



Basics of Traffic Signal Operations

Participant Learning Guide

Advantages of Installing a Traffic Signal

- Orderly movement of traffic
 - Designed with logic to prevent conflicting movements
 - Provide an opportunity for traffic on the side streets to enter the intersection at busy locations
 - Give pedestrians an opportunity to cross safely where accommodations are provided
- Increased Capacity
 - Volume = the number of vehicles that pass by a specific point during a given period of time (veh/hr)
 - Capacity = the maximum flow rate at which vehicles can pass through the intersection in an hour under current conditions
 - Increased capacity assumes:
 - The signal is placed in an appropriate location
 - The signal is properly laid out
 - The timings and other parameters are reviewed and updated on a regular basis as needed (i.e. changes in traffic patterns or volumes)
- Continuous Movement of Traffic - In a coordinated system, signals can provide continuous or nearly continuous movement, assuming favorable conditions and travel at the design speed.
- Reduced Frequency and Severity of Crashes - Often reduces angle crashes, which tend to be some of the most severe and often fatal collisions.

Disadvantages of Installing a Traffic Signal

- Increased Delay, impacting capacity at the intersection
- Disobedience of Signal - If the signal is not timed well or detection is malfunctioning, users may run a red light
- Use of less appropriate routes – If traffic signals are poorly timed and fail to provide continuous movement along a corridor, users may choose to cut through neighborhoods on local streets rather than using the collector and arterial roads designed to carry the traffic
- Increased frequency of collisions – When installed where unwarranted, traffic signals can increase the frequency of some types of collisions

- Higher maintenance cost – As compared to stop control, signalized intersections have a higher maintenance cost, including preventative maintenance, replacement of components, electricity, and staff with specialized training.

5 Basic Requirements for Traffic Control Devices

- Fulfill a need
 - Engineering study
 - Signal is warranted
 - Approved by Office of the State Traffic Administration (OSTA)
- Command respect
 - Appropriate size, color, shape
- Convey a clear, simple message
 - Standard messaging
 - Uniform – drivers know what to expect
- Command attention
 - Device can be clearly seen, even from a distance
- Provide adequate time for proper response
 - Signs placed far enough in advance
 - Drivers are not stuck in the “dilemma zone”

Major Components of a Traffic Signal

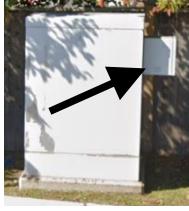
- Controller

The controller acts as the “brain” of the traffic signal, changing signal indications based on user needs. You can see in this photo that the controller cabinet is located at the far side of the intersection. The controller determines when the indication for an approach will change and how much time will be given to each movement. A controller is housed in a cabinet along with other electronic components.



Controller

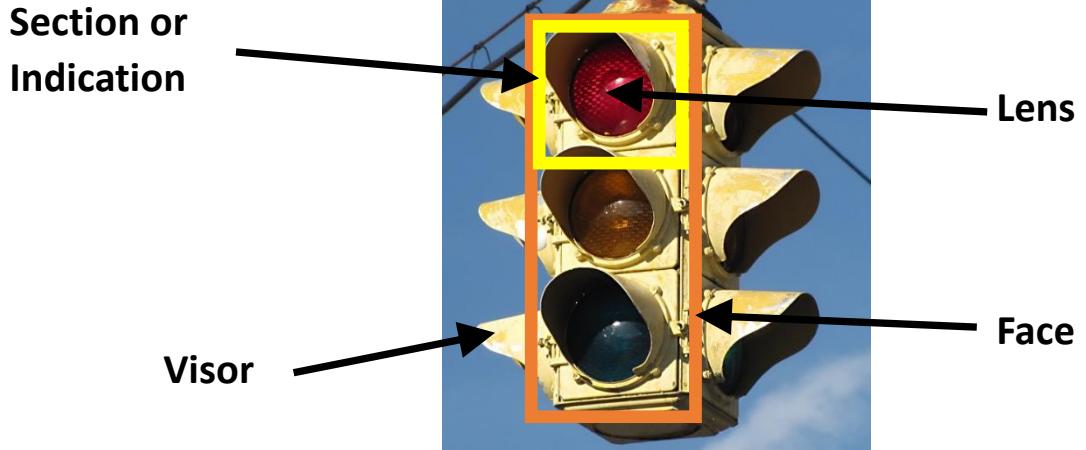
Conflict Monitor		The conflict monitor continually checks for the presence of conflicting signal indications or improper operating voltages and provides an output to the controller in response to the problem. Depending on the type of controller you're using, this may also be called a malfunction management unit.
Load Switch		Controllers run on 24 volt DC current. A load switch is used to switch power to the signal indications, which operate on 120 volt AC current. Each load switch can control up to three indications, typically the red, green, and yellow indications of a single face.
Detector Amplifier		An electrical device used to sense electrical load changes on the inductive loop detectors and provide an output to the controller for vehicle detection.
BIU (Business Unit Interface)		Interface between the Controller Unit and other devices in the cabinet assembly.
Flasher		Generates a flashing signal independent of the controller, so the signals can still flash if the controller itself goes down.
Power Supply		Supplies power to the traffic signal cabinet
Pre-Emption Detector Card		An electrical device used to detect optical inputs to the sensor and provide an output to the controller for emergency vehicle pre-emption.

Auxiliary Equipment Cabinet		Cabinet that houses separate devices used to add supplementary features to a controller assembly. Typically a municipality's pre-emption equipment will be located here, or if the police have a manual override for the controller it will be placed in the auxiliary cabinet.
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- **Display**

Used to communicate to the users of the roadway. Elements of the display include the signal heads and pedestrian signals. This also includes audio cues which may be given to blind pedestrians where audible pedestrian signals are installed.

Parts of a Signal Head



- **Supports**

- Span Poles
- Mast Arms
- Pedestals

- **Detection**

Detectors are used to identify the presence of one or more vehicles in a specific area or the passage of a vehicle past a specific point.

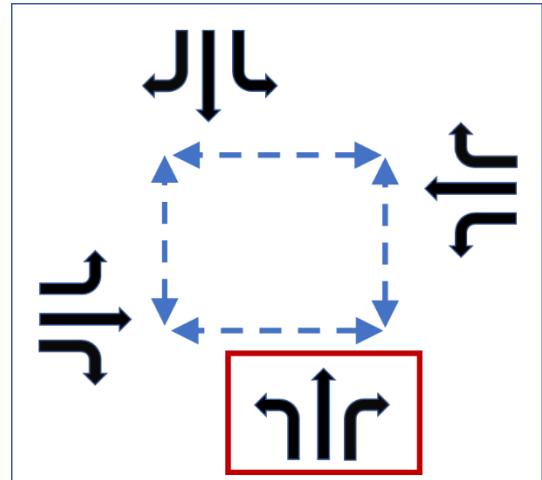
Traffic Signal Terms

- Approach

An Approach is all lanes of traffic moving towards an intersection or a mid-block location from one direction, including any adjacent parking lane(s).

- Movement

A *movement* is a user action taken at an intersection. Users can be drivers, pedestrians, or bicyclists. In the diagram we can see the blue dashed lines, which show the pedestrian movements across each approach of the intersection. At each intersection approach, we can see a left turn movement, a right turn movement, and a left turn movement.



- Protected Movement

A protected movement that has the right of way. These are sometimes called exclusive movements. An example would be if the westbound approach movements had the right of way and vehicles at all other approaches were stopped. If everyone does what the traffic signal is telling them to do, there will be no conflicts with the westbound movements. Another example of this is an exclusive pedestrian phase. All of the vehicular traffic at the intersection is stopped and the pedestrians have the right of way.

- Permissive/Permitted

A Permissive or Permitted movement must yield consistent with the rules of the road or the Uniform Vehicle Code. We typically show permissive movements with a grey or dashed arrow.

- Cycle

The cycle length is the total time required to complete one sequence of signalization around an intersection. In basic pre-timed control, the cycle length is fixed; if the signal is actuated, the cycle length varies (up to predetermined maximums) according to the number of vehicles involved.

- Interval

An interval is the part of the signal cycle, a segment of time, during which signal indications do not change.

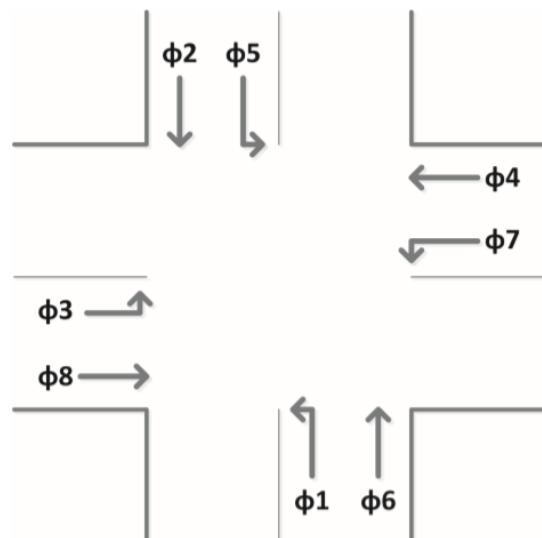
- Green Interval - The green interval is the time the green light is displayed for a phase, when the vehicles or pedestrian movements associated with that phase have the right of way.

- Yellow Interval - The yellow clearance interval is a yellow indication warning users that the red indication is going to begin. It usually follows the green, flashing yellow or flashing red interval of a phase.

- Red Clearance Interval - The red clearance interval is an optional interval that follows the yellow change interval and precedes the next conflicting green interval. It provides additional time following the yellow change interval before conflicting traffic is released.
- Pre-Timed Signal - A pre-timed signal is a traffic signal that is programmed to give green indications to movements based on a predetermined allocation of time. They operate with fixed cycle lengths and green splits and can operate either in isolation or in coordinated mode.
- Actuated Signal - Actuated controllers vary the amount of green time allocated to each phase based on traffic demand (in the form of detector calls from vehicles or pedestrians). An actuation is a signal or impulse to a controller input to cause an event or sequence of events. The signal originates from a separate source such as a detector (such as loop, microwave, video), a coordination device or manual control (e.g. manual ped button). They can operate in fully actuated mode, semi-actuated mode, or coordinated mode.
 - Semi-Actuated - A semi-actuated traffic signal uses various detection methods to identify roadway users on the minor approaches and/or major approach left-turn lanes.
 - Fully Actuated - A type of actuated controller assembly that recognizes users on all approaches.
- Phase - A phase is the green, yellow change and red clearance intervals in a cycle that are assigned to an independent traffic movement or combination of traffic movements. We typically use the National Electrical Manufacturers Association (NEMA) phasing convention.

NEMA Phasing Convention

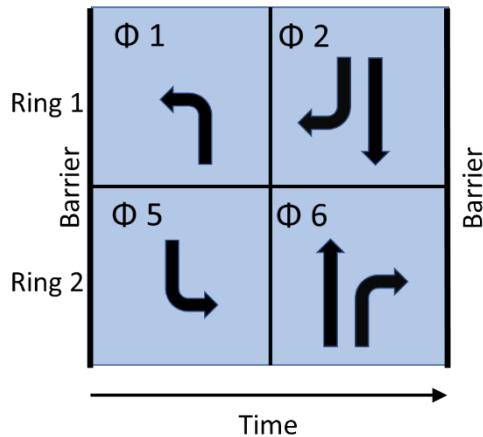
NEMA (National Electrical Manufacturers Association) phasing defines a standard of numbering the through movements with even numbers (2,4,6,8) and the left turn movements with odd numbers (1,3,5,7).



Ring and Barrier Diagram

The Ring and Barrier Diagram defines the safe sequencing of phases (and thus the movements that they control) at a signalized intersection.

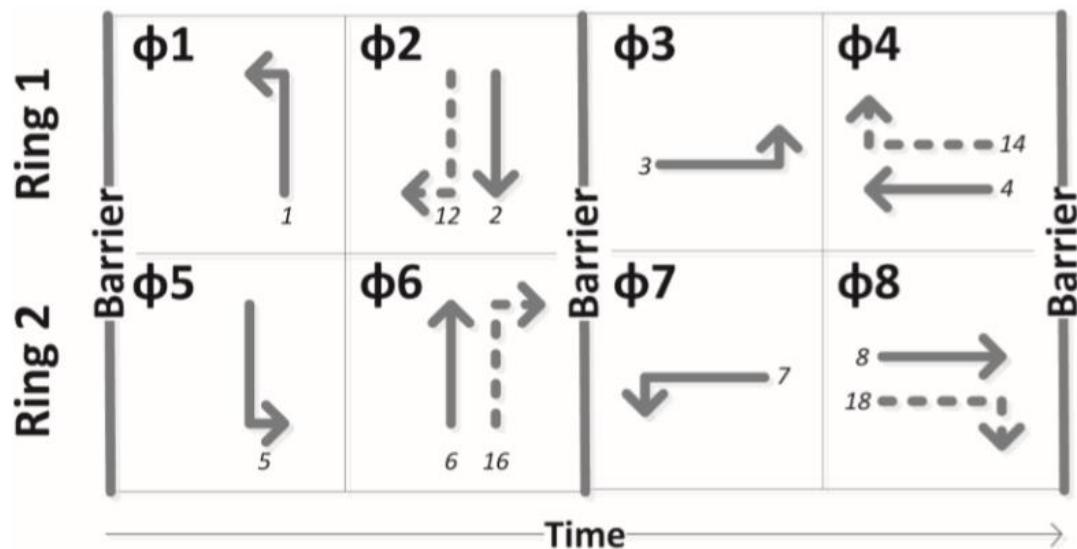
To create a NEMA ring and barrier diagram we first separate the phases into two “concurrency groups”, one group for the phases controlling the major street movements and a second group for phases controlling the minor street movements. We separate the concurrency groups by a barrier.



We define a ring as a sequence of phases that are not compatible and that must time sequentially, one after another. For the major street concurrency group, the movements controlled by phases 1 and 2 (the northbound left turn and the southbound through) must occur sequentially. Similarly, the southbound left turn and the northbound through movements, controlled by phases 5 and 6, must also occur sequentially.

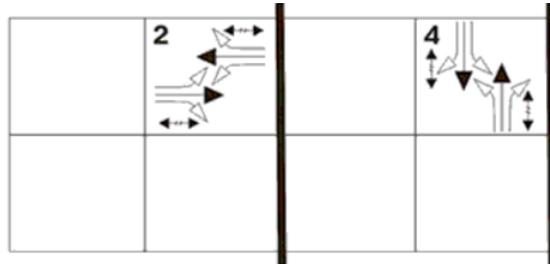
Signal Operations Follow Two Rules:

1. The phases in a ring must be served sequentially and cannot be served concurrently because they are not compatible with each other.
2. A phase in one ring may be served concurrently with phases in the other ring in the same concurrency group. For example, Phase 1 may be served concurrently with Phase 5 and Phase 6.

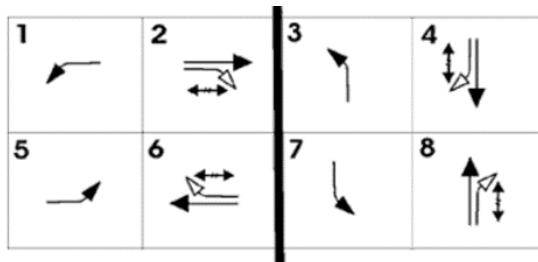


Left Turn Phasing

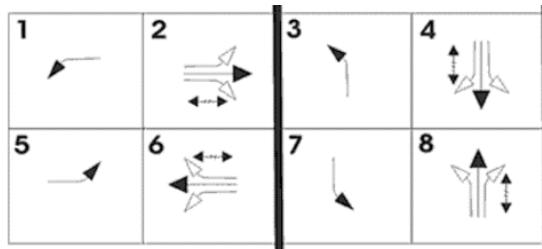
- Permitted - Signal phasing that allows two opposing approaches to time concurrently with left turns allowed after motorists yield to conflicting vehicles and pedestrians.



- Protected - Signal phasing that provides a separate phase for left-turning traffic and allowing left turns to be made only on a green left arrow signal indication, with no pedestrian movement or vehicular traffic conflicting with the left turn.



- Permitted-Protected - A combination of protected and permissive left-turn phasing.



A “doghouse” is a type of five-section signal head often used with permitted-protected phasing

