

CE474: Traffic Systems Design-Fall 2004

Class 22 – Traffic Signal System and ITS Architecture
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Topic outline

- ◆ Interchange Introduction
- ◆ Diamond Interchange Introduction
- ◆ Diamond Interchange Signal Control Introduction
- ◆ Two-phase control
- ◆ TTI Three-phase control
- ◆ TTI Four-phase control

Definitions

- Freeway: a multi-lane, median divided, limited-access roadway. In other words, a multi-lane road with some form of barrier down the middle to separate traffic, with ramps to get on and off.
- Ramp: a roadway which connects a freeway to a regular road, a regular road to a freeway, or a freeway to a freeway

Definitions

- **Interchange:** The connection of a freeway to a road or another freeway by a series of ramps. The other road or freeway being connected to is grade-separated.
- **Directional (ramp):** A ramp which turns directional to where it's going. When the term "directional" is applied to ramps it is usually referring to left exits on freeways.

Definitions

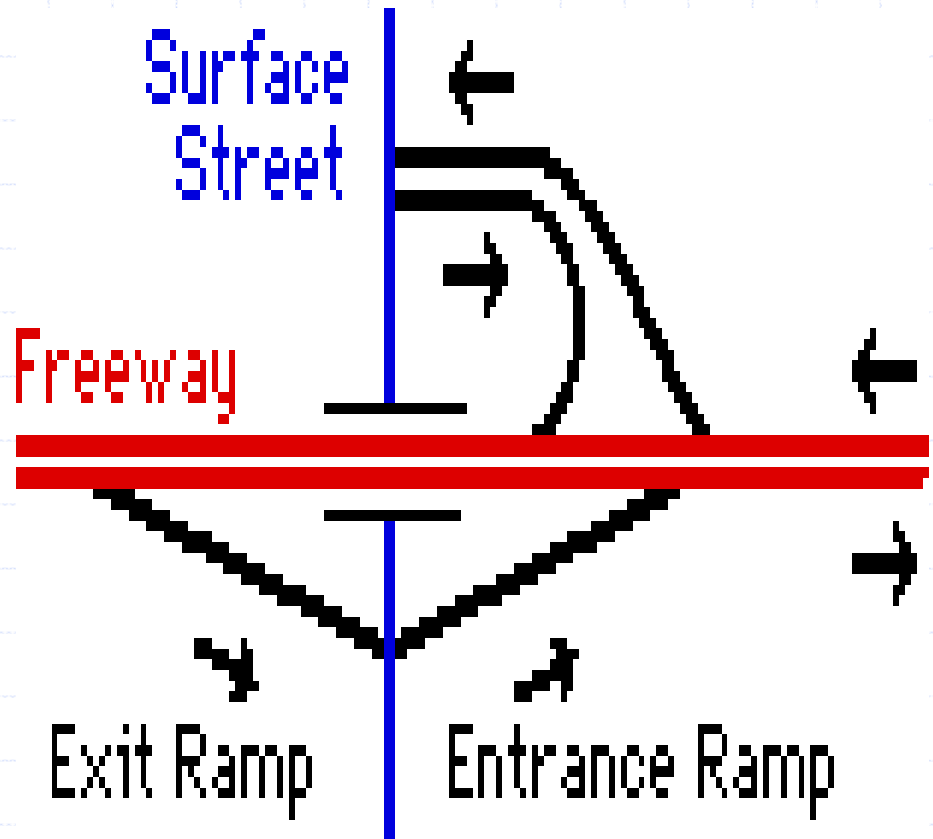
- **Flyover:** A semi-directional or directional ramp that is elevated above ground level. This ramp flies over the freeway and other ramps.
- **Cloverleaf:** Refers to cloverleaf style interchange or a single loop ramp.

An Interchange



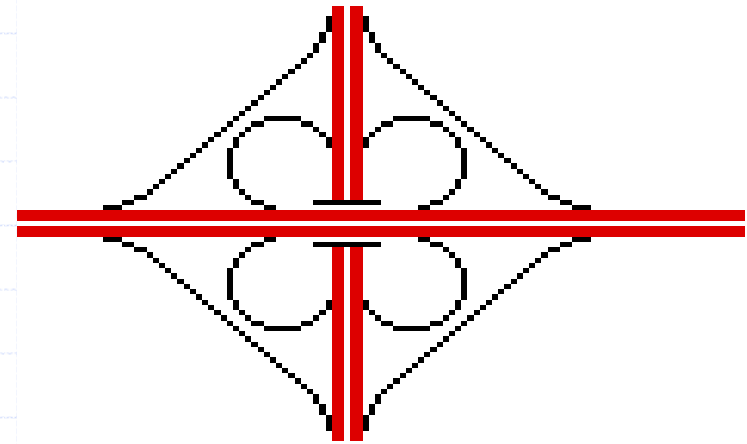
Interchanges: Introduction

Thru traffic on the freeway (red) can pass through without stopping. Even if traffic signals are installed at the ends of the ramps, traffic on the surface street (blue) also flows smoother without interference from the freeway.



The Full Cloverleaf Interchanges

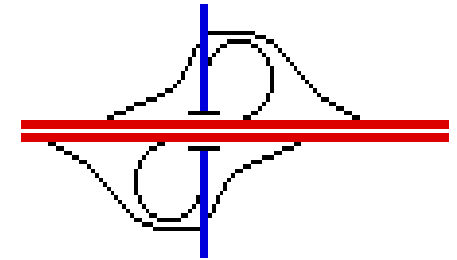
The classic cloverleaf allows "non-stop" full access between two busy roads. Traffic merges and weaves, but does not cross at-grade.



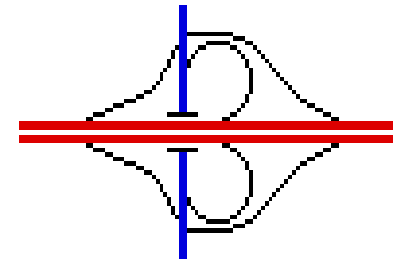
Full Cloverleaf.

Six-ramp partial cloverleaf interchanges

- The six-ramp partial cloverleaf allows traffic on the side street to flow more smoothly than a plain diamond.
- Each side of the street has an easy right turn to either direction on the freeway.



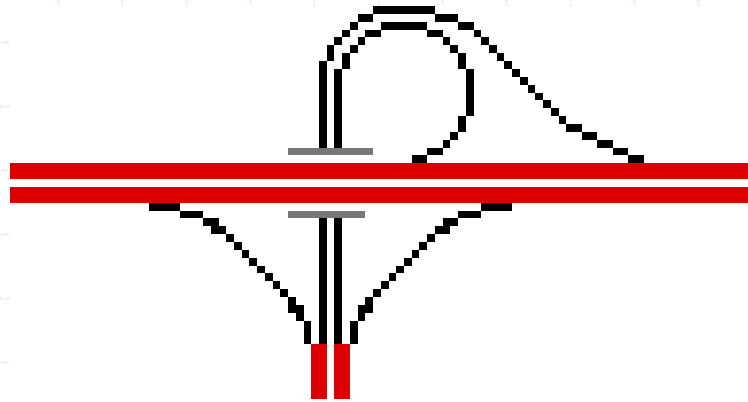
Six-ramp partial cloverleaf.



Variant favoring traffic to/from the left.

Trumpets, and other 3-way interchanges

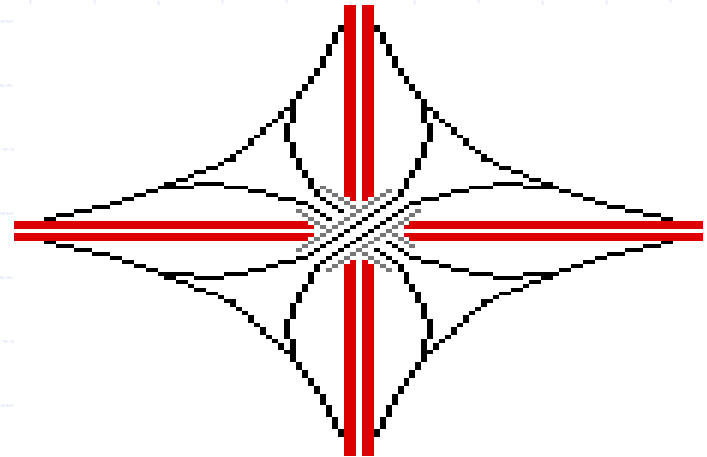
This is a conceptually simple way to end one freeway at another.



Trumpet.

Semi-Directional 4-way, or the Stack Interchanges

For two intersecting freeways. Each road has a direct connection to the other roadways, with no looping or weaving, and the ramps cross in a 4-level deck you can see for about a mile. If the ramps are two lanes wide, the interchange has quite high capacity.



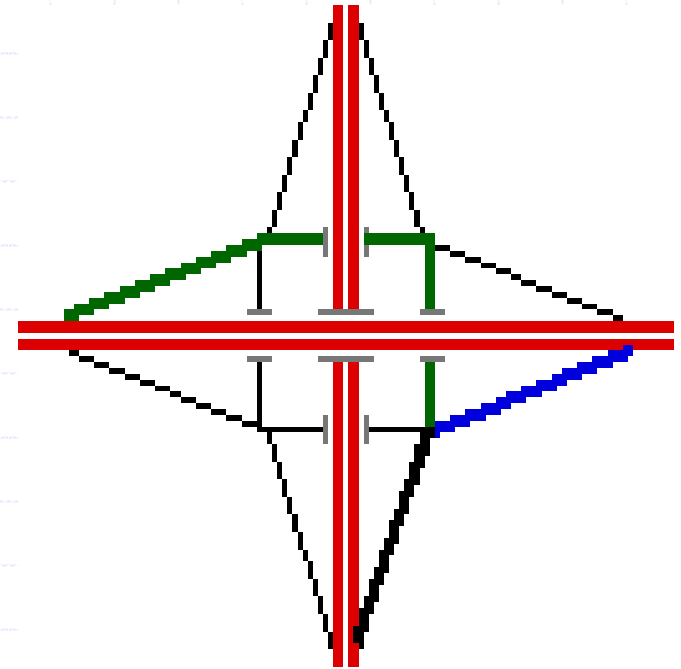
Four-level stack.

The Volleyball Interchanges

This interchange is better known as the 3-level diamond or split-level diamond.

All turning motions are handled in an intermediate square structure connecting the eight ramps.

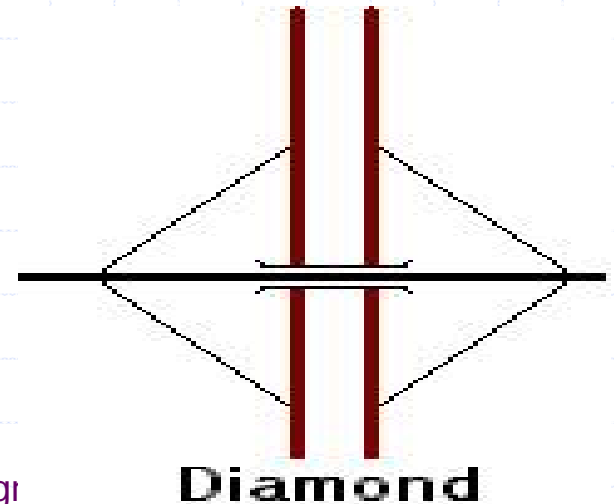
Turning traffic travels around the square in the same direction as a roundabout. Through traffic can proceed on either intersecting road without stopping.



Volleyball interchange.

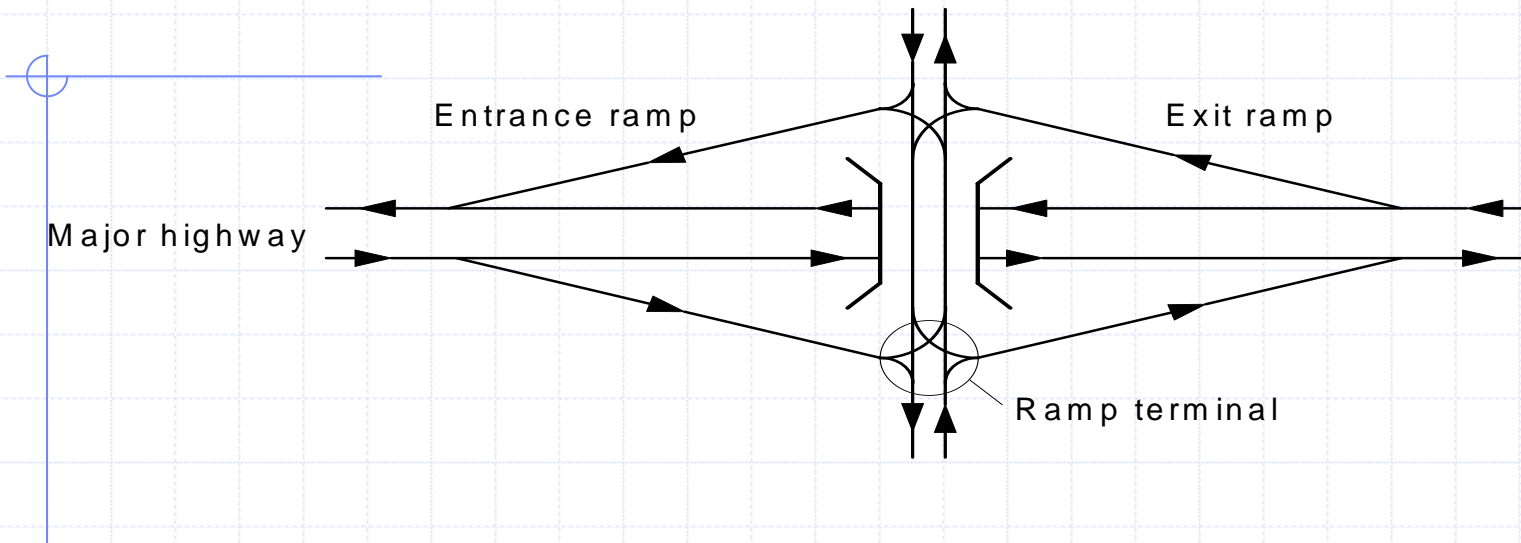
Diamond Interchange

- There are two intersections in the interchange.
- There are four ramps.
- In city environments, the four ramps may come together close enough to form one intersection. That's called a Single Point Urban Interchange (SPUI).

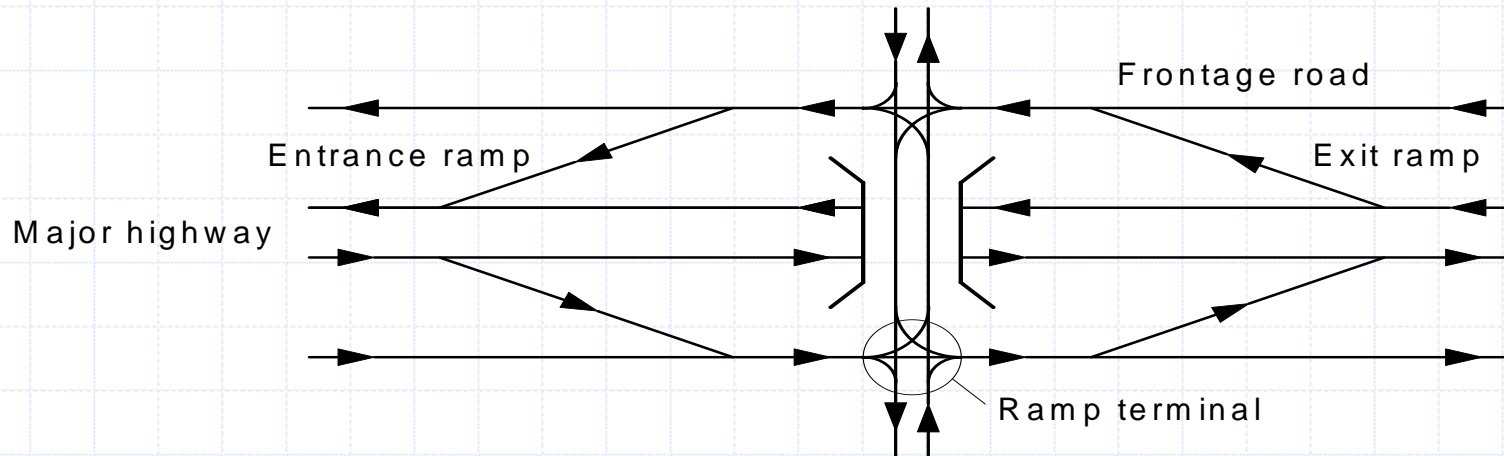


Diamond Interchange

Cross street



Cross street



Diamond Interchange: Characteristics

- The basic diamond “type” interchange is composed of four one-way diagonal ramps often aligned in a relatively narrow right-of-way.
- These two intersections can be either above the highway or below depending on elevation of the site.

Diamond Interchange: Characteristics

- The diamond interchange is the simplest and perhaps most common type of service interchange.
- Reasons of the use of diamond interchanges in urban areas:
 - The simplicity of design
 - minimum right-of-way requirements
 - Cost economy

Diamond Interchange Design Factors

- Exit ramp design should allow motorists to comfortably decrease their speed in order to egress from the freeway.
- Exit ramp location and length should also be sufficient to store vehicle queues without causing spillback conditions onto the freeway.

Diamond Interchange Design Factors

- Entrance ramp length should allow motorists a sufficient distance for increasing speed to match those on the freeway.
- Entrance ramp design must also consider queue spillback as a result of ramp metering

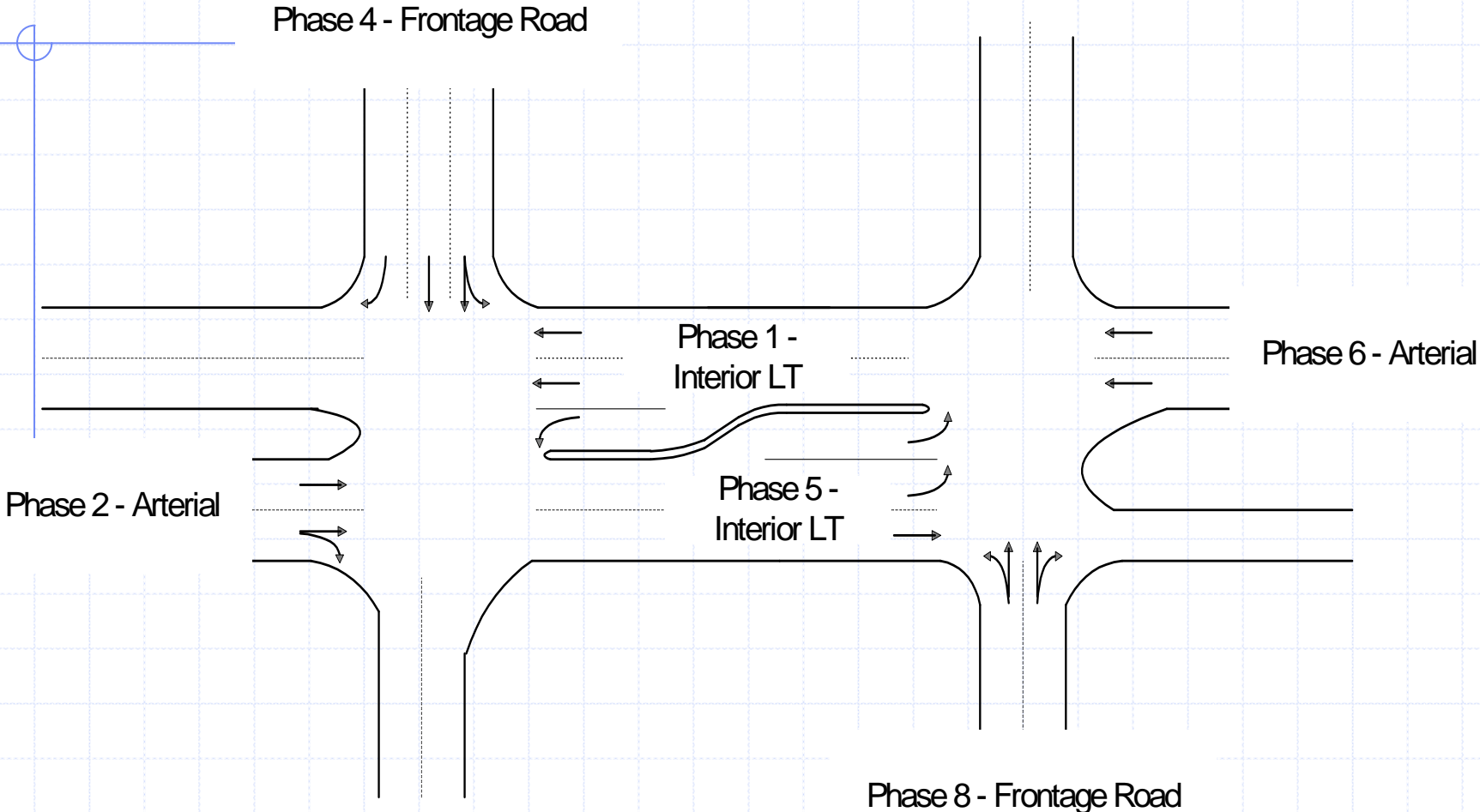
Diamond Interchange Design Factors

- The connection between the ramp and the cross street is critical and adequate turning radii must consider usage by heavy trucks and other turning traffic.
- Vertical alignment
- Sight distance
- Grades should not inhibit vehicle performance
- Ramp design and intersection spacing

Diamond Interchange Congestion Problems

- Interchange signal queues blocking merge areas of exit ramps and the frontage road.
- Interchange signal queues backing onto the freeway main lanes (Exit ramp).
- Ramp metering queues backing into the cross-street intersection.

Diamond Interchange Phasing Sketch



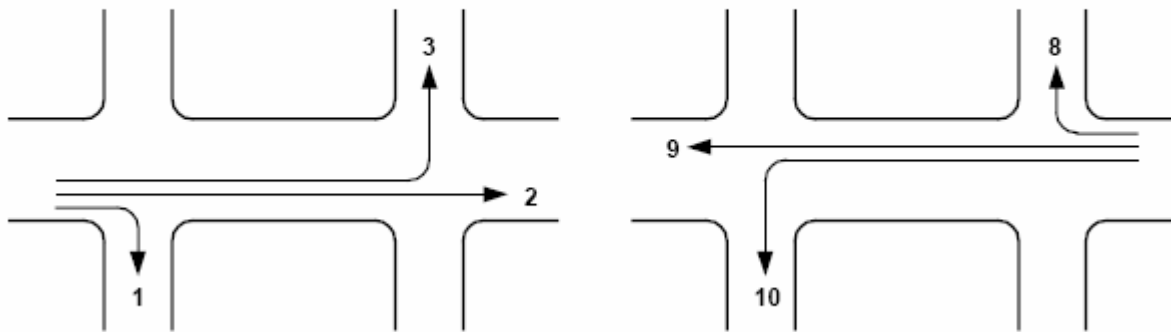
Diamond Interchange Phase Design

- The primary operational difference between diamond interchanges and “standard” intersections is that the paths of the opposing left turns interlock, so that they can not be served simultaneously.
- The phases that would normally conflict at a standard intersection, are compatible at an interchange.

Diamond Interchange Phase Design

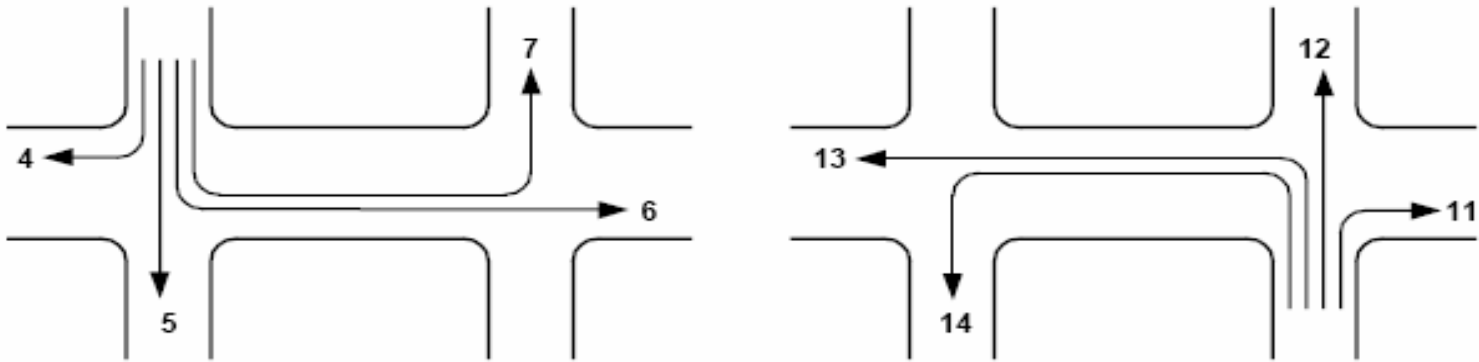
- An overlap is defined as a combination of movements that a single phase can run concurrently.
- Diamond interchange movements (18) analysis.

Cross Street Movements

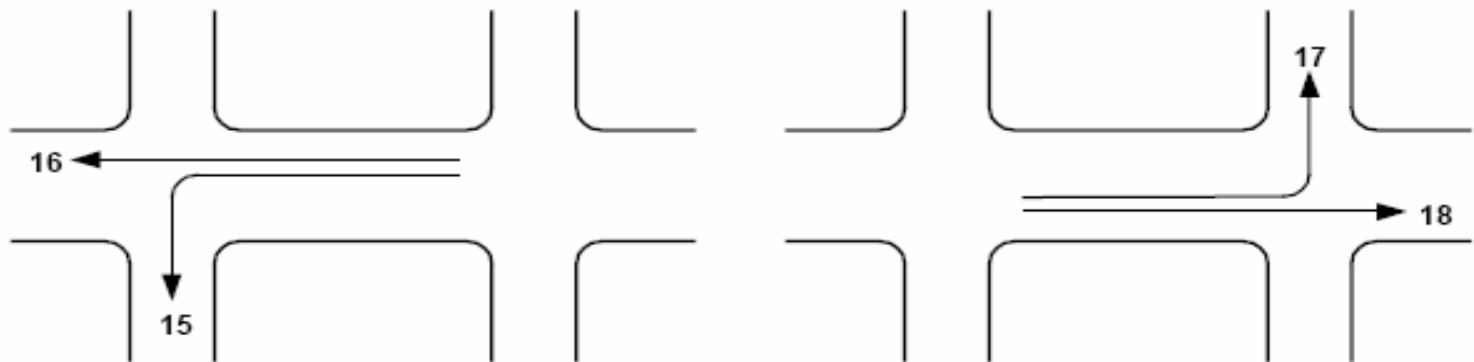


Diamond Interchange Phase Design

Frontage Road Movements



Interior Movements



Two-phase Control

- The most basic type of diamond interchange phasing is two-phase control.
- Two-phase control treats the intersections at the diamond as two intersections each having two basic phases.
- The phases are the arterial or cross-street phase and the ramp or frontage road phase.

Two-phase Control

- In two-phase control the left-turn phases $\phi 1$ and $\phi 5$ are not provided separate phases and are operated as permitted left turns.
- This type of control is used only for diamond interchanges operating under low volumes and where sight distance allows a permitted movement.

Two-phase Control

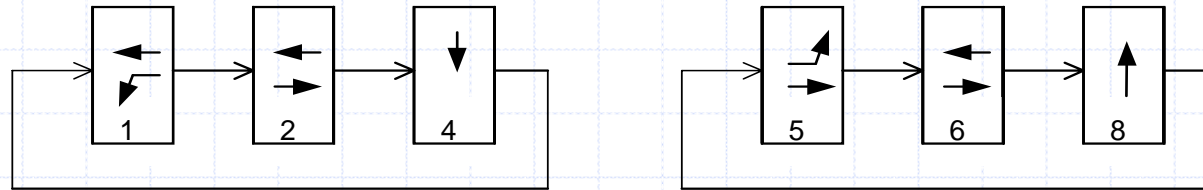
- Two-phase control reduces delay because there are fewer phases, and correspondingly lower lost time and cycle lengths.
- Two-phase control is beneficial when the left-turn and/or opposing through traffic volumes are light and left-turn movements are free to proceed during a longer duration than what otherwise would be provided.

Fixed-time Three-phase Control

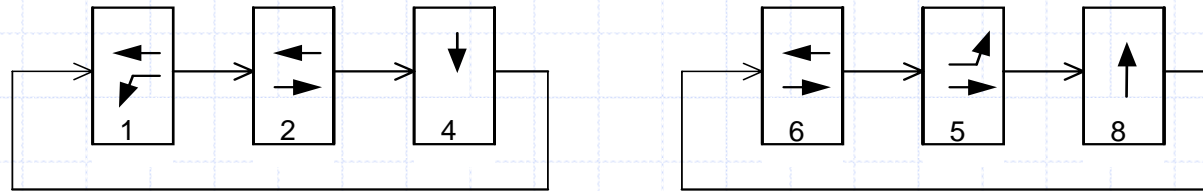
- Traditional three-phase control treats the diamond interchange as two intersections
- Each intersection having three basic movements to service.
- There are four different phase orders
 - Lead-Lead
 - Lead-Lag
 - Lag-Lead
 - Lag-Lag

Fixed-time Three-phase Control

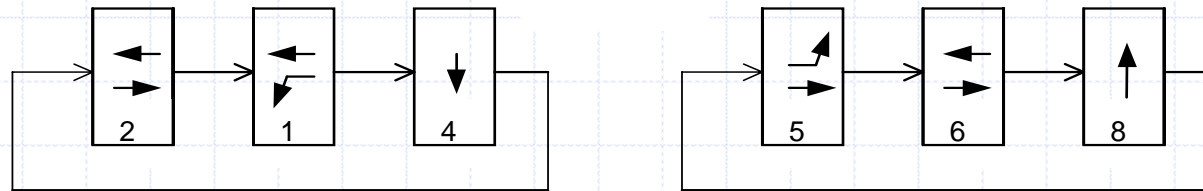
LEAD-LEAD



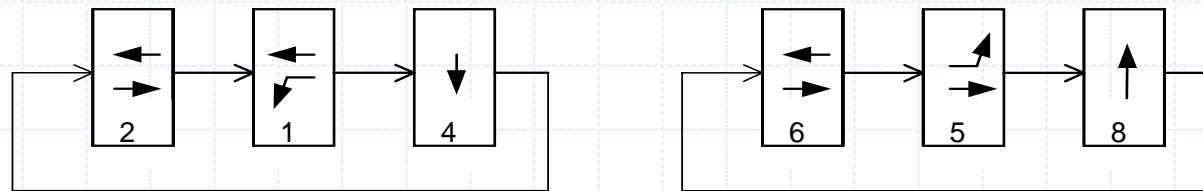
LEAD-LAG



LAG-LEAD



LAG-LAG



Fixed-time Three-phase Control

- The three phases at one of the intersections can be arranged two different ways. Interior left turns can either lead or lag the arterial street movements.
- The decision to lead or lag the left-turn movements depends largely on the intensity of the turning movements at the interchange and which approach is more critical.

Actuated Three-phase Phase Control

- The structures of three-phase actuated strategies are created through the use of barriers.
- There are three levels of flexibility that can be implemented:
 - basic
 - extended
 - flexible three-phase strategies