# IMSA Traffic Signal Field Technician II

Advancing the Future of Public Safety

Revision Date: April 21, 2023

# STUDY GUIDE


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IMSA Advancing the Future of Public Safety

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Agencies and Manuals

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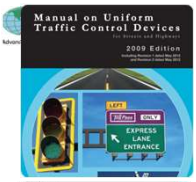


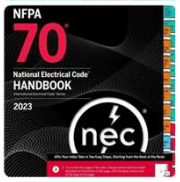


## Governing Agencies and Manuals

- FHWA (Federal Highway Administration)
- MUTCD (Manual of Uniform Traffic Control Devices)
  - Uniformity and Consistency, safety, legal compliance, and efficiency and traffic flow.
- OSHA (Occupational Safety and Health Administration
  - Worker Safety, Standard Setting, Compliance and Enforcement, whistleblower protection.
- NEC (National Electric Code)
  - Electrical Safety, National Standards, Electrical System Design, and Installation and Maintenance.
- NEMA (National Electrical Manufacturers Association
  - Standardization, Safety and Reliability, and Technical Expertise.
- IMSA (International Municipal Signal Association)
- NESC - National Electrical Safety Code
- CALTRANS/170
- ITE

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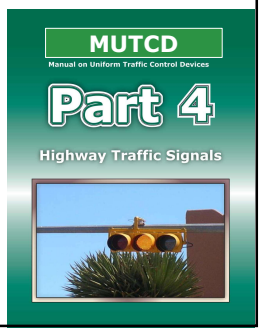
## Manual of Uniform Traffic Control Devices - MUTCD

Part 4 of the MUTCD is all about Highway Traffic Signals. This is the reference guide to all federal rules regarding Warranting, Construction, Maintaining and Inspecting.

Standards for traffic control signals are important because traffic control signals need to attract the attention of a variety of road users, including those who are older, those with impaired vision, as well as those who are fatigued or distracted, or who are not expecting to encounter a signal at a particular location.

This Manual ensures uniformity across the United States and Canada (MUTCDC).

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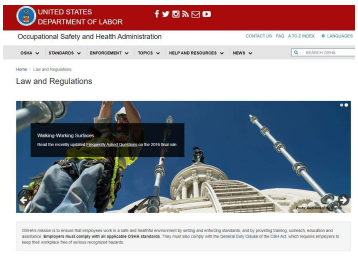
## Occupational Safety and Health Administration

OSHA stands for the Occupational Safety and Health Administration. It is a federal agency within the United States Department of Labor. OSHA's primary mission is to ensure safe and healthy working conditions for employees across various industries in the United States.

Here are some key aspects of OSHA:

1. Workplace Safety Standards
2. Inspections and Compliance
3. Training and Education
4. Recordkeeping and Reporting
5. Whistleblower Protection
6. Partnerships and Collaboration

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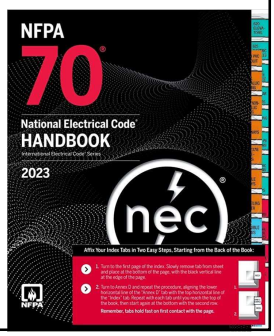
## National Electrical Code Handbook

The National Electrical Code (NEC) Handbook is a comprehensive guidebook that provides detailed interpretations, explanations, and additional information to accompany the National Electrical Code. The NEC Handbook is published by the National Fire Protection Association (NFPA), which is responsible for developing and updating the NEC.

The NEC Handbook offers the following features:

1. Commentary
2. Examples and Illustrations
3. Case Studies
4. Historical Information
5. Cross-References and Index

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## National Electrical Safety Code - NESC

The National Electrical Safety Code (NESC) is a set of safety standards and guidelines established in the United States to ensure the safe installation, operation, and maintenance of electric supply and communication systems. It is published by the Institute of Electrical and Electronics Engineers (IEEE) and is widely adopted by utility companies, electrical contractors, and regulatory bodies.

The NESC covers a wide range of topics, including:

1. General Requirements
2. Safety Rules for the Installation and Maintenance of Electric Supply Stations and Equipment
3. Safety Rules for the Installation and Maintenance of Overhead Electric Supply and Communication Lines
4. Safety Rules for the Installation and Maintenance of Underground Electric Supply and Communication Line
5. Work Rules for the Operation of Electric Supply and Communication Lines and Equipment

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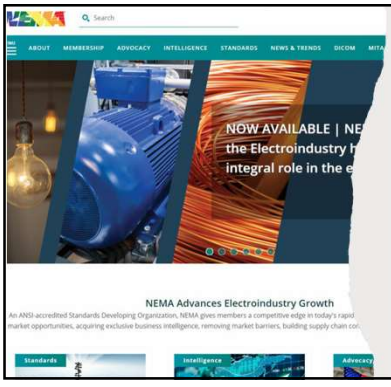


## National Electrical Manufacturers Association

The National Electrical Manufacturers Association was founded in 1926, NEMA is an ANSI-accredited Standards Developing Organization made up of business leaders, electrical experts, engineers, scientists, and technicians. NEMA convenes a neutral forum for Members to discuss industry-wide concerns and objectives under a legal umbrella by trained NEMA Staff

NEMA

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# IMSA Traffic Signal Technician II

Electrical Theory review

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## Basic Electrical theory

- **Electrical Safety**
- **Conductors and Insulators**
- **Ohms Law**
- **AC / DC**
- **Series / Parallel**
- **Grounding and Bonding**

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## Basic Electrical Theory
## Electrical Safety

Electricity is Dangerous!!!

- 30,000 non-fatal shock accidents per year
- Nearly 7 kids /day are treated in the ER for electrical shocks or burns (wall outlets)
- Estimated 60 electrocutions / yr. because of consumer products
- 126 out of 4,764 worker deaths by electrocution (2020)

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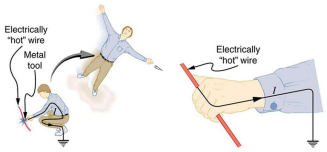
## Basic Electrical Theory
## Electrical Safety

**Electricity is Dangerous!!!**

Traffic signal technicians may be required to work on components or wiring while energized or (hot).

Using insulated tools, non-conductive tools and wearing gloves can reduce the chances of getting shocked. Also, your freehand should not be touching the cabinet, pole or any other grounded device.




Don't Complete the Circuit!

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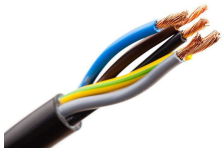
## Basic Electrical Theory
## Conductors and Insulators

**Conductors** are materials that conduct electricity.

Most metals are conductors.
Copper is the most used material for electrical wiring.

Gold and silver are better conductors than copper but are much too expensive to use for wire, however these materials are used in electronics.



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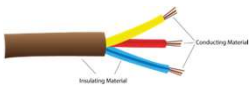
## Basic Electrical Theory
## Conductors and Insulators

**Insulators** are materials that do not conduct electricity.

Some materials commonly used as insulators are various types of plastics or rubber, glass and ceramic.

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## Basic Electrical Theory
## Ohms Law

**Understanding electricity**

Electricity flowing through wires (conductors) is similar as water flowing through pipes.

- **Voltage** is like Water Pressure
- **Current** is like amount of water
- **Resistance** is like size of the pipe

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## Basic Electrical Theory
## Ohms Law

**Voltage, Current & Resistance:**

- The basis for Ohms Law
- A ratio comparison that we use as a formula
- **E** = **I** x **R**
  - **E** = Voltage (Electromotive Force) (Volts)
  - **I** = Current (Intensity) (Amps)
  - **R** = Resistance (Ohms)

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## Basic Electrical Theory
## Ohms Law

**OHMS LAW**

**E** = **I** x **R**

**I = E / R**

**R = E / I**

**E** = Voltage (Electromotive Force) (Volts)

**I** = Current (Intensity) (Amps)

**R** = Resistance (Ohms)

There are two voltages typically used in traffic signal circuits **120 VAC** and **24 VDC** These voltages normally remain the same.

The amount of current flowing in a circuit is determined by the resistance and the voltage.

If you increase the voltage and the resistance remains the same the current will increase.

If you decrease the resistance and the voltage remains the same the current will increase.

For example, if you add another signal indication to a circuit, that reduces the resistance of that circuit, and the current will increase.(The voltage remains the same)

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## Basic Electrical Theory
## AC / DC

**AC – Alternating Current**

**DC – Direct Current**

Electric current flows in two ways, as an Alternating Current (AC) or Direct Current (DC). The main difference between AC and DC lies in the direction in which the electrons flow. In DC, the electrons flow steadily in a single direction, while electrons keep switching directions, going forward and then backwards in AC.

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## Basic Electrical Theory
## AC / DC

**AC – Alternating Current**

Alternating current AC is the type of electricity that powers our homes businesses and factories and our traffic signals. It is generated by various types of generators and distributed through the power grid. It is typically 120 volts and alternates at 60 cycles per second (60 Hertz)

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## Basic Electrical Theory
## AC / DC

**DC – Direct Current**

Direct Current DC is produced by batteries or power supplies. Electronic circuits and devices run on DC. Typical voltages used in electronics are 5 Volts, 12 Volts, and 24 Volts.

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## Basic Electrical Theory
## Series / Parallel

**Schematic Symbols**

- Diode
- Capacitor
- Inductor
- Resistor
- DC voltage source
- AC voltage source

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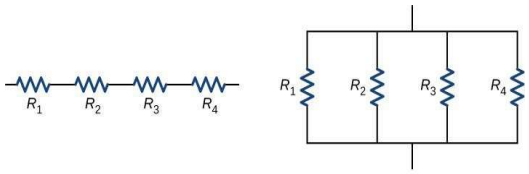
## Basic Electrical Theory
## Series / Parallel




(a) Resistors connected in series (b) Resistors connected in parallel

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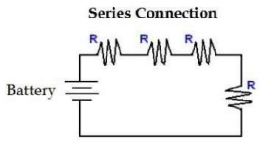
## Basic Electrical Theory
## Series / Parallel

In a series circuit the current remains constant.

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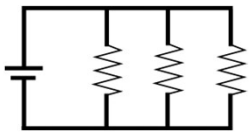
## Basic Electrical Theory
## Series / Parallel

In a Parallel circuit voltage remains constant. Traffic signal indications are wired in parallel.



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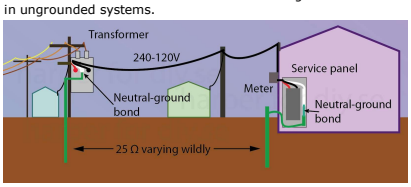
## Basic Electrical Theory
## Grounding and Bonding

**Bonding**

Article 100 of the NEC defines bonded (bonding) as "connected to establish electrical continuity and conductivity." Bonding metal parts, such as enclosures and raceways, ensures that they are all continuous on an effective ground-fault current path (EGFCP) that references back to ground (earth). The EGFCP helps operate devices such as circuit breakers and fuses or ground-fault detectors in ungrounded systems.

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## Basic Electrical Theory
## Grounding and Bonding

**Bonding**

In grounded systems, it is important to bond the equipment grounding conductors to the system grounded conductor to complete the EGFCP back to the source of electricity. The conductivity of the EGFCP is critical for protective devices to work properly. This speaks to why we scrape the paint from contact surfaces of metallic enclosures to make our electrical system bonding connections. Removing the paint, as required in Section 250.12, provides for a better connection and conductivity path.

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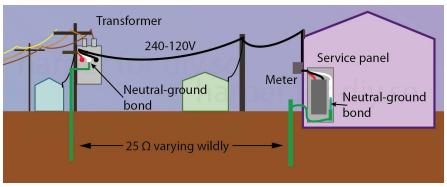
## Basic Electrical Theory
## Grounding and Bonding

**Grounding**

The NEC defines ground as "the earth." Grounding is a conductive connection, intentional or accidental, between a circuit or electrical equipment and the ground or some conductive object acting as the ground. In an airplane, for example, the fuselage acts as the ground

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## Basic Electrical Theory
## Grounding and Bonding

**Grounding and Bonding**

Section 250.4 states the general requirements for grounding and bonding of electrical systems for both grounded and ungrounded systems. For grounded systems, the NEC requires you to perform all of the following: electrical system grounding, electrical equipment grounding, electrical equipment bonding, and bonding of electrically conductive materials. In ungrounded systems, the same actions are required except for electrical system grounding. When these NEC requirements are implemented, an effective ground-fault current path is created, which is your desired end goal.

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# IMSA Traffic Signal Field Technician II

Cabinet Types

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## Cabinet Types

In a **NEMA** TS-1 configuration, the controller is connected to the back panel and other cabinet devices via three MS-type connectors designated A, B, and C with designated pin configurations. A fourth D connector may be added to provide advanced features, The difference between NEMA TS1 and TS2 is that the TS 2 Type 1 controller uses an RS-232/SDLC data link connection to the peripheral devices, with a separate power connector . The TS 2 Type 2 provides the same connectors as the TS 1 but also includes the data link connector. The **NEMA** TS2 controller assembly is nearly identical to the TS1. The two primary differences are the change in controller unit and the conflict monitor is replaced by a malfunction management unit (MMU). The TS 2 standard defines advanced traffic signal operations such as coordination and preemption, and developed standards for pretimed operations and the cabinet.

An **ITS (Intelligent Transportation System)** Cabinet provides ample space and convenient modularity for numerous applications. In addition to traffic control, the ITS cabinet is perfect for sign control and ramp meters2.

The **ATC Cabinet (ATCC)** is an open architecture traffic control cabinet based on the ITE/NEMA/AASHTO ATC suite of standards. This new cabinet family offers significant improvements to conventional cabinet designs in modularity and compact size, motorist safety, technician safety, LED compatibility, and diagnostics. The ATC Cabinet is intended to update or replace all cabinet types; NEMA TS-1, NEMA TS-2, ITS Cabinet, and Caltrans. As more and more cabinets with traditional parallel wiring between the controller and cabinet inputs and outputs (NEMA TS 1 and Model 33x cabinets) are replaced with serial bus cabinets (NEMA TS 2 and ITS Cabinet) the distinction between NEMA and ATC controllers will be less significant

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## Cabinet Types

**Door and light switch**
The door switch sends a signal to the controller to indicate when the cabinet door is open. Usually, the door switch turns off the light when the cabinet door is closed to save energy.

**Detector rack**
The Detector Rack provides housing and circuitry to detection devices (e.g., detector cards), which are sensors that detect the presence of vehicles, pedestrians, or bicycles and then send signals to the controller.

**Battery Backup System**
The battery backup system can provide enough power to the traffic signals to keep them running for a certain amount of time in case of power outages. Batter backups are often in a small closet attached to the cabinet.

**Thermostat**
The thermostat indicates the temperature inside the cabinet and should always be within a safe range of 85-165 degrees. The thermostat connects to a fan that automatically powers on when the cabinet temperature reaches 90-95 degrees.

**Power Supply**
The power supply provides regulated DC voltage and can convert AC output power to DC voltages for the equipment in the cabinet, such as camera units, detector racks, etc. We
need to ensure grounds and neutral are bonded together at the power supply source.

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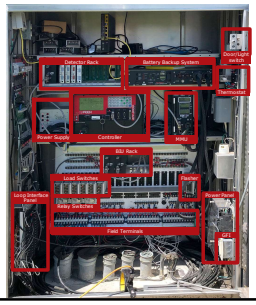
## Cabinet Types

### NEMA TS2

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## Cabinet Types

**Loop Interface Panel**
This panel ensures the signal from the inductive loop detectors that detect vehicles at intersections is properly processed and transmitted to the controller. The panel also includes interface cards, amplifiers, and filters.

**Relay Switches**
The relay switches can control the power supply to signal heads to turn load switches on and off or activate flashing modes. In the event of a power outage, they can rapidly switch a power supply to the backup battery.

**Field Terminals**
Field terminals connect the various electrical components in the cabinet to the external wires or cables that connect to the traffic signal.
Ensure that all wires are labeled according to the wiring schematics in the blueprints.

**Power Panel**
The power panel is responsible for the power input into the traffic signal cabinet. The power panel contains the power supply lines from the local electric company, various circuit breakers, and surge protectors to protect from current overload.

**GFI**
A Ground Fault Interrupter is a circuit breaker designed to protect from electrical shock by shutting off electric power in the event of a ground fault. We should never let cabinet equipment plugged into the GFI.

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## Cabinet Types

**Controller**
The controller is the brain of the cabinet responsible for the operation of the traffic signal at an intersection. It processes and responds to inputs from various devices to determine when and how to change traffic signals.

**MMU**
The Malfunction Management Unit displays the current status of the intersection and is responsible for responding to malfunctioning signals and operating voltages. For example, the MMU can put a malfunctioning signal in flashing mode until it can be repaired.

**BIU rack**
Bus Interface Unit rack provides a communication interface between the controller and external devices (e.g., camera modules and EVP equipment). The BIU uses a communication bus, such as Ethernet, to enable the controller to receive input from external devices.

**Load Switches**
Load switches are often responsible for signal phases and can be used to turn components (e.g., signal heads and pedestrian pushbuttons) on and off at appropriate times. The controller can activate a specific load switch to turn on or off a component when a signal change is required.

**Flasher**
The flasher can handle the load switches when a flash input is required, controlling the flashing mode of a traffic signal. The flashing rate is adjusted based on pre-determined specifications.

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## Controller

A traffic signal controller is a device that regulates the operation of traffic signals at intersections or road junctions. Its main purpose is to manage the flow of vehicles and pedestrians, ensuring safe and efficient movement through the intersection.

The traffic signal controller typically consists of the following components:

**Central Processing Unit (CPU)**: This is the brain of the controller, responsible for executing the control algorithms and coordinating the overall operation of the traffic signals.

**Input/Output (I/O) Modules**: These modules facilitate communication between the controller and various external devices. They receive inputs from sensors such as vehicle detectors, pedestrian push buttons, and cameras, and provide outputs to control the traffic signal lights.

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## Controller

**Timing and Control Algorithms**: The controller utilizes pre-programmed timing plans and algorithms to determine when and how the traffic signals change. These algorithms take into account factors such as traffic volumes, pedestrian demands, and the coordination with adjacent intersections.

**Communication Interfaces**: Traffic signal controllers often have communication capabilities to interact with a central traffic management system. This allows for remote monitoring and control of the signals, enabling adjustments based on real-time traffic conditions or emergencies.

**Power Supply**: The controller requires a stable power source to operate reliably. It may have built-in backup systems, such as batteries or generators, to ensure uninterrupted operation during power outages.

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## Timing Sheets

A timing sheet, also often referred to as a signal timing plan, is a crucial component in the management of traffic signals. It provides the detailed settings and operational parameters that govern how a particular traffic signal or intersection operates.

Key components of a traffic signal timing sheet may include:

- **Cycle Length:** The cycle length is the total time for the signal to complete one full cycle. This includes the phases for all directions and any pedestrian signals.
- **Phases:** Phases represent the distinct time periods within a cycle where a specific movement or set of movements is given the right of way. Each phase is assigned a start time and end time within the cycle.
- **Sequence:** The sequence refers to the order in which the phases occur during a cycle.
- **Offset:** The offset is the amount of time from when a cycle starts to when the main street green starts. This parameter is important for coordinating multiple intersections along a corridor.
- **Split:** The split refers to the amount of green time given to each phase within the cycle length.

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## Timing Sheets

- **Clearance Intervals:** These intervals include the yellow and all-red periods for a phase to provide a buffer and allow the intersection to clear before the next phase begins.
- **Walk and Pedestrian Clearance Times:** These times are specifically for pedestrian signals. The walk time is when pedestrians are displayed the walk symbol, and the pedestrian clearance time is when the flashing don't walk symbol is shown.
- **Detector Settings:** If the intersection has vehicle detection, the settings for these detectors would be specified, including what they are used for (e.g., to extend green time, call a phase, etc.)

The timing sheet is essential for several reasons. Firstly, it determines the efficiency of an intersection or a series of intersections, affecting travel times, vehicle stops, and fuel consumption. A well-optimized signal timing can significantly reduce traffic congestion and improve overall traffic flow.

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## Database

A database for traffic signal timing is a structured collection of data that is designed to efficiently store and manage information related to the timing and coordination of traffic signals. It serves as a central repository where data regarding signal plans, timings, schedules, and other related parameters are stored and accessed by traffic management systems.

The components of a traffic signal timing database typically include:

- **Signal Plan**: This component contains the details of each traffic signal installation, including its location, intersection layout, and physical characteristics. It may include information such as the number of signal heads, lane configurations, and detection equipment.
- **Timing Parameters**: This component defines the specific timing parameters for each signal phase, such as green, yellow, and red durations. These timings determine when each signal phase is active and how long it lasts, ensuring efficient and safe traffic flow.
- **Coordination Data**: Traffic signals are often coordinated to create a green wave or synchronized progression of green lights along a road corridor. The coordination data component stores information on signal offsets, cycle lengths, and splits, which are used to achieve optimal traffic progression and reduce congestion.

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## Database

- **Traffic Demand Data**: To adapt signal timings to changing traffic conditions, the database may store real-time or historical traffic demand data. This information helps adjust signal timings dynamically based on traffic volumes, patterns, and congestion levels.
- **Special Events and Emergency Plans**: The database may include provisions for special event or emergency plans, allowing traffic engineers to modify signal timings temporarily to accommodate unique traffic scenarios. This ensures flexibility and efficient management during unexpected situations.
- **Communication Protocols**: The database may incorporate communication protocols that facilitate data exchange between the traffic signal timing system and other operational systems, such as traffic management centers or Intelligent Transportation Systems (ITS) platforms. These protocols enable the system to receive real-time data and send commands for updating signal timings.
- **Reporting and Analysis**: The database may provide tools for generating reports and performing analysis on traffic signal timing data. This allows traffic engineers to evaluate the effectiveness of timing plans, identify areas for improvement, and make data-driven decisions to optimize traffic flow and safety.

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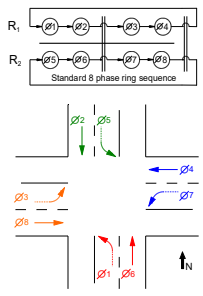
## Traffic Signal Operation Theory
## Assignment of Phases to Movements of Traffic

- Standard NEMA phasing:
  - Odd phase numbers are assigned to the left turn movements; 1,3,5,& 7
  - Even phase numbers are assigned to the thru movements; 2,4,6,& 8
  - Phases 1,2,5,6 are assigned to the Main street movements
  - Phases 3,4,7,8 are assigned to the side street movements
  - Phases rotate around the intersection in a clockwise direction
    - Phase rotation counts the left turn movements separately from the thru movements
  - Compatible and conflicting phase numbers are assigned to compatible and conflicting vehicle movements

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## 8 – Phase Ring

The eight phases are typically sequenced in a cyclic pattern, ensuring that each movement is given an appropriate amount of time to clear the intersection. The duration of each phase can vary depending on factors such as traffic volume, time of day, and pedestrian demand.

In addition to the phases, the traffic signal controller also manages other aspects such as yellow and red clearance intervals, which provide a transition between phases and allow vehicles to clear the intersection safely.

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## Traffic Signal Course

Lesson 1: Traffic Signal Maintenance / Response
Lesson 2: Troubleshooting Tools/Equipment
Lesson 3: Preventative Maintenance (PM)
Lesson 4: Detection Systems
Lesson 5: ADA Compliance
Lesson 6: School Flasher Maintenance
Lesson 7: Construction

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# IMSA Traffic Signal Field Technician II

**Lesson 1: Traffic Signal Maintenance / Response**

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## Set Up a Work Zone

Set up a safe and effective work zone.
Remember to consider:

- Traffic conditions
- Pedestrian conditions
- Other conditions

Provide proper traffic control set up procedures along with all related safety measure requirements necessary to reduce risks associated with work on or near roadways.

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## Lesson 2: Traffic Signal Maintenance / Response

- Observe intersection.
- Isolate Cabinet / Field.
- Test the actual area causing the problem.
- Determine the fault that is causing the problem.
- Correct the problem.
- Verify Functionality

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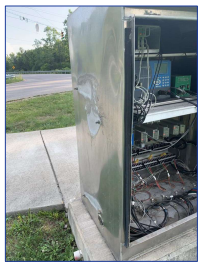
## Observe Intersection

Observe the area for the following:

- Visible damage
- Electrical damage/issues
- Hazardous concerns/issues
- Railroad present
- Excavation in proximity
- Weather related



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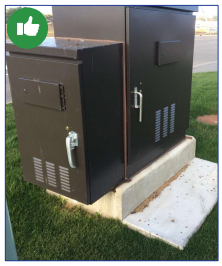
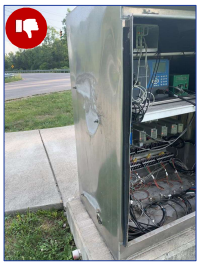
## Observe intersection

Is there any **physical damage** to the outside of the cabinet?

Is the signal in **flash mode**?

Flash mode could indicate the cabinet has been **Hit.**





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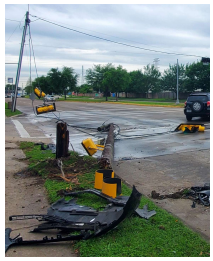
## Observe Intersection

Is there damage to the **foundation** that the cabinet is situated upon?

Is there a Train on the **railroad** at the intersection?

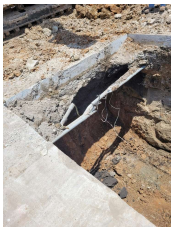
Are other assets damaged in proximity, **electrical provider** wood pole?

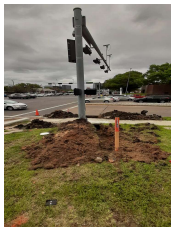


50

## Observe Intersection

Is there evidence of recent **excavation** or **asphalt repairs**?





51

## Isolate Cabinet / Field

- Observe intersection.
- **Isolate Cabinet / Field**
- Test to isolate the actual area causing the problem.
- Determine the fault that is causing the problem.
- Correct the problem.
- Verify Functionality

52

## Isolate Cabinet / Field

KEEP IT SIMPLE

**Always check to make sure the switches on the police panel are properly positioned.**


The **Police Panel** is on the exterior of the cabinet, in a small compartment on the face of the cabinet door. The police panel allows the police officer to put the intersection on auto/flash, manual/auto, or signals on/off.

53

## Isolate Cabinet / Field

**Cabinet Issues**
- Wiring
- Components and connections
- Video cards
- Controllers
- Conflict Monitors

**Field Issues**
- Wiring/termination point issues in signal
- Pole/hardware damaged
- Manhole collapsed
- Conduit broken
- Wire damaged

54

## Bus Interface Unit (BIU)

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In a traffic signal cabinet, a BIU refers to a component that interfaces with the various hardware devices and systems within the cabinet. It acts as a central control unit, allowing communication between the traffic signal controller and other peripheral devices, such as traffic detectors, signal heads, and communication equipment.

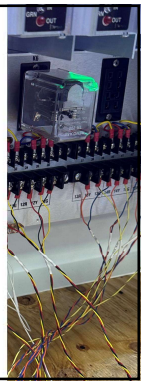
How the BIU Interacts with Various Components:

1. **Traffic Signal Controller**: The BIU connects to the traffic signal controller, which is the main brain responsible for controlling the signal timing and sequences.
2. **Traffic Detectors**: The BIU interfaces with various traffic detectors, such as inductive loop detectors or video cameras, which provide input about the presence and movement of vehicles or pedestrians.
3. **Signal Heads**: The BIU connects to the signal heads, which are the actual traffic lights. It controls the timing and sequencing of the lights based on the instructions received from the traffic signal controller.
4. **Communication Equipment**: The BIU can also include communication modules that allow the cabinet to communicate with a central traffic management system or other external devices, such as remote monitoring systems or emergency vehicle preemption systems.
5. **Power Supply**: The BIU typically receives power from the cabinet's power supply and distributes it to the connected devices as needed.

55

## Flash Transfer Relays

- **Flash Relays -**
- Flash relays, also known as flashers or flashing relays, are electrical devices used in traffic signal systems to control the flashing mode of certain signal lights. They are responsible for producing a flashing pattern in specific signal heads, typically used to indicate caution or warning to road users.
- Here's how flash relays function in traffic signals:
  - **Flashing Mode Activation:** When the traffic signal controller sends a command to activate the flashing mode for specific signal heads, it triggers the flash relay associated with those lights.
  - **Timing and Pattern Control:** Flash relays have built-in timing circuits that control the duration and pattern of the flashing mode. This can include a specific on/off time ratio, such as one second on and one second off, to create a distinct flashing pattern.
  - **Signal Light Control:** The flash relay controls the power supply to the signal lights connected to it. When activated, it cycles the power to the lights, turning them on and off according to the predetermined timing and pattern.
  - **Cautionary Signaling:** The flashing lights produced by the flash relays are typically used for cautionary signaling, such as indicating a hazardous condition, a school zone, or construction work ahead. They alert drivers to exercise caution, slow down, and be prepared to stop or yield.
  - **Synchronization:** In multi-lane or complex intersections, flash relays can be synchronized to produce a coordinated flashing pattern across multiple signal heads. This synchronization helps improve visibility and comprehension for road users approaching the intersection from different directions.
  - **Return to Normal Operation:** After the predetermined flashing period, the traffic signal controller sends a command to deactivate the flashing mode. The flash relay then returns the signal lights to their standard operation, either steady on or following the regular traffic signal timing plan.



56

IMSA
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## Isolate Cabinet / Field

- Review the **maintenance and trouble logs** inside the cabinet.
- Evaluate previous maintenance and repairs.
- Check if previous repairs be could related to the current issues.


57

## Isolate Cabinet / Field

- Run the equipment to verify **proper operation** of the controller.
- Reset the **MMU/CMU** to see if any conflicts appear.

.




58

## Isolate Cabinet / Field

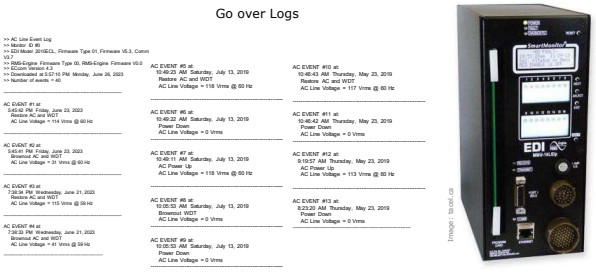
Use the MMU/CMU display to identify the **stage of the controller** at the start of the fault.

If faults are present in the MMU, the signal controller will stop timing and will **display the status** of the most recent interval.


59

## Isolate Cabinet / Field

Go over Logs






60

## Isolate Cabinet / Field

Go over Logs

```
>> Previous Fail Event Log
>> Monitor ID #0
>> EDI Model 2010ECL, Firmware Type 01, Firmware V4.5, Comm V3.5
>> RMS-Engine Firmware Type 01, RMS-Engine Firmware V1.5
>> ECcom Version 4.5
>> Downloaded at 9:40:13 AM Wednesday, March 15, 2023
>> Number of events = 25
-------------------------------------------------------------
PREVIOUS FAIL EVENT #1 at:
  2:16:45 AM Wednesday, March 15, 2023
  Fault = CU Watchdog Fault

  Channel Status:
  Ch: 1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16
      .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .
      .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .
      .  .  G  .  .  .  .  .  .  .  .  .  .  G  .  .

  Channel RMS Voltages:
  R:  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
  Y:  0  0  0  4  6  4  0  0  0  0  0  0  0  0  0  0
  G:  0  0  0 120 11  4  0  0  0  0  0  0  0 121  3  0

      AC Line = 122 Vrms @ 60Hz
      Temperature = 87 F
      Red Enable = Off   (0 Vrms)
      MC Coil (EE) = Auto   (4 Vrms)
  Special Function #1 = Off   (0 Vrms)
  Special Function #2 = Off   (0 Vrms)
      WDT Monitor = Active
```

```
-------------------------------------------------------------
PREVIOUS FAIL EVENT #2 at:
  10:28:01 PM Sunday, March 12, 2023
  Fault = CU Watchdog Fault

  Channel Status:
  Ch: 1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16
      .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .
      .  .  .  Y  .  .  .  .  .  .  .  .  .  .  .  .
      .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .

  Channel RMS Voltages:
  R:  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
  Y:  0  0  0 120  0  4  0  0  0  0  0  0  0  0  0  0
  G:  0  0  0  4 13  4  0  0  0  0  0  0  0  4  3  0

      AC Line = 122 Vrms @ 60Hz
      Temperature = 74 F
      Red Enable = Off   (0 Vrms)
      MC Coil (EE) = Auto   (4 Vrms)
  Special Function #1 = Off   (0 Vrms)
  Special Function #2 = Off   (0 Vrms)
      WDT Monitor = Active

WDT Monitor = Active
```


Image: tucsd.edu

61

## Isolate Cabinet / Field

CONFLICT – Lamp burned, field wire short, faulty transfer relay

RED FAIL – BIU Malfunction, Faulty load switch

CVM/WATCHDOG - Police panel flash ON,

24V-2 & 24V-1 – Bad power supply (external or internal)

CLEARANCE FAIL – Programming in controller

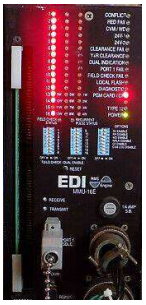
PORT 1 FAIL – Controller bad, BIU malfunction

DIG/PGM CARD – Faulty card

FIELD CHECK – Output fault

FAIL DUAL – Dual indication

INDICATION – Conflict monitor issue




62

## Isolate

Faults in a traffic signal controller can cause significant traffic disruptions, accidents, and inefficient traffic flow. Here are some of the common faults and issues:

- **Hardware failures:** These include power failures, failures in the input-output card, lamp faults, detector faults, etc. For example, if the power supply to the controller is interrupted, the traffic signals would not function.
- **Software errors:** These could be due to programming errors or bugs in the software controlling the traffic signal timing and sequencing. This could cause incorrect timing sequences, such as too short green phases or simultaneous green signals in conflicting directions.
- **Communication failures:** Modern traffic signal controllers often communicate with a central system that adjusts timings based on overall traffic conditions. Any interruption in this communication can lead to inefficient signal timings.

63

## Isolate

- **Malfunctions in the detector:** Traffic signal controllers often use detectors (like inductive loop detectors, video detectors, etc.) to sense the presence of vehicles and adjust signal timings. Malfunctions or misalignments in these detectors can cause incorrect signal changes.
- **Faulty timings or settings:** Sometimes, the programmed timings or settings may not match the actual traffic requirements, causing inefficiency and confusion.
- **Physical damage:** This could be due to weather conditions, vandalism, accidents, etc. For example, if a vehicle hits the traffic signal post, it could disrupt its operation.
- **Lamp or LED failure:** If the lamps or LEDs in the signal heads fail, the signals won't be visible to the drivers, creating dangerous conditions.
- **Signal coordination issues:** When signals along a corridor are not correctly coordinated, it can lead to stop-and-go conditions, inefficient traffic flow, and increased congestion.

64

## Isolate

In the context of traffic signal timing, a cycle fault refers to an issue or malfunction in the timing sequence of a traffic signal's signal phases and intervals. It occurs when the traffic signal does not follow the expected and predefined cycle or pattern of green, yellow, and red phases for each direction of traffic flow.

Common reasons for cycle faults in traffic signal timing include:

- **Electrical or hardware malfunctions**: Problems with the electrical components, such as faulty wiring, damaged controllers, or malfunctioning timers, can disrupt the normal cycle of the traffic signal.
- **Software glitches or programming errors**: Errors in the signal controller's software or programming can lead to cycle faults. These glitches can occur due to bugs in the programming code, incorrect signal phasing parameters, or inaccurate timing calculations.
- **Power outages or fluctuations**: Power interruptions or irregularities can disrupt the normal operation of traffic signals, causing cycle faults. When the signal controller does not receive a consistent power supply, it may fail to maintain the correct timing sequence.
- **Interference from external factors**: External factors like electromagnetic interference or faulty communication with other traffic control systems can interfere with the signal controller's operation, resulting in cycle faults.

65

## Isolate

A malfunction management unit (MMU) or a Conflict management unit (CMU) is responsible for detecting and managing faults or malfunctions / conflicts within a traffic signal system. It monitors various components and subsystems to identify issues and take appropriate actions.

Here are some common faults that can occur with a malfunction management unit:

**Failure to Detect Malfunctions**: The MMU/CMU may fail to detect certain faults or malfunctions within the traffic signal system. This could be due to software or hardware errors, inaccurate sensor inputs, or programming issues. It can result in delayed or ineffective responses to system faults.

**False Alarms**: On the other hand, the MMU/CMU may generate false alarms, indicating malfunctions when there are none. This can be caused by incorrect threshold settings, faulty sensor inputs, or software glitches. False alarms can lead to unnecessary maintenance and service calls, wasting resources.

66

## Isolate

**Communication Errors**: The MMU/CMU relies on communication interfaces and protocols to receive data from various components and subsystems of the traffic signal system. Communication faults, such as connection issues, data corruption, or protocol mismatches, can result in inaccurate information or failure to detect malfunctions.

**Faulty Decision-Making**: The MMU/CMU uses decision-making algorithms to determine the appropriate response to detected malfunctions. Programming errors or incorrect logic can lead to improper actions, such as ineffective system shutdowns, incorrect signal timings, or unnecessary alerts.

**Sensor Malfunction Detection Failure**: The MMU/CMU relies on inputs from various sensors to detect malfunctions in the traffic signal system. If the MMU fails to recognize sensor malfunctions, it may not be able to accurately identify faults or take appropriate actions.

67

## Isolate

**Inadequate Redundancy or Backup**: A malfunction / Conflict management unit should have sufficient redundancy or backup mechanisms to ensure system reliability. If the MMU/CMU lacks redundancy or backup solutions, it may not be able to handle its own faults or failures, leading to system-wide disruptions.

**Incompatibility with System Components**: The MMU/CMU must be compatible with the components and subsystems of the traffic signal system. Incompatibility issues, such as incompatible protocols or hardware interfaces, can prevent proper communication and fault detection.

**Software or Firmware Errors**: The MMU/CMU operates using software or firmware, which can be prone to bugs, coding errors, or compatibility issues. These issues can affect the performance and reliability of the unit, leading to incorrect malfunction detection or response.

Regular maintenance, testing, and software updates are crucial to mitigate these faults with a malfunction management unit. Continuous monitoring and periodic audits can help identify and rectify any issues to ensure effective fault detection and management in the traffic signal system.

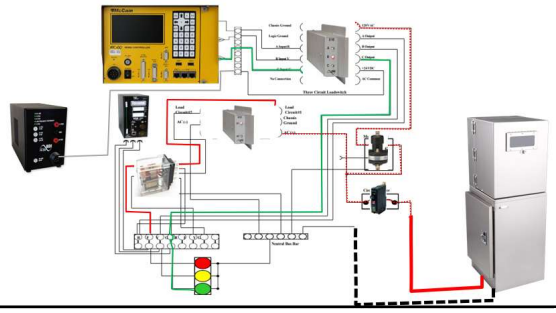
68

## Test

- Observe intersection.
- Isolate Cabinet / Field.
- Test the actual area causing the problem.
- Determine the fault that is causing the problem.
- Correct the problem.
- Verify Functionality

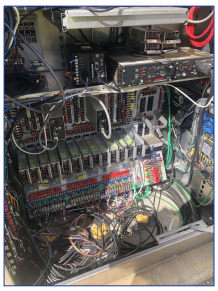
69

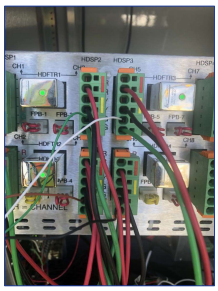
## Test



70

## Test





Use a multimeter to **test Field wiring** and ensure proper function.

If the multimeter identifies any faults in the field wiring, document findings.

71

## Test

Use a multimeter to ensure **proper voltage** to each light on the signal.

72

## Test

Test the meter before using it to troubleshoot. For a voltmeter, test the meter on a known voltage source before using. Your meter should read the correct voltage. For an ohmmeter, touch the meter leads together. The display should read 0 ohms, or very close to 0. With the leads apart it should read OL (infinity). Identify induction sensors if you are using an induction ammeter. Position the sensor around the power input wire. Set the ammeter to auto. Take the reading and remove the ammeter.

73

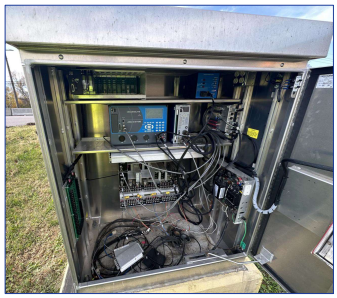
## Determine

- Observe intersection.
- Isolate Cabinet / Field.
- Test the actual area causing the problem.
- **Determine the fault that is causing the problem.**
- Correct the problem.
- Verify Functionality

74

## Determine

- Is there damage to the **wiring** or wire harness?
- Do you see any **loose wire** terminals?
- Is there any **corrosion** present?
- Are the controller's phases and signals properly assigned?
- Is there a load switch failure?



75

## Determine


**TS1 Controller**
Review the **stage of the controller** when it went into fault mode and troubleshoot.


**TS2 Controller**
Review the **controller logs** and **reports** to locate the fault numbers and troubleshoot.

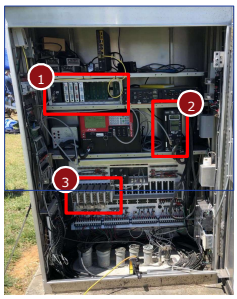
76

## Determine

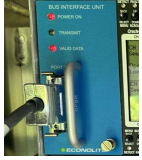
- Review the manufacturer's **manual** for the controller's logs and events you are reviewing.
- Use the display to navigate to the **logs and events.**

77

## Determine




1. BIU



2. MMU/CMU

3. Load Switch


- Is there a BIU failure?
- Is there loose wire in the MMU/CMU?
- Is there a load switch failure?

78

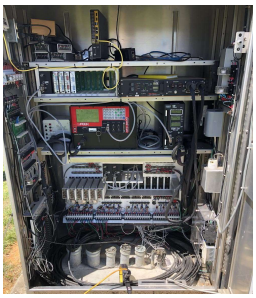
## Determine

- Check **indicator lights.**
- Review details in the controller.
- Review **intersection** wiring blueprints and manufacturer's manuals.

79

## Determine

- Listen for any **electrical noises.**
- If electrical equipment is faulty, **disconnect the power** and repair equipment.

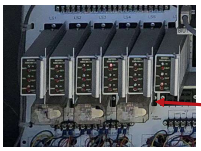


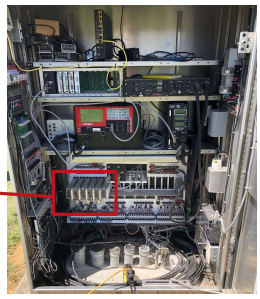
80

## Determine

What to do if you smell any burnt electrical components:

- Inspect **wiring**
- Check **relay switch**





81

## Determine

- Identify **faulty signals.**
- Review **cabinet blueprints** if signal indications not functioning.
- Rewire the signal head if an improper wiring method is used.

82

## Correct

- Observe intersection.
- Isolate Cabinet / Field.
- Test the actual area causing the problem.
- Determine the fault that is causing the problem.
- **Correct the problem.**
- Verify Functionality

83

## Correct

- Replace faulty device with new or manufacture refurbished and tested.
- Replace controller and/or Monitor with a new Engineer programmed device.
- Properly Dispose device or Send device back to the manufacturer for repairs.

84

## Correct

Changing out MMU/CMU

Program the MMU/CMU according to the:
- Intersection setup
- Wiring schematics
- Jumper diagrams

Add or remove **jumpers** with soldering iron if any phases do not align.

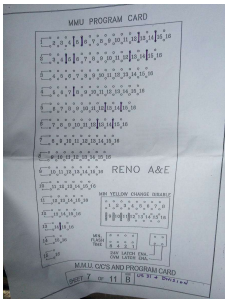
85

## Correct

Review the cabinet **wiring schematics**.

Install compatible MMU/CMU **card jumpers** listed in the wiring schematics.

Add or remove **jumpers** to align with signal phases.

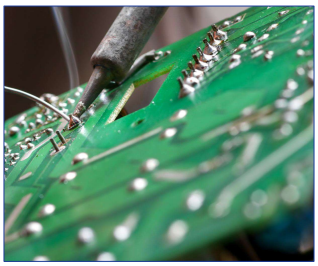



86

## Correct

Inspect the MMU/CMU for proper soldering

Check if there are any:
- Solder bubbles visible
- Soldering leaks through the jumper board



87

## Correct

After testing the wires check the following areas for faulty and/or damaged wires:

- Manholes/vaults
- Pull Boxes
- Handholes and covers
- Pinch points

88

## Correct

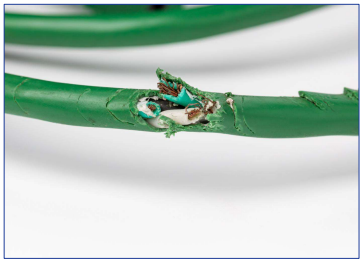
After testing inspect splices to identify **damaged wires** at:

- Handholes
- Vaults
- Junction boxes
- From the signal heads to the poles
- Inside the conduits

89

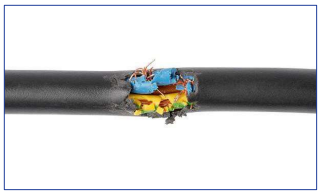
## Correct

- If pest damage is present, repair or replace the wiring.
- No Splices Underground



90

## Correct



**Replace wiring**

Replace the wiring if damaged or frayed wiring is present.

**Repair wiring**

Use a multimeter to verify voltage and continuity of wiring, and repair wiring, if necessary.

91

## Correct

- Ensure repair is put back in kind.
- Any modification must be reviewed and approved prior to install by Engineer.
- Check for proper grounding after install.

92

## Correct

**Repair** the signal if the indications are faulty and the signal is safe.

**Replace** the signal if it appears unsafe or there is any physical damage.

93

## Verify

- Observe intersection.
- Isolate Cabinet / Field.
- Test the actual area causing the problem.
- Determine the fault that is causing the problem.
- Correct the problem.
- Verify Functionality

94

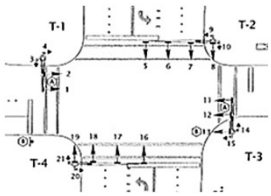
## Verify

Verify mode of operation, free or coordinated?

Observe all the cabinet devices as the traffic signal cycles through all the phases.

Walk each approach and visually verify each indication is functioning properly.

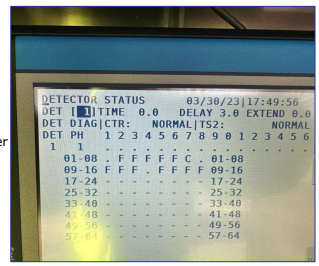
If coordinated, you MUST check Time of Day Plan and correct time on controller clock.




95

## Verify

- Use the status display to view **inputs** to the controller.
- Look up fault indications.
- Review the **detection inputs** if the controller is not picking up vehicles in the field.
- Visually match the input numbers to the cars in each lane.




96

## Cabinet Log Book

A traffic signal cabinet logbook is a documentation tool that records all the relevant activities, issues, adjustments, repairs, and maintenance performed on a specific traffic signal cabinet. It serves as an official record of the actions and operations related to the cabinet. The logbook helps maintain transparency, traceability, and accountability in managing the traffic signal system.
Here's what should typically be added to it:

- **Date and Time:** The date and time of each activity should be recorded for reference. This helps to track the chronology of events and identify patterns if any issues recur.
- **Activity Description:** This is a detailed explanation of what has occurred or what actions were taken. This could be a routine inspection, a hardware or software upgrade, a detected malfunction, the resolution of an issue, etc.
- **Persons Involved:** Names or IDs of the technicians or engineers who performed the task. This helps in identifying who to contact for more information if the need arises.
- **Equipment Details:** Any change in the equipment, whether it's an addition, removal, repair, or replacement, should be noted. This also includes any software or firmware versions in use.
- **Observations and Notes:** These can be comments on the state of the cabinet, performance notes, or any anomalies observed. This can also include potential recommendations for future action.

97

## Cabinet Log Book

The people authorized to edit a traffic signal cabinet logbook typically include traffic engineers, technicians, or other authorized personnel involved in the maintenance, repair, or monitoring of the traffic signal system. The authorization is typically granted by the traffic management department or the respective authority in charge. The importance of a traffic signal cabinet logbook lies in the following aspects:

- **Transparency and Accountability:** The logbook serves as an official record of all actions related to the traffic signal cabinet. It holds those involved in the maintenance and operation accountable for their actions.
- **Traceability:** It allows the tracing of issues to their root cause, providing a clear timeline of events leading up to an issue. This is crucial in preventive maintenance and problem-solving.
- **Continuity:** If different teams or individuals are working on the same cabinet at different times, the logbook ensures everyone has access to the full history and context, facilitating a smoother transition and continuous work.
- **Compliance and Legal Reasons:** Logbooks might be required for regulatory compliance or could serve as legal proof in case of accidents or disputes involving the traffic signal.
- **Data Analysis and Improvement:** Over time, the data from the logbook can be analyzed to identify recurring issues, peak times for certain problems, or components that frequently fail. This can lead to systemic improvements, cost savings, and more efficient traffic management

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## Cabinet Log Book

Maintaining a traffic cabinet log requires a systematic approach to record and track relevant information. Here's a suggested method for effectively managing a traffic cabinet log:

- **Determine the Log Format**: Decide on a log format that suits your needs. You can create a digital log using spreadsheet software or use a dedicated logbook. Ensure it includes fields for essential information, such as date, time, location, description of the issue, actions taken, and any additional notes.
- **Define Log Entry Requirements**: Establish clear guidelines for what should be included in each log entry. This may include documenting events such as equipment malfunctions, repairs, maintenance activities, or any significant incidents related to the traffic cabinet.
- **Assign Responsibility**: Designate a specific individual or team responsible for maintaining the traffic cabinet log. This person should be knowledgeable about the equipment and its operations.
- **Document Relevant Information**: For each log entry, record the date and time of the event, the location of the traffic cabinet, and a detailed description of the issue or activity. Include any observations, error codes, or other relevant information that may help identify patterns or diagnose recurring problems.

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## Cabinet Log Book

- **Track Maintenance Activities**: Record all maintenance and repair activities performed on the traffic cabinet, including the type of work, the date and duration of the maintenance, and the personnel involved. Note any replacement parts used or adjustments made.
- **Include Supporting Documentation**: Attach any supporting documentation, such as work orders, invoices, or photographs, to the log entry if applicable. This additional information can provide context and aid future analysis.
- **Regular Updates**: Ensure the traffic cabinet log is updated in a timely manner after each event or activity. Prompt and accurate entries will help maintain an up-to-date record and aid troubleshooting efforts.
- **Review and Analysis**: Periodically review the log to identify trends, recurring issues, or areas that require attention. Analyzing the log entries can help identify patterns, prioritize maintenance efforts, and make informed decisions for optimizing traffic cabinet performance.
- **Secure Storage**: Keep the logbook or digital file in a secure location to prevent unauthorized access or loss of data. Regularly back up digital logs to ensure data integrity.
- **Training and Communication**: Provide training to personnel responsible for maintaining the traffic cabinet log to ensure consistent and accurate documentation. Communicate any updates or changes in the log format or procedures to the relevant stakeholders.

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## Lesson Summary

- Observe intersection.
- Isolate Cabinet / Field.
- Test the actual area causing the problem.
- Determine the fault that is causing the problem.
- Correct the problem.
- Verify Functionality

101

# IMSA Traffic Signal Technician II

Lesson 2: **Troubleshooting Tools/Equipment**

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## Lesson 2: Troubleshooting Tools/Equipment

Cabinet Types
Lesson 1: Traffic Signal Response
**Lesson 2: Troubleshooting Tools/Equipment**
Lesson 3: Preventative Maintenance (PM)
Lesson 4: Detection Systems
Lesson 5: ADA Compliance
Lesson 6: School Flasher Maintenance
Lesson 7: Construction
Lesson 8: Documentation
Answer Keys

103

## Lesson Introduction-Troubleshooting Tools/Equipment

- Multimeter Testing
- Conflict Monitor Tester
- Cabinet Tester
- Bus Interface Unit (BIU) Tester
- Load Switch/Switch Pack Tester
- Ground Resistance Tester
- OTDR

104

## Troubleshooting Tools/Equipment

Multimeter Testing



105

## Troubleshooting Tools/Equipment

A multimeter is a useful tool for basic sanity checks and troubleshooting. To use a multimeter for troubleshooting, you can measure the following:

- AC & DC Supply voltages and Fuse continuity
- Transformer primary & secondary voltages
- Diode & Transistor lead voltages
- Integrated Circuit supply pin voltages
- Component resistance

To use a multimeter, you need to turn it on, select the mode you want to use, connect the multimeter to the circuit you want to test, touch the other end of the lead to the point you want to test, and read the display on the multimeter.

106

## Troubleshooting Tools/Equipment

Conflict Monitor Tester

MUTCD Chapter 4D states the conflict monitor should be tested annually with a computerized conflict monitor tester. This is accomplished by removing the intersection's monitor and running a complete test with the conflict monitor tester unit.

However, it is important to note that testing frequency may vary depending on the state or local agency requirements.

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## Troubleshooting Tools/Equipment

### PCMT-8000 USER TRAINING COURSE

The course is divided up into five video sections. The videos also reference the PCMT-8000 User's Manual. After watching the videos and reading the manual you may take the certification test. Students who wish to take the certification test should contact ATSI sales at (740) 592-2874 or sales@atsi-tester.com

Students who complete this online course and pass the certification test are eligible for 8 CEC points with IMSA.

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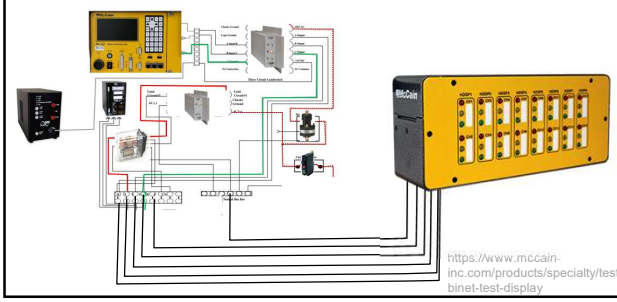
108

## Troubleshooting Tools/Equipment



https://www.mccain-inc.com/products/specialty/testers/cabinet-test-display

109

## Troubleshooting Tools/Equipment

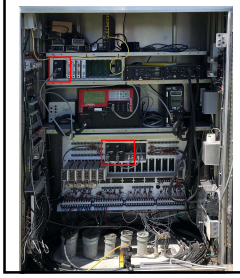
**Cabinet Test** Displays are a simple and effective tool for displaying and testing the state of traffic signals in the field or test environments.

https://www.mccain-inc.com/products/specialty/testers/cabinet-test-display

110

## Troubleshooting Tools/Equipment

BIU Tester

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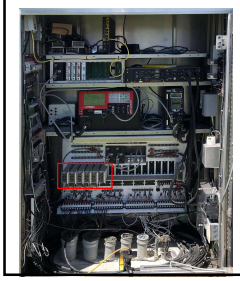
## Troubleshooting Tools/Equipment

Load Switch/Switch Pack Tester



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## Troubleshooting Tools/Equipment

Ground Resistance Tester

The Ground Resistance Tester clamps around the grounding electrode or conductor and measures the resistance to the ground. By performing measurements on intact ground systems, the tester also verifies the quality of the grounding connections and bonds. Resistance and continuity of grounding loops are also tested.

All traffic devices/equipment that is grounded shall read **25 ohms or less**.

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# IMSA Traffic Signal Technician II

Lesson 3: Preventative Maintenance (PM)

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## Preventative Maintenance (PM)

Lesson 1: Traffic Signal Maintenance / Response
Lesson 2: Troubleshooting Tools/Equipment
**Lesson 3: Preventative Maintenance (PM)**
Lesson 4: Detection Systems
Lesson 5: ADA Compliance
Lesson 6: School Flasher Maintenance
Lesson 7: Construction

115

## Preventative Maintenance (PM)

A thorough PM program follows industry guidelines and yields the following benefits:

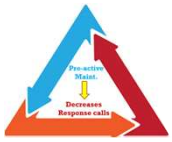
- Identify and prevent potential equipment failures before they happen
- Minimize costly repairs due to electrical damage
- Minimize the frequency and severity of traffic signal malfunctions
- Preserve and enhance equipment reliability
- Maximize life span of traffic signal installations
- Minimize the agencies exposure to liability.


116

## Preventative Maintenance (PM)

Items to be Inspected, Cleaned, Adjusted or Replaced:

- Signal Heads
- Pedestrian Assemblies
- Signal Poles
- Pull Boxes
- Traffic Signal Cabinet
- Detection
- Signs
- Battery Back Up
- Electrical Services




117

## Preventative Maintenance (PM)

Items to be Inspected, Cleaned and/or Adjusted:
Signal Heads

- Verify Heads Aligned Relative to Lanes
- Check for Cracks or Damage on Visors/Louvers
- Check for Cracks or Damage on Signals
- Check for Cracks or Damage on Hardware
- Check for tears on Gaskets in Housing
- Check Terminal Connections for tightness
- Visually Check All Signal Cable
- Verify all LED's operational

118

## Preventative Maintenance (PM)

Items to be Inspected, Cleaned, Adjusted or Replaced:
Pedestrian Assemblies

- Check for Cracks or Damage on Visors
- Check for Cracks or Damage on Lenses
- Check for Cracks or Damage on Housing
- Cracks or Damage on Hardware
- Verify Head Alignment Relative to Crosswalks
- Check for tears on Gaskets on Housing
- Verify Terminal Connections are tight

119

## Test Push Button Function

Verify that each **pedestrian push button** functions as intended.

Check if pushing the button results in the correct walk indication, sound, motion, or instructions.



120

## Inspect Actuation/Isolation Board


**Replace actuation**

First, inspect actuation for proper function. If not functioning properly, replace the actuation and test again.

**Repair actuation**

Inspect pedestrian actuation board inside the cabinet. Repair the actuation if there is no power going to the area.

121

## Inspect Input Assignments



**Assignments**

If assignments are not aligned, reprogram phases at the controller.

**Push button**

Check if the screen indicates a call has been made when pushing the button.

**Faulty button**

If the push button does not execute a call or fully depress, it could be stuck or damaged.

122

## Preventative Maintenance (PM)

Items to be Inspected, Cleaned, Adjusted or Replaced:
Signal Poles

- Verify Hand Hole Covers
- Verify End Caps
- Verify Pole Caps
- Inspect Foundations/Anchor Bolts
- Inspect Pole Welds
- Check Mounting Hardware
- Check Mounting Hardware on Signs
- Verify every pole is properly grounded

123

## Pole Grounding

- Inspect the pole and ensure it is **bonded to the ground** wire in the foundation.
- If the pole is not grounded, install a **ground wire.**

124

## Inspect Pole and Foundation

Inspect **poles** for physical damage such as dents, cracks, rust, scratches, or sagging.

Inspect the **pole foundation** for cracks, foundation shift, broken pieces, or bent bolts.

125

## Inspect Poles and Foundations

Ensure poles and foundations are free of cracks.

Check if holes are drilled to the right depth.

126

## Inspect Connections and Weld Points


Inspect pole connections and anchor bolts

Check if:

- Anchor bolts appear to be sliding off
- Grouting is missing or cracked
- Bolts/clamps need tightening
- There is damage to any weld points

127

## Secure Handholes

Inspect the **handhole** to ensure access is secured from the public with a cover and bolt or screw.

Repair, if necessary.

128

## Inspect Drainage

Drill a hole in the bottom of the grout to allow drainage.

If pole is elevated from the foundation, clear any debris.

If a pole needs to be replaced, contact the proper personnel.

129

## Preventative Maintenance (PM)

Items to be Inspected, Cleaned, Adjusted or Replaced:

Pull Boxes

- Check Boxes & Lids for Cracks
- Verify Alignment
- Check Ground bushings, straps & rod connections
- Verify Seal in Conduits

130

## Preventative Maintenance (PM)

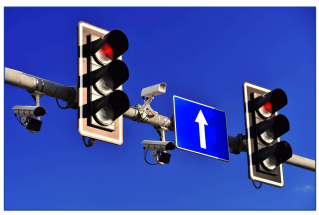
Items to be Inspected, Cleaned, Adjusted or Replaced:

Traffic Signal Cabinet

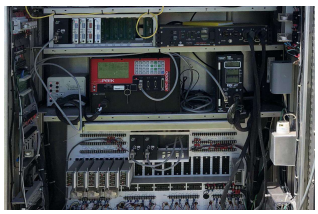
- Verify Controller Operations
- Check Cabinet Ground Reading
- Verify Cabinet Light
- Check GFI Receptacle
- Check/Replace Cabinet Filter
- Visually Check Load Switches
- Visually Check Flasher Relay
- Lubricate Hinges & Locks
- Check Terminal Connections
- Vacuum Cabinet
- Spray Insecticide if needed
- Verify Conduits are Sealed
- Verify Conflict Monitor has been Tested
- Verify Communication Online
- Verify Controller & CM Online
- Check Cabinet Base has Sealant

131

## Communication Devices



**Intersection Communication Devices**
Inspect poles and signal heads for communication devices (e.g., cameras).



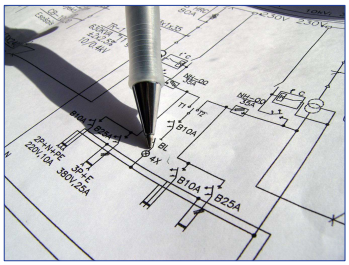
**Cabinet Communication Devices**
Inspect signal strength of cabinet and controller for IP address confirmation and fiber modems.

132

## Phases

Review the controller's programming and inspect the **programmed phases**.

Review the **wiring schematics** and **intersection layout** to determine the standard phases.




133

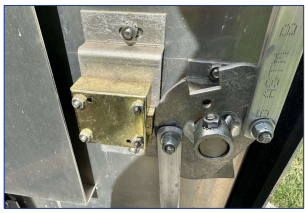
## MMU/CMU Program

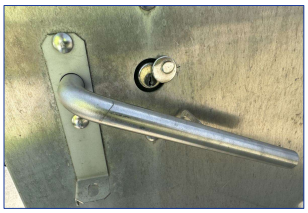
- Check the **display screen** for indication of an incorrect program.
- Reprogram the **phase in the MMU/CMU** and the controller in case of an incorrect program.

134

## Cabinet

**Locks, Hinges, and Seals**
Ensure they remain functioning and rust-free.



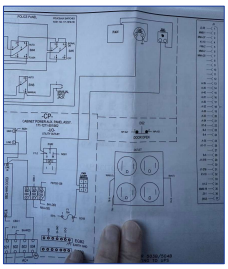


135

## Check Thermostat and Fan

Inspect the **thermostat** and ensure it is within a safe temperature range of 85-165 degrees.

Verify if the **fan** automatically powers on when the temperature reaches 90-95 degrees.



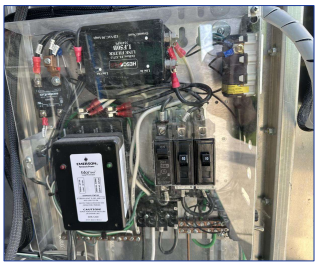
136

## Check the Power Panel

If the fan does not start, use a **multimeter** to check for voltage in the thermostat and fan.

If there is power going to the thermostat and fan, but they are still not working, replace them.

If there is no power, check the power panel.



137

## Preventative Maintenance (PM)

Items to be Inspected, Cleaned, Adjusted or Replaced:
Detection

- Verify Detection calls in Controller
- Clean Camera Lenses
- Verify Camera operation
- Check Camera Zone Placement
- Verify Detector Termination Panel
- Check Radar Detection Zone Placement
- Verify Detector Assignment
- Verify Emergency Vehicle Pre-emption Operational
- Check all Loop Amplifiers
- Check Detector Splices if not operational

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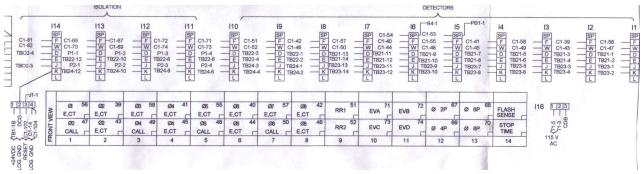
## Detector Inputs



- Review the **detector and phase inputs** programmed.
- Check the **default program** for the specific intersection.
- Reprogram the **detector inputs**, if necessary.

139

## Preventative Maintenance (PM)

Items to be Inspected, Cleaned, Adjusted or Replaced:
Signs

- Verify Street Name Signs
- Verify Regulatory Signs
- Verify if Signs Missing with plans
- Verify Ground Mounted signs in place

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## Preventative Maintenance (PM)

Items to be Inspected, Cleaned, Adjusted or Replaced:
Battery Back Up Unit

- Verify Incoming Line Voltage
- Verify DC Battery Output
- Verify AC Inverter Output
- Test System Manually
- Test Batteries if System Fails
- Replace/Clean UPS Filter
- Download Event Logs from UPS

141

## Identify Battery Faults

- Inspect the **backup battery** for faults indicated on the UPS display screen.
- Repair battery according to fault indicator.
- Verify that the battery is **charging** and check the battery connections.

142

## Inspect Battery for Damage

- Inspect the battery for **damages** such as swelling or cracks.
- **Replace the battery** if swelling, cracks, or other damage is present.

143

## Verify Voltages

- Inspect the **battery voltage.**
- Inspect the **processor.**
- Use the display menu to determine and repair the fault.

144

## Cycle Battery to Ensure Proper Function

- Use the **battery test mode** option on the inverter to check the backup battery.
- Replace the **backup battery** if the UPS is not powering the intersection when the main battery is disconnected.
- Turn on the power at the intersection.

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## Preventative Maintenance (PM)

Items to be Inspected, Cleaned, Adjusted or Replaced:
Electrical Services

- Check Meter/Disconnect Lock
- Check and Secure Transformer Door
- Verify Incoming Voltage Reading
- Verify Load Side Voltage Reading
- Check Loose Breakers
- Visually check Conductors
- Verify Electrical Service Ground Reading

146

# IMSA Traffic Signal Technician II

Lesson 4: Detection Systems

Advancing the Future of Public Safety

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## Detection Systems

Lesson 1: Traffic Signal Maintenance / Response
Lesson 2: Troubleshooting Tools/Equipment
Lesson 3: Preventative Maintenance (PM)
**Lesson 4: Detection Systems**
Lesson 5: ADA Compliance
Lesson 6: School Flasher Maintenance
Lesson 7: Construction

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## Detection Types

**Detectors and Sensors -** Detectors and sensors are used to detect and measure traffic conditions at the intersection. Inductive loop detectors, video cameras, microwave sensors, or radar sensors may be employed to detect vehicles and pedestrians, estimate traffic volume, and trigger signal changes based on demand or pre-timed plans.

1. **Loop:**
   - Loop detection, also known as inductive loop detection, is a technology used in traffic signals to detect the presence of vehicles at intersections or along roadways. It involves the installation of loops, which are wire coils embedded in the pavement, and measures changes in inductance to determine the presence and movement of vehicles.
2. **Video:**
   - Video detection in traffic signals refers to the use of cameras to monitor and detect vehicles at intersections or along roadways. It involves capturing video footage and utilizing image processing techniques to analyze the visual information and make decisions regarding traffic signal control.

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## Detection Types

**Detectors and Sensors (Continued):**

1. **Radar:**
   - Radar detection is a technology used in traffic signal systems to detect the presence and movement of vehicles on the road. It utilizes radio waves to determine the position, speed, and size of vehicles, allowing for effective traffic management and signal control.
2. **Magnetometer:**
   - A magnetometer sensor is a device used for traffic signal detection that utilizes the Earth's magnetic field to detect the presence of vehicles. It is commonly employed in traffic management systems to monitor traffic flow and control signal timings efficiently.
3. **Pucks:**
   - A traffic puck sensor, also known as an inductive loop sensor or traffic loop sensor, is a device used for traffic signal detection. It is typically embedded in the pavement of roadways and intersections and is designed to detect the presence and movement of vehicles.

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## Detection Systems - Loops

**Induction-loops:**

- **Advantages:**
  - Reliable detection of vehicles, including motorcycles and bicycles
  - Can differentiate between various vehicle sizes and lengths
  - Can detect vehicles in all weather conditions
- **Disadvantages:**
  - Requires cutting into the pavement to install the loops
  - Installation and maintenance can be costly and time-consuming
  - Limited accuracy in detection stopped or slow-moving vehicles.

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## Detection Systems - Cameras

**Camera Detection:**

**Advantages of Camera Detection in Traffic Signals:**
- Comprehensive Data
- Versatility
- Integration Potential
- Flexibility
- Multi-Purpose Usage

**Disadvantages of Camera Detection in Traffic Signals:**
- Cost
- Weather Sensitivity
- Line-of-Sight Limitations
- Privacy Concerns

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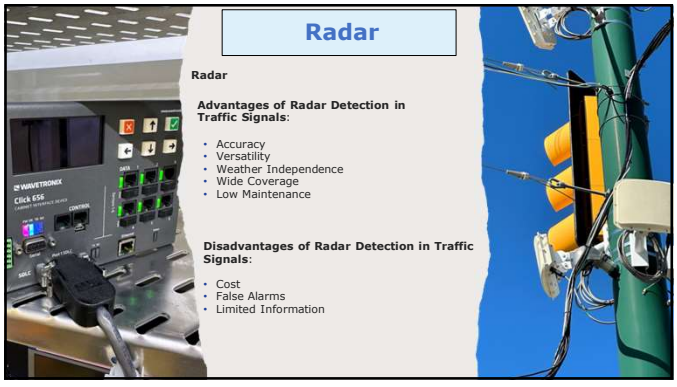


## Radar

**Radar**

**Advantages of Radar Detection in Traffic Signals**:
- Accuracy
- Versatility
- Weather Independence
- Wide Coverage
- Low Maintenance

**Disadvantages of Radar Detection in Traffic Signals**:
- Cost
- False Alarms
- Limited Information



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## Magnetometer

**Magnetometer**

**Advantages of Magnetometer Sensors for Traffic Signal Detection:**

- Intrusive Detection
- Accuracy
- Real-time Monitoring
- Low Maintenance

**Disadvantages of Magnetometer Sensors for Traffic Signal Detection:**

- Sensitivity to External Magnetic Interference
- Limited Detection Range
- Weather Conditions
- Cost

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## Pucks(Magnetometer)

**Pucks**

**Advantages:**

- Reliability
- Cost-effectiveness
- Durability

**Disadvantages:**

- Installation Complexity
- Limited Detection Range
- Maintenance Challenges

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## Detection - Phases

The detection phase assignments for traffic signals refer to the specific allocation of signal phases to different detectors or sensors used to detect the presence or movement of vehicles or pedestrians at an intersection. These assignments are typically configured in the traffic signal controller, which controls the operation of the traffic signals.

In a typical traffic signal system, there are different phases, each representing a specific combination of movements allowed or prohibited at the intersection (e.g., through traffic, left turn, right turn). The detection phase assignments determine which detectors are associated with each phase.

The purpose of the detection phase assignments is to ensure that the traffic signal operates efficiently and effectively based on the traffic demand at the intersection. By assigning detectors to specific phases, the traffic signal controller can accurately detect the presence or absence of vehicles or pedestrians in each movement area and adjust the signal timing accordingly.

For example, if a left turn movement requires a separate phase, detectors would be assigned to monitor the left turn lane and detect vehicles waiting to make a left turn. The traffic signal controller would then use this information to allocate the appropriate green time for the left turn phase.

The specific detection phase assignments can vary depending on factors such as intersection geometry, traffic patterns, and local regulations. Traffic engineers analyze the traffic conditions and design the detection phase assignments accordingly to optimize traffic flow and improve safety at the intersection

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## Detection Assignments

The process of inputting detection phase assignments for traffic signals varies depending on the specific traffic signal controller being used. However, I can provide you with a general overview of how this is typically done. Please note that this information is based on common practices as of my knowledge cutoff in September 2021, and there may have been advancements or changes since then.

- **Access the traffic signal controller**: To input detection phase assignments, you need to gain access to the traffic signal controller. This controller is typically located in a control cabinet near the intersection where the traffic signals are installed.
- **Connect to the controller**: Traffic signal controllers are often equipped with a programming interface or a communication port that allows you to connect to them. This can be done using a laptop or a specific programming device provided by the manufacturer.
- **Access the programming software**: Once connected to the controller, you need to access the programming software or interface. The specific software can vary depending on the manufacturer and model of the traffic signal controller. Examples of commonly used software include Synchro, SCATS, and ASC/3.

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## Detection Assignments

- **Identify the detection phase assignments**: Detection phase assignments determine how the traffic signal controller responds to different vehicle and pedestrian movements at the intersection. These assignments indicate which detection devices (such as loop detectors, video cameras, or radar) are associated with specific signal phases (such as green, yellow, or red).
- **Input the detection phase assignments**: Within the programming software, locate the section or menu that allows you to input or configure the detection phase assignments. This section might be named "Detection," "Phasing," or something similar. Depending on the software, you may need to specify the type of detection device used, its location within the intersection, and the associated signal phase.
- **Save and upload the configuration**: Once you have inputted the detection phase assignments, save the configuration within the programming software. Some software might require additional steps to validate and apply the changes. Afterward, you can upload the new configuration to the traffic signal controller.

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## Detection Assignments

- **Test and verify**: It is essential to thoroughly test and verify the detection phase assignments after making changes. Ensure that the traffic signals respond correctly to vehicle and pedestrian movements as specified in the assignments. Make any necessary adjustments or fine-tuning if the signals are not functioning as expected.

It's important to note that traffic signal controllers and their programming processes can vary significantly depending on the manufacturer, model, and local regulations. It is always recommended to refer to the specific documentation provided by the manufacturer or consult with local transportation authorities for precise instructions relevant to your situation

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## Extensions

- **Wireless Communication**: Integrating wireless communication capabilities into detection zones allows for real-time data transmission between the detectors and the traffic signal controller. This enables faster response times and dynamic adjustments to signal timings based on current traffic conditions.
- **Advanced Algorithms**: Using sophisticated algorithms and machine learning techniques, traffic signal systems can predict traffic patterns and optimize signal timings accordingly. These algorithms can consider historical data, traffic flow models, and even external factors like weather conditions to make intelligent decisions.

The programming and configuration of these extensions are typically done in the traffic signal controller or a centralized traffic management system. Traffic engineers and technicians program the system using specialized software provided by the manufacturer. They define the detection zones, set parameters for sensor operation, and specify the desired behavior and response of the traffic signal system based on the collected data.

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## Extensions

Extensions for traffic signal detection zones refer to additional components or features added to existing traffic signal systems to enhance their functionality. These extensions are typically designed to improve the accuracy and efficiency of traffic detection, which helps in optimizing traffic signal timings and overall traffic flow.

In a traffic signal system, detection zones are areas on the road where sensors or detectors are installed to monitor the presence and movement of vehicles. These detectors collect data about vehicle presence, speed, and volume, which is then used by the traffic signal controller to make informed decisions about when and how long to display green, yellow, and red lights.

Extensions for traffic signal detection zones can include various technologies and components, such as:

- **Additional Sensors**: Installing extra sensors, such as radar or infrared detectors, can enhance the detection capabilities of the traffic signal system. These sensors can provide more accurate and reliable data about vehicles, especially in challenging weather conditions or for non-standard vehicles like bicycles.
- **Video Detection**: Video cameras can be employed to monitor traffic at detection zones. Advanced video processing algorithms analyze the video feed to detect vehicles and extract relevant data. Video detection systems can provide detailed information about vehicle types, lane occupancy, and even traffic violations.

161

## Locking Detection

**Locking Detection**: Locking detection refers to a mechanism or system employed in traffic signals to identify and address situations where traffic signal controllers become locked or stuck in a particular state. A traffic signal may get "locked" if a fault occurs in the controller or due to some other malfunction, resulting in the signal not changing to the appropriate state or not responding to inputs correctly. Locking detection systems are designed to detect these instances and take appropriate action to restore normal operation.

The locking detection system typically monitors the signal controller's outputs and inputs, including the signal phases, timing, and sensor inputs. It analyzes the behavior of the signal controller and compares it to expected patterns and timing sequences. If the system detects a deviation from the expected behavior or a prolonged absence of changes in signal states, it triggers an alarm or initiates a response to resolve the issue. This could involve resetting the controller, engaging backup systems, or alerting maintenance personnel for further investigation and repair.

162

## Cycle Lengths

**Cycle Lengths**: Cycle lengths refer to the duration of a complete traffic signal cycle, which includes all the different phases or states of the traffic signal. A traffic signal cycle encompasses the green, yellow, and red intervals for each direction of traffic at an intersection. The cycle length determines the amount of time allocated to each phase and the sequence in which they occur.

The cycle length is an essential parameter for traffic signal timing and is typically determined based on traffic engineering studies, traffic patterns, and the specific needs of an intersection. The purpose of setting cycle lengths is to optimize the traffic flow, minimize congestion, and accommodate the demands of different directions and types of traffic.

Cycle lengths can vary significantly depending on factors such as the size and complexity of the intersection, the volume of traffic, time of day, and specific signal coordination plans in place. Longer cycle lengths may be used in heavily congested areas or during peak traffic hours to allow more vehicles to pass through, while shorter cycle lengths may be appropriate for intersections with lighter traffic.

The determination and adjustment of cycle lengths are typically carried out by traffic engineers and transportation agencies responsible for traffic signal operations. They use traffic analysis tools, historical data, and field observations to optimize the cycle lengths and fine-tune signal timing parameters to achieve the best possible traffic flow and safety outcomes at a given intersection.

163

## Mapping Detection

In traffic signal detection, mapping a detector refers to the process of associating a specific detector with a particular lane or area on the road. This mapping is crucial for accurate and efficient traffic signal control and management. Here's how it is typically done and why it is important:

- **Detector Placement**: Detectors are usually installed at specific locations on the road, such as near intersections or along lanes. The placement depends on factors like traffic flow, lane configuration, and the type of detection technology being used (e.g., loop detectors, infrared sensors, video cameras). The detectors are positioned to capture relevant information about vehicle presence, speed, and occupancy.
- **Detector Mapping**: Once the detectors are installed, they need to be mapped to corresponding lanes or areas. This involves identifying which detector corresponds to which lane(s) or section(s) of the road network. The mapping is often performed by traffic engineers or technicians based on field observations, measurements, and the design of the road infrastructure.

164

## Mapping Detection

- **Signal Timing and Control**: Mapping the detectors enables traffic engineers to accurately monitor and analyze the traffic conditions for each specific lane or area. This information is crucial for optimizing traffic signal timing and control. By knowing the traffic demand and patterns in different lanes, the signal timings can be adjusted to prioritize congested or heavily used lanes, reduce delays, and improve traffic flow efficiency.
- **Traffic Management**: Mapping detectors also facilitates efficient traffic management and incident detection. By monitoring the detectors' output, traffic authorities can identify abnormalities, such as extended queuing, high occupancy, or unexpected traffic patterns. This information can be used to promptly respond to incidents, accidents, or congestion by deploying appropriate resources and implementing alternative traffic control strategies.

165

## Detection

- Managing Vehicle Detection Systems
- Managing Pedestrian Detection Systems
- Managing EVP Systems

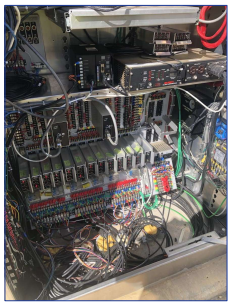
166

## Loop Detection Wiring

Use a multimeter or loop tester/analyzer to test the function of the loop detection wiring.

If wiring *is not* functioning properly:

1. Visually inspect field for **obstructions.**
2. Replace the **faulty wiring.**
3. Perform a **"one-call"** to check for any utilities located underground.



167

## Detection System Faults

**Common TS1 Faults**

- Back panel inputs and all others through the D connector
- Loops with amplifiers or cards/processors
- Radar, cards, and processors
- Physical connections from rack to controller input

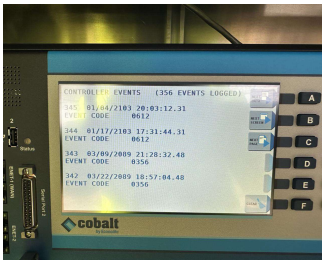
**Common TS2 Faults**

- Video cards
- Card racks
- Detector BIU to the controller
- Detector BIU enabling
- Mapping BIU input to controller input

168

## Inspect Controller Inputs/Outputs

- Review **cabinet blueprints.**
- Inspect the controller display screen as vehicles approach each phase.
- Confirm the system has a proper **voltage.**
- Inspect connections and fuses.




169

## Inspect Detector Card/Processor

Inspect **the indicator lights** to identify any detector faults and inspect **zones** to confirm proper function.

Replace **faulty equipment** and verify **programming** if vehicles are not detected in the correct zone.

170

## Reprogram Systems

Reprogram systems if **modifying detection system** programs.

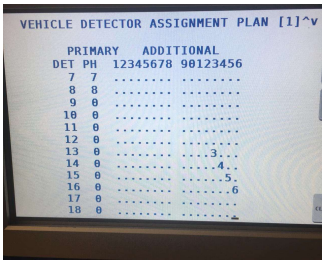
Reprogram systems if **adding new detection devices**, such as cameras, loops, or pucks.

171

## Verify Correct Operation

Inspect the **controller display screen** as vehicles approach each phase to confirm the proper function of the detection system.

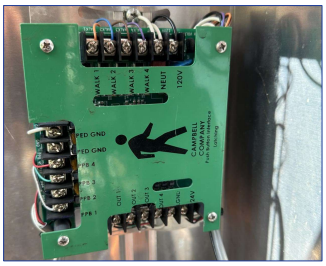
Document all **changes** in the maintenance logbook.




172

## Inspect Phase Assignments

- Review **phase assignments** in cabinet blueprints.
- Set phase assignments to run **pedestrian detection** from specific channels.
- Inspect the **detectors** and make any necessary repairs.




173

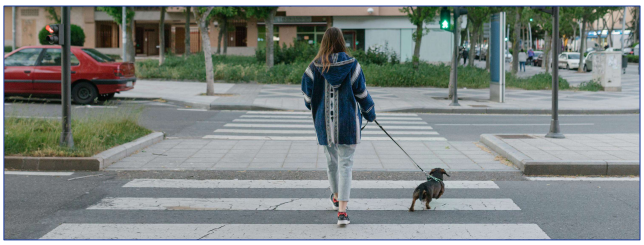
## Pedestrian Intervals

- Measure the **distance** of the pedestrian crosswalk.
- Calculate the time it would take for a pedestrian to cross that distance using a rate of **3.5 feet of road per second.**
- Set the timing interval and **test** it.

174

## Verify Proper function

Observe the full cycle of the pedestrian detection system to ensure proper function.



175

## Test EVP Detectors

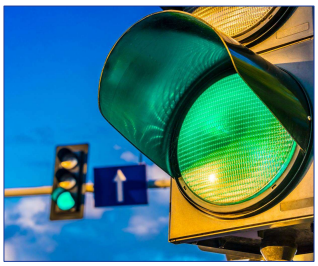
Use a **test button** to trigger the EVP system located in the signal cabinet.

Run an **emergency vehicle** through the intersection.

176

## Entry/Exit Phases

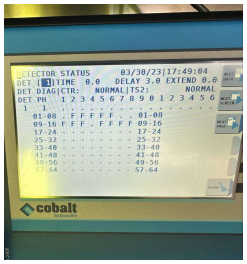
- Inspect **entry and exit phases** in the controller
- Ensure that traffic signals change in the appropriate amount of time for emergency vehicles to pass safely through an intersection

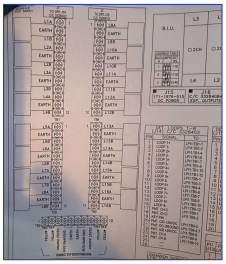


177

## Verify EVP Systems Function

Retest the EVP system to ensure proper operation and alignment of the signal and phase.



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# IMSA Traffic Signal Technician II

Lesson 5: ADA Compliance

Advancing the Future of Public Safety

179

## Traffic Signal Course Introduction

Lesson 1: Traffic Signal Maintenance / Response
Lesson 2: Troubleshooting Tools/Equipment
Lesson 3: Preventative Maintenance (PM)
Lesson 4: Detection Systems
**Lesson 5: ADA Compliance**
Lesson 6: School Flasher Maintenance
Lesson 7: Construction

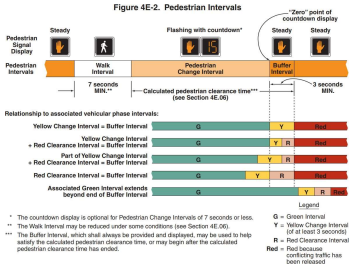
180

## Pedestrian Intervals and Signal Phases

**Intervals and Phases-**

- At intersections equipped with pedestrian signal heads, the pedestrian signal indications shall be displayed except when the vehicular traffic control signal is being operated in the flashing mode. At those times, the pedestrian signal indications shall not be displayed.
- Guidance:
  - Except as provided in Paragraph 8, the pedestrian clearance time should be sufficient to allow a pedestrian crossing in the crosswalk who left the curb or shoulder at the end of the WALKING PERSON (symbolizing WALK) signal indication to travel at a walking speed of 3.5 feet per second to at least the far side of the traveled way or to a median of sufficient width for pedestrians to wait.
- Option:
  - A walking speed of up to 4 feet per second may be used to evaluate the sufficiency of the pedestrian clearance time at locations where an extended pushbutton press function has been installed to provide slower pedestrians an opportunity to request and receive a longer pedestrian clearance time. Passive pedestrian detection may also be used to automatically adjust the pedestrian clearance time based on the pedestrian's actual walking speed or actual clearance of the crosswalk

Figure 4E-2. Pedestrian Intervals




* The countdown display is optional for Pedestrian Change Intervals of 7 seconds or less.
** The Walk Interval may be reduced under some conditions (see Section 4E.06).
*** The Buffer Interval, which shall always be provided and displayed, may be used to help satisfy the calculated pedestrian clearance time, or may begin after the calculated pedestrian clearance time has ended.

G = Green Interval
Y = Yellow Change Interval (of at least 3 seconds)
R = Red Clearance Interval
Red = Red because conflicting traffic has been released

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## ADA Requirements

- An audible push button system for traffic signals is a feature designed to assist pedestrians with visual impairments or other disabilities in safely crossing the street. It consists of a push button device located at pedestrian crossings that emits audible signals, typically in the form of chirps, beeps, or speech messages.
- The importance of an audible push button system lies in providing equal access to pedestrians with disabilities, ensuring their safety, and promoting independent mobility. By activating the audible signals, pedestrians who are blind or visually impaired can audibly detect when it is safe to cross the street, as the sounds indicate the timing of the pedestrian phase of the traffic signal.
- The Americans with Disabilities Act (ADA) in the United States sets guidelines and requirements for accessibility in various aspects of public life, including transportation. According to ADA guidelines, pedestrian push buttons at traffic signals must incorporate audible signals as a standard feature. The audible signals should have a sound level of at least 2 dB above ambient noise levels but should not exceed 5 dB above ambient noise. The push button should also provide a tactile indication, such as a vibration or raised arrow, to assist pedestrians with visual and hearing impairments.
- These requirements ensure that individuals with disabilities can navigate and cross streets safely and independently, promoting inclusivity and accessibility in the urban environment.

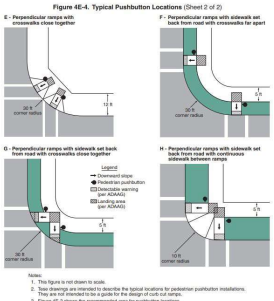
182

## ADA Requirements

The Americans with Disabilities Act (ADA) does not have specific requirements for pedestrian push button locations. However, there are guidelines and best practices that can help ensure accessibility and usability for individuals with disabilities. Here are some general considerations:

1. **Height**: The push button should be located at a height that can be easily reached by individuals using wheelchairs or other mobility devices. The recommended height is between 36 and 48 inches (91-122 cm) above the ground.
2. **Proximity**: The push button should be placed within a reasonable distance from the pedestrian crossing. It should be easily accessible without requiring individuals to step onto the roadway or maneuver around obstacles.
3. **Tactile and visual cues**: The push button should have tactile and visual cues to assist individuals with visual impairments. This typically includes a raised arrow or tactile symbol indicating the direction of the crossing, as well as auditory and visual signals to indicate when it is safe to cross.
4. **Contrast and visibility**: The push button should have high contrast colors to make it clearly visible, especially for individuals with low vision. The button should contrast with its background to ensure easy identification.
5. **Clear space**: There should be enough clear space around the push button to allow individuals using wheelchairs or mobility devices to approach and operate it comfortably. Avoid obstructions such as poles, signs, or vegetation that may impede access.

Figure 4E-4. Typical Pushbutton Locations (Sheet 2 of 2)




Notes:
1. This figure is not drawn to scale.
2. Toso drawings are intended to describe the typical locations for pedestrian pushbutton installations. They are not intended to be a guide for the design of curb cut ramps.
3. Figure 4E-3 shows the recommended area for pushbutton locations.

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# IMSA Traffic Signal Technician II

School Flasher Maintenance

184

## School Flasher Maintenance

Lesson 1: Traffic Signal Maintenance / Response

Lesson 2: Troubleshooting Tools/Equipment

Lesson 3: Preventative Maintenance (PM)

Lesson 4: Detection Systems

Lesson 5: ADA Compliance

**Lesson 6: School Flasher Maintenance**

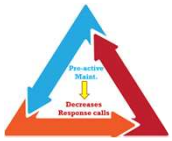
Lesson 7: Construction

185

## School Flasher Maintenance

A maintenance program follows industry guidelines and yields the following benefits:

- Identify and prevent potential equipment failures before they happen
- Minimize costly repairs
- Minimize the frequency and severity of flasher malfunctions
- Preserve and enhance equipment reliability
- Maximize life span of flasher installations
- Minimize the agencies exposure to liability.

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## School Flasher Maintenance

Items to be Inspected, Cleaned, Adjusted or Replaced:

- Beacons
- Control Cabinet
- Batteries
- Pole
- Solar Panels
- Signs
- Grounding


187

## School Flasher Maintenance

Items to be Inspected, Cleaned, Adjusted or Replaced:
Beacons

Check Single Head Alignment
Check for Cracks or Damage on Visors
Check for Cracks or Damage on Signals
Check for Cracks or Damage on Hardware
Check Gaskets on Housing
Check Terminal Connections
Visually Check All Cable
Replace LED's Out or Dim


188

## School Flasher Maintenance

Items to be Inspected, Cleaned, Adjusted or Replaced:
Control Cabinet

Manually test ON/OFF Operations
Verify Programming
Verify Time & Date
Lubricate Hinges & Locks
Check Terminal Connections
Vacuum Cabinet
Verify Conduits are Sealed
Cabinet Ground Reading
Check/Clean Graffiti

189

## School Flasher Maintenance

Items to be Inspected, Cleaned, Adjusted or Replaced:
Batteries

Verify incoming line voltage from solar panel
Check DC Battery Output
Test System
Test Batteries

190

## Cycle Battery to Ensure Proper Function

- Use the **battery test mode** option on the inverter to check the backup battery.
- Replace the **backup battery** if the UPS is not powering the intersection when the main battery is disconnected.
- Turn on the power at the intersection.

191

## School Flasher Maintenance

Items to be Inspected, Cleaned, Adjusted or Replaced:
Pole

Verify Hand Hole Covers present
Verify Pole Cap
Inspect Foundations/Anchor Bolts
Inspect Poles Wood/Steel
Verify Collar present
Check Mounting Hardware


192

## School Flasher Maintenance

Items to be Inspected, Cleaned, Adjusted or Replaced:
Solar Panels

Check Condition
Verify Solar Panel Wattage
Check for solar obstruction on panel
Check Connections/Terminals on Panel
Check Mounting Hardware

193

## School Flasher Maintenance

Items to be Inspected, Cleaned, Adjusted or Replaced:
Signs

Verify S5-1 (Diamond grade Fluorescent Yellow green) is present.

Verify R2-1/S5-2A (Speed limit w/end school zone)

Verify No cell phone in school zone sign is present

Check the mounting hardware

Check bolts for tightness


194

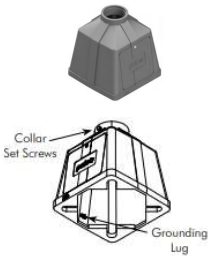
## School Flasher Maintenance

Items to be Inspected, Cleaned, Adjusted or Replaced:
Grounding

Inspect the pole and ensure it is bonded to the ground wire in the foundation.

If the pole is not grounded, install a ground wire.

Test Grounding for 25 ohm and less

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# IMSA Traffic Signal Technician II

Construction

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## Construction

Lesson 1: Traffic Signal Maintenance / Response

Lesson 2: Troubleshooting Tools/Equipment

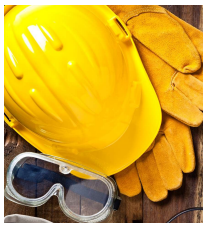
Lesson 3: Preventative Maintenance (PM)

Lesson 4: Detection Systems

Lesson 5: ADA Compliance

Lesson 6: School Flasher Maintenance

**Lesson 7: Construction**



197

## Construction

Protection from Workplace Harms and Hazards

**Personal protective equipment or PPEs** can save lives by protecting workers from injury, illness, burns, lacerations, and other occupational mishaps from machines and materials that can cause severe damage.

PPEs at your workplace include:
Safety glasses or goggles for an eye injury
Gloves for hand injuries
Hearing protection for noise exposure from loud machinery or other sounds at work
A respirator for protecting workers against insufficient oxygen environments, contaminated air, harmful dust, smoke, sprays, etc.
Special footwear that protects against hazards like tripping or slipping on wet floors

Harness - These fall-protection harnesses are secured around the shoulders, torso, and upper thighs. They have a single D-ring or web loop on the upper back (dorsal) for attaching a self-retracting lifeline or shock-absorbing lanyard that connects to a secure anchor point on a building or structure. The position of the D-ring reduces strain on the wearer's body and keeps the wearer upright in the harness during and after a fall. Some safety harnesses have additional D-rings on the shoulders, hips, or chest that allow them to be used for positioning, ladder climbing, and raising or lowering workers into confined spaces.

198

## Construction

During construction safety must be a top priority, be aware of dangerous conditions such as:
Operator using equipment incorrect (i.e. using a bucket truck as crane)

Contractor leaving trip hazards

Sidewalk closed signs not in place during demolition

Trench Hazards (i.e. contractor not using proper shoring or not putting up fencing)

Bucket Trucks reaching over lanes – SEE https://www.youtube.com/watch?v=jZ8UdvCqp0
8
Improper Road Closures

Working during rush hour

Working too close to power lines


199

## Construction

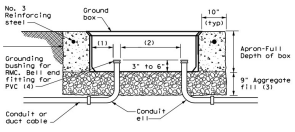
- Review the **construction plan** from the engineer.
- Inspect the field to ensure parameters **match** the construction plan.
- Notify the engineer of any discrepancies before construction materials are ordered.

200

## Junction/Pull Boxes

Ground Box Types – A, B, C, D & E Reinforced Polymer Concrete prefabricated Dimensions. Provide ground boxes Types A, B, C, D, and E with the following inside minimum dimensions (width × length × depth) ± 1/4 in.

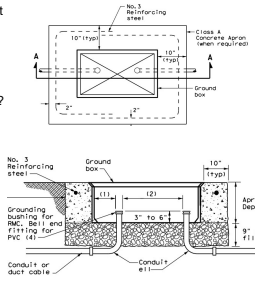
- Type A—11-1/2 in. × 21 in. × 10 in., (122311)
- Type B—11-1/2 in. × 21 in. × 20 in., (122322)
- Type C—15-1/4 in. × 28-1/4 in. × 10 in., (162911)
- Type D—15-1/4 in. × 28-1/4 in. × 20 in., (162922)
- Type E—11-1/2 in. × 21 in. × 16 in., (122317)




201

## Junction/Pull Boxes

- Are the ground boxes the correct size and in the correct locations called for by the plans?
- Ensure 9 inches of gravel are on the base?
- Does the pull box have the correct apron?
- Ensure cement/concrete is clear from edges and holes?
- Are all the pull box lids marked with proper wording?
- Do all the 90s have bell ends?
- Are all the cables properly tagged/phased?
- Are all the 90s covered/foamed?
- Do the bolts properly fit?
- **NO SPLICING IN CONDUIT OR BOX**




202

## Junction/Pull Boxes

Use an ohm tester to ensure the grounding system meets the standard of **25 ohms or less**.

Add multiple **ground rods** if the grounding system is more than 25 ohms.

203

## Conductors

Wire types:

- Type T – Dry Locations
- Type TW – Dry or Wet
- THHN – Dry, High Temperature
- **XHHW – High Moisture & Heat Resistance**
- UF – Direct Buried in Soil or Concrete


204

## Conductors

Phasing tape: At least 6" inches must be covered as per NEC


205

## Conductors

Spare conductors must be insulated on each end, even if it is not connected.

Heat Shrink

Wing Nut

206

## Conductors

Common Conductor Sizes for Traffic Signal Cables:

5 – Conductor stranded 12awg copper

7 – Conductor stranded 12awg copper

20 – Conductor stranded 12awg copper

No pulling with Truck, Backhoe, Winch Truck

Do not pull wire on surface that cars will run over wire .

207

## Conductors

Are all conductors installed as per plans?

Are all conductors XHHW insulated?

Has Conduit Been Cleaned prior to Pulling wire?

Have Wires Been Megger Tested?

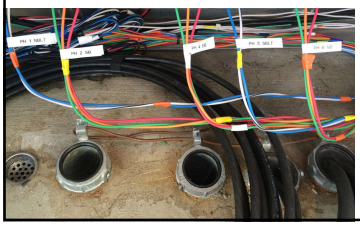
Are all cables properly Tagged and or Phased correctly?

**NO SPLICING**

208

## WIRE LABELING

- Ensure that all wires are labeled according to the wiring schematics in the blueprints. You will thank yourself in the long run with good cable labeling.




209

## Conduit

An electrical conduit is a piping system used to carry electrical wiring. The purpose of conduits is to protect the enclosed wiring from fires, mechanical damages, and corrosion. Conduits protect electrical wires as well as any individual who come in close proximity to electrical wires.
Prior to work starting review the following:
Detail Sheets
Layout sheets
Estimate Summary Sheet
Change Orders

210

## Conduit

Inspect conduit:
Make sure proper pipe being used is Metallic or Non-Metallic depending on specifications.

All Exposed conduits must be RMC Metallic.
Make sure trenches are over18" from the finish grade to the top of the pipe.

EMT is not approved for any Traffic Signal Projects.
All support Claps, connectors and bolts must be stainless steel or galvanized. **NO NAILS ALLOWED**.

211

## Conduit

RMC needs to be supported within 3 ft of LB or Box.
All rigid metal conduit must have metal galvanized conduit fittings.

All metal conduits must be reamed to avoid wire damage.
When entering a cabinet, service or box grounding bushing must be installed to provide proper grounding.

Expansion Joints must be used on Concrete wall.
Cold Weather = Expansion Joint expanded
Hot Weather = Expansion Joint Retract

212

## Conduit

PVC Electrical Conduit / Non-Metallic Conduit
Grey Color RPVC is the only conduit allowed for electrical underground, SCH 40 & 80 depending on the Specification and the Estimate Summary Sheet.

All unused conduits shall be capped. DUCT TAPE NOT APROVED AS A CAP.

All PVC conduits must be reamed to avoid wire damage.
Only proper primer and solvent cement will be used to bond conduit to fittings.
All Fittings will be grey PVC only. **NO WATER FITTINGS**
All Ends in Pull Boxes will have Bell Ends
PVC can only be bent by approved heater / **NO DIRECT FIRE!**

213

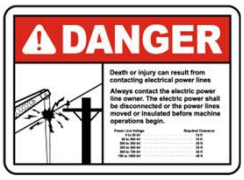
## Foundation

Prior to work starting:
It is Mandatory for contractor to call 811 for locates, onsite you should have a confirmation number.

In addition to 811 you need to call water dept, and traffic operations and any other utility not on 811.

All foundations must be placed in accordance with Plans. This is to ensure line of sight and mast arm length is sufficient.

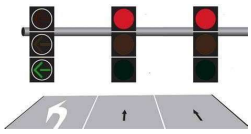
Poles cannot be installed within 10ft clearance of power lines




214

## Foundation

Prior to Drilling make sure foundation is where plans call for, if not mast arm & signal heads will not line up with road and pavement markings.



215

## Foundation

- Cages must be centered to Sona-tube
- Cage rebar and spirals must be done per specs.
- Anchor bolts must be centered to cage.
- Bolt and plates must be leveled .
- Anchor bolts must be straight when pouring concrete.
- Ground Rod must be driven all the way into the ground (do not cut ground rod).

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## Foundation

Collars are recommended for all poles over 8ft

All bases must be grounded

Screw in anchors will be approved as foundation alternative as per engineer depending on soil condition.

Installation of screw in anchors
https://www.youtube.com/watch?v=9RDaW-PKQIE

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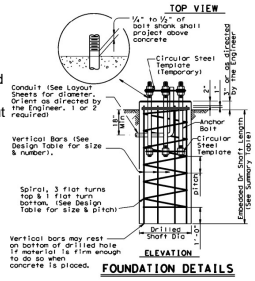
## Foundation

- The material is approved as per submittals
- Pole foundation locations are correct as per plans
- Foundation is correct size and depth
- The correct number and size of rebar has been used
- Ground rod is in the correct place
- Concrete on foundation is flush and has proper grout
- Bolts are set to the correct height
- Correct number of conduits are per plans
- Washers are installed correct on bolts
- The base is level
- Pole is not leaning when set
- Pole is properly grounded when installed

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# IMSA Traffic Signal Technician II

Glossary

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## PHASE INTERVALS

Traffic engineers analyze traffic patterns, conduct traffic studies, and use computer simulation models to determine the appropriate duration for each phase interval. The goal is to allocate sufficient time for each movement to clear the intersection while minimizing delays and maximizing traffic throughput. The specific timing parameters, such as green time, yellow time, and all-red time, are set based on these considerations.

By adjusting phase intervals, traffic engineers can optimize signal timing to improve traffic flow, reduce congestion, enhance pedestrian safety, and achieve better overall intersection performance. Continuous monitoring and analysis of traffic conditions may lead to periodic adjustments in phase intervals to accommodate changing traffic patterns and optimize signal operations.

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## Cycle Faults

Resolving a cycle fault in traffic signal timing typically involves the following steps:

- **Identification**: The first step is to identify that a cycle fault has occurred. This can be done through visual observation or through monitoring systems that detect abnormalities in the traffic signal's timing patterns.
- **Troubleshooting**: Once the cycle fault is identified, traffic engineers or technicians need to investigate the underlying cause. This may involve inspecting the hardware components, checking the signal controller's software and programming, and assessing the power supply.
- **Rectification**: Depending on the cause of the cycle fault, appropriate actions can be taken to resolve the issue. This may include repairing or replacing faulty hardware components, fixing software glitches, reprogramming the signal controller, or addressing power supply issues.
- **Testing and verification**: After the necessary repairs or adjustments are made, the traffic signal's timing should be thoroughly tested to ensure that the cycle fault has been resolved. This typically involves monitoring the signal's operation for a period of time and analyzing its performance.

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## Split Timing

Split timing in the context of traffic signal timing refers to the division of time between different phases of a traffic signal. Each phase generally represents a specific direction of traffic or type of movement, such as north-south traffic, east-west traffic, left-turn movements, pedestrian crossings, etc. The 'split' is the proportion of time dedicated to each of these movements in a complete cycle of the traffic signal.

Traffic engineers design and implement split timing based on careful observations of traffic patterns, studies of traffic volumes at different times of the day, and assessments of safety considerations. The objective is to maximize the efficiency of the intersection and reduce delays for all users.

Split timing is done to achieve the following benefits:

- **Improved Traffic Flow:** Properly set split timing can improve traffic flow by ensuring that the green light is given to traffic movements based on demand. For instance, if more cars are going north-south than east-west during a particular time of day, then the north-south phase would get a larger split to accommodate that higher demand.
- **Reduced Congestion:** With effective split timing, traffic signals can help reduce congestion at intersections. This is because vehicles would spend less time waiting at red lights, and more time moving through the intersection.

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## Split Timing

- **Increased Safety:** Split timing can help increase safety by reducing conflicts between different movements at the intersection. For example, giving a separate phase (and thus split) to left-turning vehicles can prevent them from colliding with oncoming traffic.
- **Adaptability to Varying Traffic Conditions:** Traffic engineers can adjust split timing to accommodate varying traffic conditions. For example, during rush hours, more time may be given to movements with higher demand.
- **Enhanced Pedestrian Safety:** By providing specific phases (and splits) for pedestrian movements, split timing can help enhance pedestrian safety.
- **Improved Fuel Efficiency and Reduced Emissions:** By reducing unnecessary stopping and waiting times at traffic signals, effective split timing can help improve fuel efficiency of vehicles and reduce emissions.

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## Traffic Signal Coordination

**Traffic signal coordination** refers to the synchronization of traffic signals along a specific route to promote an orderly and efficient movement of traffic. The aim of signal coordination is to allow vehicles to proceed at a predetermined speed, ideally without stopping.

**Components of Traffic Signal Coordination:**

- **Cycle Length:** The time required for a signal to complete one full sequence of its phases (for instance, from green to yellow to red, and back to green).
- **Offset:** This is the timing difference between the start of the green indication in one signal phase at an intersection and the start of the green indication in the same signal phase at the next downstream intersection. Proper offset helps to maintain the flow of traffic without unnecessary stopping.
- **Green Split:** This is the division of the cycle time among the various phases. This division should ideally be based on traffic demand to ensure that there's enough time for vehicles to pass safely.
- **Inter-green Period:** The time between the end of the green phase of one signal group and the start of the green phase of the next signal group. It often includes the yellow and all-red intervals.
- **Network and Route Selection:** A group of signals can be coordinated along a single route, a network of intersections, or multiple routes depending on the specific need and traffic flow.

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## Traffic Signal Coordination

**Advantages of Traffic Signal Coordination:**

- **Efficient Traffic Flow:** Properly coordinated traffic signals allow for a smoother flow of traffic, minimizing stops and delays.
- **Fuel Efficiency and Emission Reduction:** By reducing unnecessary stops and idle time at intersections, traffic signal coordination can result in more fuel-efficient vehicle operation and less emission of pollutants.
- **Safety Improvement:** Coordinated traffic signals can contribute to a safer roadway environment by reducing erratic driving behaviors like unnecessary braking and acceleration, which can lead to accidents.
- **Maximize Capacity:** Coordinated signals help to utilize the full capacity of the roadway, helping to handle more vehicles efficiently.

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## Traffic Signal Coordination

**Disadvantages of Traffic Signal Coordination:**

- **Difficulty in Balancing Multiple Traffic Directions:** It can be challenging to balance the needs of traffic moving in multiple directions, especially in complex urban environments. Prioritizing one direction can lead to increased delay for other directions.
- **Increased Delay for Pedestrians:** Coordinated signals often prioritize vehicular traffic, which can result in longer wait times for pedestrians trying to cross intersections.
- **Complexity and Cost:** Designing, implementing, and maintaining a coordinated traffic signal system can be complex and costly, requiring traffic engineering expertise and regular adjustments to keep up with changing traffic patterns.
- **Inefficiency During Off-Peak Hours:** While coordination is beneficial during peak traffic periods, it can lead to unnecessary waiting times at intersections during off-peak hours when traffic volumes are lower.

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## Traffic Signal Coordination Terms

In the field of traffic signal timing and coordination, several common terms are used to describe the various elements and operations of the system. Here are some of the main ones:

- **Cycle Length**: The total time for all signal phases to occur once in a sequence. This includes green, yellow, and red indications for all approaches.
- **Phase**: Refers to the part of the cycle allocated to movements in one or more directions. For example, north and southbound traffic could represent one phase, and east and westbound another.
- **Split**: The portion of the cycle length allocated to a specific phase or set of phases. For example, a 60-second cycle might have a 30-second split for the north-south phase and a 30-second split for the east-west phase.
- **Offset**: The time difference between the start of the green light in the coordinated phase at one intersection and the start of the green light in the coordinated phase at an adjacent intersection.

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## Traffic Signal Coordination Terms

- **Green Time**: The part of the cycle in which the signal is green and vehicles are permitted to move through the intersection.
- **Yellow Time**: A short period that signals the impending end of the green phase, advising motorists to prepare to stop.
- **All-Red Time**: A short period when all directions are red to clear the intersection before the next phase starts. This helps prevent collisions.
- **Inter-green Time (or Clearance Interval)**: The combined time of yellow and all-red periods.
- **Coordination**: The synchronization of signals along a corridor to provide smooth flow of traffic with minimal stopping.
- **Progression**: The movement of platoons of vehicles along a corridor without stopping. Ideally, once a vehicle enters the coordinated system, it will continue to meet green lights as it travels down the corridor.

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## Traffic Signal Coordination Terms

- **Cycle Failure**: Occurs when the demand exceeds the capacity of the intersection, resulting in vehicles unable to clear the intersection within one cycle.
- **Permitted/Protected Phases**: Permitted phases allow turning movements but also allow conflicting through movements. Protected phases provide exclusive right-of-way to specific movements and no conflicting movements are permitted.
- **Platoon**: A group of vehicles moving together through a network of intersections.
- **Saturation Flow Rate**: The maximum flow rate that can be achieved by a lane during a given duration under prevailing conditions.
- **Lost Time**: The portion of the green phase that is lost to starting and stopping delays.

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## Vehicle Platooning

Vehicle platooning refers to a technique in transportation where a group of vehicles travel closely together in a coordinated manner, following a lead vehicle. This concept is often associated with autonomous or semi-autonomous vehicles, as they can communicate with each other and maintain a safe and efficient driving pattern. A coordinated signal plays a crucial role in enabling vehicle platooning.

In a coordinated signal, the lead vehicle sends continuous or periodic signals to the following vehicles, indicating its speed, acceleration, and other relevant information. These signals are transmitted using wireless communication technologies such as Dedicated Short-Range Communications (DSRC) or Cellular Vehicle-to-Everything (C-V2X) systems. The following vehicles receive these signals and adjust their own speed and acceleration accordingly, maintaining a consistent distance and relative positioning.

The coordinated signal allows the vehicles in the platoon to synchronize their movements, resulting in benefits such as improved traffic flow, increased fuel efficiency, and enhanced safety. By maintaining close proximity and avoiding unnecessary acceleration or braking, platooning reduces aerodynamic drag and allows vehicles to operate in a more energy-efficient manner. This can lead to reduced fuel consumption and emissions.

Furthermore, coordinated signaling enables rapid and coordinated responses to changes in the lead vehicle's behavior, such as braking or changing lanes. It allows the following vehicles to anticipate and react accordingly, ensuring a smooth and efficient flow of traffic within the platoon.

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## Progression

In traffic engineering, progression refers to the coordination of traffic signals in a way that allows groups or "platoons" of vehicles to move through a series of intersections with minimal stopping. This method maximizes the efficiency of traffic flow, particularly along heavily trafficked routes or during peak hours.

When traffic signals are set up in a progressive sequence, the green lights are timed so that once vehicles start moving, they will ideally encounter green lights at each subsequent intersection. This is done in both directions along a road or route.

For example, if you're driving down a main road with several traffic lights, a well-coordinated progression system would mean that after you stop at the first red light, and then start moving again when it turns green, you should be able to keep moving through most or all of the remaining lights without having to stop again, assuming you maintain the designated speed limit.

Progression not only helps with traffic flow, it can also reduce vehicle emissions (since vehicles aren't idling at red lights as often) and improve fuel efficiency.

Please note that actual traffic conditions and variability (like vehicles turning, pedestrian crossings, buses stopping, etc.) can disrupt the ideal progression sequence, making it a challenging problem in traffic engineering. This is where advanced traffic control systems and even concepts like vehicle-to-infrastructure (V2I) communication in smart cities come into play, to optimize this as much as possible

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## Phase Concurrency

In traffic signal coordination, phase concurrency refers to the ability of two or more traffic signal phases to operate simultaneously at an intersection. Each traffic signal phase represents a specific movement of traffic, such as through traffic, left turns, or pedestrian crossings. By allowing concurrent phases, traffic engineers can optimize the flow of traffic and minimize delays at intersections.

Phase concurrency is particularly useful when coordinating signal timings for adjacent intersections or for complex intersection layouts. It allows for more efficient traffic movement by enabling vehicles from different directions to proceed simultaneously, reducing overall wait times and increasing the capacity of the intersection.

For example, if one intersection has a green light for through traffic while the adjacent intersection has a green light for left turns, vehicles can move through both intersections at the same time, improving the overall traffic flow.

Traffic signal coordination systems typically analyze traffic patterns and adjust the timings of different signal phases to optimize phase concurrency and reduce congestion. These systems consider factors such as traffic volume, turning movements, pedestrian crossings, and the overall traffic demand in order to determine the most effective coordination strategy

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