre-emption to indicate when a signal was in pre-emption and which movement had right-of-way. These blue and white lights were driven by load switch channels in the M or S cabinet and a special relay was included in the assembly to prevent the Conflict Monitor from faulting on the flashing indicator lights.

.2 The P6 TS2 assembly has no provisions for driving these indication lights or preventing an MMU fault if indication lights were installed. Instead, any blue and white indication lights must be driven from the pre-emption detection equipment in the field and not from the P6 controller assembly. This is described in the Ministry Technical Bulletin TE-2015-01.

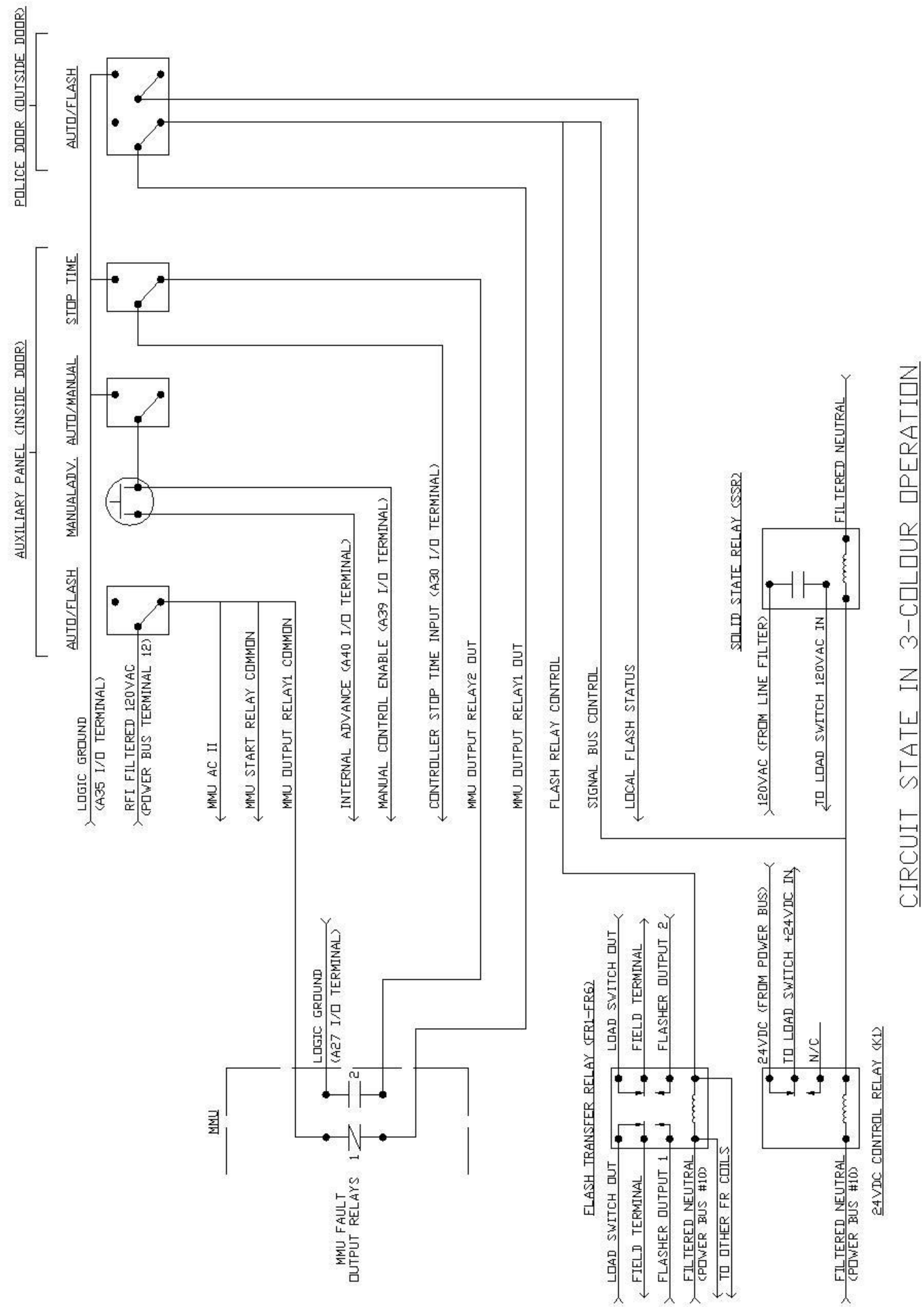
705 FLASH CONTROL SYSTEM

705.1 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 MMU, auxiliary panel flash switch and police-door flash switch 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 41* is a schematic diagram of the FCC. Note that all relays and switches are shown in the three-colour operation position.



CIRCUIT STATE IN 3-COLOUR OPERATION
POLICE DOOR (OUTSIDE DOOR)
AUTO/FLASH
AUXILIARY PANEL (INSIDE DOOR)
AUTO/FLASH
MANUAL ADV.
AUTO/MANUAL
STOP TIME
LOGIC GROUND (A35 I/O TERMINAL)
RFI FILTERED 120VAC (POWER BUS TERMINAL 12)
MMU AC II
MMU START RELAY COMMON
MMU OUTPUT RELAY1 COMMON
INTERNAL ADVANCE (A40 I/O TERMINAL)
MANUAL CONTROL ENABLE (A39 I/O TERMINAL)
CONTROLLER STOP TIME INPUT (A30 I/O TERMINAL)
MMU OUTPUT RELAY2 OUT
MMU OUTPUT RELAY1 OUT
FLASH RELAY CONTROL
SIGNAL BUS CONTROL
LOCAL FLASH STATUS
SOLID STATE RELAY (SSR)
120VAC (FROM LINE FILTER)
TO LOAD SWITCH 120VAC IN
FILTERED NEUTRAL
MMU
LOGIC GROUND (A27 I/O TERMINAL)
MMU FAULT OUTPUT RELAYS
1
2
FLASH TRANSFER RELAY (FR1-FR6)
LOAD SWITCH OUT
FIELD TERMINAL
FLASHER OUTPUT 2
LOAD SWITCH OUT
FIELD TERMINAL
FLASHER OUTPUT 1
FILTERED NEUTRAL (POWER BUS #10)
TO OTHER FR COILS
24VDC (FROM POWER BUS)
TO LOAD SWITCH +24VDC IN
N/C
FILTERED NEUTRAL (POWER BUS #10)
24VDC CONTROL RELAY (K1)

Figure 41. Flash Control Circuit Schematic

705.2 FLASH CONTROL CIRCUIT COMPONENTS

705.2.1 Inside Flash Switch

.1 At the top-inside of the P6 cabinet assembly door is the Auxiliary Panel. The inside flash switch is located on the Auxiliary Panel.

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

- .1 The 120 VAC supply to the MMU is lost. This opens the MMU fault relay 1 contact which cuts power to the flash transfer relay inputs. This switches the load switch output out of the designated 'flash colour' field terminal and switches in the system flasher outputs to put the signal in flash. The open fault relay also cuts power to the 24VDC control relay (K1) next to the flash transfer relays and the Solid State Relay (SSR) in the Power Distribution Panel. De-energizing the 24VDC control relay removes 24VDC from all the load switch inputs. De-energizing the SSR removes 120VAC from the load switch outputs. This effectively disables all load switches and ensures only the designated flash colour is flashing on any signal heads in the field.
- .2 Power to the MMU start relay is cut. This is a precaution to prevent the assembly from trying to start. However this should not be an issue as MMU power loss is the reason the assembly is in flash.
- .3 Power to the input of the MMU fault relay is lost. Again this is a precaution as the MMU fault relay contact should be open when the MMU loses its 120VAC supply.

705.2.2 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. 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 from the MMU fault relay 1 output is removed from the Flash Transfer Relays, the 24VDC Control Relay and the Solid State Relay coils. De-energizing the Flash Transfer Relays switches the load switch output out of the designated 'flash colour' field terminals and switches in the system flasher outputs to put the signal in flash. De-energizing the 24VDC control relay (K1) removes the 24VDC power from the load switch inputs. De-energizing the Solid State Relay removes 120VAC from the load switch outputs. This effectively disables all load switches and ensures only the designated flash colour is flashing on any signal heads in the field.

.2 A logic ground signal is placed on the MMU's Local Flash input. This will suspend MMU output monitoring and will light up the local flash indicator LED on its front panel.

705.2.3 Conflict Monitor Output Relay

.1 The MMU has two output fault relays: Output Relay 1 and Output Relay 2.

.2 The output relays are controlled by the internal circuitry of the MMU. Output Relay 1 stays closed when in 3-colour operation and opens when there is a fault. Output Relay 2 is the opposite, it stays open when in 3-colour operation and closes on a fault.

.3 During three-colour operation, Output Relay 1 supplies 120 VAC power to the outside flash switch, this in turn supplies power to the Flash Transfer Relays and the 24VDC Control Relay (K1).

.4 During an MMU fault, Output Relay 2 closes which places a Logic Ground signal on the controller unit Stop Time input. This allows service personnel to observe the state of the controller assembly when the fault occurred.

705.2.4 Flash Transfer Relays, Intersection Flasher, Solid State Relay and the 24VDC Control Relay

.1 The inside flash switch, outside flash switch and MMU Output Relay 1 contacts determine whether the Flash Transfer Relays have 120VAC at their input coils or not.

.2 During 3-colour operation the ultimate source of this 120VAC is from the 120VAC RFI filter in the Power Distribution Panel via the Power Bus

Panel, the inside flash switch, the MMU Output Relay and finally the outside flash switch.

.3 Each Flash Transfer Relay is a two-pole electro-mechanical relay. The common of each pole is connected to the 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 system flasher module.

.4 The system flasher as discussed in Section 802 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.

.5 During three-colour operation, the flash transfer relays are energized. Power is supplied to the field outputs by the Solid State Relay in the Power Distribution Panel through the load switch fusing, load switches and flash transfer relays.

.6 During flashing operation, the flash transfer relays are de-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.

.7 All traffic controller assemblies are pre-wired for an all-red flash. Therefore only the red load switch 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.

.8 The 24VDC Control Relay is a 120VAC input relay that switches the 24VDC power supply to the 'Signal Bus' which is the daisy-chain connection between all load switch 24VDC inputs. Without 24VDC at their inputs, the load switches are disabled. When the MMU is in fault or the inside/outside flash switch has been set to flash, 120VAC is cut from the 24VDC Control Relay input, disabling the load switches.

.9 The Solid State Relay (SSR) located in the Power Distribution Panel is a 120VAC input relay that switches RFI filtered 120VAC power to the load switch outputs via the field protection fuses F1-F8. Without 120VAC at their outputs, the load switches are disabled. When the MMU is in fault or the inside/outside flash switch has been set to flash, 120VAC is cut from the SSR input, disabling the load switches.

706 MANUAL CONTROL SWITCHES

706.1 EQUIPMENT LOCATION

.1 In the P6 traffic controller assembly, the manual control switches are located on the Auxiliary Panel at the top-inside of the cabinet door.

706.2 AUTO/MANUAL SWITCH

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

.2 During normal operation, this switch remains in the AUTO position. When it 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.

706.3 INTERVAL ADVANCE PUSHBUTTON

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

.2 During normal operation, this pushbutton is not used. When the AUTO/MANUAL switch is placed in the MANUAL position, operation of the pushbutton 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 2

Section 800

Traffic Controller Assembly Operations

Electrical and ITS Engineering

June 2019

801 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.

802 POWER-UP OPERATION

802.1 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 malfunction management unit is not in a fault state.

802.2 POWER-UP INITIALIZATION

.1 The MMU powers up, energizing its start-delay relay after approximately 2 seconds (±0.5s). This provides power to the Controller Unit.

.2 The Controller Unit powers up and enters its start-up interval. The start-up interval is programmed in the Controller Unit in accordance with the traffic signal Signal Timing Sheet (STS).

.3 The MMU output relay energizes after the minimum flash time has expired. This is determined by the min flash jumpers installed on the MMU Program Card, it is typically 5s. While the relay is de-energized, it applies a stop-timing signal to the controller unit. When the relay energizes, it supplies 120 VAC power to the Flash Transfer Relays, the Solid State Relay (SSR) and the 24VDC Control Relay through the outside flash switch.

.4 During the minimum flash period the controller unit phase outputs are active but frozen by the stop-time input. However, the intersection remains in flash.

.5 During minimum flash the flash transfer relays, 24VDC control relay and the SSR are de-energized. In this state the flash transfer relays are connecting the outputs from the system 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 because all load switches are disabled due to the de-energized 24VDC control and solid state relays.

.6 The Advance Warning sub-panel flash transfer relays are also de-energized during minimum flash. This switches the Advance Warning flasher modules to the outputs so any Advance Warning Signs will flash when the traffic signal is in flash.

803 FLASHING TO THREE-COLOUR OPERATION

803.1 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 MMU 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.

803.2 TRANSFER FROM POWER-UP INITIALIZATION

.1 Once the MMU minimum flash time has expired, the MMU sets its output relays to their no-fault state. The MMU relay 1 output closes and energizes the flash transfer relays, 24VDC relay and solid state relay. The MMU relay 2 output opens and removes the controller unit stop time input.

.2 The SSR energizes, supplying 120 VAC power to the load switches.

.3 The 24VDC relay energizes, supplying 24VDC to the load switch inputs.

.4 Flash transfer relays FR1-FR6 now supply power to the field terminals from the load switch outputs instead of the system flasher. All 3-colour outputs from the load switches are now seen in the field.

803.3 TRANSFER FROM A FAULT CONDITION

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

.2 When in fault the SSR is de-energized and the load switch outputs are without 120VAC.

.3 When in fault the 24VDC control relay is de-energized and the load switch inputs are without 24VDC.

.4 When in fault the flash transfer relays FR1-FR6 switch the system flasher outputs to the flashing field terminals instead of the load switch outputs. All 3-colour load switch outputs are not seen in the field because the load switches are disabled.

.5 The Advance Warning sub-panel flash transfer relays are also de-energized during a fault. This switches the Advance Warning flasher modules to the outputs so any Advance Warning Signs will flash when the traffic signal is in flash.

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

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

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

.7 When the MMU resets, it immediately resets its output relays to their no-fault state. Output relay 1 restores 120 VAC power to the flash transfer relays, 24VDC control relay and the SSR. Output relay 2 removes the stop-time signal and resets the controller unit. Now 3-colour operation is restored.

.8 The SSR energizes, supplying 120 VAC power to the load switches.

.9 The 24VDC relay energizes, supplying 24VDC to the load switch inputs.

.10 Flash transfer relays FR1-FR6 now supply power to the field terminals from the load switches instead of the system flasher. The phase outputs that are not switched by FR1 to FR6 are seen in the field now that the load switches have 24VDC input power and 120 VAC output power.

803.4 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 is placed in the flash position, power is removed from the controller unit and MMU. Power is also removed from the flash transfer relays, 24VDC control relay and the SSR since the MMU output relay 1 is de-energized while the MMU is off.

.2 When the inside flash switch is placed in the three-colour operation position, power is applied to the controller unit and MMU.

.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 802.2 and 803.2* for details.

.4 When the outside flash switch is placed in the flash position, power is removed from flash transfer relays, 24VDC control relay and the SSR and a Logic Ground signal is applied to the MMU Local Flash Status input.

.5 MMU Local Flash places the MMU output relays in a fault state and the signal will be in flash as described in *Clauses 803.3.1 to 803.3.4*.

.6 When the outside flash switch is placed in the three-colour operation position, power is applied to the flash transfer relays, 24VDC control relay and the SSR. The MMU Local Flash input is removed and the MMU keeps the signal in flash for the minimum flash time as determined by the jumpers on the MMU Program Card.

804 THREE-COLOUR TO FLASHING OPERATION

804.1 INTRODUCTION

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

  .1 The MMU 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.

804.2 TRANSFER DUE TO A FAULT CONDITION

.1 When the MMU detects a fault condition, it de-energizes its output relays. Output relay 1 removes power from the transfer relays, 24VDC control relay and the SSR.

.2 When in fault the SSR is de-energized and the load switch outputs are without 120VAC.

.3 When in fault the 24VDC control relay is de-energized and the load switch inputs are without 24VDC.

.4 When in fault the flash transfer relays FR1-FR6 switch the system flasher outputs to the flashing field terminals instead of the load switch outputs. The field outputs that are not switched by FR1 to FR6 are dead because the load switches are disabled.

.5 The Advance Warning sub-panel flash transfer relays are also de-energized during a fault. This switches the Advance Warning flasher modules to the outputs so any Advance Warning Signs will flash when the traffic signal is in flash.

.6 The MMU output relay 2 applies a Logic Ground signal to the controller unit stop-time input. The controller unit remains in the interval at which the fault occurred. It will remain this way until the cause of the fault is removed and service personnel reset the MMU.

804.3 TRANSFER DUE TO THE FLASH CONTROL SWITCHES

.1 When the inside flash switch is placed in the flash position, power is removed from the controller unit and MMU.

.2 The MMU output relay 1 is de-energized while the MMU is off. This removes 120VAC from the inputs of the flash transfer relays, 24VDC control relay and the SSR.

.3 The SSR is de-energized and the load switch outputs are without 120VAC.

.4 The 24VDC control relay is de-energized and the load switch inputs are without 24VDC.

.5 The flash transfer relays FR1-FR6 switch the system flasher outputs to the flashing field terminals instead of the load switch outputs. The field outputs that are not switched by FR1 to FR6 are dead because the load switches are disabled.

.6 The Advance Warning sub-panel flash transfer relays are de-energized. This switches the Advance Warning flasher modules to the outputs so any Advance Warning Signs will flash when the traffic signal is in flash.

.7 When the outside flash switch is placed in the flash position, power is removed from flash transfer relays, 24VDC control relay and the SSR and a Logic Ground signal is applied to the MMU Local Flash Status input.

.8 MMU Local Flash places the MMU output relays in a fault state and the signal will be in flash as described in *Clauses 803.3.1 to 803.3.4*.

TRAFFIC CONTROLLER ASSEMBLY MANUAL
VOLUME 2

Section 900

Traffic Controller Operation at Intersections

Electrical and ITS Engineering

June 2019

901 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.

902 SIGNAL OUTPUT ASSIGNMENTS

902.1 INTRODUCTION

.1 The Ministry has adopted a standard method of assigning controller unit phases, MMU channels and load switches. The assignments of the common intersections, described in *Section 100*, are shown in *Tables 1 through 8*. The standard assignment represents the factory configuration of new traffic controller assemblies.

902.2 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.

.2 Information on the phase assignments at each intersection is contained on the intersection Signal Timing Sheet (STS). A copy of this is kept in the traffic controller cabinet.

.3 Be aware that anytime you see a protected/permissive left turn as in *Table 3*, there is the potential for a situation referred to as a left-turn trap. A trap situation occurs when ∅A1 & ∅A2 are green and a vehicle is detected for the ∅A1→ left turn movement and there is no traffic waiting on the cross-street. In this scenario only the ∅A2 traffic must be stopped to allow ∅A1→ left-turn traffic to proceed. Operators of vehicles on the ∅A2 movement waiting to turn left will see a yellow light and may incorrectly assume that opposing ∅A1 through traffic will also be stopping. If this happens, they may turn left in front of oncoming traffic which they wrongly assume is about to stop.

.4 Be aware that the left-turn trap can also occur when a directional pre-emption call is received. If there are vehicles on the ∅A2 movement waiting in the intersection to turn left and a pre-emption call is made which requests ∅A1 be serviced but not ∅A2 there is the potential for a trap. The left turning ∅A2 traffic will see a yellow light and may incorrectly assume ∅A1is also seeing a yellow light. The ∅A2 left turners may then turn left in conflict with oncoming ∅A1 traffic.

.5 The Cobalt and Naztec 980 controller units have an all-red-clearance anti-trap program feature. 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 (a phase with no display in the field), is inserted before the left-turn movement creating the all-red interval. Refer to the Cobalt and Naztec 980 Programming Manuals on how to implement all-red clearance. This feature manages the anti-trap for normal intersection operation and not the pre-emption left-turn trap.

.6 The Cobalt and Naztec 980 controller units also have an all-red-clearance anti-trap program feature used before servicing a pre-emption call. This feature ensures all phases in the intersection have an all-red interval before a pre-emption call sequence is serviced. Refer to the Cobalt and Naztec 980 Programming Manuals on how to implement pre-emption all-red clearance. This feature manages the anti-trap for the pre-emption sequence left-turn trap and not the normal operation left-turn trap.

902.3 MMU CHANNEL ASSIGNMENTS

.1 Column 3 of each table shows the MMU channel assigned to monitor the field outputs. Each MMU channel has an input circuit for the Red, Yellow, and Green outputs of each phase or overlap.

.2 All unassigned conflict monitor channels have their Red circuit inputs directly connected to 120 VAC line. This is done by installing a jumper between the 120VAC in terminal and the Red output terminal in any unused load switch sockets.

902.4 LOAD SWITCH ASSIGNMENTS

.1 Columns 3 and 4 of each table show the standard load switch assignments. There are sixteen load switch sockets in the P6 Controller Assembly. Although each cabinet comes pre-wired for all possible load switches, only those required at each intersection are 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. Typically load switches LS1 to LS8 are used for vehicle phases 1 to 8 respectively.

.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 Red input/output for Don't Walk. Load switches LS9 to LS12 are typically used for the pedestrian movements on phases 2, 4, 6 & 8 respectively.

.4 Load switches LS13 to LS16 are typically used for overlap OLA, OLB, OLC and OLD respectively.

.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. Load switch outputs of signals not displayed during flashing operation are directly routed to the field terminals.

Table 17. Simple Two-Phase Intersection

C/U Phase	Movement/Function	Conflict Monitor Channel	Load Switch (R/Y/G)
1		1	LS1
2	∅A (Highway)	2	LS2
3		3	LS3
4	∅B (Cross Street)	4	LS4
5		5	LS5
6		6	LS6
7		7	LS7
8		8	LS8
9	∅A Ped	9	LS9
10	∅B Ped	10	LS10
11		11	LS11
12		12	LS12
13		13	LS13
14		14	LS14
15		15	LS15
16		16	LS16

Table 18. Three-Phase T-Intersection

C/U Phase	Movement/Function	Conflict Monitor Channel	Load Switch (R/Y/G)
1		1	LS1
2	∅A (Highway)	2	LS2
3		3	LS3
4	∅C (Cross Street)	4	LS4
5		5	LS5
6	∅B (Highway)	6	LS6
7		7	LS7
8		8	LS8
9	∅A Ped	9	LS9
10	∅C Ped	10	LS10
11	∅B Ped	11	LS11
12		12	LS12
13		13	LS13
14		14	LS14
15		15	LS15
16		16	LS16

Table 19. Intersection with Protected/Permissive Left Turn on the Highway

C/U Phase	Movement/Function	Conflict Monitor Channel	Load Switch (R/Y/G)
1	∅A2-> (Highway - Left Turn)	1	LS1
2	∅A1 (Highway)	2	LS2
3		3	LS3
4	∅B (Cross Street)	4	LS4
5		5	LS5
6	∅A2 (Highway)	6	LS6
7		7	LS7
8		8	LS8
9	∅A2 Ped	9	LS9
10	∅B Ped	10	LS10
11	∅A1 Ped	11	LS11
12		12	LS12
13		13	LS13
14		14	LS14
15		15	LS15
16		16	LS16

Table 20. Intersection with Protected/Permissive Left Turn on the Cross Street

C/U Phase	Movement/Function	Conflict Monitor Channel	Load Switch (R/Y/G)
1		1	LS1
2	∅A (Highway)	2	LS2
3	∅B1-> (Cross Street - Left Turn)	3	LS3
4	∅B2 (Cross Street)	4	LS4
5		5	LS5
6		6	LS6
7		7	LS7
8	∅B1 (Cross Street)	8	LS8
9	∅A Ped	9	LS9
10	∅B2 Ped	10	LS10
11		11	LS11
12	∅B1 Ped	12	LS12
13		13	LS13
14		14	LS14
15		15	LS15
16		16	LS16

Table 21. Intersection with Dual Left Turn on the Highway

C/U Phase	Movement/Function	Conflict Monitor Channel	Load Switch (R/Y/G)
1	∅A2-> or Ay (Highway Left Turn)	1	LS1
2	∅A1 (Highway)	2	LS2
3		3	LS3
4	∅B (Cross Street)	4	LS4
5	∅A1-> or Ax (Highway Left Turn)	5	LS5
6	∅A2 (Highway)	6	LS6
7		7	LS7
8		8	LS8
9	∅A1 Ped	9	LS9
10	∅B Ped	10	LS10
11	∅A2 Ped	11	LS11
12		12	LS12
13		13	LS13
14		14	LS14
15		15	LS15
16		16	LS16

Table 22. 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)
1	∅A2-> or ∅Ay (Highway)	1	LS1
2	∅A1 (Highway)	2	LS2
3	∅B (Cross Street)	3	LS3
4	∅C (Cross Street)	4	LS4
5	∅A1-> or ∅Ax (Highway)	5	LS5
6	∅A2 (Highway)	6	LS6
7		7	LS7
8		8	LS8
9	∅A1 Ped	9	LS9
10	∅B Ped	10	LS10
11	∅A2 Ped	11	LS11
12	∅C Ped	12	LS12
13		13	LS13
14		14	LS14
15		15	LS15
16		16	LS16

Table 23. Dual Left Turn on Highway and Protected/Permissive Left Turn on Cross Street

C/U Phase	Movement/Function	Conflict Monitor Channel	Load Switch (R/Y/G)
1	∅A2-> or ∅Ay (Highway)	1	LS1
2	∅A1 (Highway)	2	LS2
3		3	LS3
4	∅B1 (Cross Street)	4	LS4
5	∅A1-> or ∅Ax (Highway)	5	LS5
6	∅A2 (Highway)	6	LS6
7	∅B1-> (Cross Street Left Turn)	7	LS7
8	∅B2 (Cross Street)	8	LS8
9	∅A1 Ped	9	LS9
10	∅B1 Ped	10	LS10
11	∅A2 Ped	11	LS11
12	∅B2 Ped	12	LS12
13		13	LS13
14		14	LS14
15		15	LS15
16		16	LS16

Table 24. Eight-Phase Quadruple Protected or Protected/Permissive Intersection

C/U Phase	Movement/Function	Conflict Monitor Channel	Load Switch (R/Y/G)
1	∅A2-> or ∅Ay (Highway)	1	LS1
2	∅A1 (Highway)	2	LS2
3	∅B2-> or ∅By (Cross Street Left Turn)	3	LS3
4	∅B1 (Cross Street)	4	LS4
5	∅A1-> or ∅Ax (Highway)	5	LS5
6	∅A2 (Highway)	6	LS6
7	∅B1-> (Cross Street Left Turn)	7	LS7
8	∅B2 (Cross Street)	8	LS8
9	∅A1 Ped	9	LS9
10	∅B1 Ped	10	LS10
11	∅A2 Ped	11	LS11
12	∅B2 Ped	12	LS12
13		13	LS13
14		14	LS14
15		15	LS15
16		16	LS16

903 CONTROLLER UNIT RUN-MODE DISPLAY

903.1 ACCESSING THE RUN-MODE DISPLAY

.1 The controller unit run-mode status displays are very useful tools for determining the current traffic controller assembly status.

.2 The instructions presented in this chapter describe only how to access the most basic status information used to assist in the location of traffic controller assembly faults. For more information you should refer to the manufacturer's manuals. Additionally, the Cobalt has a very good help menu system for each of its programming parameters.

.3 The data in the Naztec 980 is organized in a menu system. Available menu options are accessed by using the adjacent key pad. You can access the status displays as follows:

- .1 The Main Menu key jumps directly to the main menu display.
- .2 The Status sub-menus can be accessed by pressing '7' or by moving the cursor with the arrow keys and selecting Status with the 'ENTR' key.
- .3 The most useful run-mode status display is now found under Timing. The Timing status screen is full of details on the current operation of the Controller Unit including: Current state of each ring, current active phase, current colour being displayed, current run timer value, current vehicle and pedestrian calls by phase, current time of day pattern and sequence, and if a pre-emption sequence is active. You are strongly urged to read the Naztec 980 manual on each of the status screens.
- .4 The 'ESC' key returns to the previous menu display.

.4 The Cobalt 'Classic View' is also organized in a menu system. Available menu options are accessed by using the adjacent key pad. You can access the status displays as follows:

- .1 The Main key jumps directly to the main menu display.
- .2 The Status Display sub-menus can be accessed by pressing '7' or by moving the cursor with the arrow keys and selecting Status with the 'ENTER' key.

.3 The most useful run-mode status display is now found under Controller. The Controller status screen shows gives all the details on the current operation of the Controller Unit including: Current state of each ring, current active phase, current colour being displayed, current run timer value, current vehicle and pedestrian calls by phase, current time of day pattern and sequence, and if a pre-emption sequence is active. It also gives an overview of the current coordination status if the signal is in coordination. You are strongly urged to read the Cobalt manual regarding each of the status screens. On the Cobalt you can also move the cursor over an item and press the 'HELP' button to read the help screen on that particular parameter.

.4 The 'SUB' key returns to the previous menu display.

904 MALFUNCTION MANAGEMENT UNIT DISPLAYS

904.1 MMU STATUS DISPLAYS

.1 The MMU-16E and MMU-1600D MMUs use their front panel LED indicators to provide signal and fault status information. The Double Diamond MMU uses an LCD to display all signal and fault status information.

.2 During normal operation, the displays indicate the currently active signals for the corresponding channel. Refer to *Clause 902.3* 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 MMU will immediately re-display the failure-display indications upon restoration of power.

904.2 MMU-16E FAULT DISPLAY

.1 Once the MMU16E has been triggered by a fault the channel status display will sequence through several display modes automatically:

.1 Active Signals.

.2 Field signals active at the time of the fault for 6 seconds.

.3 Fault Channels (if applicable) - The channels involved in the fault will flash their respective Green AND Yellow AND Red indicators simultaneously at a 4 Hz rate for 2 seconds.

.4 Field Check Status (if applicable) - The inputs with Field Check Status will flash their respective indicators simultaneously with the FIELD CHECK STATUS indicator at a 4 Hz rate for 2 seconds.

.5 Recurrent Pulse Status (if applicable) - The inputs with Recurrent Pulse Status will flash their respective indicators simultaneously with the RECURRENT PULSE STATUS indicator at a 4 Hz rate for 2 seconds.

.2 The Fault Status Display LEDs of the MMU-16E displays thirteen fault conditions in addition to the Type 12 or 16 mode and AC LINE status.

.1 CONFLICT Indicator - The CONFLICT indicator will be illuminated when a Conflict Fault is detected.

.2 RED FAIL Indicator - The RED FAIL indicator will be illuminated when a Red Fail Fault is detected. The RED FAIL indicator will flash once every 2 seconds if the RED ENABLE input is not active, or in the Type 16 mode, if the LOAD SW ITCH FLASH bit is set to 1 in the Type 0 message from the Controller Unit.

.3 CVM / WD (Controller Voltage Monitor / Watchdog) Indicator - The CVM / W D indicator will be illuminated when a Controller Voltage Monitor Fault is detected. If the External Watchdog monitor option (W D ENABLE) is enabled and the MMU-16E is triggered by an External Watchdog output failure, the CVM / WD indicator will be illuminated. See Section

.4 24V-1, 24V-2 (Voltage Monitor) Indicators - These indicators will be illuminated when the MMU-16E has detected a +24V MONITOR-1 or +24V MONITOR-2 failure. The 24V-1 and 24V-2 indicators will flash once every 2 seconds if the +24V MONITOR INHIBIT input is TRUE.

.5 CLEARANCE FAIL Indicator – The CLEARANCE FAIL indicator will be illuminated when a Minimum Yellow Change Fault is detected.

.6 Y+R CLEARANCE Indicator - The Y+R CLEARANCE indicator will be illuminated when a Yellow Change plus Red Clearance Fault is detected. The channel(s) that caused the Y+R Clearance fail will show only the Green indicator during the Fault Channel sequence.

.7 DUAL INDICATION Indicator - The DUAL INDICATION indicator will be illuminated when a DUAL INDICATION Fault is detected

.8 PORT 1 FAIL Indicator - The PORT 1 FAIL indicator will be illuminated when a Port 1 Failure is detected. The PORT 1 FAIL indicator will flash every 2 seconds if the TYPE SELECT input is True (low) and the PORT 1 DISABLE input is True (low) (i.e. Type 16 mode with Port 1 communications disabled).

.9 FIELD CHECK FAIL Indicator - The FIELD CHECK FAIL indicator will be illuminated when a Field Check Fault is detected.

.10 LOCAL FLASH Indicator - The LOCAL FLASH indicator is illuminated when the LOCAL FLASH STATUS input is True.

.11 DIAGNOSTIC Indicator - The DIAGNOSTIC indicator will illuminate when the MMU-16E has detected an internal diagnostic failure. Due to the nature of these hardware/firmware failures, other indicators that may also be displayed may not be valid for trouble shooting purposes. If a Type Fault is detected the DIAGNOSTIC indicator will be illuminated and the TYPE 12 indicator will flash at a rate of 2Hz.

.12 PGM CARD / CF Indicator - The PGM CARD / CF indicator will illuminate when the Program Card is removed or not inserted fully. If the unit is in the Configuration Change Fault (CF) mode, the PGM CARD / CF indicator will flash at a 4 Hz rate.

.13 TYPE 12 Indicator - The TYPE 12 indicator is illuminated when the MMU-16E is programmed for Type 12 operation. If a Type Fault is detected the DIAGNOSTIC indicator will be illuminated and the TYPE 12 indicator will flash at a rate of 2Hz.

.14 POWER Indicator - The POW ER indicator will flash at a rate of 2Hz when the AC LINE voltage is below the drop-out level. It will illuminate steadily when the AC LINE voltage returns above the restore level.

.15 FIELD CHECK STATUS Indicator - The FIELD CHECK STATUS indicator will illuminate when a fault has been detected with Field Check Status. The indicator will then flash at a rate of 4Hz for a 2 second interval when the Channel Status display is showing the inputs with Field Check Status.

.16 RECURRENT PULSE STATUS Indicator - The RECURRENT PULSE STATUS indicator will illuminate when a Conflict, Red Fail, or Dual Indication fault has been detected with Recurrent Pulse Status. The indicator will then flash at a rate of 4Hz for a 2 second interval when the Channel Status display is showing the inputs with Recurrent Pulse Status.

.17 RECEIVE Indicator - The RECEIVE indicator will be illuminated for a 20 msec pulse each time a Port 1 message is correctly received from the Controller Unit.

.18 TRANSMIT Indicator - The TRANSMIT indicator will be illuminated for a 20 msec pulse each time a Port 1 message is transmitted to the Controller Unit.

.19 COMM Indicator - The COMM indicator will be illuminated for a 20 msec pulse each time a message is correctly received on the EIA-232 Port.

904.3 MMU-1600D FAULT DISPLAY

.1 When a fault is detected by the MMU-1600D, the field status is latched and the field input involved in the detected fault will flash at a 5 Hz rate. The following table lists the information displayed on the Field Status indicators during the various fault conditions.

Table 25. MMU-1600D Field Status Indicators on Fault

FAULT CONDITION	FIELD STATUS INDICATION
24V-1/24V-2CVM / WD PORT 1 FAIL	**ON** - Field inputs that were ON for at least 33 milliseconds at the time of the fault.
CONFLICT	**ON** - Field inputs that were ON for at least 33 milliseconds at the time of the fault. **FLASHING** - Field inputs that were ON and were the cause of the fault.
DIAG FAIL	**FLASHING –** The binary coded value of the diagnostic error code with channel 1 being the least significant bit and channel 16 the most significant bit. **NOTE:** This may be incorrectly displayed depending on the type of diagnostic failure being experienced.
SHORT YEL	**ON** - Field inputs that were ON for at least 100 milliseconds at the time of the fault. **FLASHING** - The Yellow field inputs on which a Short Yellow was detected.

FAULT CONDITION	FIELD STATUS INDICATION
SHORT CLR	**ON** - Field inputs that were ON for at least 33 milliseconds at the time of the fault. **FLASHING -** The Green field inputs that were not OFF for at least 2.7 seconds before a conflicting channel was detected as active.
FIELD CHK	**ON** - Field inputs that were ON for at least 33 milliseconds at the time of the fault. **FLASHING -** The field inputs that did not agree with the load switch commands from the CU.
LOC FLASH **PRGM CARD**	Current field status. (NOT LATCHED)
RED FAIL	**ON** - Field inputs that were ON for at least 100 milliseconds at the time of the fault. **FLASHING** - All field inputs for the channel(s) that had no display.
DUAL IND	**ON** - Field inputs that were ON for at least 100 milliseconds at the time of the fault. **FLASHING** - Field inputs that were ON and were the cause of the fault.

904.4 DOUBLE DIAMOND FAULT DISPLAYS

.1 When a fault is detected on the controller outputs, the Double Diamond MMU trips its output relay and the Fault LED on the front panel comes on. The failure type is indicated on the right side of the MMU's display. In general, these fault states follow these rules:

.1 **For any of the latched modes**, the R-Y-G, Port1, Line, and Signal Voltage screens are all frozen and latched to the state at the time the fault was registered. These screens will thus appear as they were at the time the fault occurred. All other status screens are also frozen at the time of failure. The failed state and display will be stored indefinitely, even through power interruptions, until the unit is manually reset.

.2 **If a fault is defined as always latched**, latch mode is not optional, it is always latched.

.3 **If MMU is set to latch only if latch enabled**,the unit will latch as above only if that particular failure is programmed for latching operation. If not, the failure can self-heal.

.4 **If the MMU is set to always latched if failure mode enabled**,the unit will always latch if the failure mode itself is enabled, i.e. the failure mode itself is optional, but not the latching behavior of the MMU.

.2 The following describes each type of fault display:

.1 <u>Conflict Fault Detected</u> - This type of fault is always latched. Some combination of incompatible greens or yellows (or walks in type 12 mode) occurred at the same time for a period longer than the allowable recognition time. 'CONF' is displayed vertically on the right-hand side of the display. The state of each channel when the fault occurred is shown on the left-hand side of the display.

.2 <u>Red Failure Fault Detected</u> - This type of fault is always latched. One or more channels have no indications at all above the required signal thresholds. 'RED FAIL' is displayed vertically on the right-hand side of the display. The state of each channel when the fault occurred is shown on the left-hand side of the display.

.3 <u>No Yellow Fault Detected</u> - This type of fault is always latched if the failure mode is enabled. 'NO YEL' is displayed vertically on the right-hand side of the display. The display is latched at the time of failure, but the Y of the offending channel flashes to indicate that a yellow did not come on after green. Please note that the flashing yellow signal does not mean it was actually ON at the time the failure was logged. It simply indicates which yellow was absent. No Yellow Fail monitoring can be inhibited by MIN Yellow Disable jumper programming on the Programming Card (when a TS 2 card is inserted.) The Red Enable input must be active for this failure mode to occur.

.4 <u>Minimum (or Short) Yellow Fault Detected</u> - This type of fault is always latched if the failure mode is enabled. 'SHRT YEL' is displayed vertically on the right-hand side of the display. The display is latched at the time of failure, but the Y of the offending channel flashes to indicate that, when it cleared, the yellow came on but was on for too short a time (i.e. less than 2.7 seconds.) **Note:** The flashing yellow signal does not mean it was actually ON at the time the failure was logged, it simply indicates which yellow was short. Min Yellow Fail monitoring can be inhibited by MIN Yellow Disable jumper programming on the Programming Card

.5 Clearance Fault Detected - This type of fault is always latched if the failure mode is enabled. ‘CLR FAIL’ is displayed vertically on the right-hand side of the display. The display is latched at the time of failure, but a g flashes (ch 2 in this case) to indicate the channel with the clearance failure. Clearance failure is similar to short yellow but is based on the time from the end of green to some other conflicting green being less than 2.7 seconds. Clearance failure is not inhibited by Min Yellow Inhibit (as set in jumper programming.)

.6 Multiple Indications Fail - This type of fault is always latched if the failure mode is enabled. ‘MULT IND’ is displayed vertically on the right-hand side of the display. Multiple indications fail is a result of more than one signal being on within the same channel. Multiple indications is an optional monitoring mode, and must be programmed before it will occur. The state of each channel when the fault occurred is shown on the left-hand side of the display.

.7 +24VDC Failure Detected – This fault occurs if the controller assembly 24VDC supply is seen to fail by the MMU. This type of fault is only latched when the MMU unit latch is enabled. ‘24V1/24V2’ or ‘24V LTCH’ is displayed vertically on the right-hand side of the display. The state of each channel when the fault occurred is shown on the left-hand side of the display.

905 DETECTOR, LOAD SWITCH, ADVANCE WARNING FLASHER AND PRE-EMPTION INPUT INDICATORS

905.1 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 Most of the detectors used by the Ministry have additional indicators for loop faults. Typically a steady loop fault LED indicates a failed loop. A flashing loop fault LED indicates there was a problem with the loop which has since gone away. This can indicate a failing loop. As their operation is not standardized, refer to the manufacturer's documentation for further details.

905.2 LOAD SWITCH INDICATORS

.1 Each load switch is equipped with two sets of LED indicators. One set shows the state of the low-voltage input for the red, yellow and green channels which is controlled by the controller unit phase outputs. The other set of indicators show the state of the corresponding high-voltage output, which is connected to the flash transfer relay or field terminal.

.2 On a pedestrian load switch, green indicates Walk and Red indicates Don't Walk.

.3 During normal operation, only one matching pair of indicators should be on.

905.3 FLASHER MODULE INDICATORS

.1 All flasher modules have two red indicators, one for each channel. The red indicators will flash alternately whenever the high-voltage flasher outputs are on.

905.4 PRE-EMPTION RELAY INDICATORS

.1 Each pre-emption relay has an indicator LED which is lit when the relay is energized.

.2 Only one of the rail pre-emption relays should be energized at any given time. If this is not the case the controller assembly will go into flash. Therefore only one relay indicator should be on between the two relays.

.3 The emergency pre-emption relays place a pre-emption call to the controller unit when they are de-energized by the field pre-emption equipment. Therefore all emergency pre-emption LED indicators should be on when there are no pre-emption calls being made.

.4 The low-priority pre-emption relays place a call when they are energized by external pre-emption equipment. Therefore all low-priority pre-emption relays should be off when no pre-emption calls are being made.

906 TROUBLESHOOTING

906.1 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. This could introduce further problems, prolonging the troubleshooting process.

.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.

906.2 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.

906.3 DEFINE THE PROBLEM

.1 Take time to examine the controller unit and MMU 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 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.

906.4 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.

906.5 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 recurring problems.