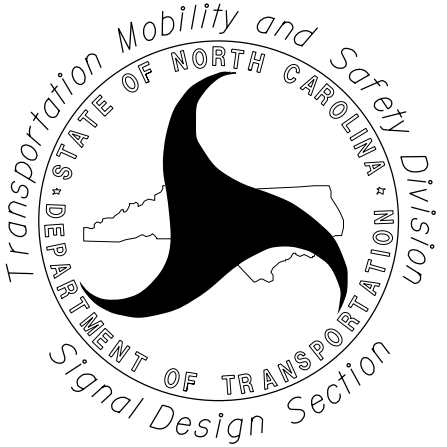
Design Manual

Signal Design Section



Part 1

Summary of Changes to the Signal Design Section Design Manual (July 2021)

General Changes

- Signals & Geometrics is now Signal Design Section
- Removed All Metric Measurement References
- Standards based on 2009 Manual on Uniform Traffic Control Devices (MUTCD) and incorporates Notice of Proposed Amendments (NPA) released in December 2020 if they are not in conflict with current MUTCD standards
- Most Sheets Reflect Update Date of 7-21
- Errata and Corrections Dated 12-21

Section 1: Controller and Software

- Removed References to 170 Software
- Updated to current local controller software being used: OASIS, ASC/3, SE-PAC, and Trafficware Apogee (formerly Naztec Apogee)
- Added list highlighting operational issues with various local controller software and where they are used

Section 2: Phasing

- Included Pedestrians in Phasing Orientation
- Added Additional Phasing Orientation for new Style Intersections including DDI and CFI
- Updated Phasing Diagrams for Backup Protect and Flashing Yellow Arrows
- Removed Dallas Phasing
- Added Alternate (TOD/Time of Day) Phasing Info

Section 3: Signal Heads

- Clarification on use of Flashing YELLOW ARROW and 5-Section *Doghouse* heads for both right and left turns
- Clarification on use of Right RED ARROW display
- Added Straight Through GREEN ARROW, U-Turn, and Bi-Modal signal displays
- Added Guidance for Protected/Permissive Dual Left Turns
- Modified some standard signal displays
    - Preferred Practice to use Flashing YELLOW ARROW displays
    - Use of ARROW displays for intersection approaches with no through movements

Section 4: Loops and Detection

- Added High Speed Loop Placement Guidance for 35, 60, and 65 MPH approaches
- Guidance for Microwave and Video Detection

Section 5: Signal Plan Elements

- Updated Drawing Notes
- Removed Timing and Loop Charts for 170 software and Added Timing and Loops Charts for ASC/3 software
- Added Clearance Diagram for Superstreets and U-Turns
- Updated Clearance Time info for use with Flashing YELLOW ARROW left turn displays
- Updated Common Plan Symbols Legend
- Add Info for Naming and Numbering Plan Sheets and CADD Files
- Updated Signal Face ID Details
- Updated Misc. Format Items
  - Added NCBELS Block
  - NCDOT Approval Block
  - Plan Revision vs. Supersede

Section 6: Pedestrian Signal Heads and Crossings

- Added Pushbutton Guidance and Median Pushbuttons
- Added Leading Pedestrian Intervals (LPIs)
- Single Stage vs. 2-Stage and Multi-Stage Crossings
- Added Accessible Pedestrian Signal Heads

Section 7: Beacons

- Renamed from Flashers to Beacons
- Expanded Head Arrangement for Single Lane Intersection Beacon
- Clarified Distance for Loop Placement and Advance Signs for Actuated Beacons
- Added Loop Placement Guidance for 35, 60, and 65 MPH approaches
- Added Pedestrian Hybrid Beacon and Emergency Hybrid Beacon

Section 8: Signs

- Updated Signs used on Signal Plans

Section 9: Pavement Markings

- Added Crosswalk and Stop Line guidance for:
  - Superstreets
  - Diverging Diamond Interchanges (DDIs)
  - Intersections with Medians and/or Islands

Section 10: (Wood and Metal) Signal Poles

- Updated Metal Pole Loading Schedules
- Added info for Metal Pole Numbering and Labeling on Plan Sheets
  - New and Reused Poles
  - Standard Case Strain Poles

Section 11: Traffic Counts

- Updated Years Shown in Traffic Counts
- Added Sheet for Cross Product Determination

Section 12: Bus Transit Signals

- Removed *Geometric Turn Lane Details*
- Created new section with Guidance for Bus Rapid Transit Signals

Section 13: Preemption

- Updated Preemption Charts to Include Exit Phase and Update Terms
- Removed 170 Software Charts
- Added Charts for SE-PAC, ASC/3, and Trafficware Apogee software
- Updated Ped Clear Before Preempt Time for Emergency Vehicle Preemption (EVP)
- Updated Preemption Signal Heads and Displays, Including Flashing YELLOW ARROW
- Added Info for Pre-Signal and Queue Cutter
- Added Discussion of Simultaneous vs. Advance Preemption and Differences in Timing

Section 14: Closed Loop Signal Systems

- Removed Section; May be replaced by a new section in a Future Revision

Summary of Changes to the Signal Design Section Design Manual (February 2023)

Section 1: Controller and Software

- Added MAXTIME Software

Section 2: Phasing

- Errata and Corrections Dated 2-23

Section 3: Signal Heads

- Updated Signal Head Displays for Approaches with No Through Movement

Section 5: Signal Plan Elements

- Updated Notes
- Added Loop Chart for MAXTIME Software
- Added Timing Charts for MAXTIME Software and LPIs

Section 6: Pedestrian Signal Heads and Crossings

- Updated use and timing for Leading Pedestrian Intervals (LPI)

Section 7: Beacons

- Clarified LPIs are normally not used with Pedestrian Hybrid Beacons (HAWK)
- Updated Pedestrian Hybrid Beacon (HAWK) for newer/currrent version of SE-PAC software
- Updated Emergency Vehicle Hybrid Beacon (HAWK) for newer/current version of SE-PAC software

Table of Contents

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.

MAXTIME	OASIS	ASC/3	SE–PAC	Trafficware Apogee
Added Initial [VD-Loop Chart]	N/A	Use Added Initial [VD-Loop Chart]	N/A	Added Init. [VD-Loop Chart]
Added Initial [VD-Timing Chart]	Sec per Actuation [VD-Timing Chart]	Seconds/Actuation [VD-Timing Chart]	Added Initial [VD-Timing Chart]	Added Initial [VD-Timing Chart]
Advance Walk [LPI]	Advanced Walk [LPI]	Delay Green [LPI]	Advance Walk [LPI]	Green/Ped Delay [LPI]
Backup Prevent [Red Revert]	Backup Protect [Red Revert]	Backup Prevent [Red Revert]	N/A	Backup Protect [Red Revert]
Delay	Delay	Delay	Delay	Delay
Delay During Green	Full Time Delay	Green Delay (Type G Detector)	N/A	N/A
Dual Entry	Dual Entry	Dual Entry	Dual Entry	Dual Entry
Dynamic Max	Dynamic Max	Dynamic Max	Dynamic Max	Dynamic Max
Extend	Stretch	Extend	Extend (Stretch)	Extend
Max 1	Maximum Green	Maximum 1	Maximum 1	Maximum 1
Max Recall	Max Recall	Max Recall	Max Recall	Max Recall
Maximum Initial [VD]	Max Variable Initial [VD]	Maximum Initial [VD]	Maximum Initial [VD]	Maximum Initial [VD]
Minimum Gap [VD]	Minimum Gap [VD]	Minimum Gap [VD]	Minimum Gap [VD]	Minimum Gap [VD]
Minimum Initial	Min Green	Minimum Initial	Min Green	Min Green
Min Recall	Min Recall	Vehicle Recall	Min Recall	Min Recall
Non Lock Detector	Vehicle Call Memory	Locking Detector	Vehicle Call Memory	Lock Calls
Passage	Extension	Vehicle Extension	Passage Gap	Gap, Extension
Ped Clear	Don't Walk	Ped Clear	Pedestrian Clear	Pedestrian Clear
Ped Recall	Ped Recall	Ped Recall	Ped Recall	Ped Recall
Phase Omit	Phase Omit	Phase Omit	Phase Omit	Phase Omit
Red Clear	Red Clearance	Red Clear	Red Clear	Red Clear
Red Rest	Red Rest	Red Rest	N/A	Red Rest
Soft Recall	Soft Recall	Soft Recall	Soft Recall	Soft Recall
Switch	Switch	Cross Switch	Switch	Switch (Phase)
Time Before Reduction [VD]	Time Before Reduction [VD]	Time Before Reduction [VD]	Time Before Reduction [VD]	Time Before Reduction [VD]
Time to Reduce [VD]	Time to Reduce [VD]	Time to Reduce [VD]	Time to Reduce [VD]	Time to Reduce [VD]
Yellow Change	Yellow Clearance	Yellow Change Interval	Yellow Change	Yellow Clear

Controller and Software

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.
1.0

MAXTIME (by QFree)

- Standard NCDOT Signal Software
- Used on Isolated intersections and a majority of state operated signal systems
- Use only with 2070LX Controller

OASIS Software

- Designed exclusively for NCDOT
- Used in Asheville, Chapel Hill-Carrboro, Concord, Gastonia, Goldsboro, Jacksonville, Kinston, Rocky Mount, Salisbury, Winston-Salem, and Wilmington Signal Systems in 170 cabinets
- Not compatible with 2070LX Controller; Use 2070E Controller

ASC/3

- Used in Burllngton-Graham, Durham, Elizabeth City, Fayetteville, Greenville, and High Point Signal Systems in 170 cabinets
- Used in Cary Signal System with NEMA TS-2 cabinet and equipment
- Use with 2070LX Controllers

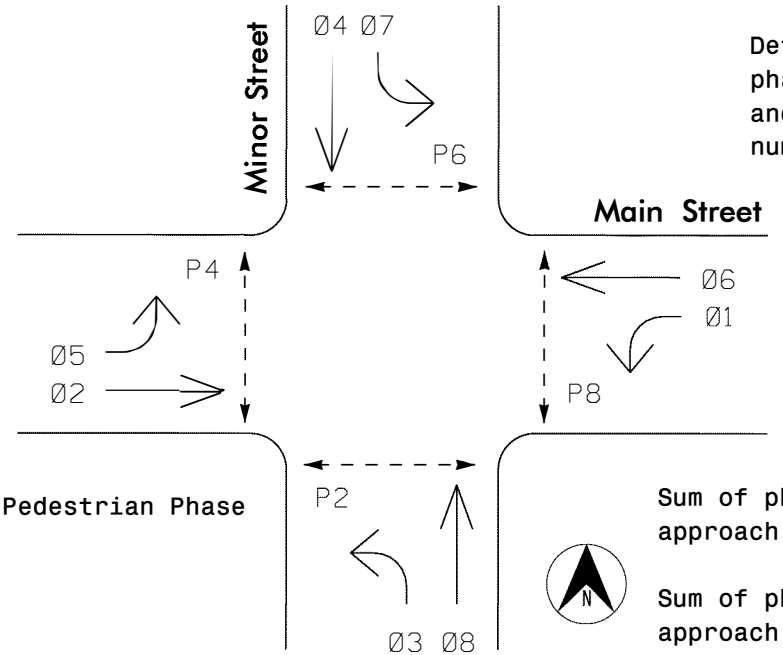
SE–PAC

- Used in Hickory and Raleigh Signal Systems in 170 cabinets
- No Full Time Delay Programming
- No Red Revert Programming
- No Red Rest Programming
- Cannot Modify Detector Inputs for Alternate (Time of Day) Phasing

Trafficware Apogee (Formerly Naztec Apogee)

- Used in Greensboro Signal System in 170 cabinet
- No Full Time Delay Programming
- Cannot Modify Detector Inputs for Alternate (Time of Day) Phasing

Standard NEMA Orientation
Dual Ring Cabinet
Major Street Oriented East–West



P#= Pedestrian Phase

Phase Numbering

Phase 2 - Eastbound through movement
Phase 4 - Southbound through movement
Phase 6 - Westbound through movement
Phase 8 - Northbound through movement

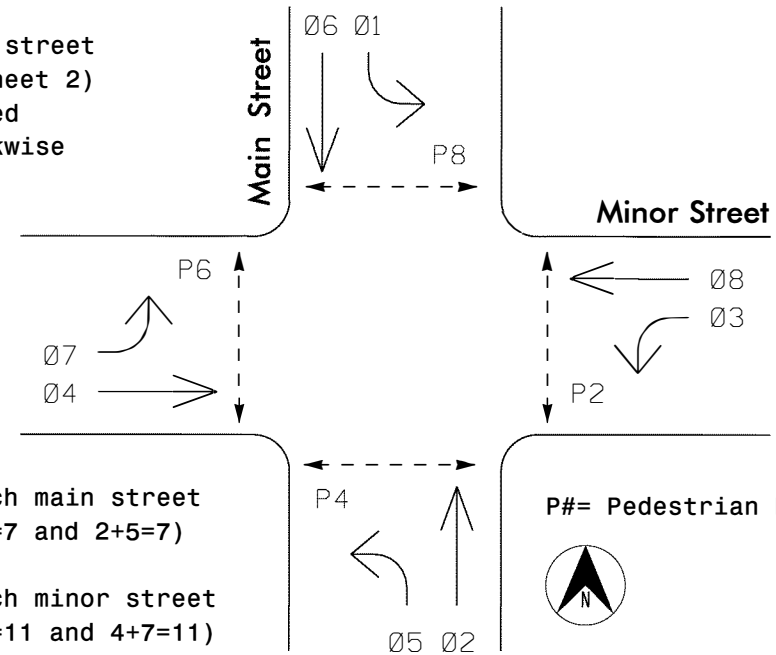
Pair turning movements with the through movements if an exclusive left turn phase (protected or protected/permissive) is not used.
If location is being added to an existing system, match phase numbering to the system.

Determine main street phase 2 (see sheet 2) and then proceed numbering clockwise

Sum of phases for each main street approach is 7. (1+6=7 and 2+5=7)

Sum of phases for each minor street approach is 11. (3+8=11 and 4+7=11)

Standard NEMA Orientation
Dual Ring Cabinet
Major Street Oriented North–South



P#= Pedestrian Phase

Phase Numbering

Phase 2 - Northbound through movement
Phase 4 - Eastbound through movement
Phase 6 - Southbound through movement
Phase 8 - Westbound through movement

Pair turning movements with the through movements if an exclusive left turn phase (protected or protected/permissive) is not used.
If location is being added to an existing system, match phase numbering to the system.

Numbering of NEMA Phases

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TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

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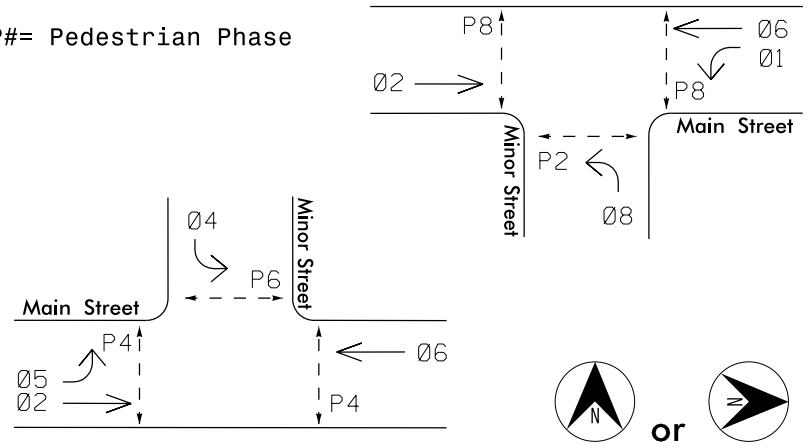
SHEET 1 OF 8

Determining Movement Phase Numbers
Tee Intersections

P#= Pedestrian Phase

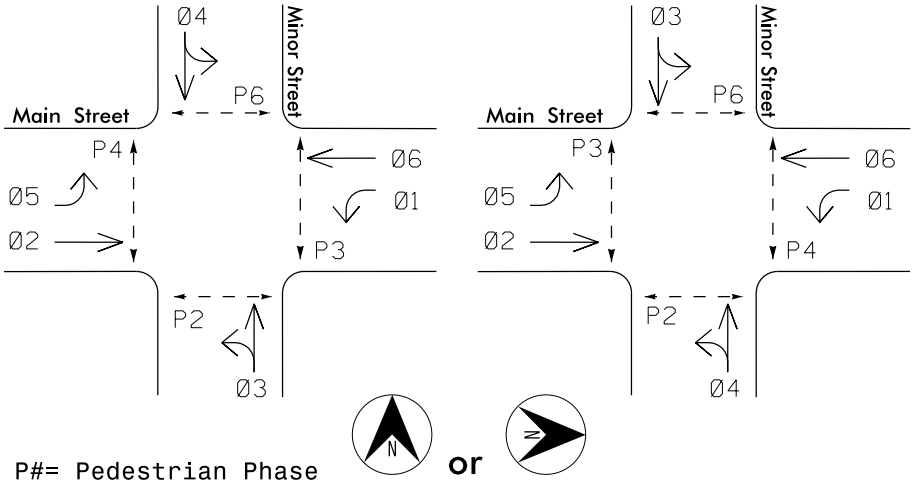


Phase Numbering

Movement numbering will conform to standard NEMA phasing shown on Sheet 1.
Phase 2 - Eastbound or Northbound through movement
Phase 4 - Southbound or Eastbound Stem of Tee movement
Phase 6 - Westbound or Southbound through movement
Phase 8 - Northbound or Westbound Stem of Tee movement

Pedestrian phases normally operate and are named with the adjacent parallel through movement.

Determining Movement Phase Numbers
Split Side Streets



P#= Pedestrian Phase

Phase Numbering

Main street movement numbering will conform to standard NEMA phasing shown on Sheet 1.
For side street movement numbering:
- If one approach is desired to be serviced first, label it phase 3 and the other approach phase 4.
- If there is no desire for either approach to be serviced first, label phase 4 for the eastbound or southbound movement and phase 3 for the westbound or northbound movement.

Pedestrian phases normally operate and are named with the adjacent parallel through movement.

Numbering of NEMA Phases

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TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

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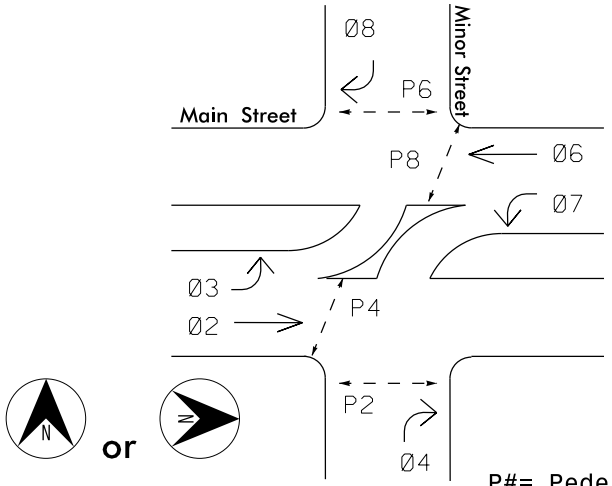
Determining Superstreet Phase Numbers
Cross Intersections w/"Leftovers"



P#= Pedestrian Phase

Phase Numbering

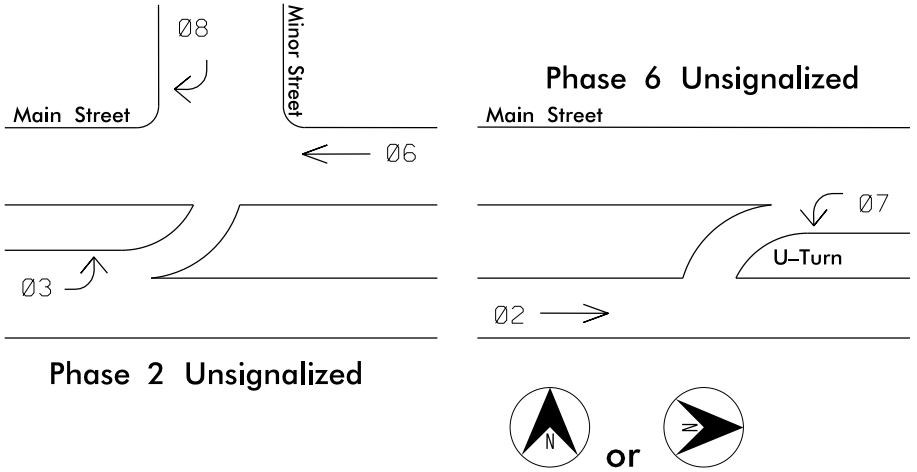
This convention may be required for use with some types of signal equipment and software

Main street through movement numbering will conform to standard NEMA phasing shown on Sheet 1.

For left turn and side street movement numbering:
- Phase should be an odd number on the opposite side of NEMA barrier (3 or 7).
- Sum of main street phases used at a superstreet signal should total 9 (2+7=9 or 3+6=9).
- Program phases 3+8 and/or 4+7 for Dual Entry.
- At a cross intersection, each "pair" of movements may be operated by separate controllers and cabinets to facilitate system coordination.

U-Turns may be permitted or prohibited as part of the left turn move and may vary by intersection.

Determining Superstreet Phase Numbers
U–Turn Only and Tee Intersections



Phase Numbering

Main street through movement numbering will conform to standard NEMA phasing shown on Sheet 1.

No signal heads needed for through movement adjacent to left turn movement if there is no signalized conflicting movement.

For left turn movement numbering:
- Phase should be an odd number on the opposite side of NEMA barrier (3 or 7).
- Sum of main street phases used at a superstreet signal should total 9 (2+7=9 or 3+6=9).
- Program phases 3+8 and/or 4+7 for Dual Entry.

Numbering of NEMA Phases

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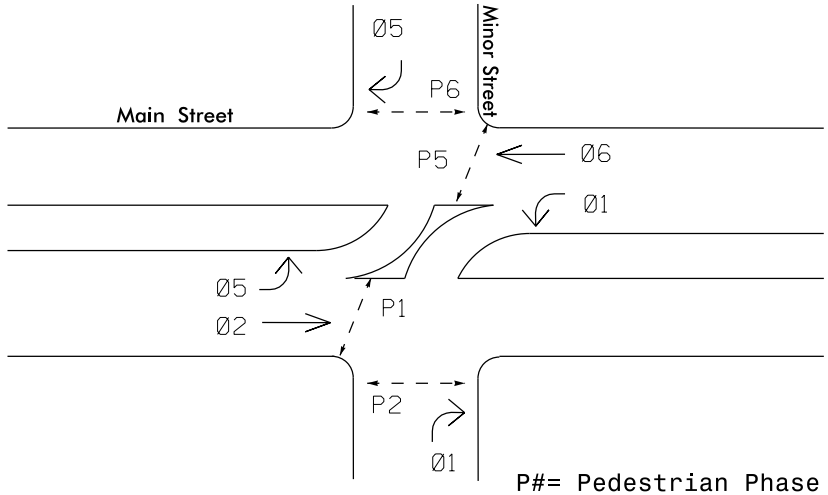
Superstreet Phase Numbering Using One Cabinet

Cross Intersections w/"Leftovers"

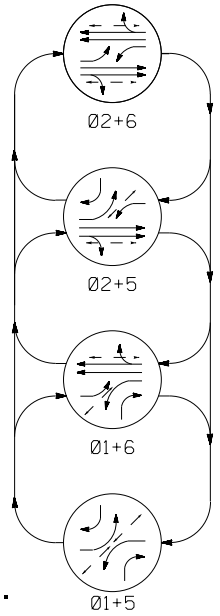
Some types of signal equipment and software will allow for both sides of a leftover at a superstreet with a cross intersection to operate and control the entire intersection with one controller and cabinet. The phasing does not need to cross the barrier or require special programming to maintain coordination. Any adjacent u-turn signals, if present, will need to operate on an independent cabinet and controller from the main crossover and be phased as shown on the previous sheet. When equipment allows and it is desirable to control both leftovers with one cabinet and controller, the phasing shown below may be used.

U-Turn Signal on separate cabinet



P#= Pedestrian Phase

PHASING DIAGRAM



Phase Numbering

This convention may be used with some types of signal equipment and software.

Main street through movement numbering will conform to standard NEMA phasing shown on Sheet 1.

For left turn and side street movement numbering:

- Right turns are not required to be signalized. They can be STOP, YIELD, or free flow if design allows.
- Left turn and right turn overlap (if signalized) should be numbered the same phase. Phase should be an odd number that corresponds to traditional NEMA through phase (1 with 6) or (5 with 2).
- Operational phasing pairs are 2+6, 1+6, 2+5, and 1+5. Do not program phases for Dual Entry.

U-Turns may be permitted or prohibited as part of the left turn move and may vary by intersection.

Determining Movement Phase Numbers
Reverse RCI – No Side Street Through Movements

Phase Numbering

Movement numbering will conform to standard NEMA phasing shown on Sheet 1 and as shown below:

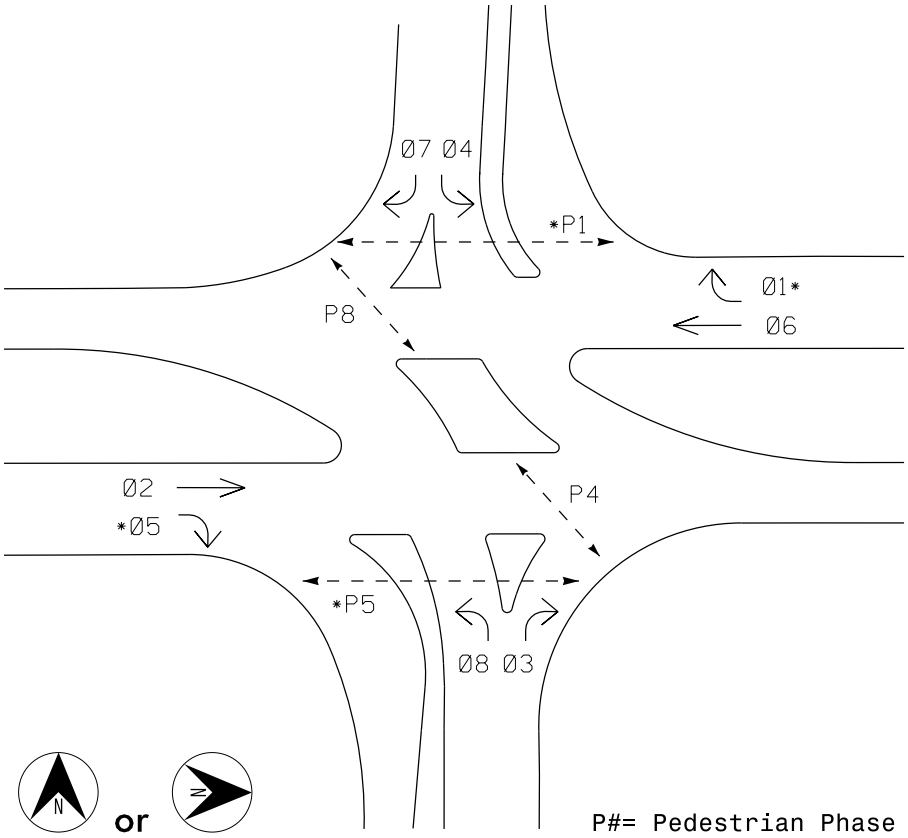
Phase 2 - Eastbound or Northbound Through Movement
Phase 6 - Westbound or Southbound Through Movement

Phase 3 - Westbound or Northbound Right Turn
Phase 4 - Eastbound or Southbound Left Turn
Phase 7 - Eastbound or Southbound Right Turn
Phase 8 - Westbound or Northbound Left Turn

- Movements shown by Phases 1 and 5 may be unsignalized free flow if no pedestrian crosswalk is marked.
- If left turns are allowed off of main street, they should be phases 1 and 5 and the corresponding right turns shall operate with corresponding through phase.
- Do Not program any phase for Dual Entry.

Pedestrian movements:
- Pedestrian phases 4 and 8 should be designed as a 2 stage crossing.
- Pedestrian crossings across right turns (phase 1 and/or 5) could be unsignalized if those vehicle movements are operated as Yield or Free Flow movements.

* Phases 1 and 5 provide for a protected (exclusive) pedestrian crossing with no vehicle conflicts. These could also operate with permissive phase 2 and 6 right turn conflicts if desired. As noted above, phases 1 and 5 may also be used for main street left turn phases if needed.



Numbering of NEMA Phases

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

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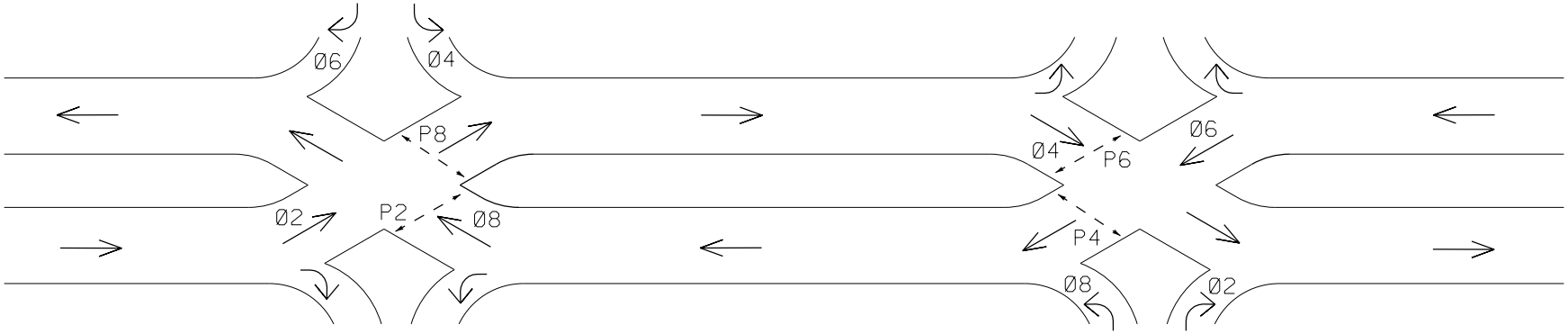
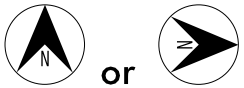
Determining Movement Phase Numbers
Diverging Diamond Intersections





P#= Pedestrian Phase

Phase Numbering

Movement numbering will conform to standard NEMA phasing shown on Sheet 1 and as shown below:

Phase 2 - Eastbound or Northbound Entrance Crossover
Phase 4 - Eastbound or Northbound Exit Crossover
Phase 6 - Westbound or Southbound Entrance Crossover
Phase 8 - Westbound or Southbound Exit Crossover

- Sum of phases used at a DDI crossover signal should total 10 (2+8=10 or 4+6=10).
- Each "pair" of crossover movements may be operated by separate controllers and cabinets to facilitate system coordination.
- All signal heads should be programmed for Red Flash.
- All Phases should be programmed for Red Rest.
- Program phases 2+6 and/or 4+8 for Dual Entry as needed.

Ramp movements:

- Turning movements onto ramps are usually unsignalized.
- Movements from ramps may be signalized, free flow, or a STOP or YIELD condition based on individual design.
- If movements off ramps are signalized, number phases as shown.
- A Timed Overlap (TOL) or dummy phase may be necessary between normal phases to allow extra clearance time if distances between crossover and ramps are excessive.

Pedestrian phases normally operate and are named with the adjacent parallel through movement.

Determining Movement Phase Numbers
Continuous Flow Intersections (CFI)

Phase Numbering

Movement numbering will conform to standard NEMA phasing shown on Sheet 1 and as shown below:

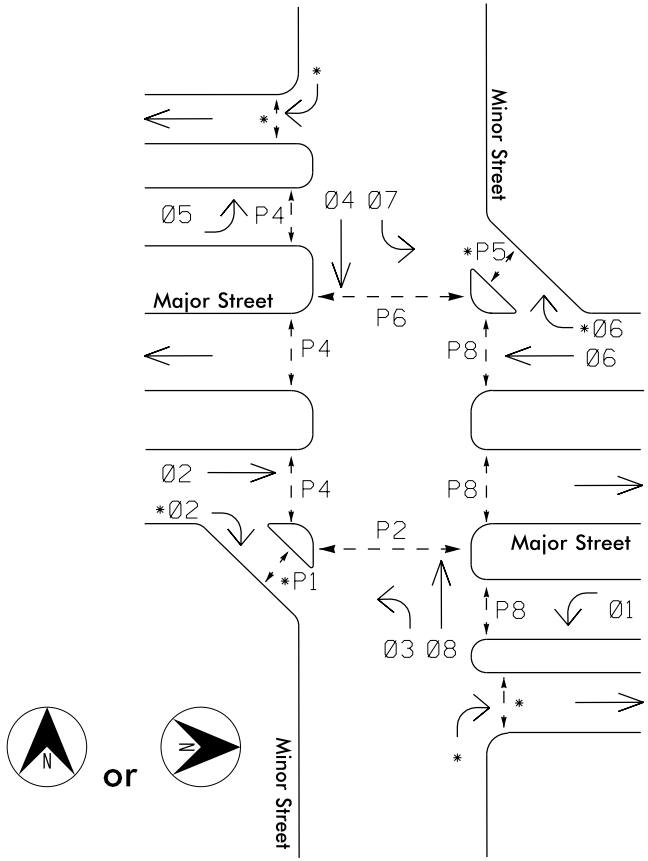
Phase 1 - Major Street WB or SB Left Turn
Phase 2 - Major Street EB or NB Through and Right Turn
Phase 3 - Minor Street WB or NB Left Turn
Phase 4 - Minor Street EB or SB Through Movement
Phase 5 - Major Street EB or NB Left Turn
Phase 6 - Major Street WB or SB Through and Right Turn
Phase 7 - Minor Street EB or SB Left Turn
Phase 8 - Minor Street WB or NB Through Movement

Phases 2 and 6 Through Movements shall operate as concurrent overlaps during phase 1 and/or phase 5.

* Indicates may also be an unsignalized (Yield or Free Flow) movement

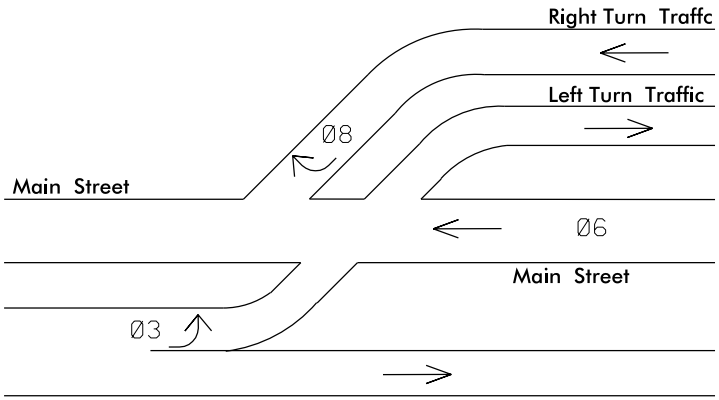
Pedestrian Movements

- Crossings on minor street right turns onto ramps for major street are usually unsignalized.
- Crossings of major street right turn bays may be signalized or a Yield condition based on individual intersection design.
- Pedestrian crossings for phase 4 and/or phase 8 may need to be multi-stage, but should be designed to provide as efficient a pedestrian crossing as possible.

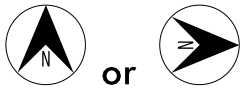


P#= Pedestrian Phase

Continuous Flow Intersections (CFI)
Crossover Before Intersection



Phase 2 Unsignalized



Phase Numbering

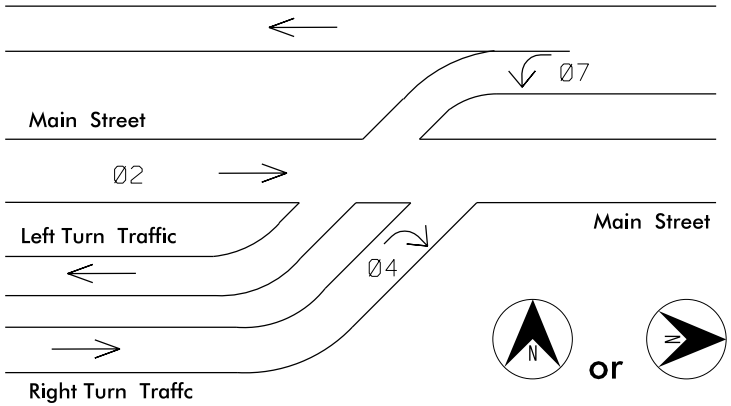
No signal heads needed for (EB/NB) through movement adjacent to left turn crossover movement.

For crossover movement numbering:
- Main street through movement numbering will conform to standard NEMA phasing shown on Sheet 1. SB/WB Through movement should be main phase 6.
- Left Turn Phase should be an odd number on the opposite side of NEMA barrier (3).
- Right Turn may be Yield or Free Flow based on roadway design. If signalized, it should be a side street through phase compatible with main street left turn phase (8).
- Program phases 3+8 for Dual Entry.

Each crossover may be operated by separate controllers and cabinets to facilitate coordination.

Continuous Flow Intersections (CFI)
Crossover Before Intersection

Phase 6 Unsignalized



Phase Numbering

No signal heads needed for (WB/SB) through movement adjacent to left turn crossover movement.

For crossover movement numbering:
- Main street through movement numbering will conform to standard NEMA phasing shown on Sheet 1. NB/EB Through movement should be main phase 2.
- Left Turn Phase should be an odd number on the opposite side of NEMA barrier (7).
- Right Turn may be Yield or Free Flow based on roadway design. If signalized, it should be a side street through phase compatible with main street left turn phase (4).
- Program phases 4+7 for Dual Entry.

Each crossover may be operated by separate controllers and cabinets to facilitate coordination.

Numbering of NEMA Phases

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

2–Phase
With or Without Flashing Yellow Arrow

PHASING DIAGRAM

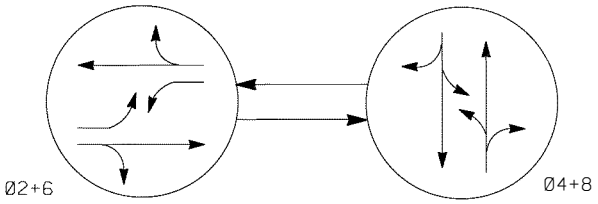


TABLE OF OPERATION			
SIGNAL FACE	PHASE Ø2+6	PHASE Ø4+8	FLASH

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

2–Phase
Tee Intersection
With or Without Flashing Yellow Arrow

PHASING DIAGRAM

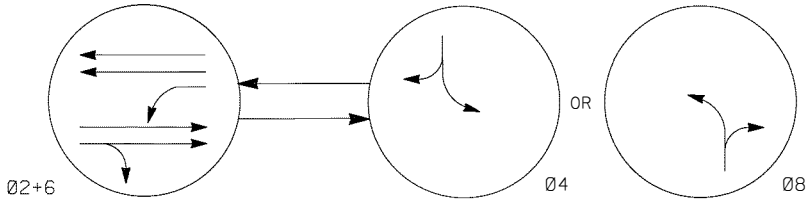


TABLE OF OPERATION			
SIGNAL FACE	PHASE Ø2+6	*	FLASH

* Ø4 or Ø8 (Minor Street)

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

Phasing Typicals: 2–Phase Operation

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TRANSPORTATION MOBILITY AND SAFETY DIVISION
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STD. NO.
2.1.1
SHEET 1 OF 1

3–Phase
Minimum Recall
Protected or Protected/Permissive
at Cross Intersection
Without Flashing Yellow Arrow

PHASING DIAGRAM

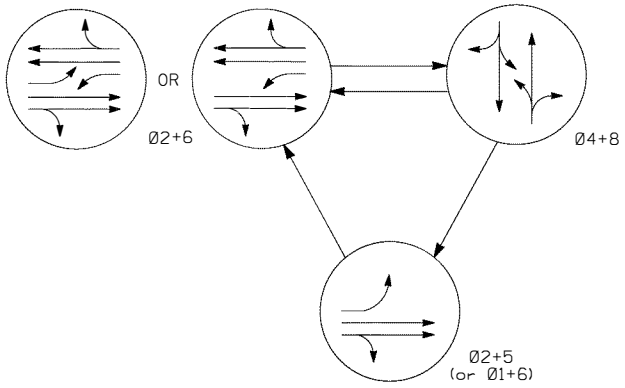


TABLE OF OPERATION				
SIGNAL FACE	PHASE *	Ø 2 + 6	Ø 4 + 8	FLASH

Use appropriate omit note(s)

* Ø2+5 or Ø1+6 (Major Street Lefts)

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

3–Phase
Minimum Recall
Protected or Protected/Permissive
at Cross Intersection
With Flashing Yellow Arrow
OR With Backup Protection

PHASING DIAGRAM

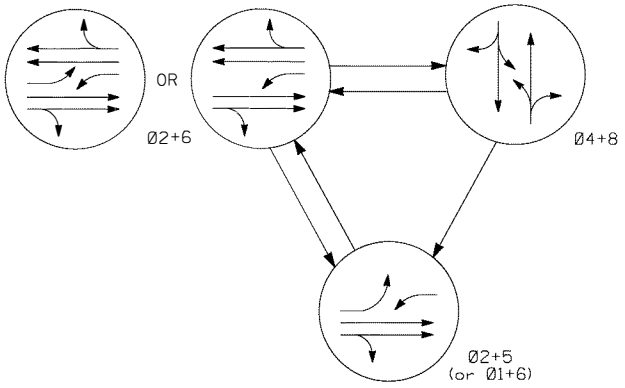


TABLE OF OPERATION				
SIGNAL FACE	PHASE *	Ø 2 + 6	Ø 4 + 8	FLASH

Use appropriate lead/lag note(s) OR Backup Protection (Red Revert) notes

* Ø2+5 or Ø1+6 (Major Street Lefts)

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

Phasing Typicals: 3–Phase Operation

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.
2.1.2
SHEET 1 OF 3

3–Phase
Minimum Recall
Split–Side Street
With or Without Flashing Yellow Arrow

PHASING DIAGRAM

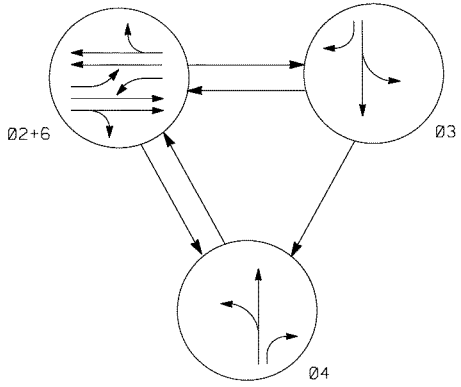


TABLE OF OPERATION				
SIGNAL FACE	PHASE			
	Ø2+6	Ø3	Ø4	FLASH

Use appropriate phase reversal note(s)

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

3–Phase
Soft Recall
Protected or Protected/Permissive at Intersection
With Flashing Yellow Arrow

PHASING DIAGRAM

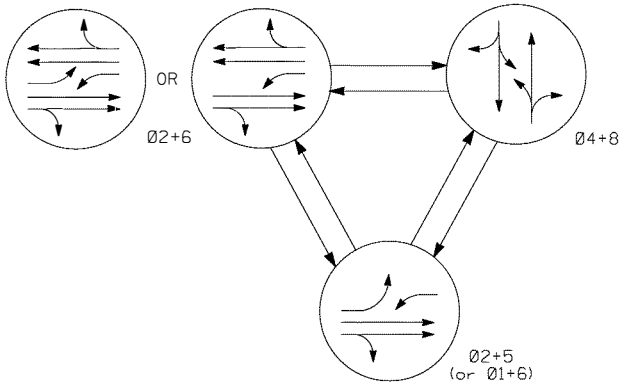


TABLE OF OPERATION					
SIGNAL FACE	PHASE				
	*	Ø2+6	Ø4+8	FLASH	

* Ø2+5 or Ø1+6 (Major Street Lefts)

Use appropriate lead/lag note(s)

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

Phasing Typicals: 3–Phase Operation

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.
2.1.2
SHEET 2 OF 3

3–Phase
Minimum Recall
Protected or Protected/Permissive
at Tee Intersection
With or Without Flashing Yellow Arrow

PHASING DIAGRAM

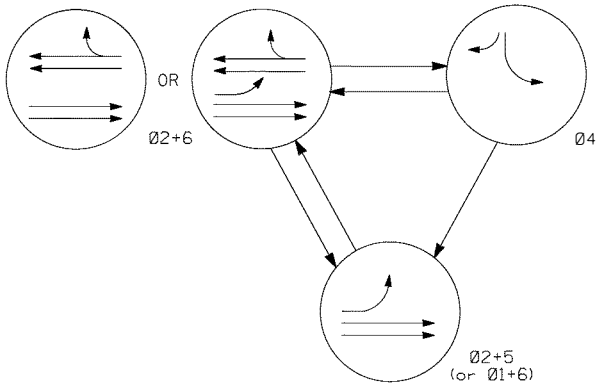


TABLE OF OPERATION				
SIGNAL FACE	PHASE *	PHASE Ø2+6	PHASE Ø4	PHASE FLASH

Use appropriate lead/lag note(s)

* Ø2+5 or Ø1+6 (Major Street Lefts)

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

3–Phase
Minimum Recall
Lagging Left Operation
Protected or Protected/Permissive
at Tee Intersection
With or Without Flashing Yellow Arrow

PHASING DIAGRAM

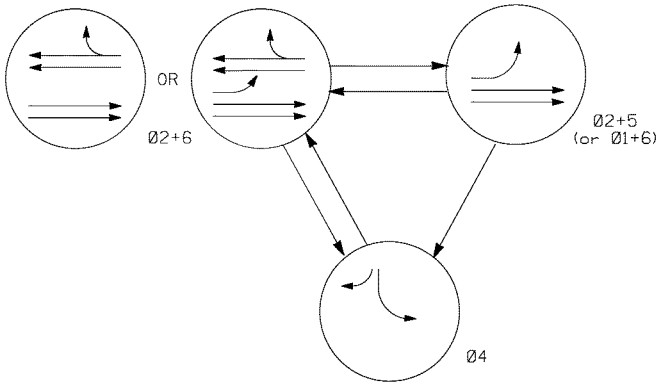


TABLE OF OPERATION				
SIGNAL FACE	PHASE Ø2+6	PHASE *	PHASE Ø4	PHASE FLASH

Use appropriate lead/lag note(s)

* Ø2+5 or Ø1+6 (Major Street Lefts)

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

Phasing Typicals: 3–Phase Operation

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.
2.1.2
SHEET 3 OF 3

4–Phase
Minimum Recall
Protected or Protected/Permissive Main Street
Split–Side Street
Without Flashing Yellow Arrows

PHASING DIAGRAM

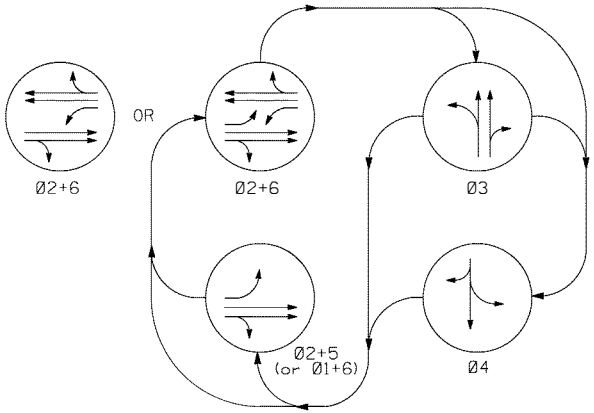


TABLE OF OPERATION					
SIGNAL FACE	PHASE *	Ø 2 + 6	Ø 3	Ø 4	FLASH

Use appropriate omit and phase reversal note(s)

* Ø2+5 or Ø1+6 (Major Street Lefts)

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

4–Phase
Minimum Recall
Protected or Protected/Permissive Main Street
Split–Side Street
With Flashing Yellow Arrows
OR With Backup Protection

PHASING DIAGRAM

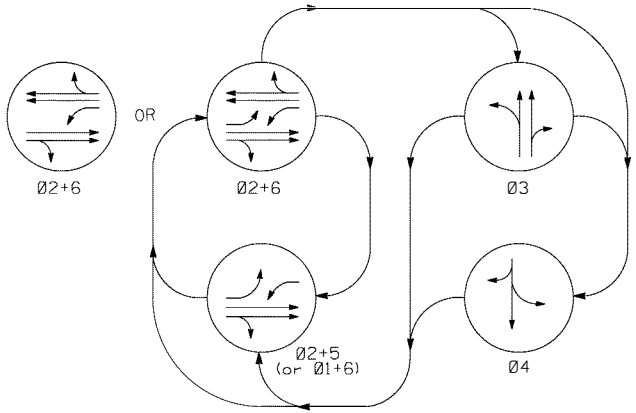


TABLE OF OPERATION					
SIGNAL FACE	PHASE *	Ø 2 + 6	Ø 3	Ø 4	FLASH

Use appropriate lead/lag OR Backup Protection (Red Revert) and phase reversal note(s)

* Ø2+5 or Ø1+6 (Major Street Lefts)

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

Phasing Typicals: 4–Phase Operation

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.
2.1.3
SHEET 1 OF 4

4–Phase
Minimum Recall
Protected or Protected/Permissive Main Street
Protected/Permissive Side Street
Without Flashing Yellow Arrows

PHASING DIAGRAM

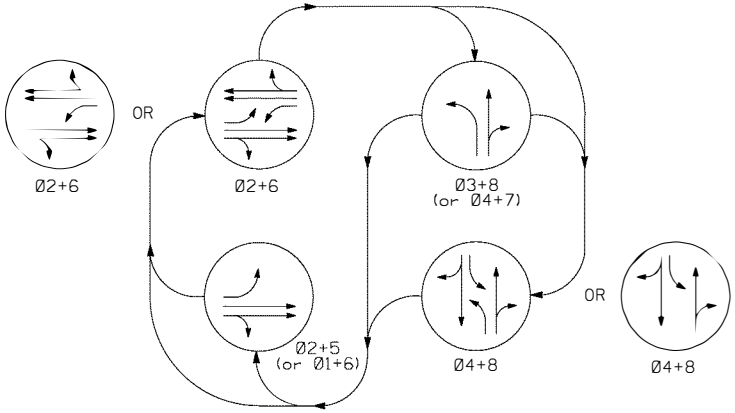


TABLE OF OPERATION					
SIGNAL FACE	PHASE *	Ø2+6	PHASE **	Ø4+8	FLASH

Use appropriate omit note(s)

* Ø2+5 or Ø1+6 (Major Street Lefts)
** Ø3+8 or Ø4+7 (Minor Street Lefts)

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

4–Phase
Minimum Recall
Protected or Protected/Permissive Main Street
Protected or Protected/Permissive Side Street
With Flashing Yellow Arrows
OR With Backup Protection

PHASING DIAGRAM

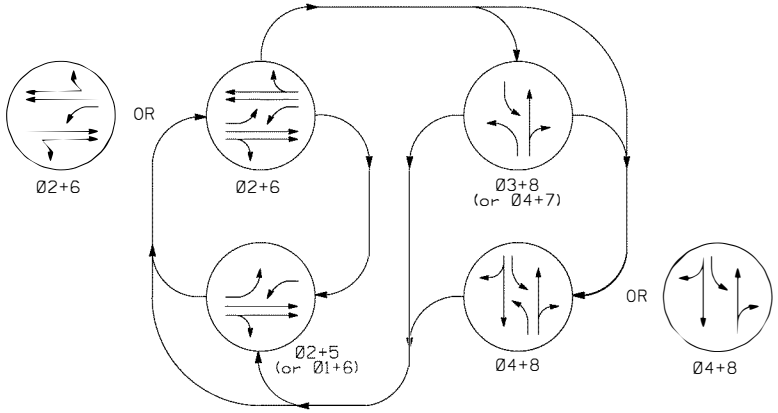


TABLE OF OPERATION					
SIGNAL FACE	PHASE *	Ø2+6	PHASE **	Ø4+8	FLASH

Use appropriate lead/lag OR Backup Protection (Red Revert) and phase omit note(s)

* Ø2+5 or Ø1+6 (Major Street Lefts)
** Ø3+8 or Ø4+7 (Minor Street Lefts)

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

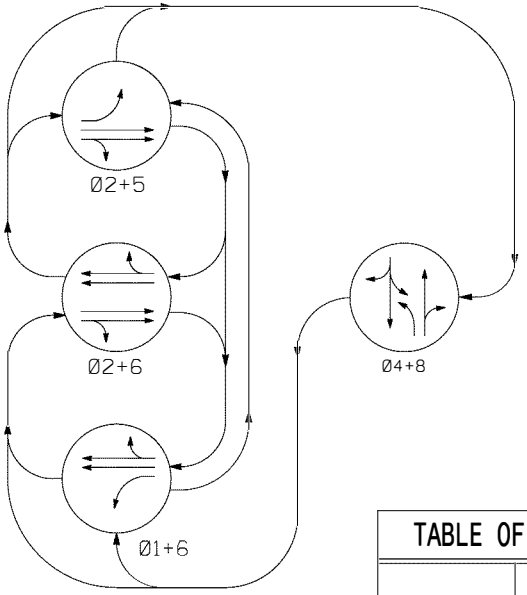
Phasing Typicals: 4–Phase Operation

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.
2.1.3
SHEET 2 OF 4

4–Phase
Minimum Recall
Lead–Lag Operation

PHASING DIAGRAM



Use appropriate lead/lag note(s)

TABLE OF OPERATION					
SIGNAL FACE	PHASE				
	Ø1+6	Ø2+6	Ø2+5	Ø4+8	FLASH

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

4–Phase
Soft Recall
Protected or Protected/Permissive Main Street
Protected or Protected/Permissive Side Street
With Flashing Yellow Arrows
OR With Backup Protection

PHASING DIAGRAM

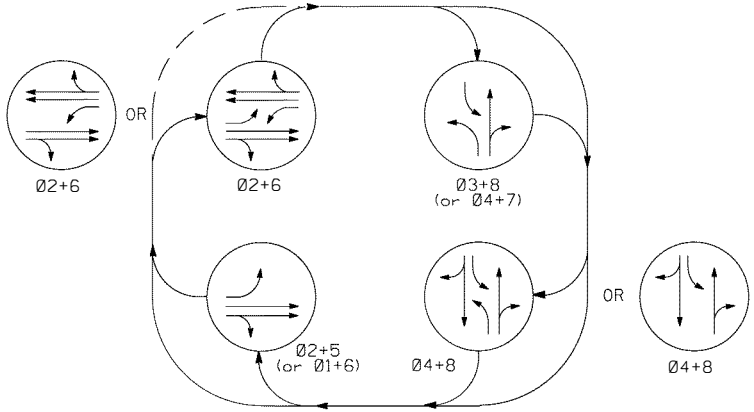


TABLE OF OPERATION					
SIGNAL FACE	PHASE				
	*	Ø2+6	**	Ø4+8	FLASH

Use appropriate lead/lag OR Backup Protection (Red Revert) note(s)

* Ø2+5 or Ø1+6 (Major Street Lefts)
** Ø3+8 or Ø4+7 (Minor Street Lefts)

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

Phasing Typicals: 4–Phase Operation

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO. 2.1.3

4–Phase
Soft Recall
Protected/Permissive Main Street
Split–Side Street

PHASING DIAGRAM

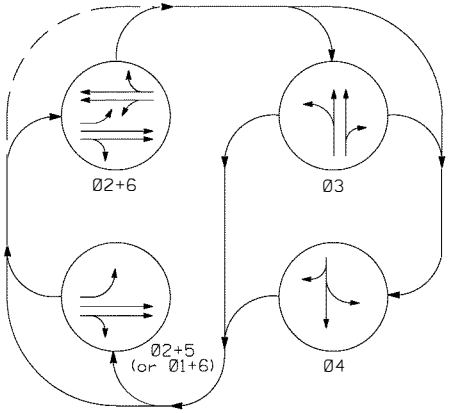


TABLE OF OPERATION					
SIGNAL FACE	PHASE *	Ø 2 + 6	Ø 3	Ø 4	FLASH

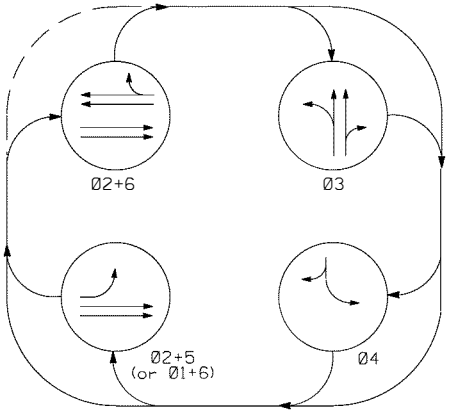
Use appropriate omit note(s) and phase reversal note(s)

* Ø2+5 or Ø1+6 (Major Street Lefts)

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

4–Phase
Soft Recall
Protected Main Street
Split–Side Street

PHASING DIAGRAM



Ø3 approach is one–way only

TABLE OF OPERATION					
SIGNAL FACE	PHASE *	Ø 2 + 6	Ø 3	Ø 4	FLASH

Use appropriate lead/lag and phase reversal note(s)

* Ø2+5 or Ø1+6 (Major Street Lefts)

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

Phasing Typicals: 4–Phase Operation

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.
2.1.3
SHEET 4 OF 4

5–Phase
Minimum Recall
Protected/Permissive Main Street
Without Flashing Yellow Arrows
Without Backup Protection

PHASING DIAGRAM

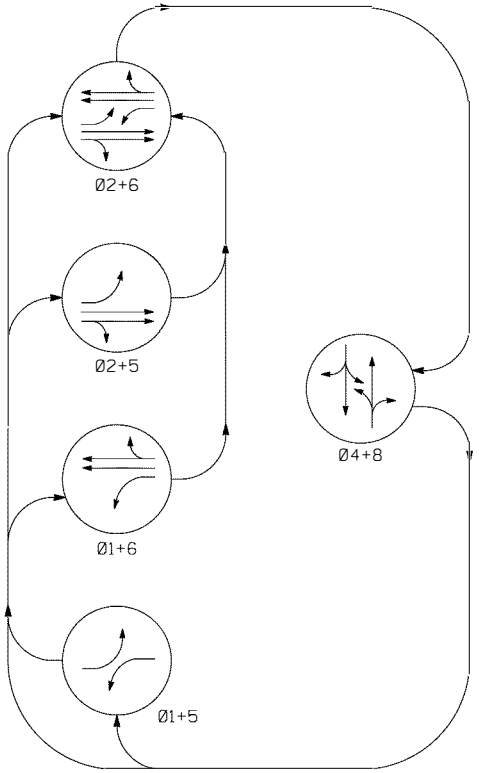


TABLE OF OPERATION						
SIGNAL FACE	PHASE					
	Ø1+5	Ø1+6	Ø2+5	Ø2+6	Ø4+8	FLASH

Use appropriate omit note(s)

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

5–Phase
Minimum Recall
Protected/Permissive Main Street
Without Flashing Yellow Arrows
With Backup Protection

PHASING DIAGRAM

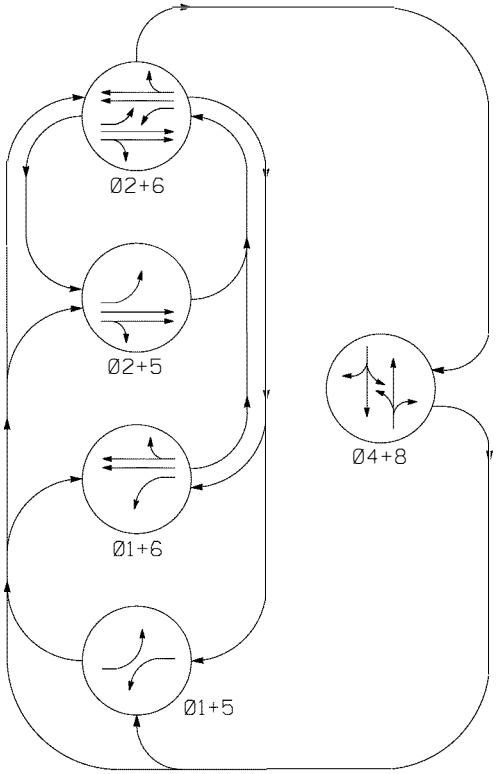


TABLE OF OPERATION						
SIGNAL FACE	PHASE					
	Ø1+5	Ø1+6	Ø2+5	Ø2+6	Ø4+8	FLASH

Use backup protect note(s)

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

Phasing Typicals: 5–Phase Operation

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.
2.1.4
SHEET 1 OF 4

5–Phase
Minimum Recall
Protected/Permissive Main Street
With Flashing Yellow Arrows

PHASING DIAGRAM

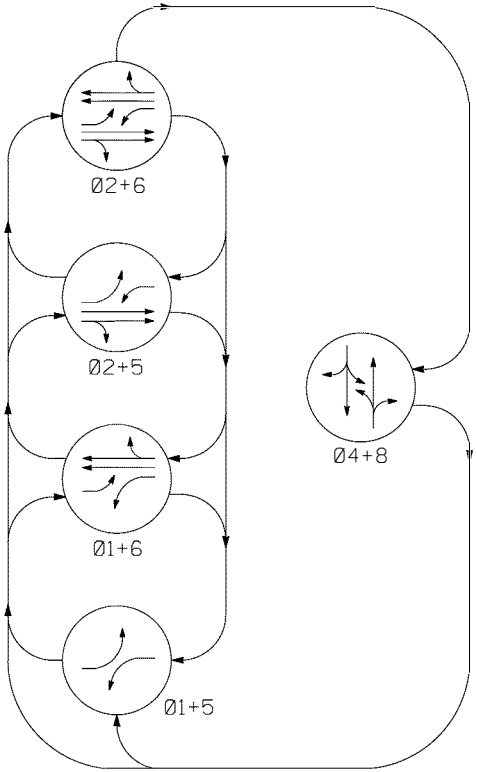


TABLE OF OPERATION						
SIGNAL FACE	PHASE					
	Ø1+5	Ø1+6	Ø2+5	Ø2+6	Ø4+8	FLASH

Use appropriate lead/lag note(s)

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

5–Phase
Minimum Recall
Protected Main Street

PHASING DIAGRAM

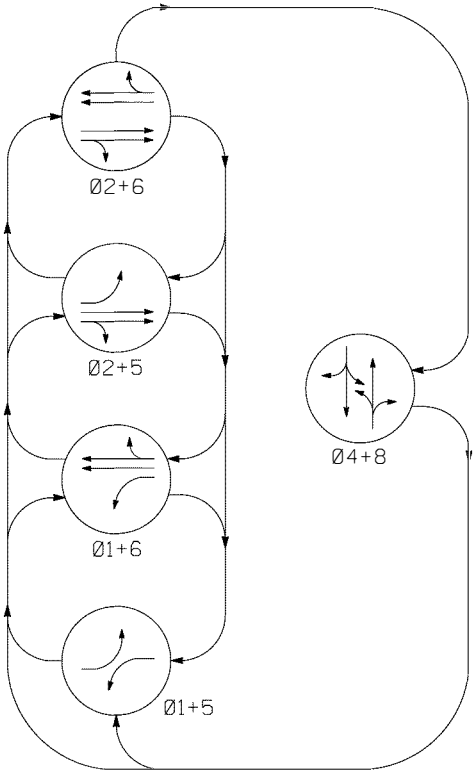


TABLE OF OPERATION						
SIGNAL FACE	PHASE					
	Ø1+5	Ø1+6	Ø2+5	Ø2+6	Ø4+8	FLASH

Use appropriate lead/lag note(s)

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

Phasing Typicals: 5–Phase Operation

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.
2.1.4
SHEET 2 OF 4

5–Phase
Minimum Recall
Lead–Lag Operation Main Street
Protected/Permissive Side Street

PHASING DIAGRAM

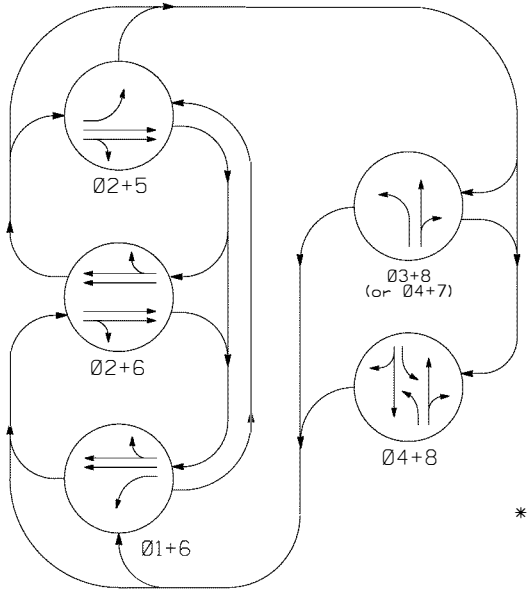


TABLE OF OPERATION						
SIGNAL FACE	PHASE					
	Ø1+6	Ø2+6	Ø2+5	**	Ø4+8	FLASH

** 03+8 or 04+7 (Minor Street Lefts)

Use appropriate lead/lag, phase omit, and/or phase reversal note(s)

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

5–Phase
Minimum Recall
Lead–Lag Operation Main Street
Split Side Street

PHASING DIAGRAM

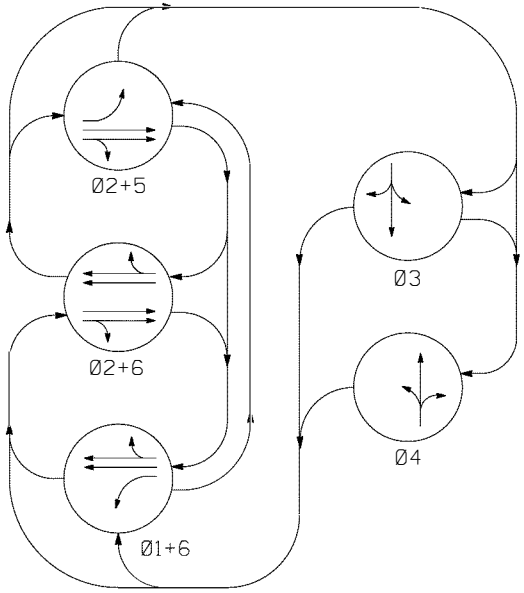


TABLE OF OPERATION						
SIGNAL FACE	PHASE					
	Ø1+6	Ø2+6	Ø2+5	Ø3	Ø4	FLASH

Use appropriate lead/lag and phase reversal note(s)

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

Phasing Typicals: 5–Phase Operation

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.
2.1.4
SHEET 3 OF 4

5–Phase
Soft Recall
Protected Main Street
OR Protected/Permissive Main Street
With Flashing Yellow Arrows

PHASING DIAGRAM

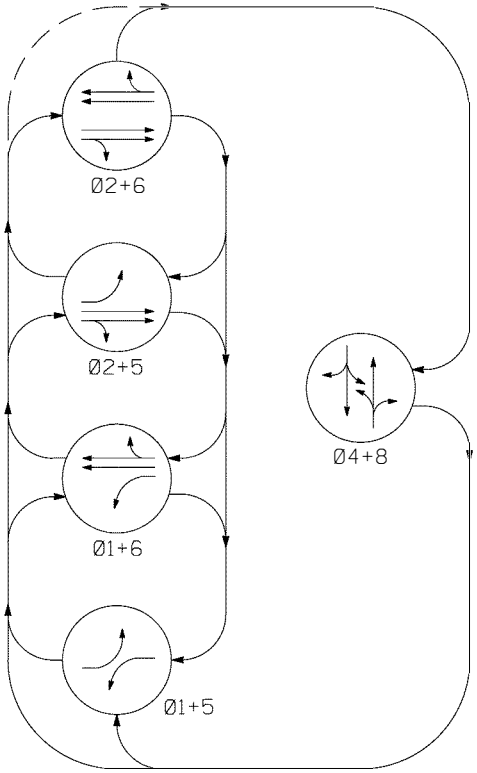


TABLE OF OPERATION						
SIGNAL FACE	PHASE					
	Ø1+5	Ø1+6	Ø2+5	Ø2+6	Ø4+8	FLASH

Use appropriate lead/lag note(s)

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

5–Phase
Minimum Recall
Protected or Protected/Permissive Side Street
With or Without Flashing Yellow Arrows

PHASING DIAGRAM

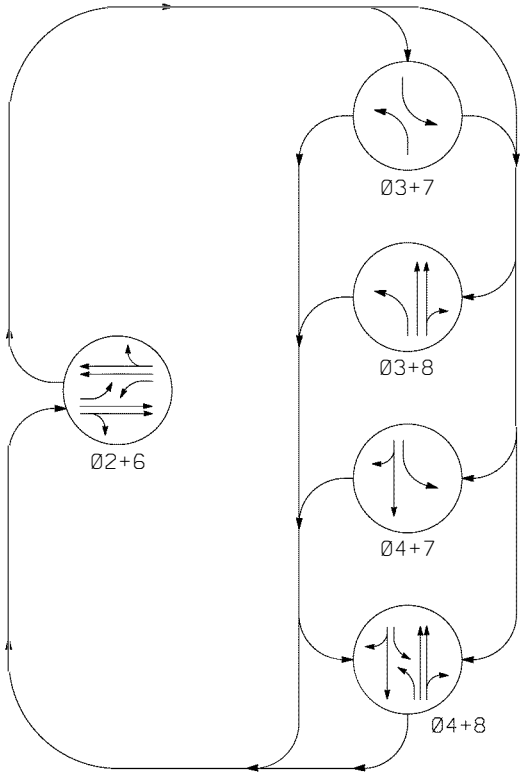


TABLE OF OPERATION						
SIGNAL FACE	PHASE					
	Ø2+6	Ø3+7	Ø3+8	Ø4+7	Ø4+8	FLASH

Use appropriate lead/lag or phase omit note(s)

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

Phasing Typicals: 5–Phase Operation

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

7-21

STD. NO.
2.1.4
SHEET 4 OF 4

6–Phase
Minimum Recall
Protected/Permissive Main Street
Split Side Street
Without Flashing Yellow Arrows

PHASING DIAGRAM

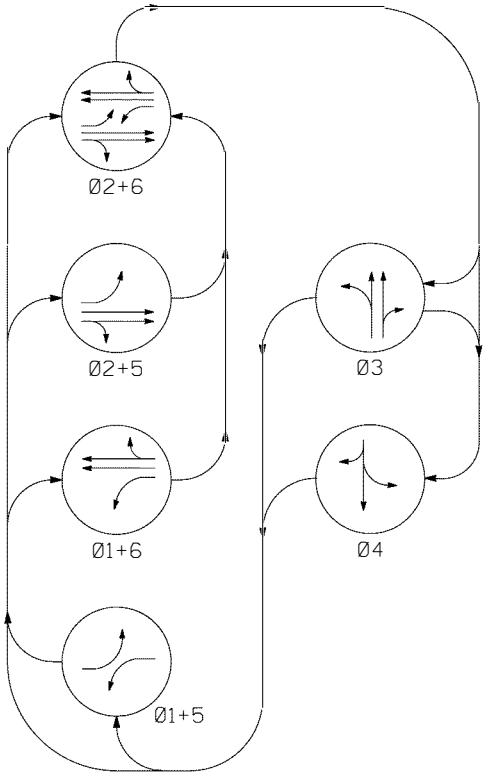


TABLE OF OPERATION							
SIGNAL FACE	PHASE						
	Ø1+5	Ø1+6	Ø2+5	Ø2+6	Ø3	Ø4	FLASH

Use appropriate omit and phase reversal note(s)

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

6–Phase
Minimum Recall
Protected/Permissive Main Street
Protected/Permissive Side Street
Without Flashing Yellow Arrows

PHASING DIAGRAM

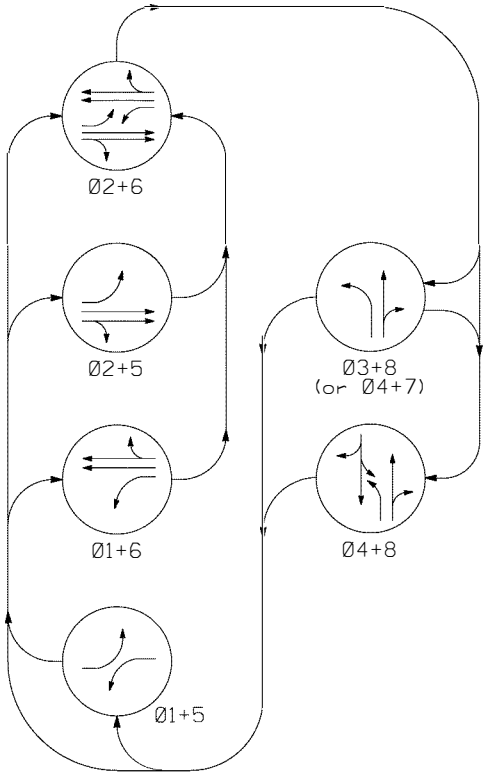


TABLE OF OPERATION							
SIGNAL FACE	PHASE						
	Ø1+5	Ø1+6	Ø2+5	Ø2+6	**	Ø4+8	FLASH

** 03+8 or 04+7 (Minor Street Lefts)

Use appropriate omit note(s)

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

Phasing Typicals: 6–Phase Operation

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.
2.1.5
SHEET 1 OF 4

6–Phase
Minimum Recall
Protected/Permissive Main Street
Split Side Street
With Red Revert

PHASING DIAGRAM

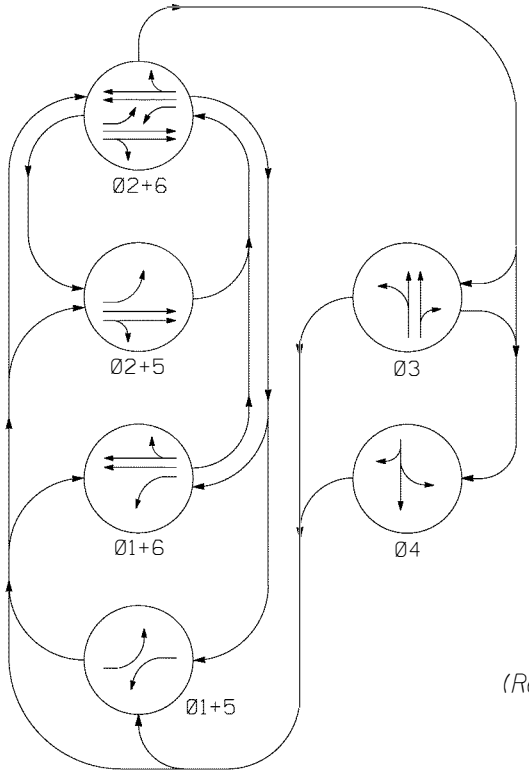


TABLE OF OPERATION							
SIGNAL FACE	PHASE						
	Ø1+5	Ø1+6	Ø2+5	Ø2+6	Ø3	Ø4	FLASH

Use appropriate Backup Protection (Red Revert) and phase reversal note(s)

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

6–Phase
Minimum Recall
Protected/Permissive Main Street
Protected/Permissive Side Street
With Red Revert

PHASING DIAGRAM

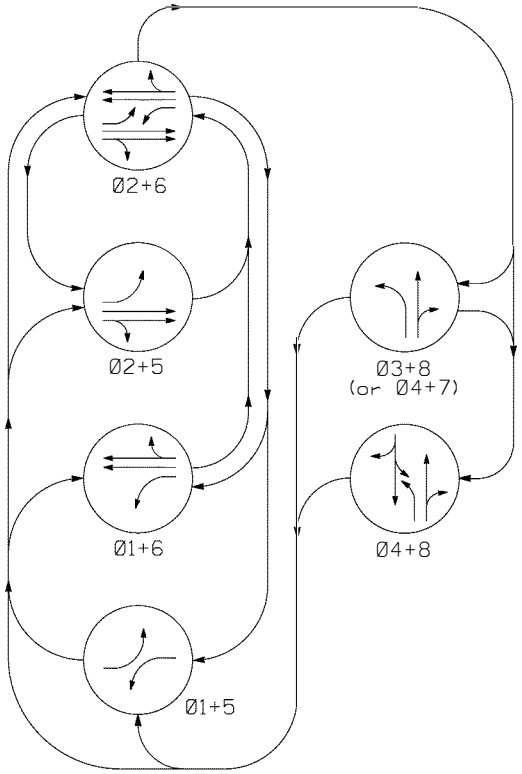


TABLE OF OPERATION							
SIGNAL FACE	PHASE						
	Ø1+5	Ø1+6	Ø2+5	Ø2+6	**	Ø4+8	FLASH

** Ø3+8 or Ø4+7 (Minor Street Lefts)

Use appropriate Backup Protection (Red Revert) and phase omit note(s)

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

Phasing Typicals: 6–Phase Operation

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO. 2.1.5

6–Phase
Minimum Recall
Protected Main Street
OR Protected/Permissive Main Street
With Flashing Yellow Arrows
Split Side Street

PHASING DIAGRAM

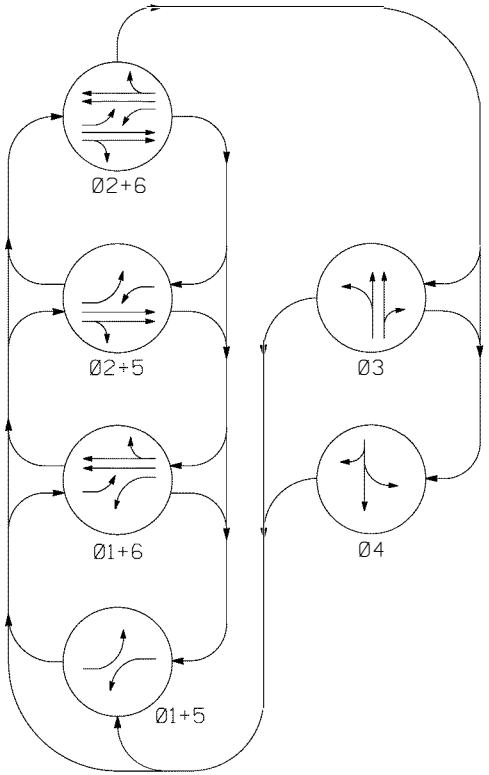


TABLE OF OPERATION							
SIGNAL FACE	PHASE						
	Ø1+5	Ø1+6	Ø2+5	Ø2+6	Ø3	Ø4	FLASH

Use appropriate lead/lag and phase reversal note(s)

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

6–Phase
Minimum Recall
Protected Main Street
OR Protected/Permissive Main Street
With Flashing Yellow Arrows
Protected/Permissive Side Street

PHASING DIAGRAM

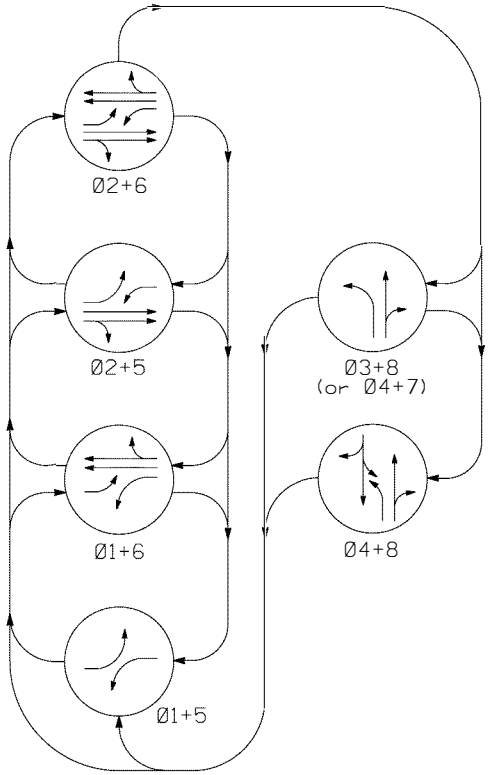


TABLE OF OPERATION							
SIGNAL FACE	PHASE						
	Ø1+5	Ø1+6	Ø2+5	Ø2+6	**	Ø4+8	FLASH

** 03+8 or 04+7 (Minor Street Lefts)

Use appropriate lead/lag and/or phase omit note(s)

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

Phasing Typicals: 6–Phase Operation

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.
2.1.5
SHEET 3 OF 4

6–Phase
Soft Recall
Protected Main Street
OR Protected/Permissive Main Street
With Flashing Yellow Arrows
Split Side Street

PHASING DIAGRAM

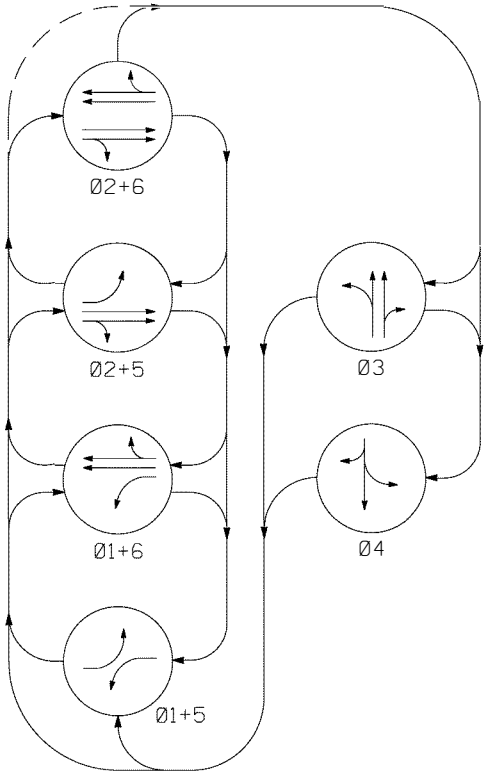


TABLE OF OPERATION							
SIGNAL FACE	PHASE						
	Ø1+5	Ø1+6	Ø2+5	Ø2+6	Ø3	Ø4	FLASH

Use appropriate lead/lag and phase reversal note(s)

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

6–Phase
Soft Recall
Protected Main Street
OR Protected/Permissive Main Street
With Flashing Yellow Arrows
Protected/Permissive Side Street

PHASING DIAGRAM

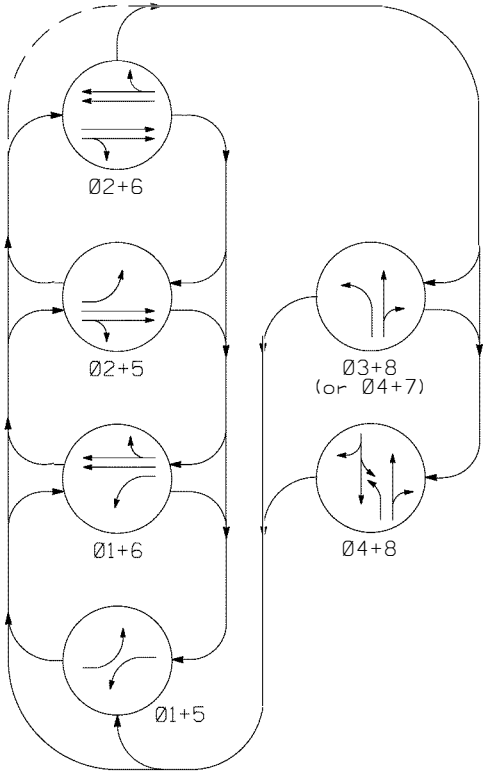


TABLE OF OPERATION							
SIGNAL FACE	PHASE						
	Ø1+5	Ø1+6	Ø2+5	Ø2+6	**	Ø4+8	FLASH

** 03+8 or 04+7 (Minor Street Lefts)

Use appropriate lead/lag and/or phase omit note(s)

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

Phasing Typicals: 6–Phase Operation

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.
2.1.5
SHEET 4 OF 4

7–Phase
Minimum Recall
Lead–Lag Main Street

PHASING DIAGRAM

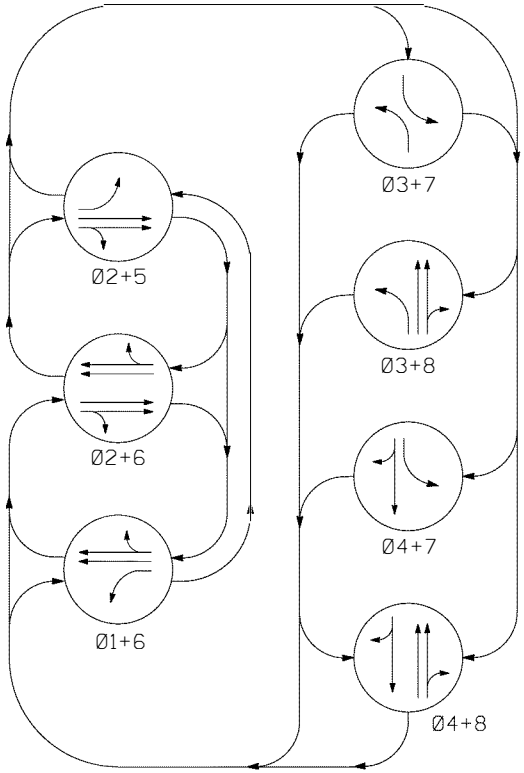


TABLE OF OPERATION								
SIGNAL FACE	PHASE							
	Ø1+6	Ø2+6	Ø2+5	Ø3+7	Ø3+8	Ø4+7	Ø4+8	FLASH

Use appropriate phase omit and phase reversal note(s)

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

7–Phase
Minimum Recall
Protected/Permissive Main Street
Without Flashing Yellow Arrows
Lead–Lag Side Street

PHASING DIAGRAM

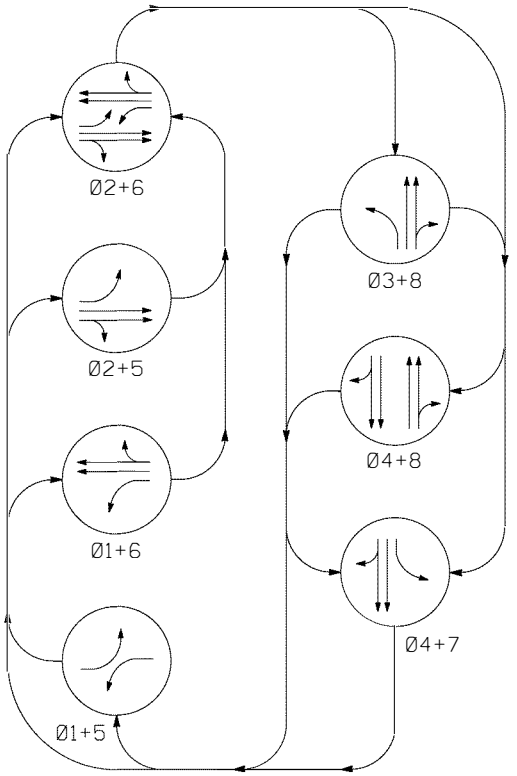


TABLE OF OPERATION								
SIGNAL FACE	PHASE							
	Ø1+5	Ø1+6	Ø2+5	Ø2+6	Ø3+8	Ø4+8	Ø4+7	FLASH

Use appropriate phase omit and phase reversal note(s)

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

Phasing Typicals: 7–Phase Operation

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.
2.1.6
SHEET 1 OF 2

7–Phase
Minimum Recall
Protected/Permissive Main Street
With Red Revert
Lead–Lag Side Street

PHASING DIAGRAM

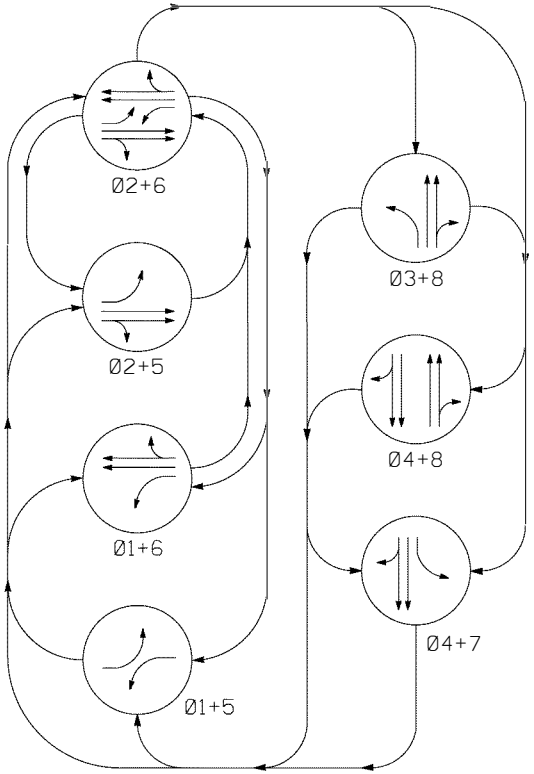


TABLE OF OPERATION								
SIGNAL FACE	PHASE							
	Ø1+5	Ø1+6	Ø2+5	Ø2+6	Ø3+8	Ø4+8	Ø4+7	FLASH

Use appropriate phase omit and phase reversal note(s)

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

7–Phase
Minimum Recall
Protected Main Street
OR Protected/Permissive Main Street
With Flashing Yellow Arrows
Lead–Lag Side Street

PHASING DIAGRAM

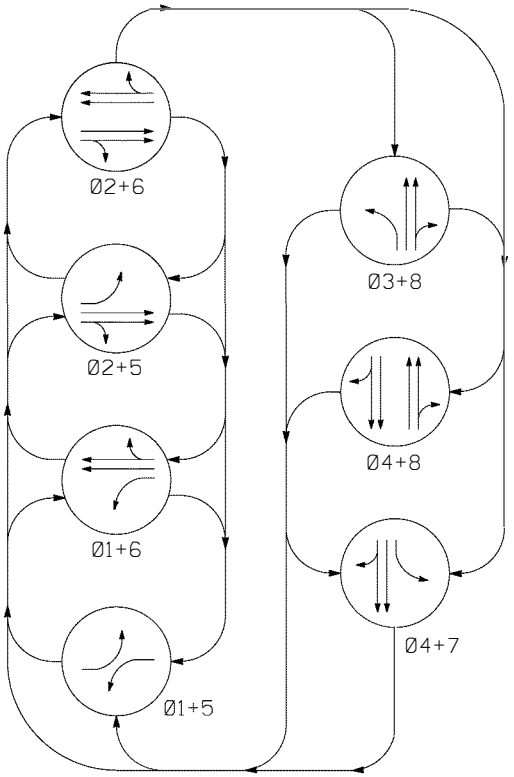


TABLE OF OPERATION								
SIGNAL FACE	PHASE							
	Ø1+5	Ø1+6	Ø2+5	Ø2+6	Ø3+8	Ø4+8	Ø4+7	FLASH

With older controllers, the phase numbering may need to be modified

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

Phasing Typicals: 7–Phase Operation

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.
2.1.6
SHEET 2 OF 2

8–Phase
Minimum Recall
Protected/Permissive Main Street
Without Flashing Yellow Arrows
Protected or Protected/Permissive Side Street

PHASING DIAGRAM

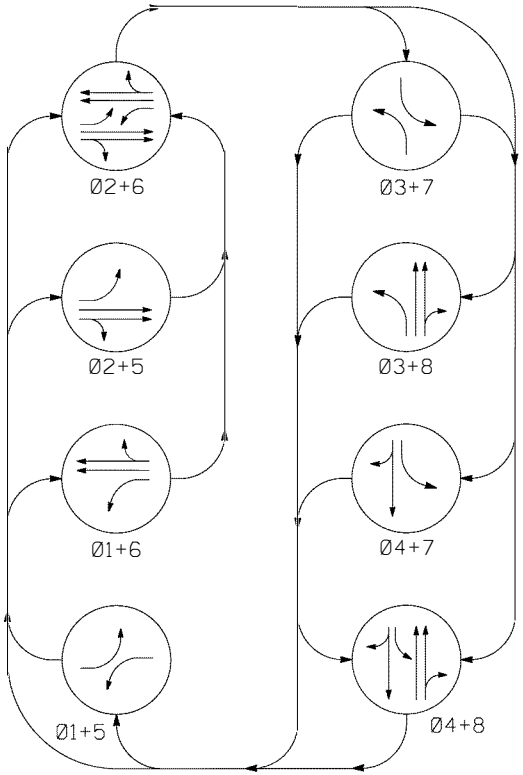


TABLE OF OPERATION									
SIGNAL FACE	PHASE								
	Ø1+5	Ø1+6	Ø2+5	Ø2+6	Ø3+7	Ø3+8	Ø4+7	Ø4+8	FLASH

Use appropriate omit note(s)

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

8–Phase
Minimum Recall
Protected/Permissive Main Street
With Backup Protection
Protected or Protected/Permissive Side Street

PHASING DIAGRAM

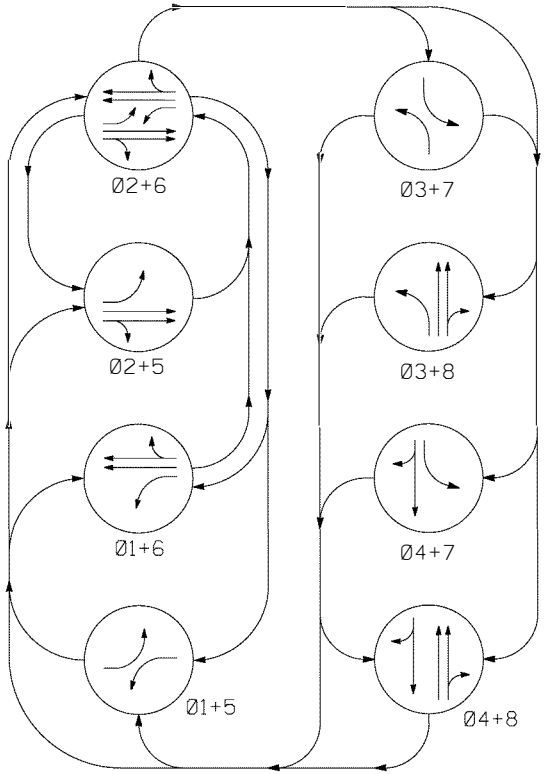


TABLE OF OPERATION									
SIGNAL FACE	PHASE								
	Ø1+5	Ø1+6	Ø2+5	Ø2+6	Ø3+7	Ø3+8	Ø4+7	Ø4+8	FLASH

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

Phasing Typicals: 8–Phase Operation

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.
2.1.7
SHEET 1 OF 4

8–Phase
Minimum Recall
Protected and Protected/Permissive Main Street
Without Flashing Yellow Arrows
Protected and Protected/Permissive Side Street

PHASING DIAGRAM

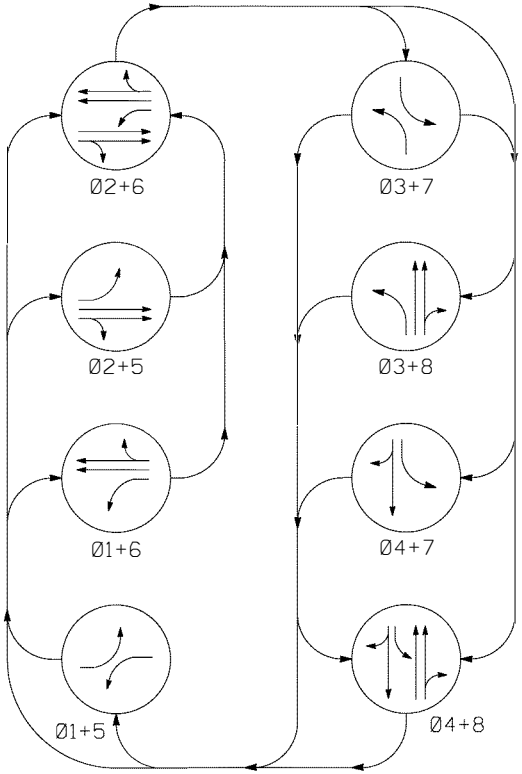


TABLE OF OPERATION									
SIGNAL FACE	PHASE								
	01+5	01+6	02+5	02+6	03+7	03+8	04+7	04+8	FLASH

Use appropriate omit note(s)

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

8–Phase
Soft Recall
Protected Main Street
Protected Side Street

PHASING DIAGRAM

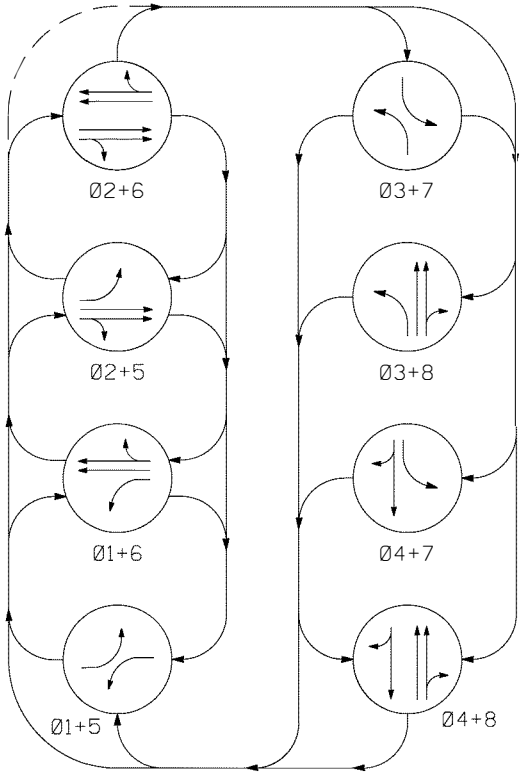


TABLE OF OPERATION									
SIGNAL FACE	PHASE								
	01+5	01+6	02+5	02+6	03+7	03+8	04+7	04+8	FLASH

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

Phasing Typicals: 8–Phase Operation

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.
2.1.7

8–Phase
Minimum Recall
Protected/Permissive Main Street
With Yellow Arrows
Protected/Permissive Side Street
With or Without Flashing Yellow Arrows

PHASING DIAGRAM

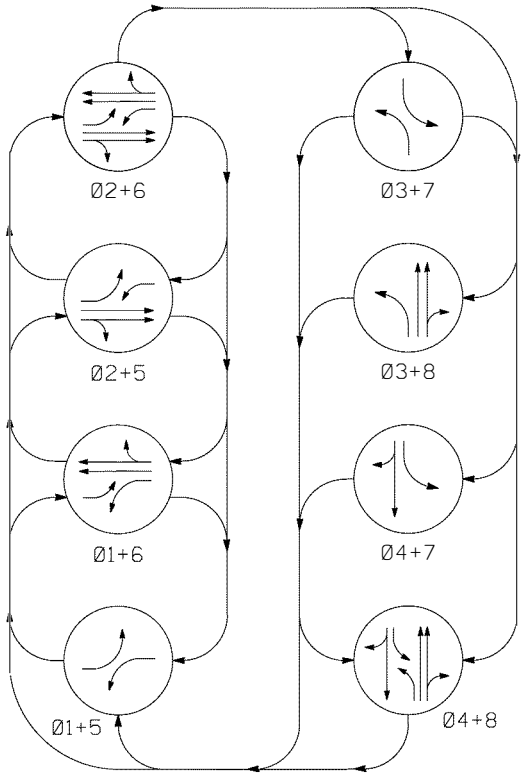


TABLE OF OPERATION

SIGNAL FACE	PHASE								
	01+5	01+6	02+5	02+6	03+7	03+8	04+7	04+8	FLASH

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

8–Phase
Minimum Recall
Protected/Permissive Main Street
With Yellow Arrows
Protected Side Street

PHASING DIAGRAM

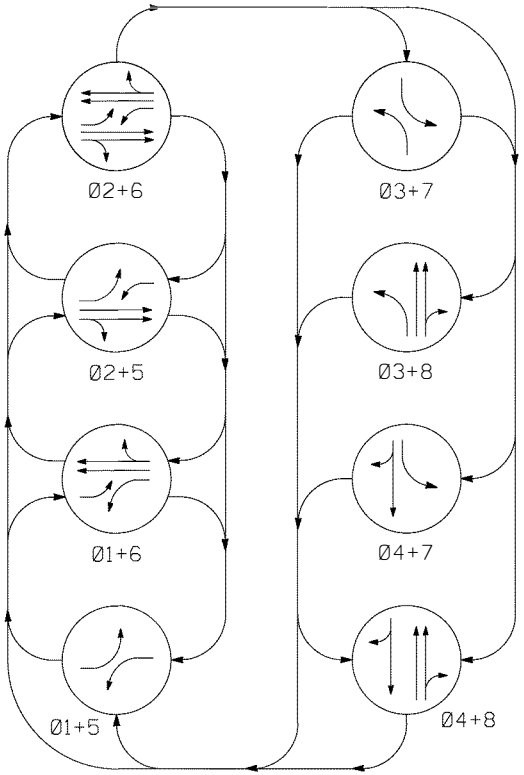


TABLE OF OPERATION

SIGNAL FACE	PHASE								
	01+5	01+6	02+5	02+6	03+7	03+8	04+7	04+8	FLASH

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

Phasing Typicals: 8–Phase Operation

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.
2.1.7
SHEET 3 OF 4

8–Phase
Minimum Recall
Protected Main Street
Protected/Permissive Side Street
With or Without Flashing Yellow Arrows

PHASING DIAGRAM

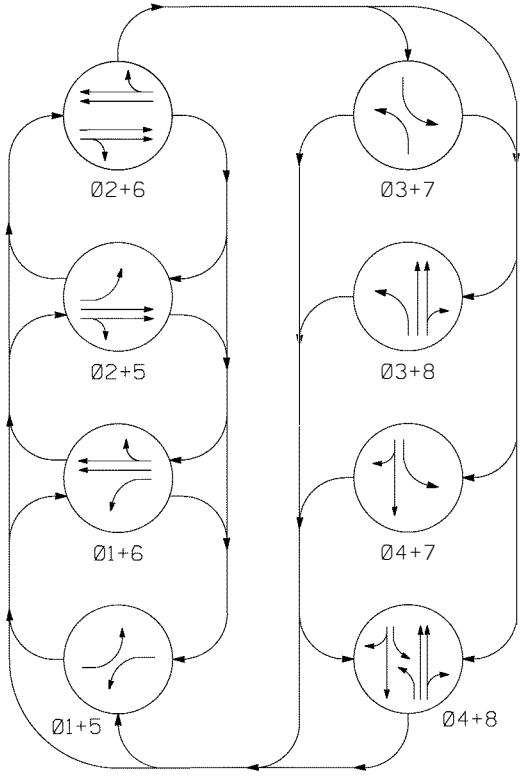


TABLE OF OPERATION

SIGNAL FACE	PHASE								
	01+5	01+6	02+5	02+6	03+7	03+8	04+7	04+8	FLASH

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

8–Phase
Minimum Recall
Protected Main Street
Protected Side Street

PHASING DIAGRAM

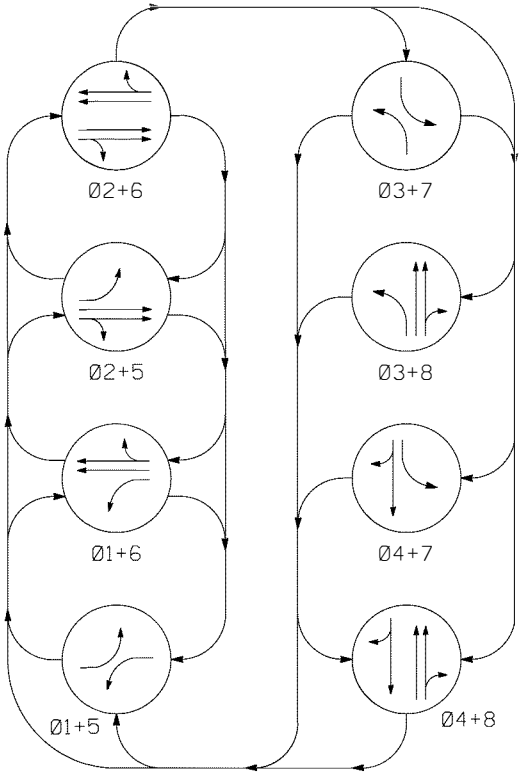


TABLE OF OPERATION

SIGNAL FACE	PHASE								
	01+5	01+6	02+5	02+6	03+7	03+8	04+7	04+8	FLASH

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

Phasing Typicals: 8–Phase Operation

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.
2.1.7
SHEET 4 OF 4

Red Revert Backup Protection

Yellow Trap and Dynamic Backup Control

A "yellow trap" occurs when a traffic signal cycles directly from concurrent through phases to a fully protected phase opposing a permitted phase (also known as "backing up"). This situation is avoided in a signal design whenever possible. Typically, phase omits or forcing the signal to cycle through the side street (even if there are no vehicle calls) to serve the protected phase have been used to protect against a "yellow trap."

Backup Protection (Red Revert/Backup Prevent)

Backup Protection is a feature that allows the signal to cycle from a permissive left turn phase on the main street to a protected phase and avoid a "yellow trap." In 2070 OASIS software, it is known as Red Revert. In ASC/3 software, it is known as Backup Prevent. Backup Protection simulates an all red "dummy" phase by clearing the through phase(s) to red for a brief interval before cycling to the adjacent protected left turn phase and then returning to green again; the opposing through phase will stay red for the duration of the protected turning phase.

The time that the adjacent through phase displays red before returning to green is a function of the backup protect time. Typically the backup protect time is programmed to (at least) 5 seconds to avoid the appearance of improper operation.

Conditions for Use

1. Used primarily with 2070 OASIS or ASC/3 Software
2. Cannot be used with older NEMA TS-1, TS-2, 170, 2033, or other 2070 software (such as SE-PAC or Trafficware Apogee)
3. Used only on the main street (phases 2+6)
4. May be used when there is one or two protected/permissive phases (1 and/or 5) on the main street
5. Use in conjunction with 5-section (doghouse) heads or where left turn phase has only one opposing lane.
6. Use in place of phase omit and clearing through the side street.
7. Do NOT use with Railroad Preemption if the main street is the approach that crosses the tracks and is used in the Track Clearance Phase.

When Used On Plans:

- Typically set red revert time for phase 2 and/or phase 6 to 5.0 seconds.
- Default red revert time for all other phases is 2.0 seconds.
- Use the following note on plans:
  Enable backup protect for phase 2 (and/or 6) to allow the controller to clear from phase 2+6 to phase 2+5 (and/or 1+6) by progressing though an all red display.

Alternate (Time of Day) Phasing Notes

Alternate (Time of Day) Phasing is a useful tool when a protected turn mode is required during certain times of day, but the signal may operate in a permissive mode at other times of the day. While Alternate Phasing options may be shown on the signal plan, it is not required that any or all of them be used, or how long they are used. The use of Alternate Phasing should be at the discretion of the Division Traffic Engineer. This discretion may be delegated to the local municipal traffic engineer if the signal operates as part of a municipal signal system.

Phasing Designation

The Default Phasing is always the least restrictive mode. Normally all permissive movements are allowed during this phasing. Even though the use of permissive turns is encouraged, never restrict phasing so that only permissive phases are served and the ability to serve a protected turn phase during a cycle if needed is disabled.

The number and need for alternate phases may vary. Most commonly, the alternate phase restricts permissive left turns to a protected only mode. This may be for one, any, or all turn phases. One phasing program may restrict permissive left turns on all approaches. A second phasing program may allow protected/permissive lefts on the side street but restrict permissive lefts on the main street. Another phasing program may allow protected/permissive lefts on the main street but restrict permissive lefts on the side street. Alternate phasing may used for only one approach on a street; one approach may be protected only while the other approach operates in a permissive (or protected/permissive) mode. Another phasing program may allow for the use of an exclusive pedestrian phase during certain hours. If more than one alternate phase program is used at an intersection, they should be numbered in a sequence from least restrictive to most restrictive.

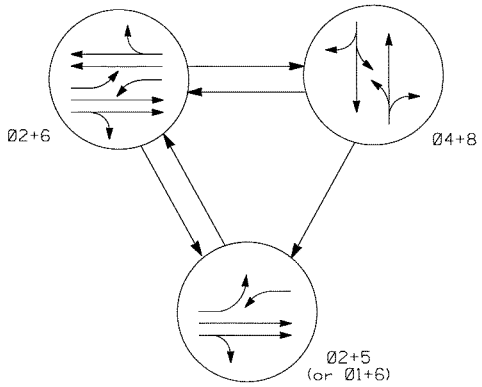
When an alternate phase is used, the signal head should be set to flash based on its default phase. The flashing operation of a signal head does not change based a Alternate Phasing (Time of Day) plan.

Preemption Operation

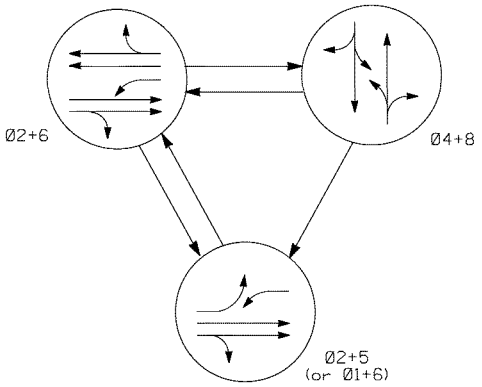
If Alternate Phasing is utilized at a location with (railroad or emergency) preemption, this may also affect the operation of the signal during preemption. It may be necessary to provide Alternate Phasing diagrams for the Preemption phasing in addtion to the Preemption phasing based on Default phasing operation.

3 Phase
Protected/Permissive Left One Direction
Permissive Only Left Other Direction

DEFAULT PHASING DIAGRAM



ALTERNATE PHASING DIAGRAM



Phase 5 may be lagged (Phase 1 if 1+6 is used)

THIS ASSUMES A 4-SECTION FYA IS USED FOR THE LEFT TURN ON ONE APPROACH (PHASE 5) AND A 3-SECTION FYA IS USED FOR THE LEFT TURN ON THE OTHER APPROACH OF MAIN STREET

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

DEFAULT PHASING TABLE OF OPERATION

SIGNAL FACE	PHASE Ø2+5	PHASE Ø2+6	PHASE Ø4+8	FLASH
51	←	←FY	←R	←Y
61	←FY	←FY	←R	←Y

ALTERNATE PHASING TABLE OF OPERATION

SIGNAL FACE	PHASE Ø2+5	PHASE Ø2+6	PHASE Ø4+8	FLASH
51	←	←R	←R	←Y
61	←FY	←FY	←R	←Y

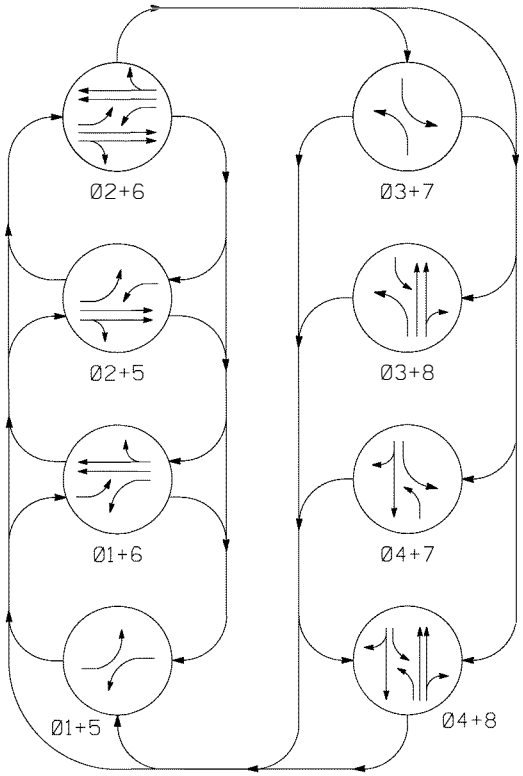
Alternate Phasing Operation

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

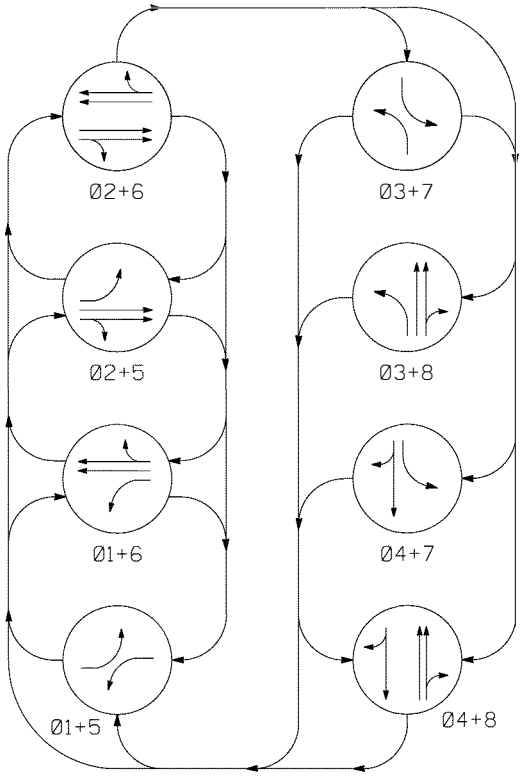
STD. NO.
2.3.2
SHEET 1 OF 2

8 Phase
Protected/Permissive Default Phasing
Protected Only Alternate Phasing

DEFAULT PHASING DIAGRAM



ALTERNATE PHASING DIAGRAM



NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

DEFAULT PHASING TABLE OF OPERATION

SIGNAL FACE	PHASE Ø1+5	Ø1+6	Ø2+5	Ø2+6	Ø3+7	Ø3+8	Ø4+7	Ø4+8	FLASH
11	←	←	←FY	←FY	←R	←R	←R	←R	←Y
31	←R	←R	←R	←R	←	←	←FY	←FY	←R
51	←	←FY	←	←FY	←R	←R	←R	←R	←Y
71	←R	←R	←R	←R	←	←FY	←	←FY	←R

ALTERNATE PHASING TABLE OF OPERATION

SIGNAL FACE	PHASE Ø1+5	Ø1+6	Ø2+5	Ø2+6	Ø3+7	Ø3+8	Ø4+7	Ø4+8	FLASH
11	←	←	←R	←R	←R	←R	←R	←R	←Y
31	←R	←R	←R	←R	←	←	←R	←R	←R
51	←	←R	←	←R	←R	←R	←R	←R	←Y
71	←R	←R	←R	←R	←	←R	←	←R	←R

Alternate Phasing Operation

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO. 2.3.2

2070 OASIS with 170 Cabinet

OASIS 2070 LOOP & DETECTOR INSTALLATION CHART

INDUCTIVE LOOPS					DETECTOR PROGRAMMING							
LOOP	SIZE (FT)	DISTANCE FROM STOP LINE (FT)	TURNS	NEW LOOP	PHASE	CALLING	EXTENSION	FULL TIME DELAY	STRETCH TIME	DELAY TIME	SYSTEM LOOP	NEW CARD
1A	6X40	0	2–4–2	–	1	Y	Y	–	–	15 **	–	–
					6 #	Y	Y	Y	–	3	–	–
1B	6X40	0	2–4–2	Y	1	Y	Y	–	–	15	–	Y
2A/S1	6X6	420	5	Y	2	Y	Y	–	–	–	Y	Y
3A	6X40	0	2–4–2	Y	3	Y	Y	–	–	15 *	–	Y
					8 #	Y	Y	–	–	–	–	Y
4A	6X40	0	2–4–2	Y	4	Y	Y	–	–	–	–	Y
5A	6X40	0	2–4–2	Y	5	Y	Y	–	–	15 *	–	Y
					2 #	Y	Y	Y	–	3	–	Y
6A	6X6	300	EXISTING	–	6	Y	Y	–	–	–	–	–
7A	6X40	0	2–4–2	Y	7	Y	Y	–	–	15 **	–	Y
					4 #	Y	Y	–	–	3	–	Y
8A	6X40	0	2–4–2	Y	8	Y	Y	–	–	10	–	Y

Reduce for Clip Delay During Alternate (Protected Only) Phasing
Full Time Delay During Permissive Phase Only

Disable Delay/No Clip During Alternate (Protected Only) Phasing
No Clip Delay During Permissive Phase

Disable Delay/No Clip During Alternate (Protected Only) Phasing
Full Time Delay During Permissive Phase Only

Reduce for Clip Delay During Alternate (Protected Only) Phasing
Clip Delay During Permissive Phase

* Disable Delay During Alternate Phasing Operation.
** Reduce Delay to 3 Seconds During Alternate Phasing Operation.
\# Disable Phase Call For Loop(s) During Alternate Phasing Operation.

See Std. 5.1, Sheet 1 for Full Loop Detector Programming Chart Information

Alternate Phasing Operation

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

2070 ASC/3

ASC/3 DETECTOR INSTALLATION CHART

DETECTOR					PROGRAMMING							
LOOP	SIZE (FT)	DISTANCE FROM STOP LINE (FT)	TURNS	NEW LOOP	PHASE	CALLING	EXTEND TIME	DELAY TIME	USE ADDED INITIAL	TYPE	SYSTEM LOOP	NEW CARD
1A	6X40	0	2–4–2	-	1	Yes	-	15 **	-	S	-	-
					6 #	Yes	-	3	-	G	-	-
1B	6X40	0	2–4–2	X	1	Yes	-	15	-	S	-	X
2A/S1	6X6	420	5	X	2	Yes	-	-	X	N	X	X
3A	6X40	0	2–4–2	X	3	Yes	-	15 *	-	S	-	X
					8 #	Yes	-	–	-	S	-	X
4A	6X40	0	2–4–2	X	4	Yes	-	-	-	S	-	X
5A	6X40	0	2–4–2	X	5	Yes	-	15 *	-	S	-	X
					2 #	Yes	-	3	-	G	-	X
6A	6X6	300	EXISTING	-	6	Yes	-	-	X	N	-	-
7A	6X40	0	2–4–2	X	7	Yes	-	15 **	-	S	-	-
					4 #	Yes	-	3	-	S	-	X
8A	6X40	0	2–4–2	X	8	Yes	-	10	-	S	-	X

Reduce for Clip Delay During Alternate (Protected Only) Phasing
Full Time Delay During Permissive Phase Only

Disable Delay/No Clip During Alternate (Protected Only) Phasing
No Clip Delay During Permissive Phase

Disable Delay/No Clip During Alternate (Protected Only) Phasing
Full Time Delay During Permissive Phase Only

Reduce for Clip Delay During Alternate (Protected Only) Phasing
Clip Delay During Permissive Phase

* Disable Delay During Alternate Phasing Operation.
** Reduce Delay to 3 Seconds During Alternate Phasing Operation.
\# Disable Phase Call For Loop(s) During Alternate Phasing Operation.

NOTE: The operation of Alternate (TOD) Phasing for ASC/3 software is the same for both a 170 platform and the NEMA TS–2 platform used in the Cary Signal System. The individual charts are different, but the same programming principles apply.

See Std. 5.1, Sheet 2 (170 Cabinet) or Sheet 3 (NEMA Cabinet) for Full Loop Detector Programming Chart Information

Alternate Phasing Operation

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

SE-PAC 2070 LOOP & DETECTOR UNIT INSTALLATION CHART

INDUCTIVE LOOPS						DETECTOR PROGRAMMING															
							TIMING		OPERATION MODE											STATUS	
									0	1	2	3	4	5	6	7				
LOOP NO.	SIZE (ft)	TURNS	DIST. FROM STOP LINE (ft)	NEW	EXISTING	ASSIGNED PHASE	DELAY	EXTEND (STRETCH)	VEHICLE	PEDESTRIAN	1 CALL	STOP A	STOP B	PROT/PER LEFT	PROT/PER THROUGH	AND	SWITCH	SYSTEM LOOPS	NEW	EXISTING
1A	6X40	2–4–2	0	–	X	1	5 SEC.	– SEC.	X	–	–	–	–	–	–	–	–	–	–	X
1B	6X40	2–4–2	0	X	–	1	15 SEC.	– SEC.	X	–	–	–	–	–	–	–	–	–	X	–
2A/S1	6X6	5	420	X	–	2	– SEC.	– SEC.	X	–	–	–	–	–	–	–	–	X	X	–
3A	6X40	2–4–2	0	X	–	3	5 SEC.	– SEC.	X	–	–	–	–	–	–	–	–	–	X	–
4A	6X40	2–4–2	0	X	–	4	– SEC.	– SEC.	X	–	–	–	–	–	–	–	–	–	X	–
5A	6X40	2–4–2	0	X	–	5	5 SEC.	– SEC.	X	–	–	–	–	–	–	–	–	–	X	–
6A	6X6	5	300	–	X	6	– SEC.	– SEC.	X	–	–	–	–	–	–	–	–	–	–	X
7A	6X40	2–4–2	0	X	–	7	3 SEC.	– SEC.	X	–	–	–	–	–	–	–	–	–	X	–
8A	6X40	2–4–2	0	X	–	8	10 SEC.	– SEC.	X	–	–	–	–	–	–	–	–	–	X	–

NOTE: SE–PAC software cannot be programmed for variable phasing or Full Time Delay of the detector loops. When Alternate (TOD) Phasing is used, the detector loop should not call or extend the permissive phase; it should only be programmed to call and extend the protected turn phase with a 5 second delay. This 5 second delay serves to provide a clip delay for the loop, if applicable. Even if no clip delay is required, the 5 second delay serves to provide a brief delay prior to calling the protected phase during protected/permissive operation (normally 15 seconds).

See Std. 5.1, Sheet 4 for Full Loop Detector Programming Chart Information

Alternate Phasing Operation

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

Trafficware Apogee 2070

LOOP & DETECTOR UNIT INSTALLATION CHART
TRAFFICWARE APOGEE SOFTWARE 2070 CONTROLLER

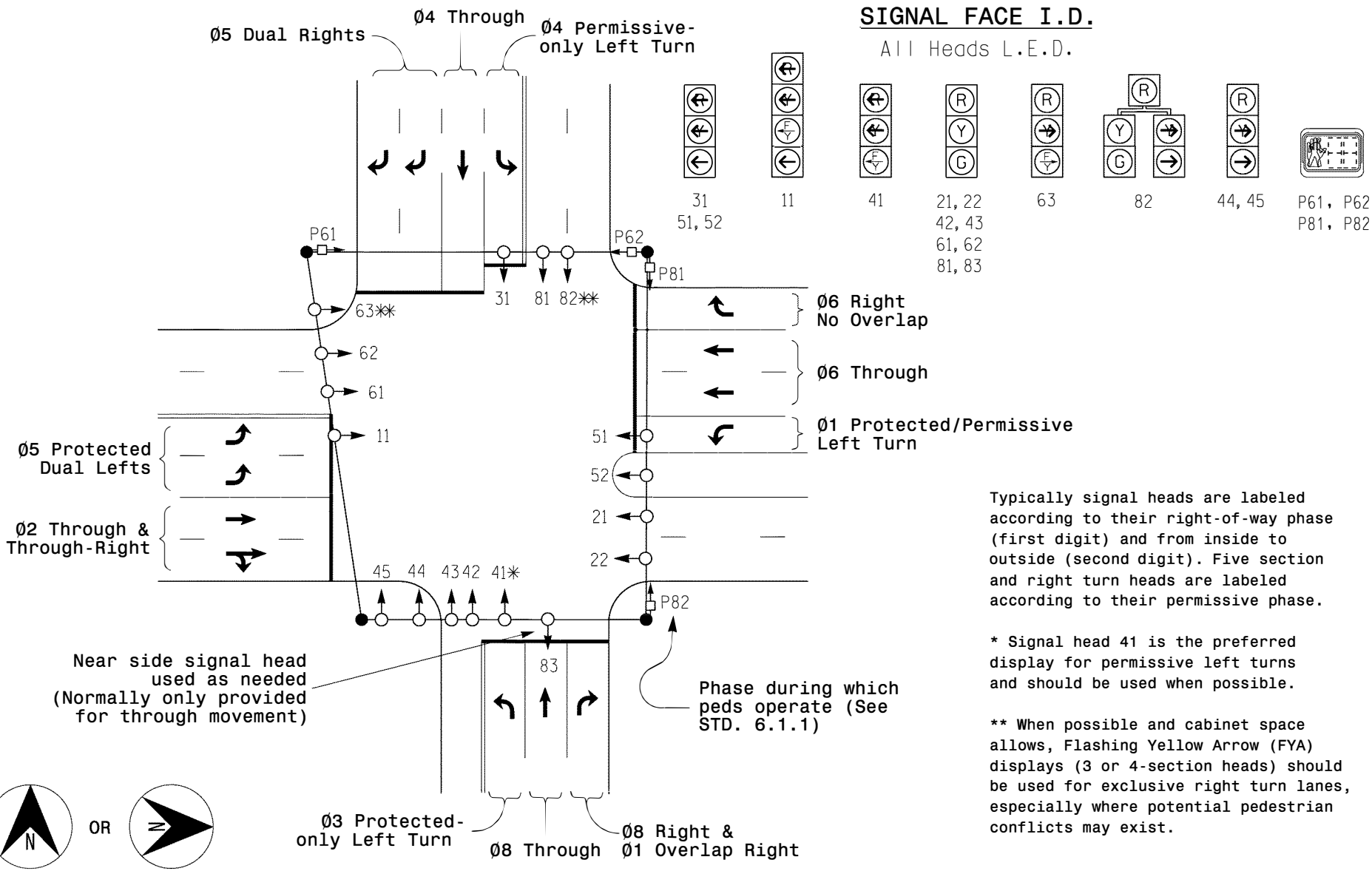
INDUCTIVE LOOPS					DETECTOR PROGRAMMING								
LOOP	SIZE (FT)	DISTANCE FROM STOP LINE (FT)	TURNS	NEW LOOP	PHASE	SWITCH (PHASE)	DELAY TIME	STRETCH TIME	CALLING	EXTENSION	ADDED INIT.	SYSTEM LOOP	NEW CARD
1A	6X40	0	2–4–2	–	1	–	5	–	X	X	–	–	–
1B	6X40	0	2–4–2	X	1	–	15	–	X	X	–	–	X
2A/S1	6X6	300	5	X	2	–	–	–	X	X	X	X	X
3A	6X40	0	2–4–2	X	3	–	5	–	X	X	–	–	X
4A	6X40	0	5	X	4	–	–	–	X	X	–	–	X
5A	6X40	0	2–4–2	X	5	–	5	–	X	X	–	–	X
6A	6X6	300	EXIST	–	6	–	–	–	X	X	X	–	–
7A	6X40	0	2–4–2	X	7	–	5	–	X	X	–	–	X
8A	6X40	0	2–4–2	X	8	–	10	–	X	X	–	–	X

NOTE: Trafficware Apogee software cannot be programmed for variable phasing or Full Time Delay of the detector loops. When Alternate (TOD) Phasing is used, the detector loop should not call or extend the permissive phase; it should only be programmed to call and extend the protected turn phase with a 5 second delay. This 5 second delay serves to provide a clip delay for the loop, if applicable. Even if no clip delay is required, the 5 second delay serves to provide a brief delay prior to calling the protected phase during protected/permissive operation (normally 15 seconds).

See Std. 5.1, Sheet 5 for Full Loop Detector Programming Chart Information

Alternate Phasing Operation

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION



Typically signal heads are labeled according to their right-of-way phase (first digit) and from inside to outside (second digit). Five section and right turn heads are labeled according to their permissive phase.

* Signal head 41 is the preferred display for permissive left turns and should be used when possible.

** When possible and cabinet space allows, Flashing Yellow Arrow (FYA) displays (3 or 4-section heads) should be used for exclusive right turn lanes, especially where potential pedestrian conflicts may exist.

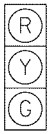
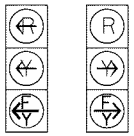
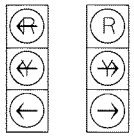
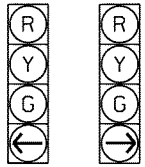
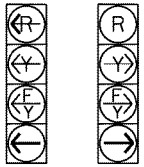
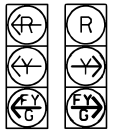
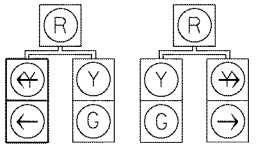
Typical Numbering of Signal Heads

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

7-21

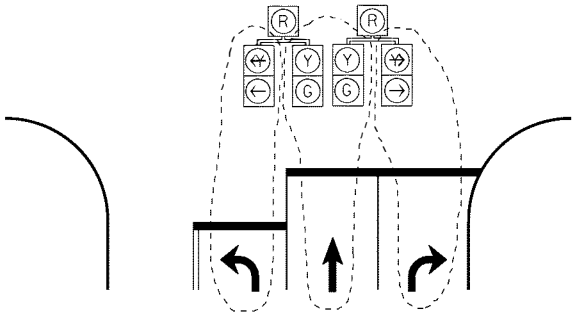
STD. NO.
3.0.1
SHEET 1 OF 1

Signal Head Types

SIGNAL HEAD	 3-Section	 3-Section	 3-Section	 4-Section Vertical	 4-Section	 3-Section Bi-Modal (Bottom Section)	 5-Section
USAGE	All situations where other signal heads are not recommended	Permitted Turn OR No Through Movement	Protected Turn OR No Through Movement	Split Phasing RR Clearance EV Preempt	Protected/ Permissive Turn OR Alternate Phasing	Protected/ Permissive Turn w/ Vertical Clearance or Metal Pole Issues	Protected/ Permissive (Left) Turn; Right Turn Overlap
PLACEMENT	Lane Line or Lane ℄	Lane ℄	Lane ℄	Lane Line or Lane ℄	Lane ℄	Lane ℄	Lane Line

Number of Signal Faces

A minimum of two signal faces is required for the through movement. This total includes the through signal face belonging to the 5-section "shared" head that may control adjacent left or right turn lanes. When possible, one signal face should be used for each exclusive turn lane. On approaches with multiple through lanes, or a through lane and a shared through-turn lane, one signal face should be used for each through lane.



The display shown has two signal heads each of which is comprised of two signal faces for a total of four signal faces. The two faces with CIRCULAR displays belong to the through move, and each face with ARROWS belong to the left and right turn moves. Since the two center faces control the through (major) movement, it is in conformance with the above requirement.

Clarification: A 5-section head is an assembly of two signal faces which share a common CIRCULAR RED indication.

Per Section 4D.11 of the 2009 MUTCD, if the 85th percentile, posted, statutory, or design speed is 45 MPH or more, one signal head should be used per each through lane on the approach.

General Guidelines for Signal Head Usage

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO. **3.0.2**

Use of Flashing YELLOW ARROW Signal Heads for Left Turns

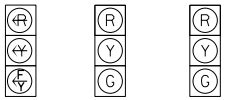
A flashing YELLOW ARROW (FYA) face is the preferred signal display for exclusive permissive left turns in North Carolina. While comparable to a CIRCULAR GREEN in meaning and use, the flashing YELLOW ARROW has proven in studies to have better driver comprehension and compliance and a safer crash record. The flashing YELLOW ARROW is an exclusive display for turning vehicles and should be used for an exclusive left turn lane whenever a permissive left turn is allowed.

If a left turn operates only in permissive mode and has an exclusive turn lane, a 3-section signal head with a flashing YELLOW ARROW in the bottom section should be used. If a left turn is to operate in a protected/permissive or variable (alternate) phasing mode, where both protected and permissive left turn movements may be allowed, a 4-section signal head should be used. In some cases, a 3-section bi-modal signal face may be used in place of a 4-section signal head for a protected/permissive left turn.

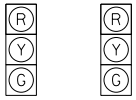
The flashing YELLOW ARROW head should be centered over the exclusive left turn lane(s). Note that the flashing YELLOW ARROW head is an exclusive head for controlling the left turn, and at least two (2) signal heads are still required for the through movement. A flashing YELLOW ARROW display cannot be used for a permissive left turn when the left turn is part of combined through and left turn lane. When FYAs are used for left turns, the yellow and red clearance times should be the same for concurrent through phases (2+6 and/or 4+8).

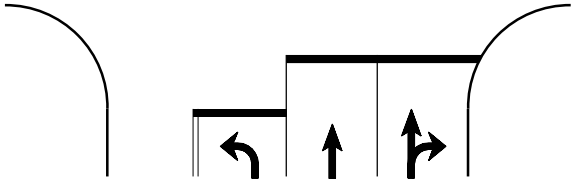
In limited cases where a flashing YELLOW ARROW is not used for the permissive left turn display, a shared 3-section head of CIRCULAR displays may be used. When used, the 3-section CIRCULAR display head should be located on the lane line between the exclusive left turn and through (or shared through-right) lane.

Flashing YELLOW ARROW Head for Left Turn



Shared CIRCULAR GREEN for Permissive Left Turn



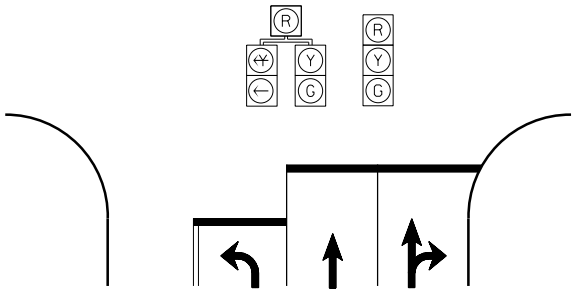


Flashing YELLOW ARROW displays for left turns shall be used when possible:

- When the turn lanes are offset (separated) from the through lanes
- When the opposing travel lanes use (3-section or 4-section) FYAs, are fully protected (single or dual) lefts, or other situations where signal phasing may allow for a lagging protected left turn and/or a "yellow trap" may otherwise be an issue during clearance.
- Where turning vehicles may conflict with pedestrians in a crosswalk
- Along corridors, where other FYA displays are used for left turns
- To reinforce, along with a sign, a mandatory turn is required from an extended lane or a "lane drop" situation, or where a turn is required but the lane may continue beyond the intersection.
- At Railroad Preempt locations, which may eliminate the need for blankout signs.

Use of 5–Section Left Turn Signal Faces

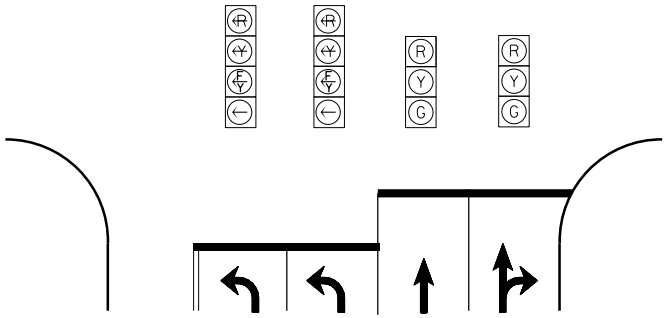
Traditionally, a 5-section "doghouse" head has been used for protected/permissive left turning movements. This head uses a combination of CIRCULAR and ARROW displays, and is often used as a "shared" head between the turning movement and the through movement, although the head has also been used exclusively for the turning left movement.



The 5-section head has a combination of ARROW and CIRCULAR displays, all of which work to control the left turn movement. When mounted over a lane line and used as a shared head, the CIRCULAR displays also serve to control the through (major) movement, counting as one of the two signal faces required for the through (major) movement. In limited situations, it may be necessary to use the 5-section head for protected/permissive left turn movements. When used, it should be part of a shared head arrangement. In no case should a 5-section head be used as exclusive head to control a left turn movement.

Protected/Permissive Dual Left Turn Signal Display

Dual Left Turns have traditionally always operated in a protected only mode. In some situations, it may be advantageous to operate a dual left turn in a protected/permissive mode without sacrificing safety. If used, the protected/permissive mode should be part of an Alternate Phasing option that also includes an option for protected only left turns if needed.



Protected/Permissive Dual Lefts may be considered:

- Good Sight Distance of Opposing Traffic
- Opposing Speed ≤ 45 MPH
- 2 or Fewer Opposing Through or Through/Right Lanes
- Low Opposing Volume or Cross Product
- No Pedestrian Conflicts with Permissive Turn Mode

The use of Protected/Permissive Dual Left Phasing must be approved by:

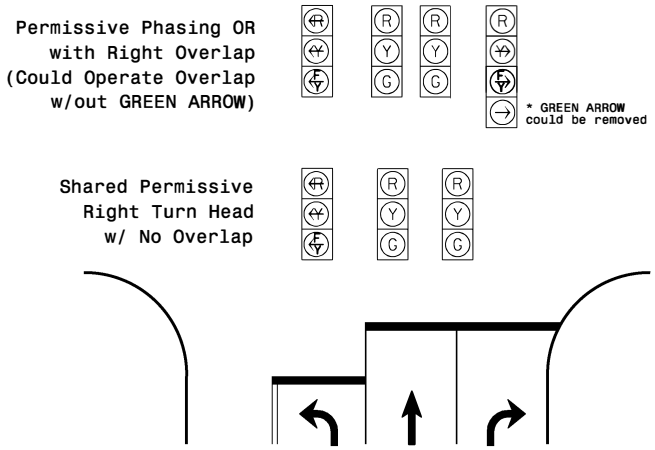
- State Signals Engineer
- Regional Traffic Engineer
- Division Traffic Engineer
- Municipal Traffic Engineer, if applicable

Use of Flashing YELLOW ARROW Signal Heads for Right Turns

A Flashing YELLOW ARROW (FYA) face is the preferred signal display for exclusive permissive right turns in North Carolina. While comparable to a CIRCULAR GREEN in meaning and use, the flashing YELLOW ARROW has proven benefits over the use of the CIRCULAR GREEN display for permissive turns. The flashing YELLOW ARROW is intended to be an exclusive display for turning vehicles and should be used for an exclusive right turn lane whenever a permissive right turn is allowed. While the flashing YELLOW ARROW is the preferred display for a permissive right turn, it is still acceptable to use a shared CIRCULAR GREEN display for a permissive right turn in an exclusive turn lane. When a CIRCULAR GREEN display is used, it should be in a shared signal head mounted over the lane line.

If a right turn operates only in permissive mode and has an exclusive turn lane, a 3-section signal head with a flashing YELLOW ARROW in the bottom section should be used. If a right turn operates in a protected/permissive mode, also known as overlap with an adjacent protected left turn, a 4-section signal head may be used. In some cases, a 3-section bi-modal signal head may be used in place of a 4-section signal head. In addition, in some situations where a right overlap movement is used, a flashing YELLOW ARROW display may be used for the overlap. In these situations, a 3-section head may be used instead of a 4-section head, as the GREEN ARROW is not displayed.

The flashing YELLOW ARROW head should be centered over the right turn lane(s). Note that the flashing YELLOW ARROW face is an exclusive display for controlling the right turn, and 2 signal heads containing CIRCULAR RED, YELLOW, and GREEN displays are still required for the through movement. A flashing YELLOW ARROW display cannot be used for a permissive right turn when the right turn is part of a combined through and right turn lane.



Flashing YELLOW ARROW displays for right turns should be used:

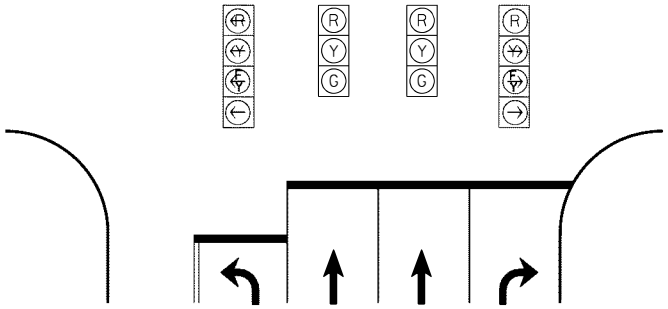
- When the turn lanes are offset (separated) from the through lanes
- Where turning vehicles in an exclusive turn lane may conflict with pedestrians in a crosswalk
- For right overlaps if the right turn has to yield to any conflicting U-Turn movements
- To reinforce, along with a sign, a mandatory turn is required from an extended right lane or a "lane drop" situation, or where a turn is required but the lane may continue beyond the intersection
- At Railroad Preempt locations, which may eliminate the need for blankout signs

Use of 5–Section "Doghouse" Signal Head for Right Turns

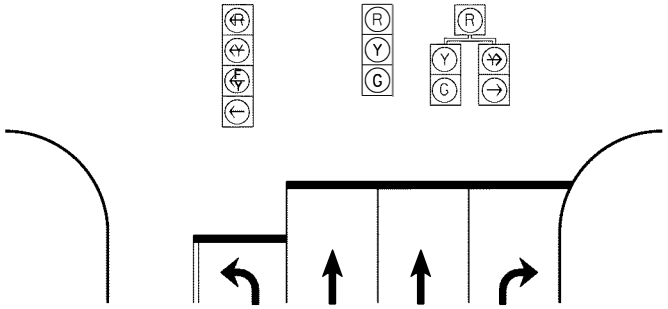
A 5-section "doghouse" head has previously been used for protected/permissive turning movements (a right turn overlap). While the flashing YELLOW ARROW (FYA) is the preferred display for right turns, it may not always be possible to use this display. Some signal cabinets are limited by the number of load switches available to monitor displays and outputs. Most cabinets have load switches to only support the use of 4 FYA displays, which normally require 2 load switches per FYA. Since left turns are typically exposed to more conflicts, priority is given to using FYAs for left turn displays. When multiple phases use FYAs for left turns, there is typically not enough load switches remaining to support FYA right turn displays. As a result, the 5-section "doghouse" display is still used for many right turn overlaps.

The 5-section head is an assembly of 2 signal faces, a combination of ARROW and CIRCULAR displays but share a common CIRCULAR RED indication, all of which work to control the designated turn movement. When used, the head should be mounted over the lane line and be used as part of a shared head arrangement. When used as a shared head, the CIRCULAR displays also serve to control the through (major) movement, counting as one of the two signal faces required for the through (major) movement. As noted, it may often be necessary to use the 5-section head for right turn overlap movements. A 5-section head should not be used as an exclusive head to control a right turn movement.

Flashing YELLOW ARROW for Right Turn



5-Section Head for Right Turn



In the cases shown in Std. 3.2, the Flashing YELLOW ARROW signal heads for right turns are the preferred display. A shared 5-section display may be used for the right turn if needed. In most situations, for consistency, do not mix right turn flashing YELLOW ARROW displays and 5-section heads at the same intersection.

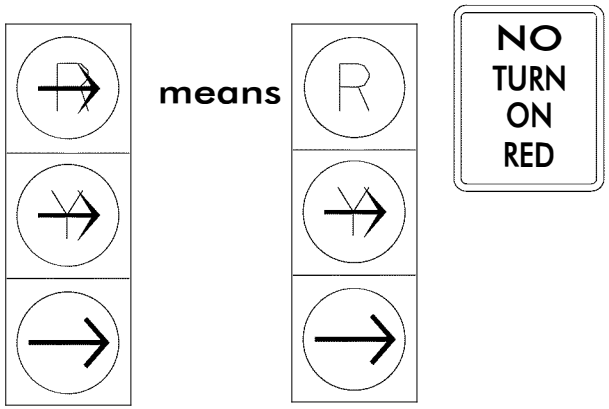
Use of CIRCULAR RED vs. RED ARROW

(Section 4D.04 of the 2009 MUTCD)

In accordance with NC General Statute 20-158, vehicles facing a steady red light (signal) shall stop at the marked stop line and shall remain stopped until a signal indication to proceed is displayed unless the vehicle is turning right. A vehicle is permitted to make a right on red, subject to applicable traffic laws and yielding the right of way to other roadway users, unless a traffic control device, such as a sign, is in place prohibiting a turn on red. This statute does not distinguish between a CIRCULAR RED and a RED ARROW display.

In compliance with the MUTCD, vehicles facing a steady RED ARROW signal display shall stop at the marked stop line and shall remain stopped until a signal indication to proceed is displayed. A vehicle shall NOT make a turn on a (left or right) RED ARROW. In North Carolina, vehicles are prohibited from making a left turn on red from a one way street onto another one way street at all times.

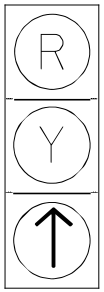
It shall be NCDOT practice to display a CIRCULAR RED indication whenever possible and allow right turns on red unless otherwise prohibited. This may include the use of a CIRCULAR RED in a signal head otherwise containing a steady GREEN ARROW and/or flashing YELLOW ARROW and a steady YELLOW ARROW indication.



RED ARROWs for right turns should only be used in special situations, after approval from the Signal Design Section, such as:

- The right turn movement shall have a full time No Turn on Red restriction.
- At an intersection with preemption
- Where the signal phasing might allow for the right turn display to be different than the adjacent through movement (the Right Turn signal displays Red while the adjacent through movement heads display Green)
- If the display of a CIRCULAR RED might otherwise require louvers or the use of a "RIGHT TURN SIGNAL" (R10-10R) sign.

Use of Straight–Through GREEN ARROW

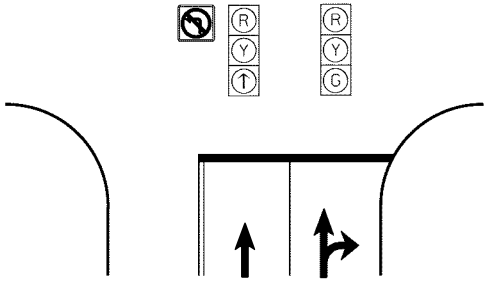


As provided in Section 4D.05 of the MUTCD, a steady straight-through GREEN ARROW may be used instead of a CIRCULAR GREEN display on an approach to discourage a turn that would be a wrong way movement:

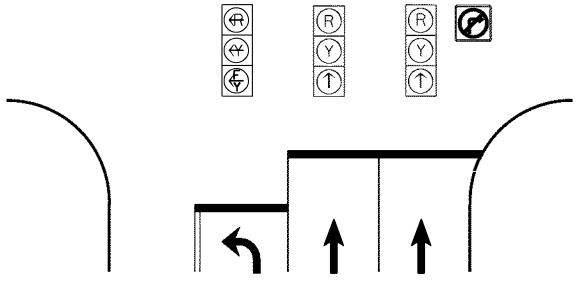
- On an approach intersecting a one way street
- On an approach intersecting a (freeway) interchange exit ramp
- On an approach with a unique geometric design that prohibits turns
- Other locations where a right and/or left turn is prohibited or not possible.

The use of a straight-through GREEN ARROW shall be in a 3-section head that use CIRCULAR YELLOW and CIRCULAR RED sections. The use of a signal head(s) with a straight-through GREEN ARROW may be displayed with an adjacent signal head using all CIRCULAR displays and count as one of the required through heads for that approach. If no turns are allowed or possible on an approach at an intersection, all of the required signal heads for that approach may display a straight-through GREEN ARROW in place of a CIRCULAR GREEN. The use of a straight-through GREEN ARROW signal display shall be a supplement to any required turn prohibition signs posted at the intersection.

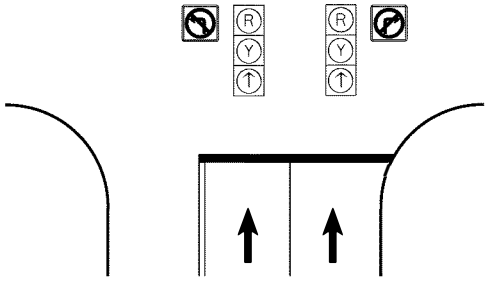
A single-section straight-through GREEN ARROW may be used over a lane or approach that has no vehicle or pedestrian conflicts and is otherwise free flow with no stopping or yielding (as opposed to remaining unsignalized), however, these single-section GREEN ARROW displays are rarely used in North Carolina.



No Left Turn Allowed

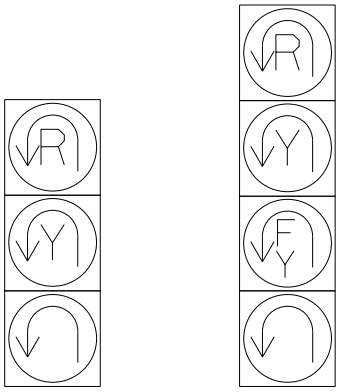


No Right Turn Allowed
Inside Thru Lane Could
Also Display CIRCULAR GREEN



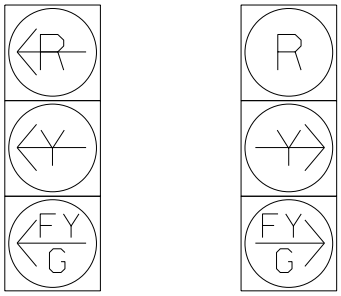
No Turns Allowed
(Sign R3-3 may be used in
place of R3-1 and R3-2 signs)

Use of U–Turn Display and Bi–Modal Signal Faces



U–Turn Signal Displays

A U-Turn Display should be used for any lane that is designated exclusively for a U-Turn move. No other movement should be allowed from that lane. If used, a U-TURN ARROW should used in place of all corresponding left or right turn steady or flashing ARROW sections in that signal face and have the same meaning as the turn ARROW of the same color, except that a CIRCULAR RED display may still be used in a right turn head.



Bi–Modal Signal Display

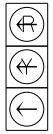
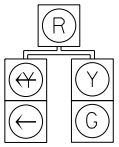
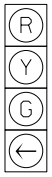
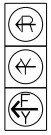
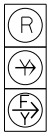
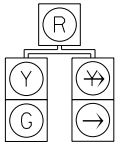
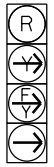
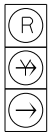
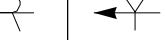
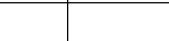
The 3-section bi-modal signal display is an alternative protected/permissive display to the 4-section head. It should be used when a protected/permissive display with a Flashing YELLOW ARROW is desirable, but use of a 4-section head is not practical:

- Vertical Clearance Issues where a 4-section head would be too low to clear traffic and the span can not be raised
- Other overhead utility conflicts prevent the use of a 4-section head
- Existing metal pole and/or mast arm loadings that do not support the additional load of a 4-section head.

When used, the bi-modal section shall be the bottom section, capable of displaying both a Flashing YELLOW ARROW and steady GREEN ARROW, though not simultaneously. The steady YELLOW ARROW (middle) section shall not be used for a Flashing YELLOW ARROW in a bi-modal display.

Programming for Flashing Operation of Signal Heads

Signals may flash during certain types of malfunctions or equipment failures. For statewide consistency, traffic signal heads should be set to flash the displays shown in the event of flashing operation:

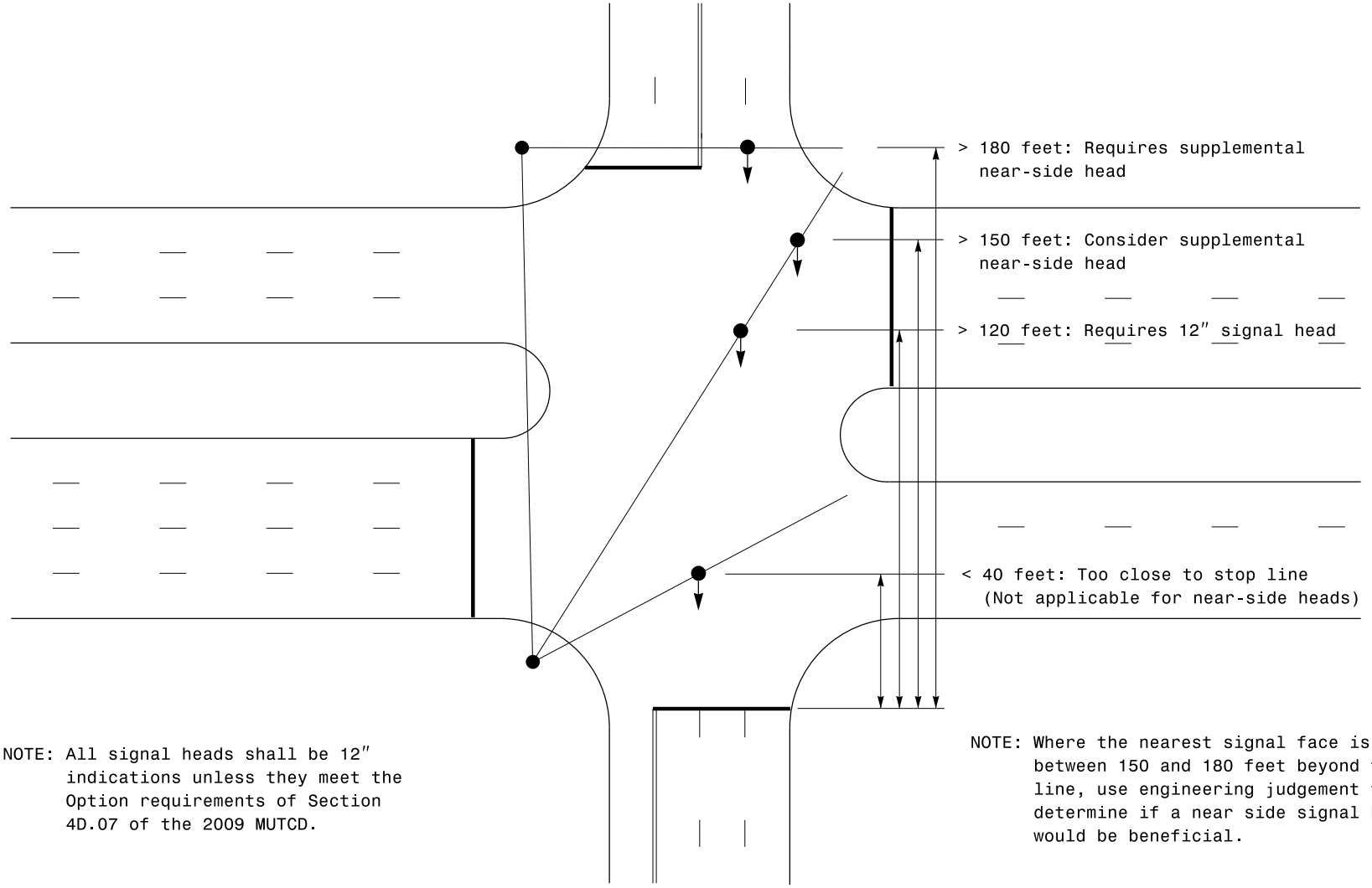
SIGNAL HEAD										
MAJOR STREET										
MINOR STREET										

Flashing display does not change if a RED ARROW is used in place of a CIRCULAR RED for right turn displays.

Program all signal heads on the same approach to flash concurrently.

At some intersections, such as those utilizing Railroad Preemption, engineering judgement may be used to modify or alter the flashing operation. This modification may include flashing the minor street through movements yellow and the main street red or using a red flash on all approaches (equivalent of an all way stop).

Allowable Signal Head Distance from Stop Line



NOTE: All signal heads shall be 12″ indications unless they meet the Option requirements of Section 4D.07 of the 2009 MUTCD.

NOTE: Where the nearest signal face is located between 150 and 180 feet beyond the stop line, use engineering judgement to determine if a near side signal head would be beneficial.

Reference: Section 4D.14 of the 2009 MUTCD.

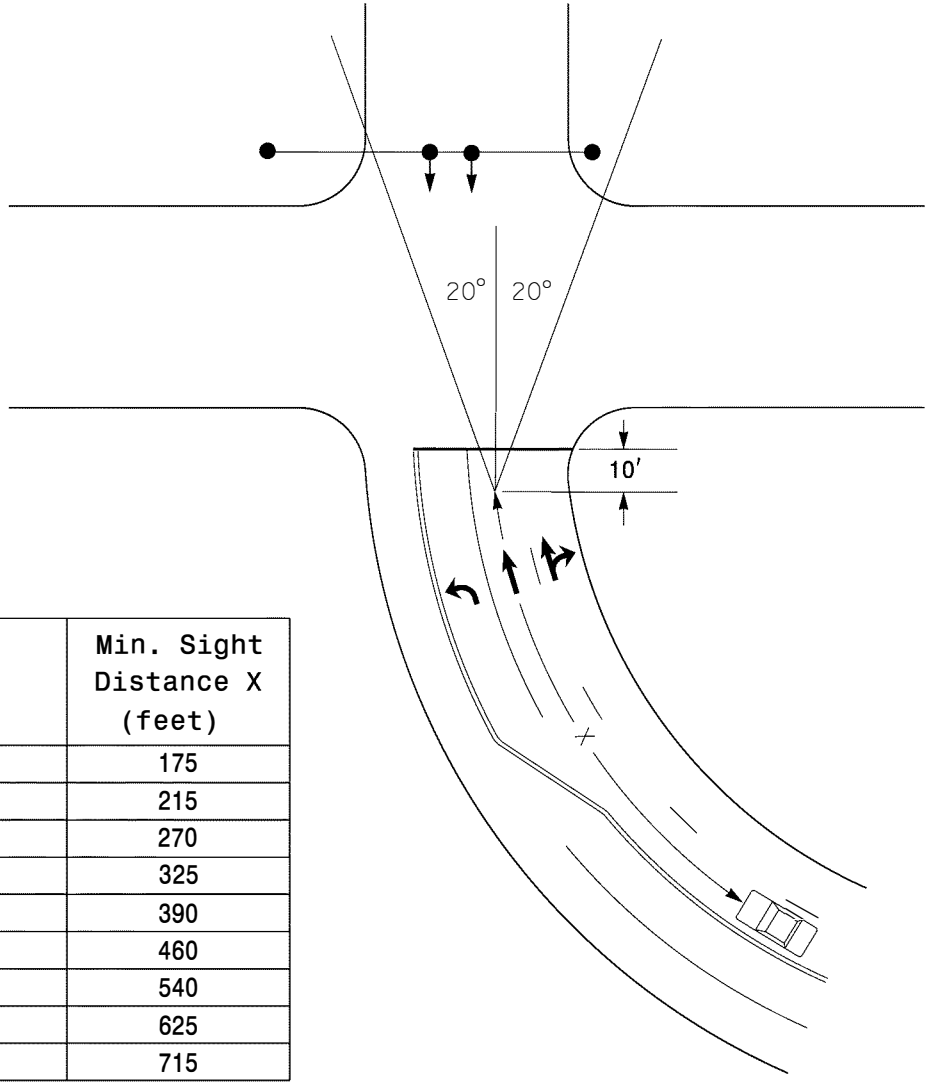
MUTCD Requirements for Signal Heads

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

7-21

STD. NO.
3.1
SHEET 1 OF 2

Signal Face Visibility Parameters



Speed (MPH)	Min. Sight Distance X (feet)
20	175
25	215
30	270
35	325
40	390
45	460
50	540
55	625
60	715

To conform to Section 4D.13 of the 2009 MUTCD, locate one, and preferably both, signal heads within a cone of vision extending 20 degrees to the left and right of the centerline of all the approach lanes in the direction of travel.

To conform to Section 4D.12 of the 2009 MUTCD, the driver should be able to continuously view the signal face from the minimum sight distance for the 85th percentile speed.

Where this visibility requirement cannot be met, erect a suitable sign (such as a Signal Ahead Sign) to warn approaching traffic (Section 4D.12 of the 2009 MUTCD) or install a supplemental near side head.

Reference: Table 4D-2 of the 2009 MUTCD.

MUTCD Requirements for Signal Heads

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

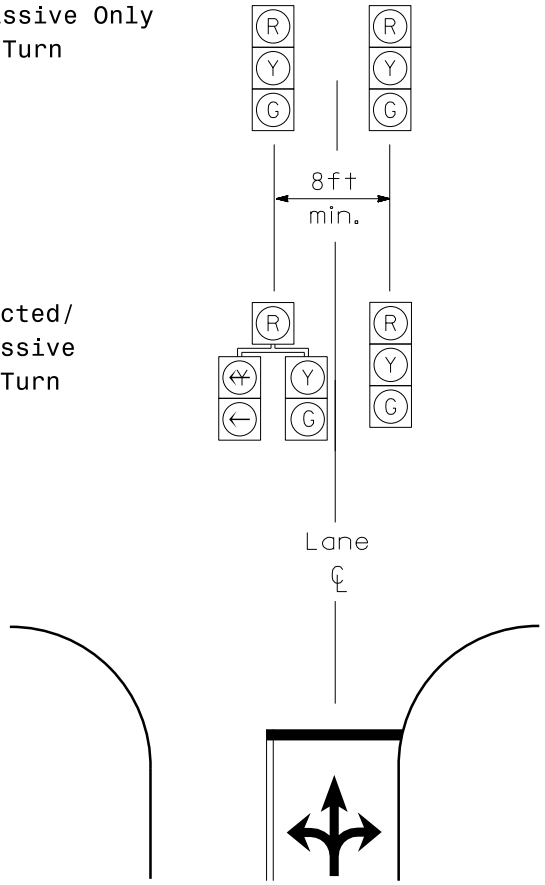
STD. NO.
3.1
SHEET 2 OF 2

CASE 1

Standard Main or Side Street Signal Head Configuration

1A - Permissive Only Left Turn

1B - Protected/ Permissive Left Turn



CASE 2

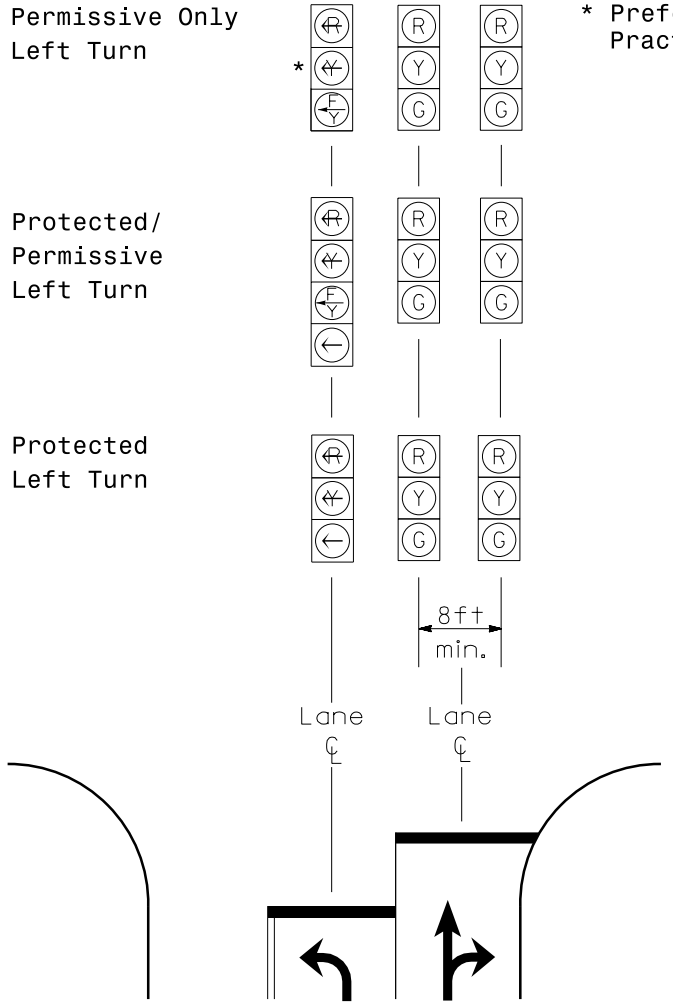
Standard Main or Side Street Signal Head Configuration

2A - Permissive Only Left Turn

2B - Protected/ Permissive Left Turn

2C - Protected Left Turn

* Preferred Practice



Signal Head Approach Displays and Alignment

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

7-21

STD. NO.
3.2

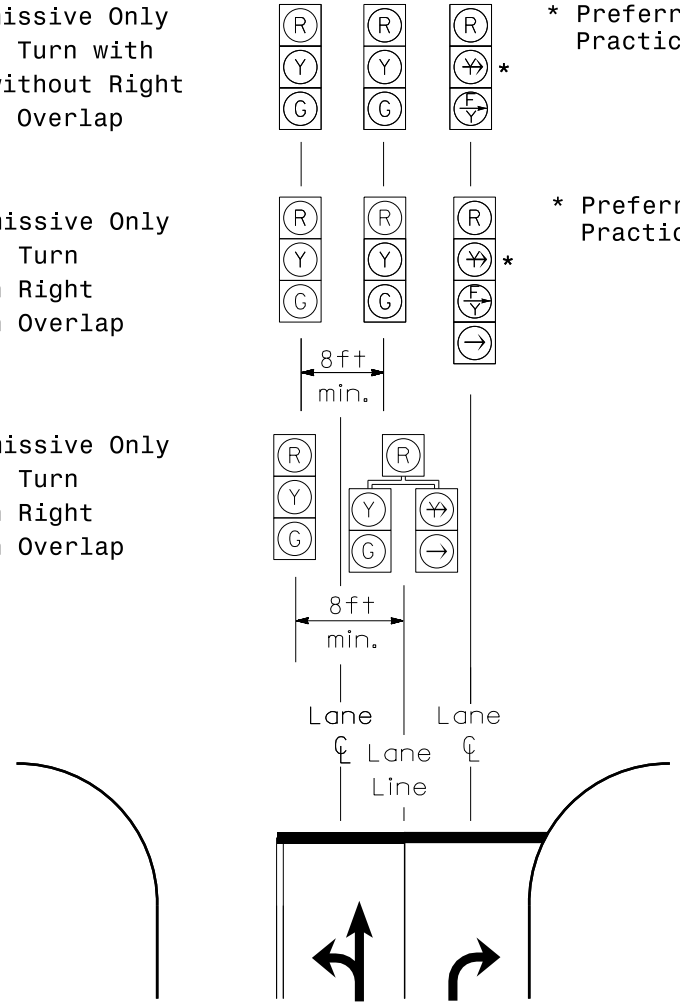
CASE 3 (1 OF 2)

Standard Main or Side Street Signal Head Configuration

3AF - Permissive Only Left Turn with or without Right Turn Overlap

3AP - Permissive Only Left Turn with Right Turn Overlap

3AR - Permissive Only Left Turn with Right Turn Overlap



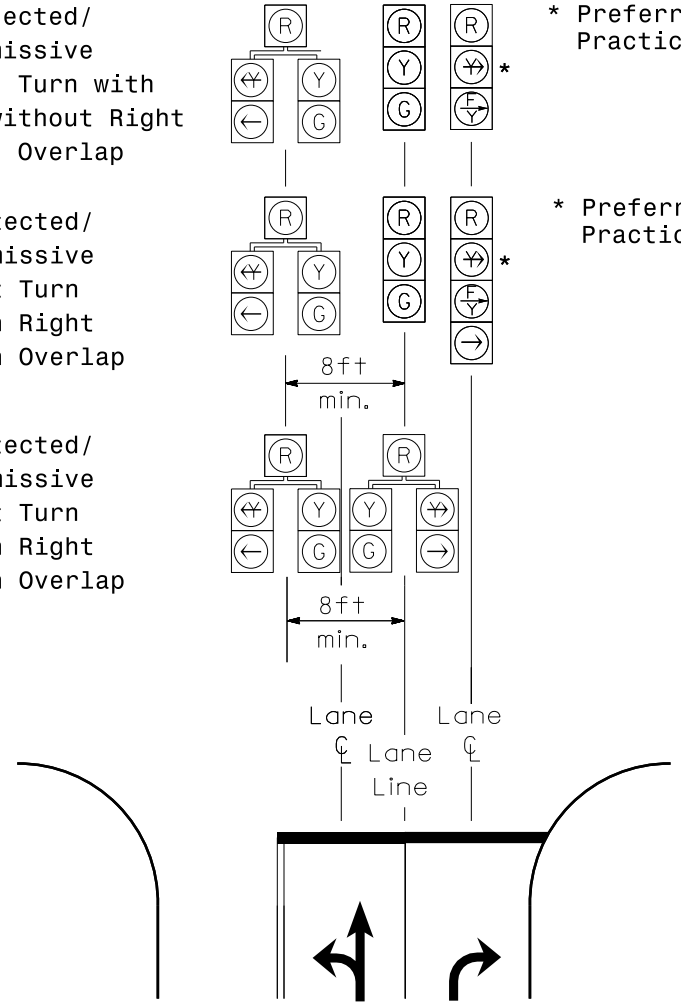
CASE 3 (2 OF 2)

Standard Main or Side Street Signal Head Configuration

3BF - Protected/ Permissive Left Turn with or without Right Turn Overlap

3BP - Protected/ Permissive Left Turn with Right Turn Overlap

3BR - Protected/ Permissive Left Turn with Right Turn Overlap



Signal Head Approach Displays and Alignment

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

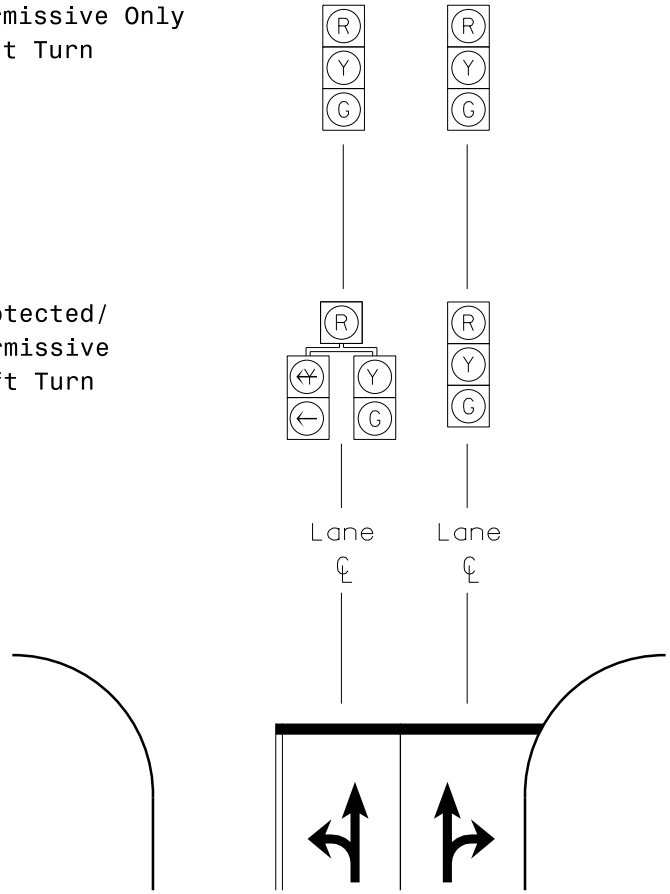
STD. NO. 3.2

CASE 4

Standard Main or Side Street Signal Head Configuration

4A - Permissive Only Left Turn

4B - Protected/ Permissive Left Turn



CASE 5 (1 OF 3)

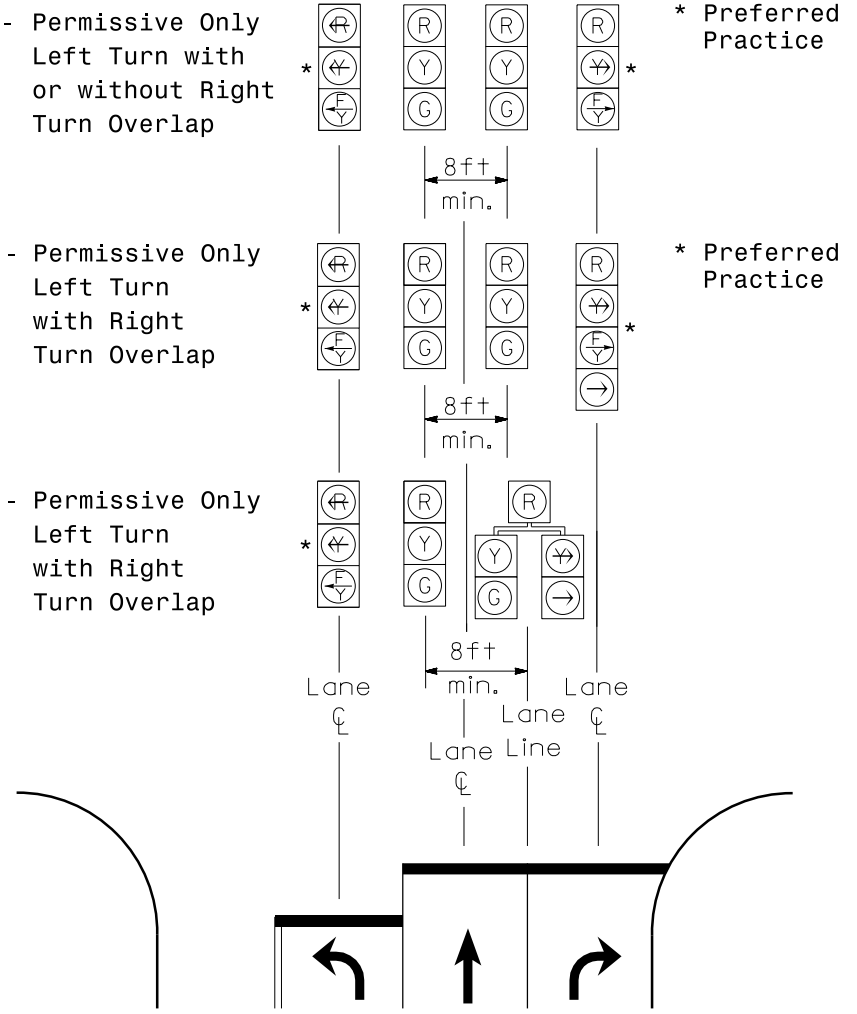
Standard Main or Side Street Signal Head Configuration

5AF - Permissive Only Left Turn with or without Right Turn Overlap

5AP - Permissive Only Left Turn with Right Turn Overlap

5AR - Permissive Only Left Turn with Right Turn Overlap

* Preferred Practice



Signal Head Approach Displays and Alignment

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

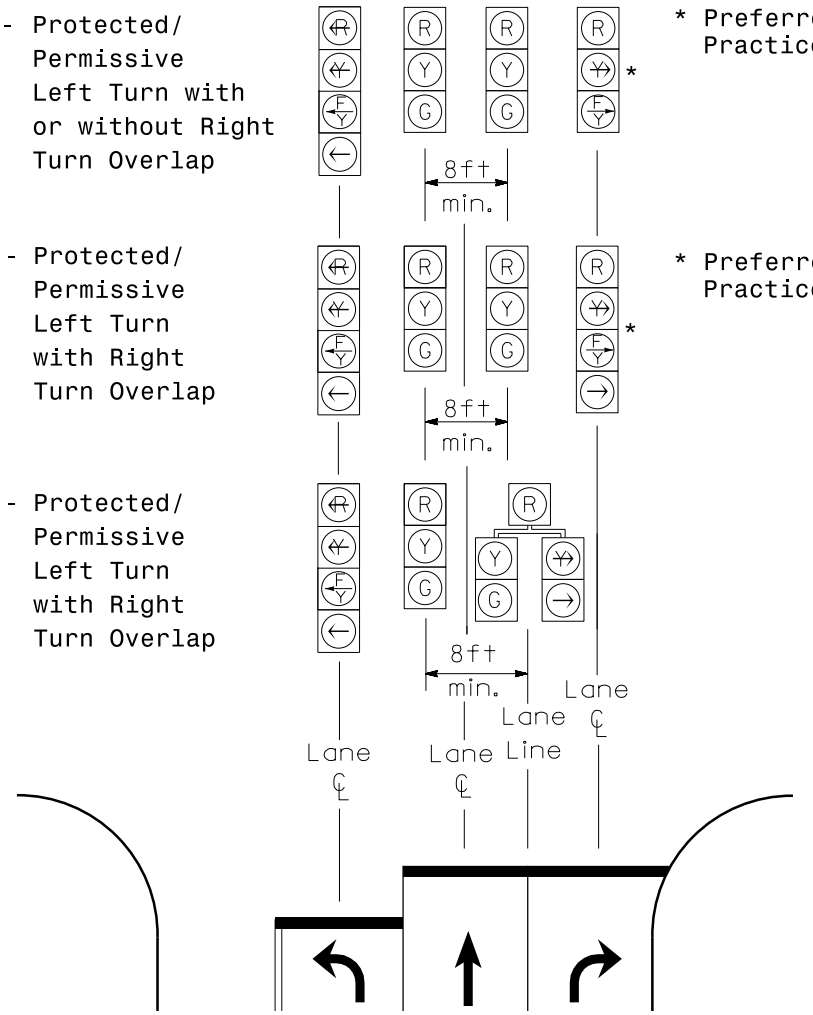
CASE 5 (2 OF 3)

Standard Main or Side Street Signal Head Configuration

5BF - Protected/ Permissive Left Turn with or without Right Turn Overlap

5BP - Protected/ Permissive Left Turn with Right Turn Overlap

5BR - Protected/ Permissive Left Turn with Right Turn Overlap



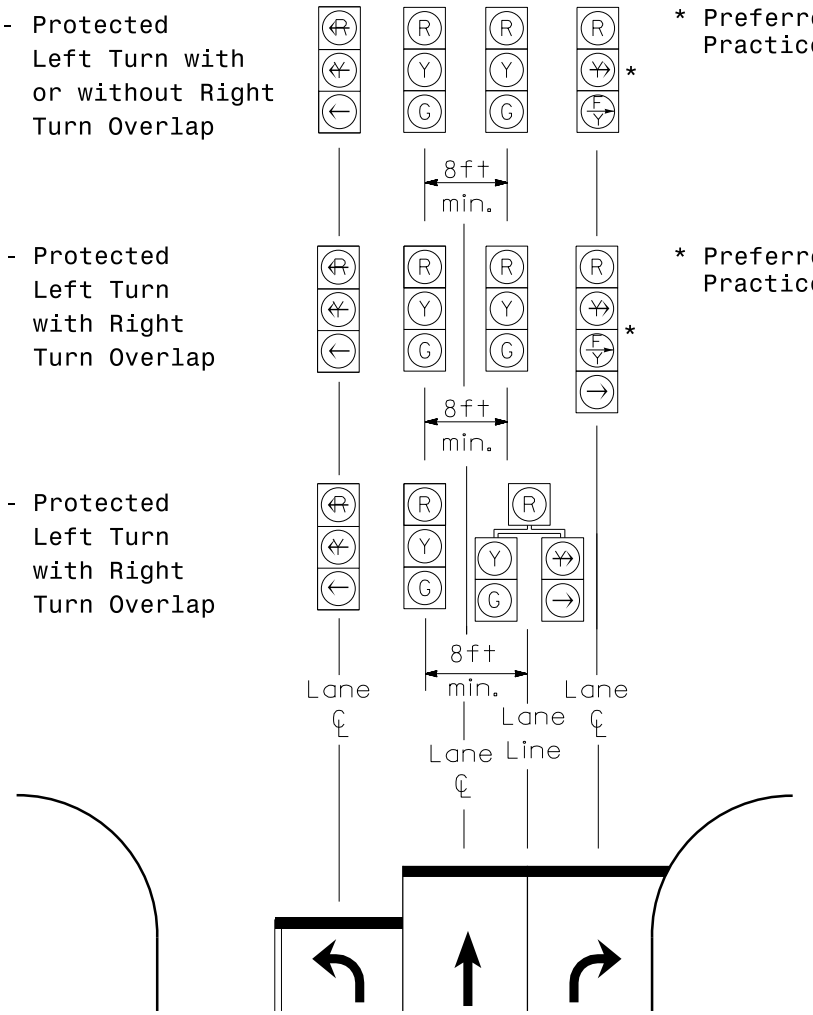
CASE 5 (3 OF 3)

Standard Main or Side Street Signal Head Configuration

5CF - Protected Left Turn with or without Right Turn Overlap

5CP - Protected Left Turn with Right Turn Overlap

5CR - Protected Left Turn with Right Turn Overlap



Signal Head Approach Displays and Alignment

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

CASE 6

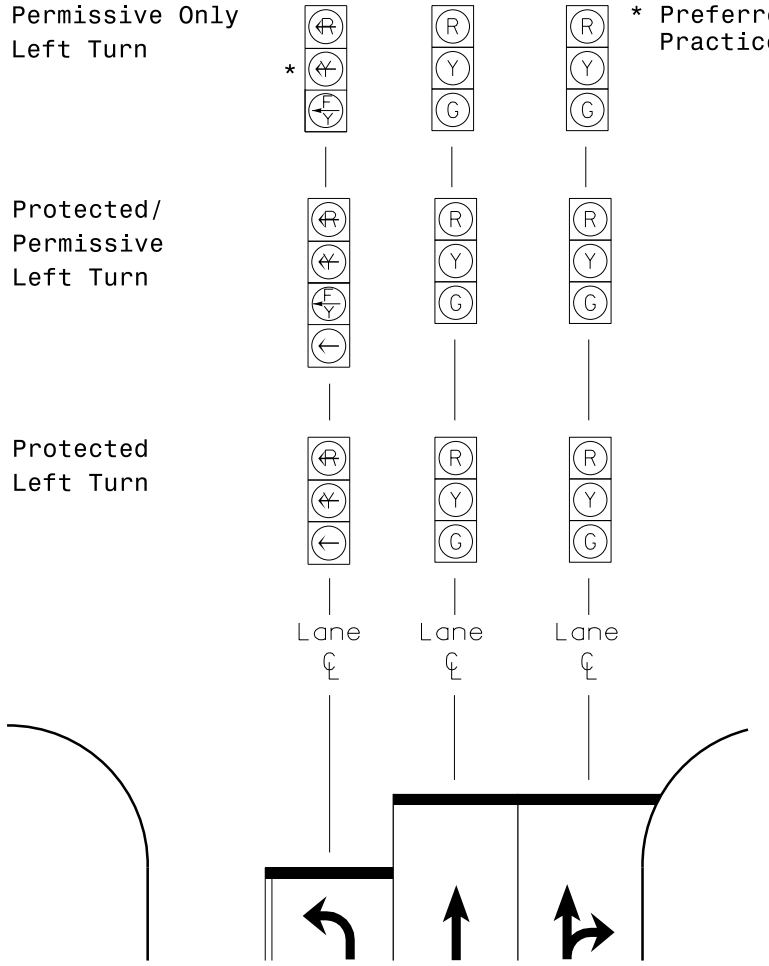
Standard Main or Side Street
Signal Head Configuration

6A - Permissive Only Left Turn

6B - Protected/ Permissive Left Turn

6C - Protected Left Turn

* Preferred Practice



CASE 7 (1 OF 3)

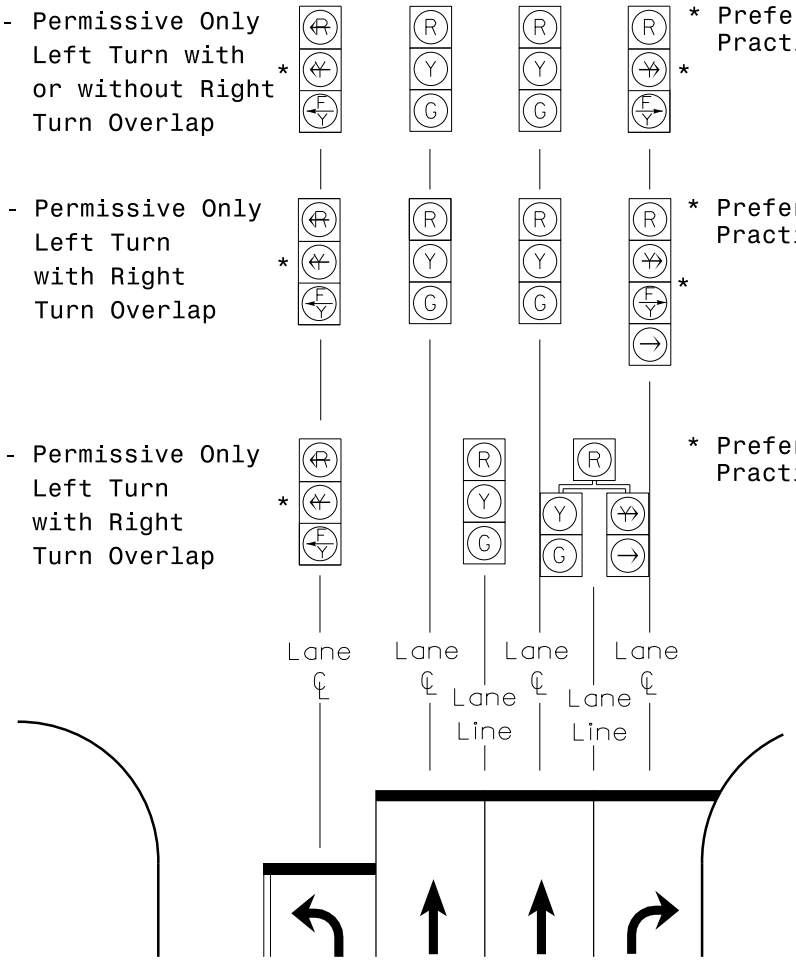
Standard Main or Side Street
Signal Head Configuration

7AF - Permissive Only Left Turn with or without Right Turn Overlap

7AP - Permissive Only Left Turn with Right Turn Overlap

7AR - Permissive Only Left Turn with Right Turn Overlap

* Preferred Practice



Signal Head Approach Displays and Alignment

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.
3.2

CASE 7 (2 of 3)

Standard Main or Side Street
Signal Head Configuration

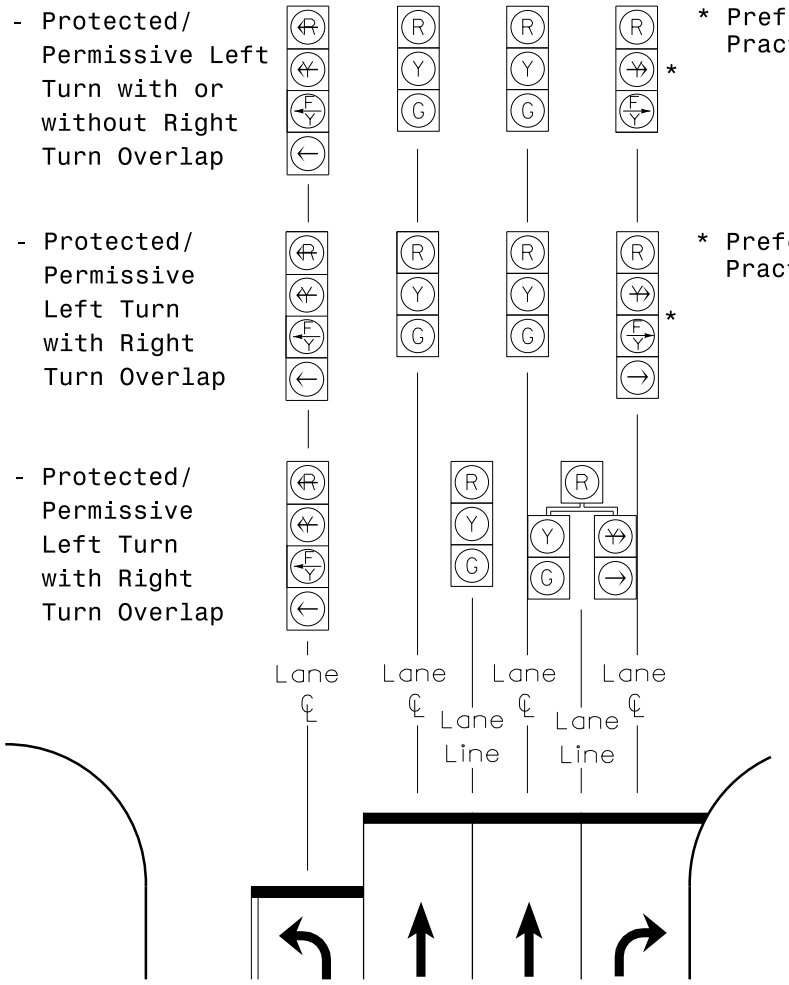
7BF - Protected/ Permissive Left Turn with or without Right Turn Overlap

7BP - Protected/ Permissive Left Turn with Right Turn Overlap

7BR - Protected/ Permissive Left Turn with Right Turn Overlap

* Preferred Practice

* Preferred Practice



CASE 7 (3 OF 3)

Standard Main or Side Street
Signal Head Configuration

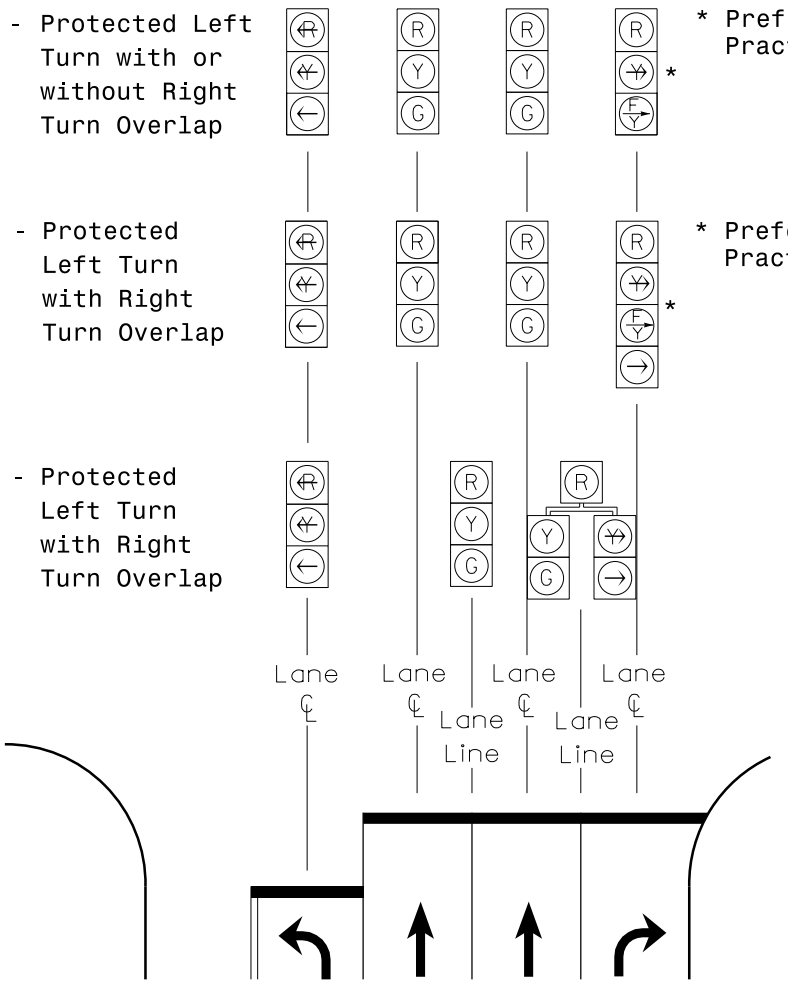
7CF - Protected Left Turn with or without Right Turn Overlap

7CP - Protected Left Turn with Right Turn Overlap

7CR - Protected Left Turn with Right Turn Overlap

* Preferred Practice

* Preferred Practice

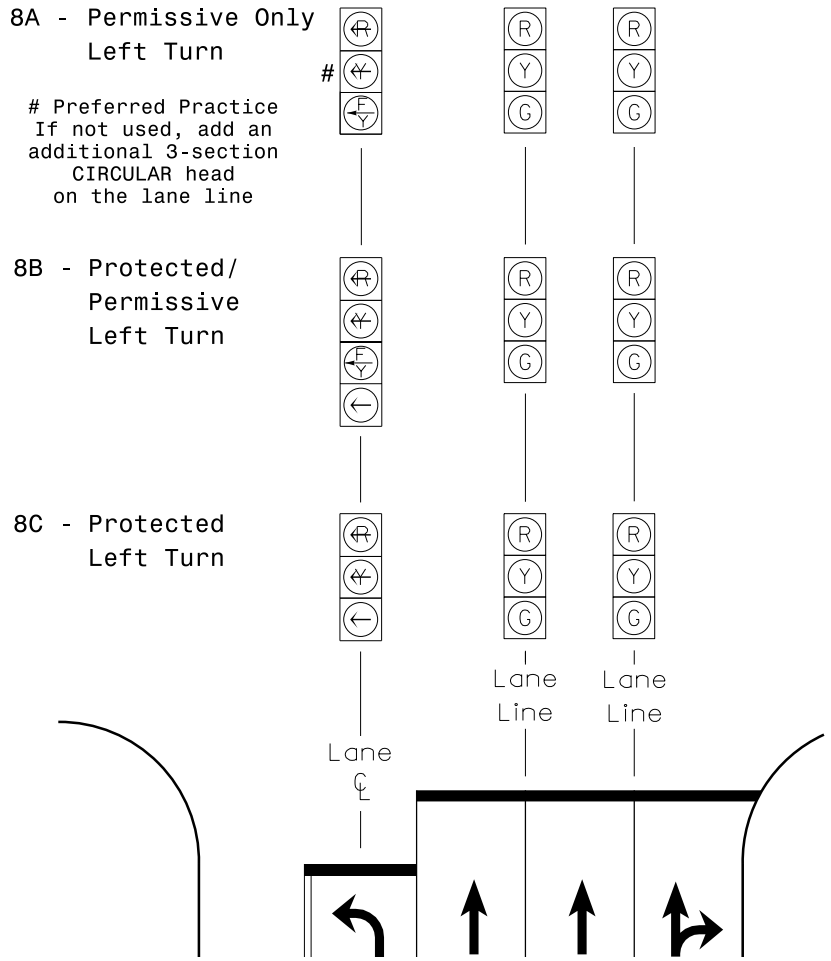


Signal Head Approach Displays and Alignment

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

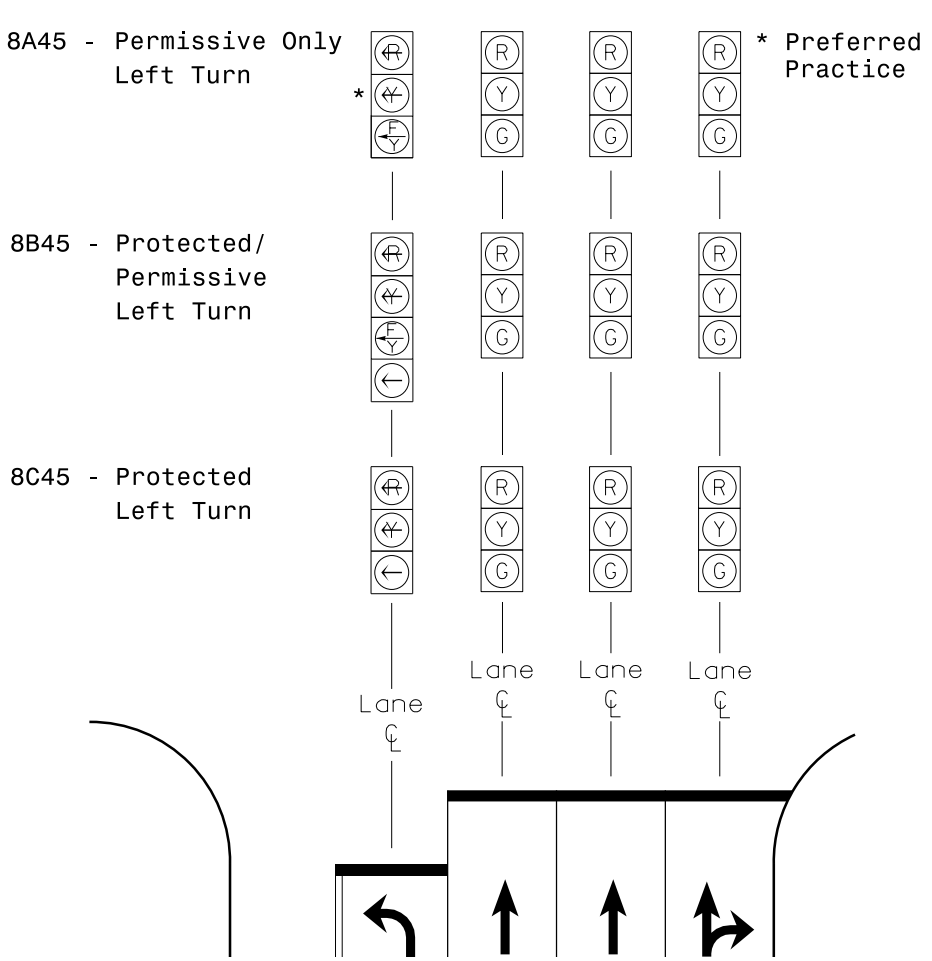
CASE 8 (1 OF 2)
(Speeds less than 45 MPH)

Standard Main or Side Street
Signal Head Configuration



CASE 8 (2 OF 2)
(Speeds 45 MPH or above)

Standard Main or Side Street
Signal Head Configuration



Signal Head Approach Displays and Alignment

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

CASE 9 (1 OF 3)

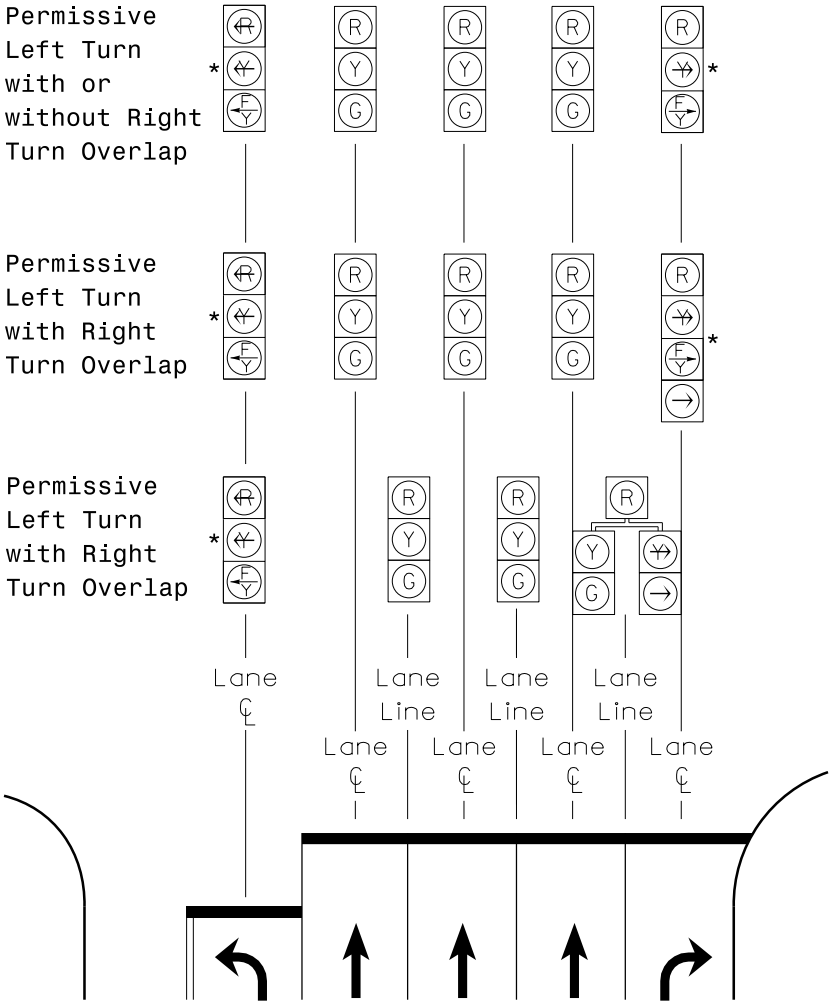
Standard Main or Side Street
Signal Head Configuration

* Preferred Practice

9AF - Permissive Left Turn with or without Right Turn Overlap

9AP - Permissive Left Turn with Right Turn Overlap

9AR - Permissive Left Turn with Right Turn Overlap



CASE 9 (2 OF 3)

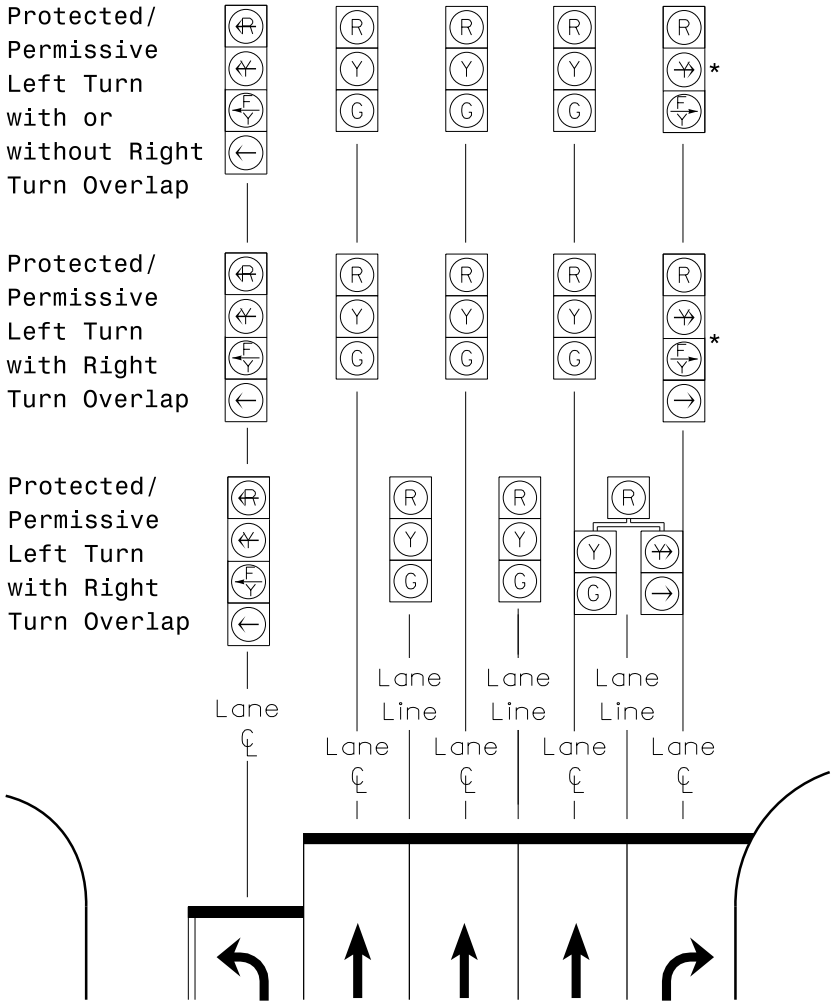
Standard Main or Side Street
Signal Head Configuration

* Preferred Practice

9BF - Protected/ Permissive Left Turn with or without Right Turn Overlap

9BP - Protected/ Permissive Left Turn with Right Turn Overlap

9BR - Protected/ Permissive Left Turn with Right Turn Overlap



Signal Head Approach Displays and Alignment

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.
3.2

CASE 9 (3 OF 3)

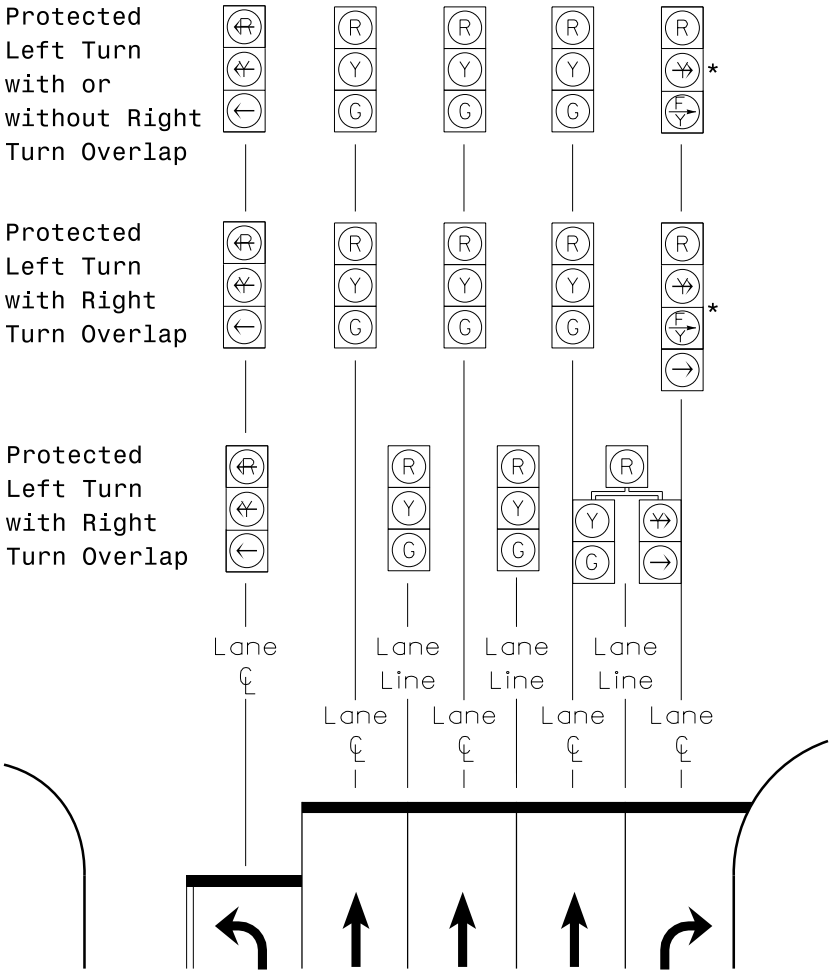
Standard Main or Side Street
Signal Head Configuration

* Preferred Practice

9CF - Protected Left Turn with or without Right Turn Overlap

9CP - Protected Left Turn with Right Turn Overlap

9CR - Protected Left Turn with Right Turn Overlap



CASE 10 (1 OF 2)

(Speeds less than 45 MPH)

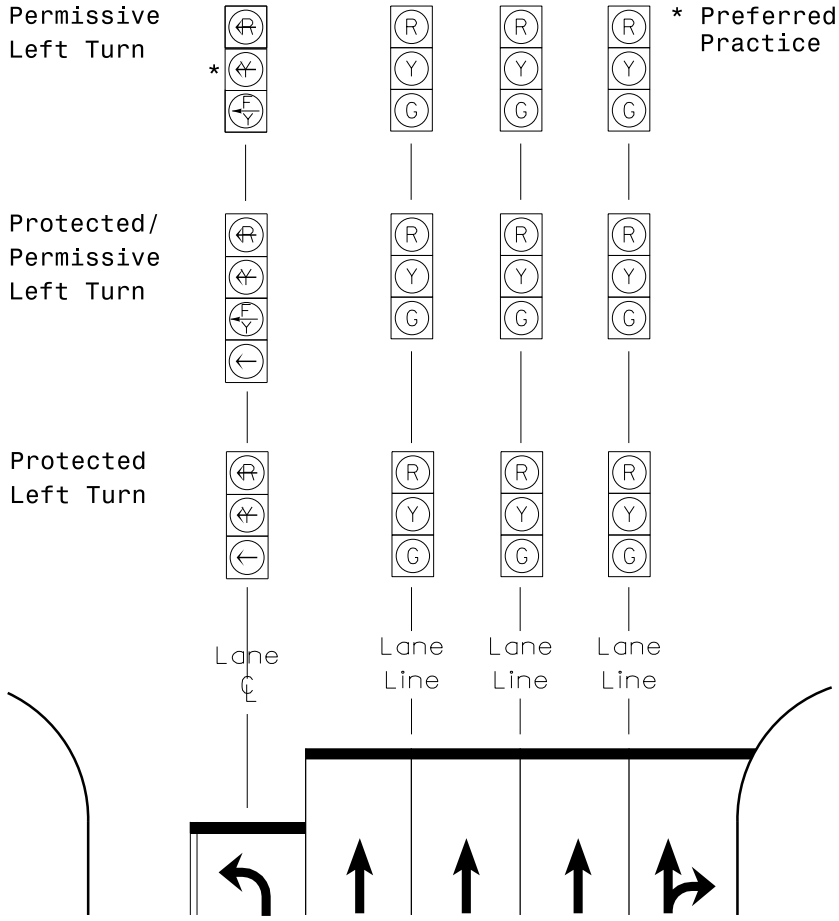
Standard Main or Side Street
Signal Head Configuration

* Preferred Practice

10A - Permissive Left Turn

10B - Protected/ Permissive Left Turn

10C - Protected Left Turn



Signal Head Approach Displays and Alignment

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

CASE 10 (2 OF 2)

(Speeds 45 MPH or above)

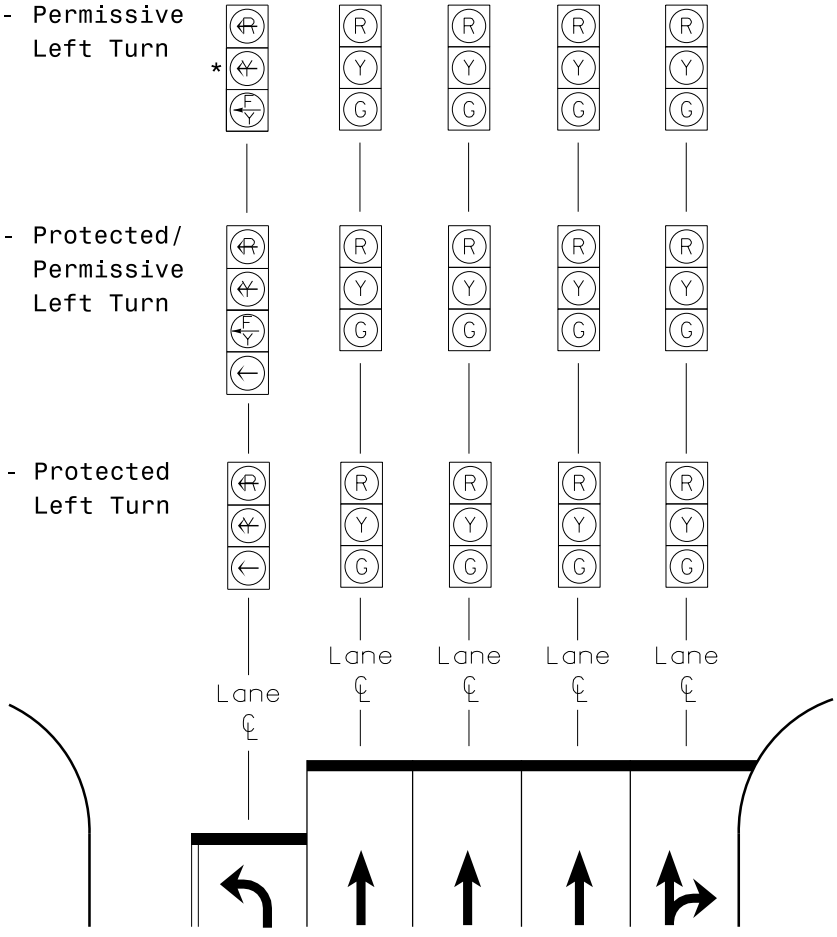
Standard Main or Side Street
Signal Head Configuration

* Preferred Practice

10A45 - Permissive Left Turn

10B45 - Protected/ Permissive Left Turn

10C45 - Protected Left Turn

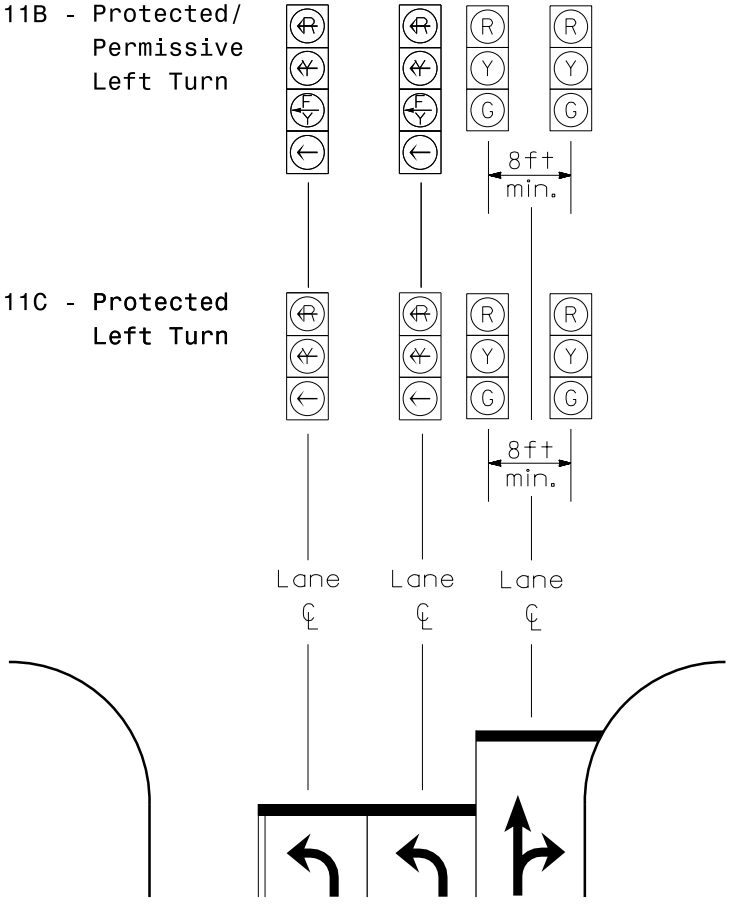


CASE 11

Main or Side Street
Signal Head Configuration
for Dual Left Turn Movements

11B - Protected/ Permissive Left Turn

11C - Protected Left Turn



Signal Head Approach Displays and Alignment

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

7-21

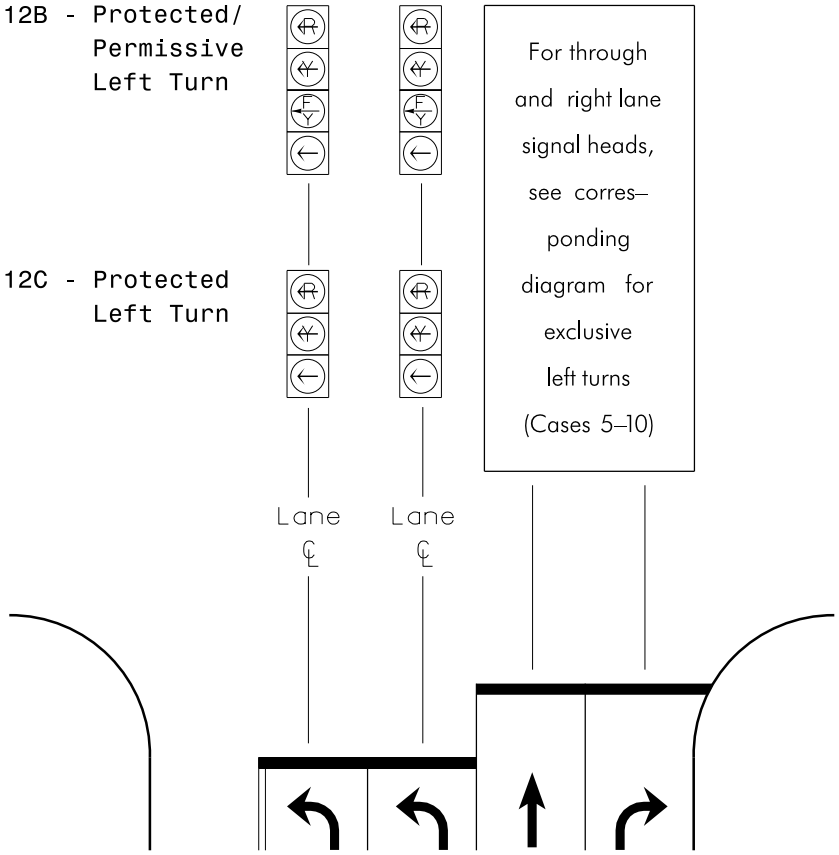
STD. NO.
3.2
SHEET 10 OF 29

CASE 12

Main or Side Street
Signal Head Configuration
for Dual Left Turn Movements

12B - Protected/
Permissive
Left Turn

12C - Protected
Left Turn



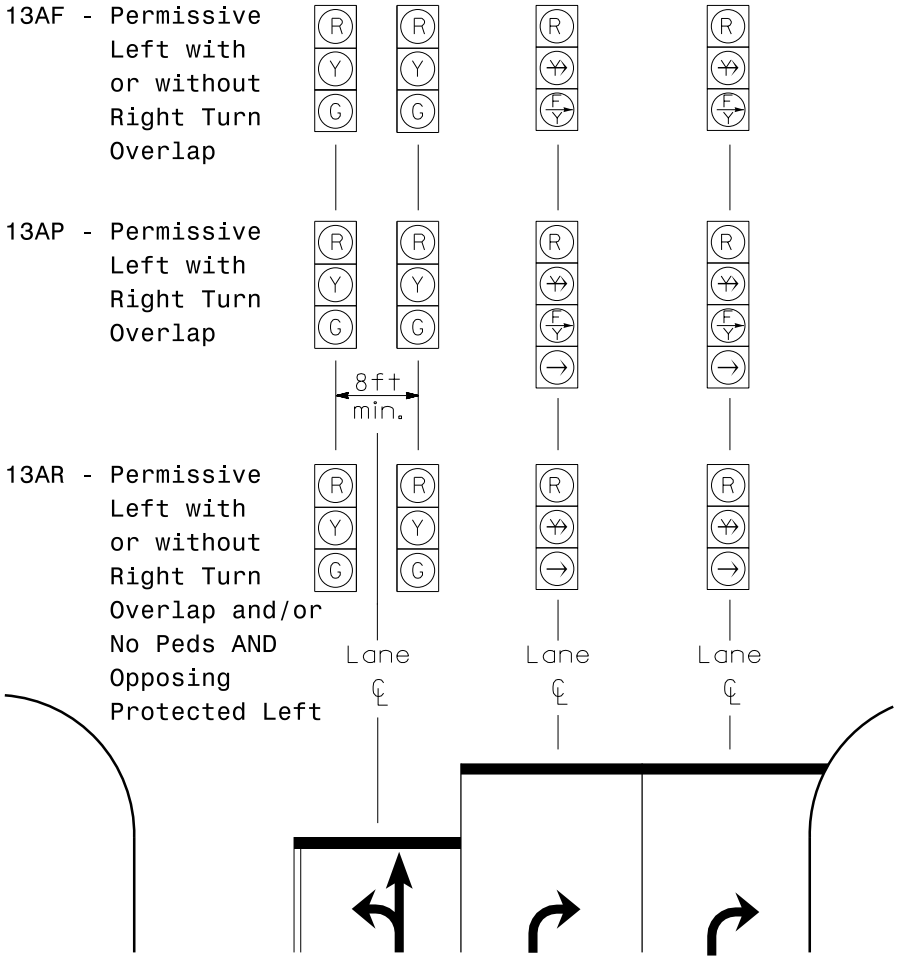
CASE 13

Main or Side Street
Signal Head Configuration
for Dual Right Turn Movements

13AF - Permissive
Left with
or without
Right Turn
Overlap

13AP - Permissive
Left with
Right Turn
Overlap

13AR - Permissive
Left with
or without
Right Turn
Overlap and/or
No Peds AND
Opposing
Protected Left



Signal Head Approach Displays and Alignment

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

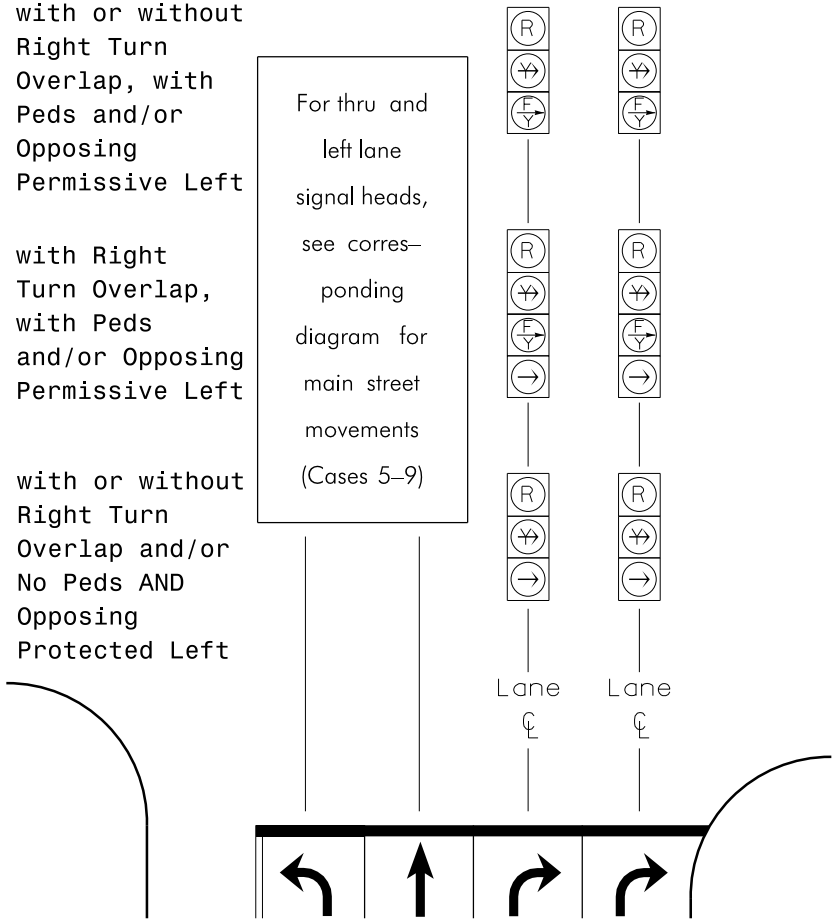
CASE 14

Main or Side Street
Signal Head Configuration
for Dual Right Turn Movements

14F - with or without Right Turn Overlap, with Peds and/or Opposing Permissive Left

14P - with Right Turn Overlap, with Peds and/or Opposing Permissive Left

14R - with or without Right Turn Overlap and/or No Peds AND Opposing Protected Left

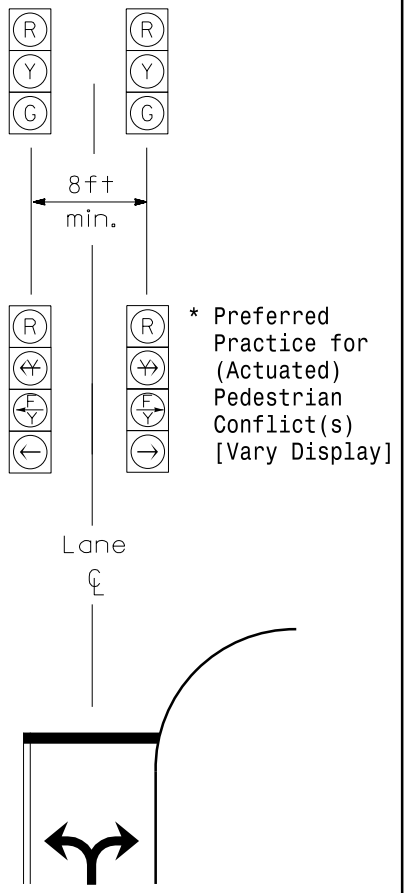


CASE 15 (1 OF 3)

No Through Movement
Signal Head Configuration

15LSA - LOW SPEED ONLY without Opposing Approach OR Permissive Left with Opposing Approach OR with Peds

15BP - Use when each turning movement conflict may vary each cycle based on the presence or lack of pedestrians



* Preferred Practice for (Actuated) Pedestrian Conflict(s) [Vary Display]

NOTE: A second display for the designated major movement (either left or right) is required. Pole/side mount this signal head to avoid image of dual turn display.

Signal Head Approach Displays and Alignment

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

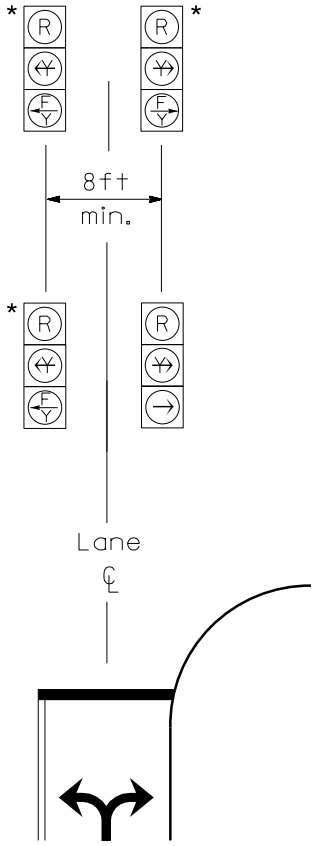
CASE 15 (2 OF 3)

No Through Movement
Signal Head Configuration

* A 4-Section FYA may be used for signal head if a display based on pedestrian demand is desired

15A - Pedestrian and/or Vehicle conflict for both turning movements*

15AR - Pedestrian and/or vehicle conflcit for left turn*; NO Pedestrian AND Vehicle conflict for right turn



NOTE: A second display for the designated major movement (either left or right) is required. Pole/side mount this signal head to avoid image of dual turn display.

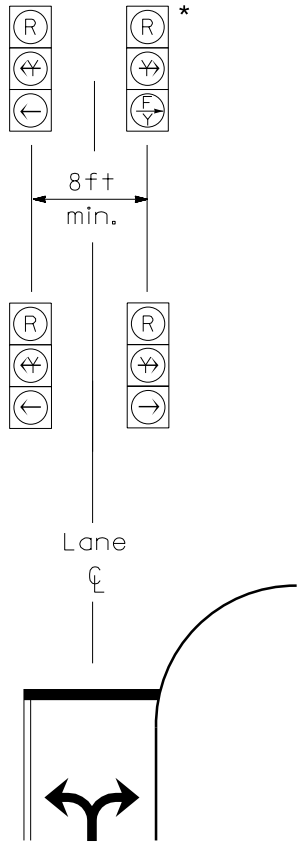
CASE 15 (3 OF 3)

No Through Movement
Signal Head Configuration

* A 4-Section FYA may be used for signal head if a display based on pedestrian demand is desired

15C - NO Pedestrian AND Vehicle conflict for left turn; Pedestrian and/or vehicle conflcit for right turn*

15CR - NO Pedestrian AND Vehicle conflict for both turning movements



NOTE: A second display for the designated major movement (either left or right) is required. Pole/side mount this signal head to avoid image of dual turn display.

Signal Head Approach Displays and Alignment

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

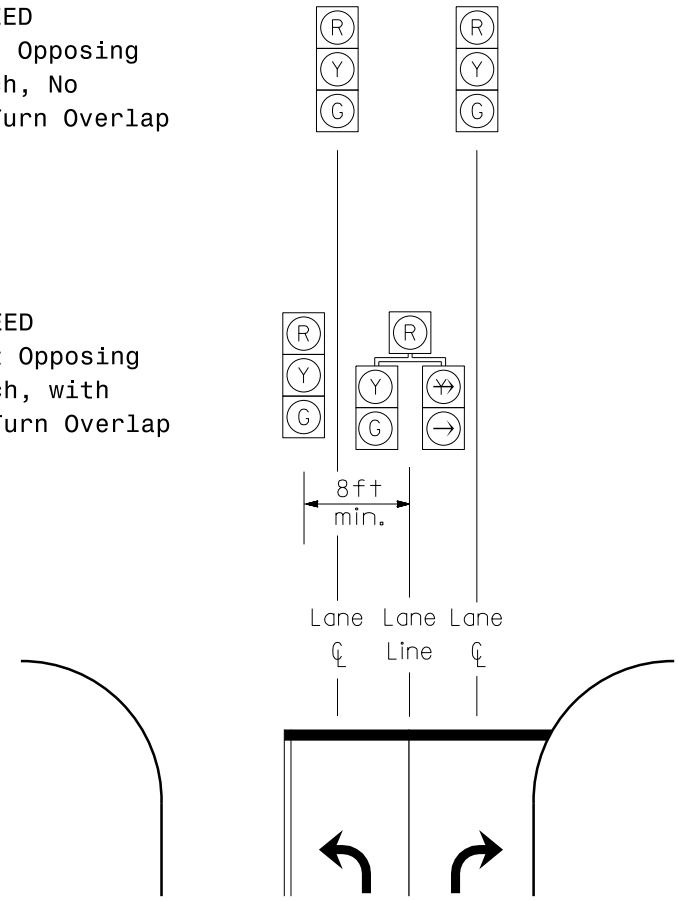
STD. NO.
3.2

CASE 16 (Case 1 of 4)

No Through Movement
Signal Head Configuration

16LS - LOW SPEED without Opposing Approach, No Right Turn Overlap

16LSR - LOW SPEED without Opposing Approach, with Right Turn Overlap



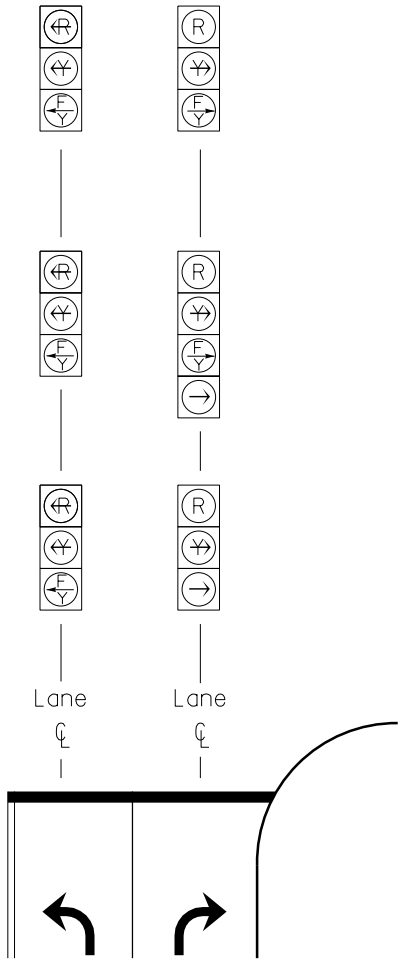
CASE 16 (Case 2 of 4)

No Through Movement
Signal Head Configuration

16A - Conflicting Vehicle or Ped Movements for Both Turns

16AP - Conflicting Vehicle or Ped Movements for Left Turn; Conflicts may vary for Right Turn

16AR - Conflicting Vehicle or Ped Movements for Left Turn; No vehicle and ped conflict for Right Turn



NOTE: A second display for the designated major movement (either left or right) is required. Pole/side mount this signal head to avoid image of dual turn display.

Signal Head Approach Displays and Alignment

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

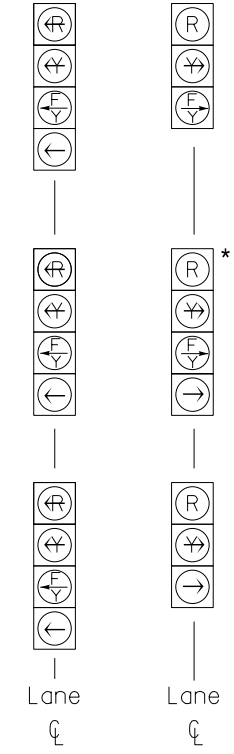
CASE 16 (Case 3 of 4)

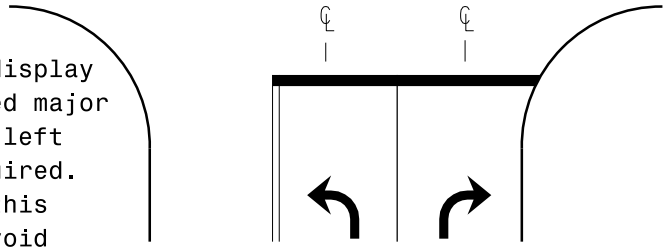
No Through Movement
Signal Head Configuration

16B - Conflicts may vary for one or left turn; Conflicting Vehicle or Ped Movements for Right Turn

16BP - Conflicts may vary for one or both turns

16BR - Conflicts may vary for one or left turn; No Conflicting Vehicle or Ped Movements for Both Turns





NOTE: A second display for the designated major movement (either left or right) is required. Pole/side mount this signal head to avoid image of dual turn display.

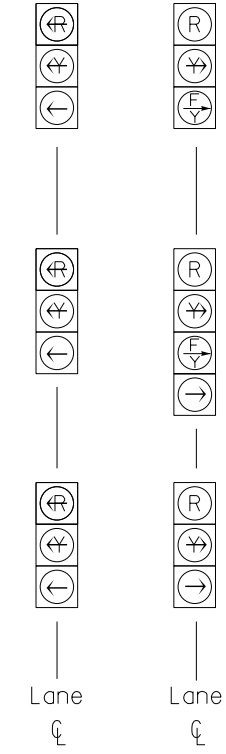
CASE 16 (Case 4 of 4)

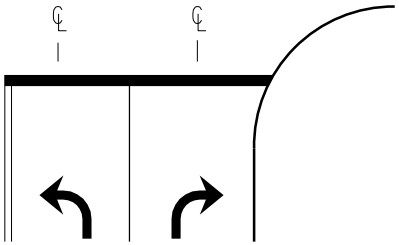
No Through Movement
Signal Head Configuration

16C - No Conflicting Vehicle or Ped Movements for Left Turn; Conflicting Vehicle or Ped Movements for Right Turn

16CP - No Conflicting Vehicle or Ped Movements for Left Turn; Conflicts may vary for Right Turn

16CR - No Conflicting Vehicle or Ped Movements for Both Turns





NOTE: A second display for the designated major movement (either left or right) is required. Pole/side mount this signal head to avoid image of dual turn display.

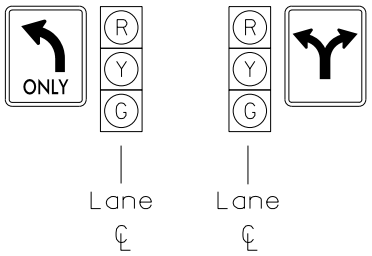
Signal Head Approach Displays and Alignment

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

CASE 17

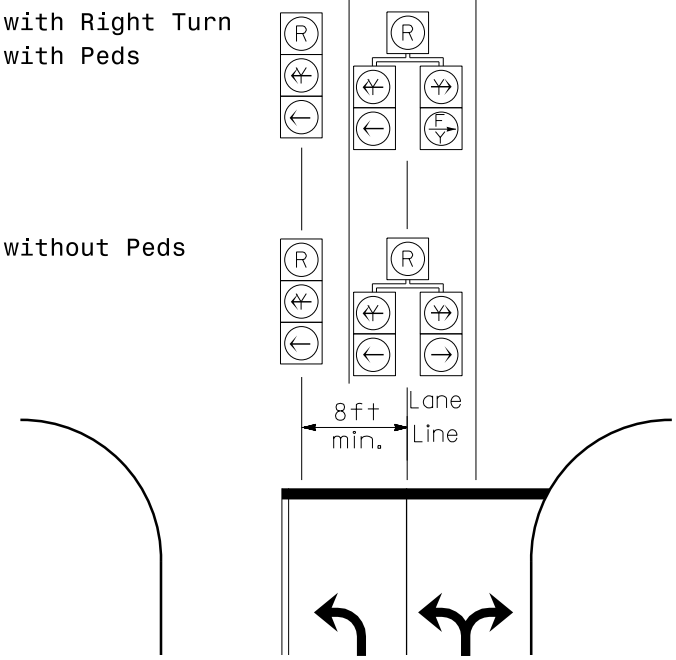
No Through Movement
Signal Head Configuration

17AS - Low Speed,
with Signs



17CP - with Right Turn
with Peds

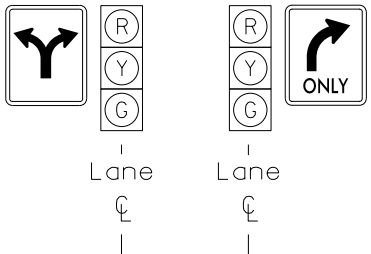
17C - without Peds



CASE 18 (1 OF 2)

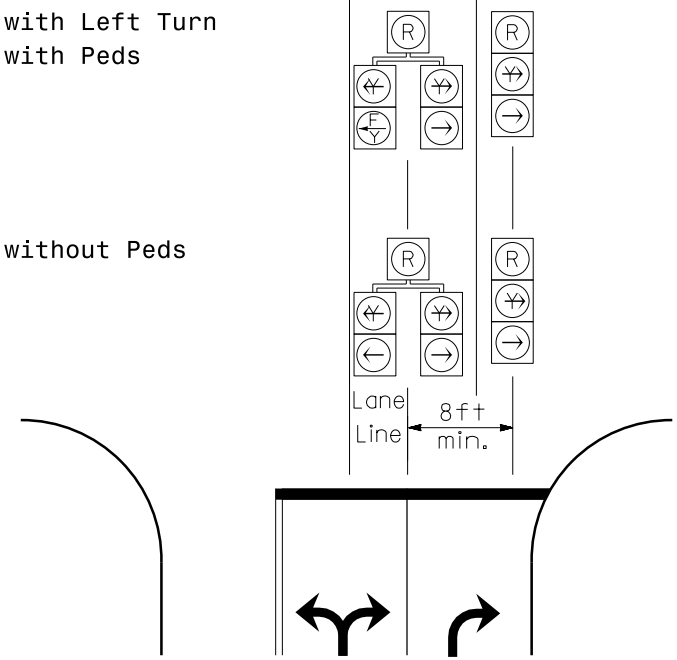
No Through Movement
Signal Head Configuration

18AS - Low Speed,
with Signs



18AR - with Left Turn
with Peds

18CR - without Peds



Signal Head Approach Displays and Alignment

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

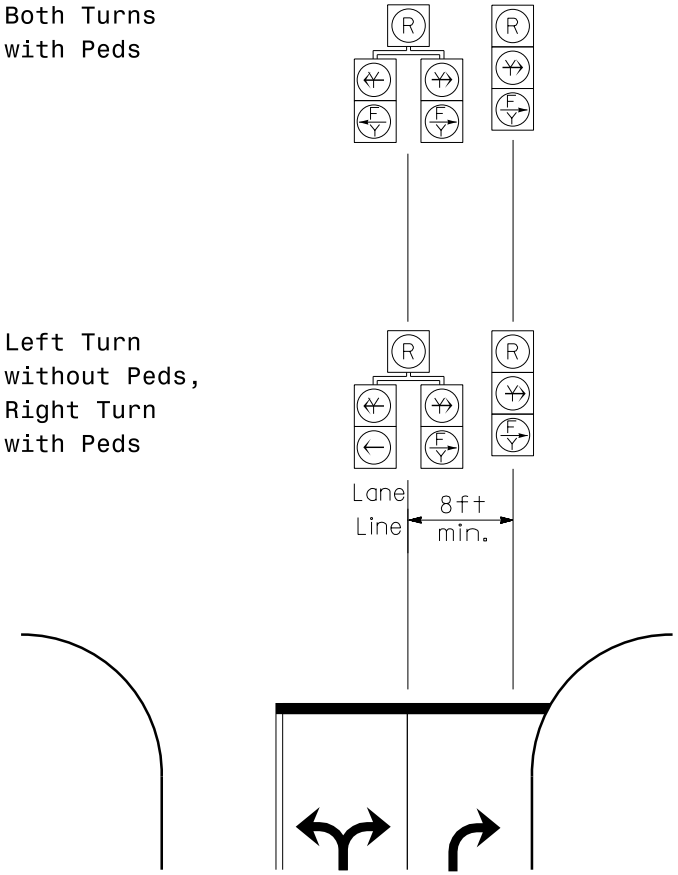
STD. NO.
3.2

CASE 18 (2 OF 2)

No Through Movement
Signal Head Configuration

18AF - Both Turns with Peds

18CF - Left Turn without Peds, Right Turn with Peds



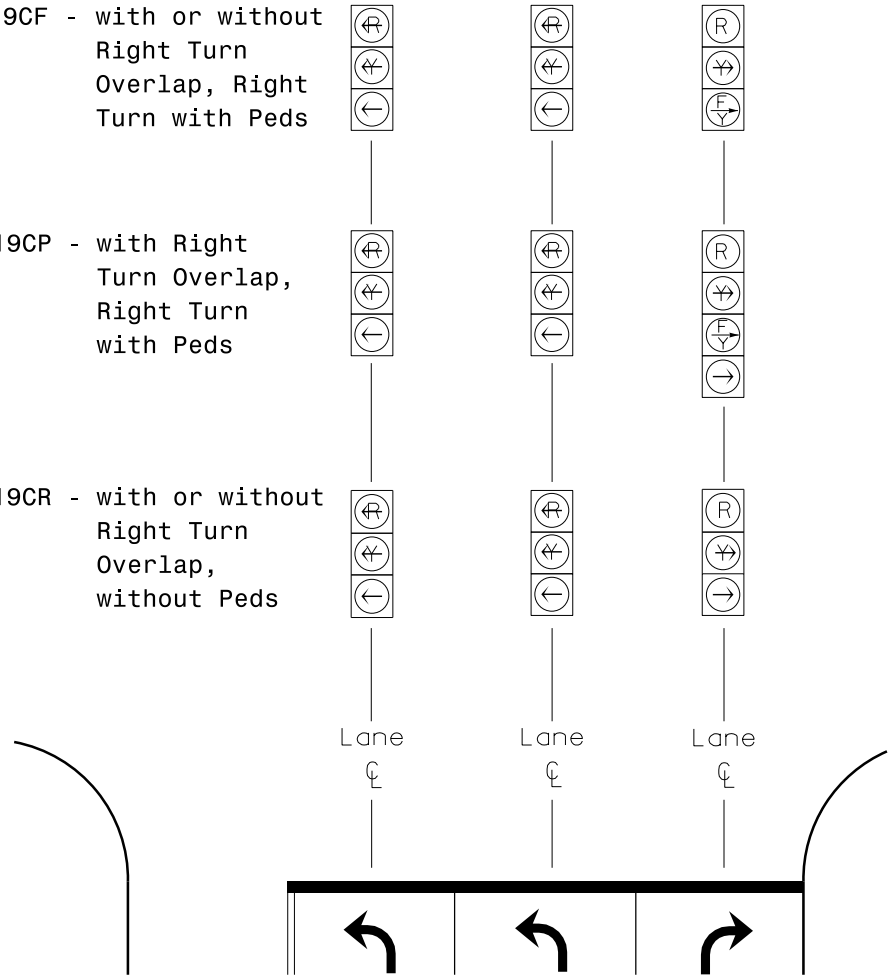
CASE 19

No Through Movement
Signal Head Configuration

19CF - with or without Right Turn Overlap, Right Turn with Peds

19CP - with Right Turn Overlap, Right Turn with Peds

19CR - with or without Right Turn Overlap, without Peds



Signal Head Approach Displays and Alignment

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.
3.2

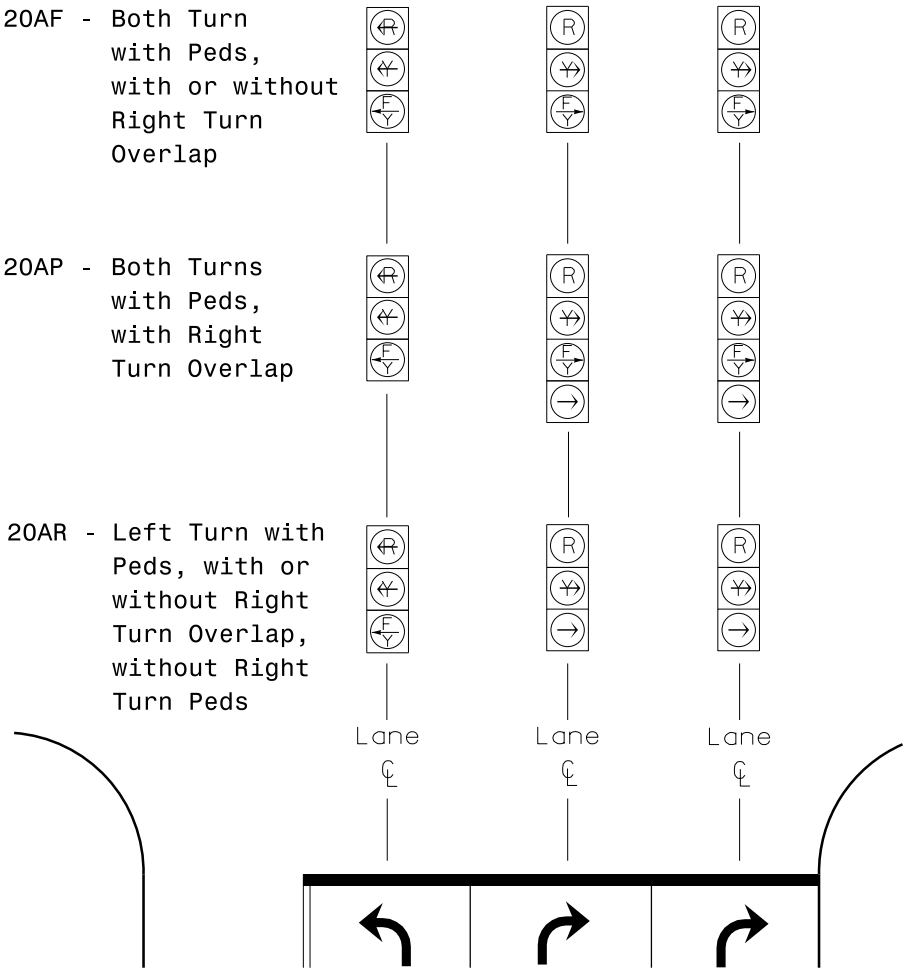
CASE 20 (1 OF 2)

No Through Movement
Signal Head Configuration

20AF - Both Turn with Peds, with or without Right Turn Overlap

20AP - Both Turns with Peds, with Right Turn Overlap

20AR - Left Turn with Peds, with or without Right Turn Overlap, without Right Turn Peds



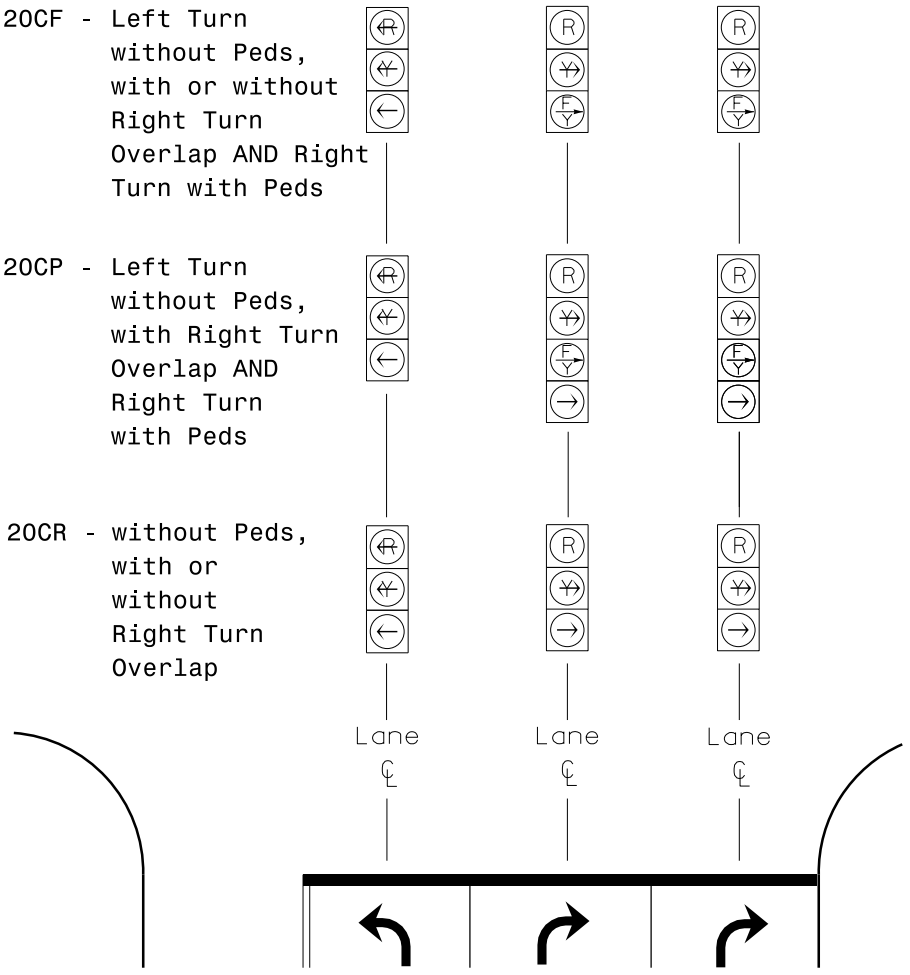
CASE 20 (2 OF 2)

No Through Movement
Signal Head Configuration

20CF - Left Turn without Peds, with or without Right Turn Overlap AND Right Turn with Peds

20CP - Left Turn without Peds, with Right Turn Overlap AND Right Turn with Peds

20CR - without Peds, with or without Right Turn Overlap



Signal Head Approach Displays and Alignment

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

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STD. NO.
3.2
SHEET 18 OF 29

CASE 21

No Through Movement
Signal Head Configuration

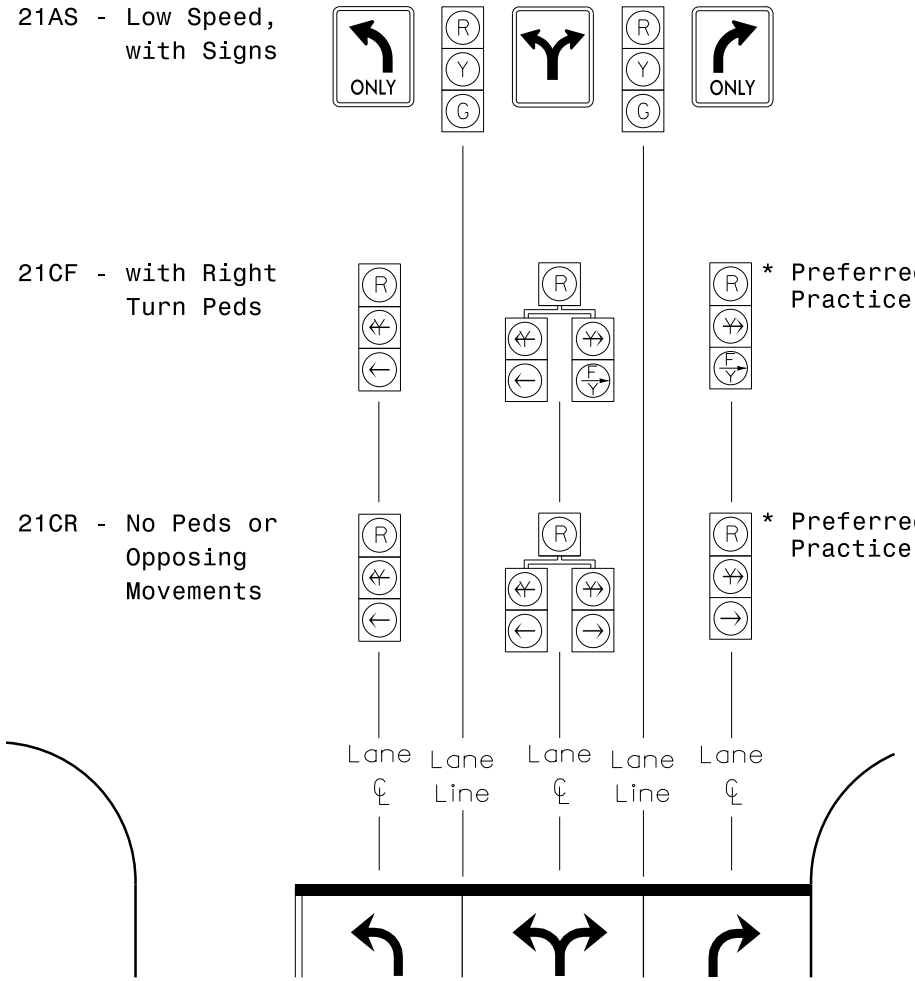
21AS - Low Speed, with Signs

21CF - with Right Turn Peds

21CR - No Peds or Opposing Movements

* Preferred Practice

* Preferred Practice



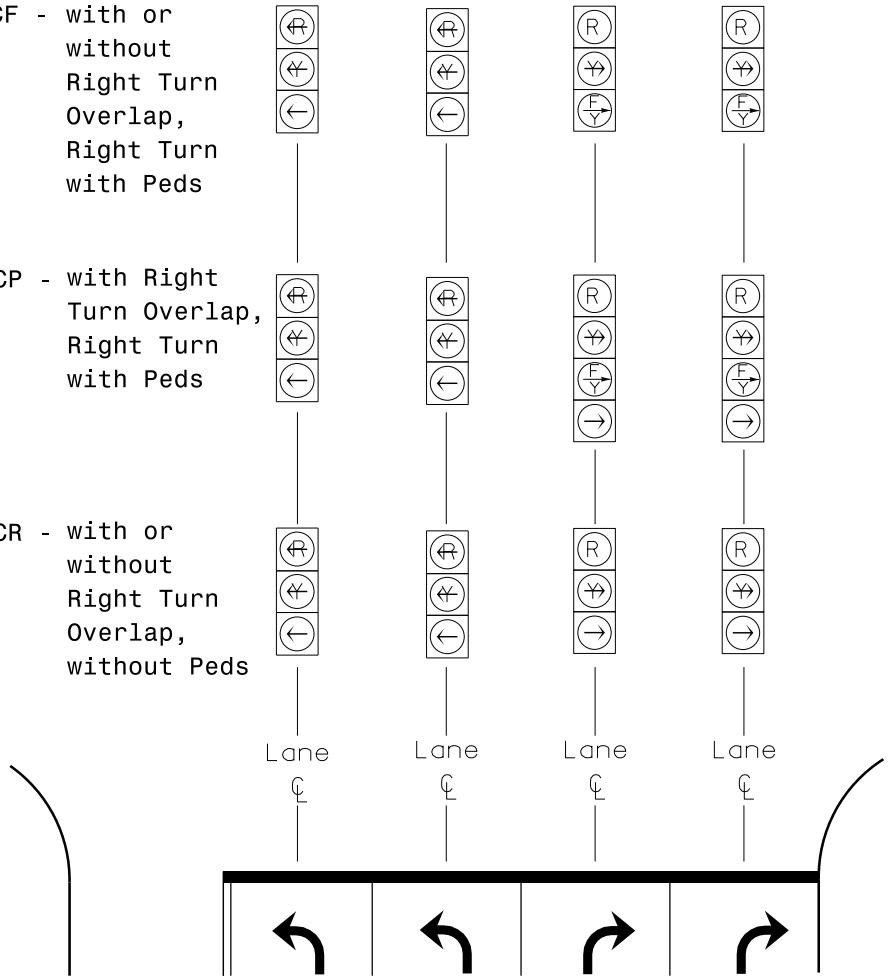
CASE 22

No Through Movement
Signal Head Configuration

22CF - with or without Right Turn Overlap, Right Turn with Peds

22CP - with Right Turn Overlap, Right Turn with Peds

22CR - with or without Right Turn Overlap, without Peds



Signal Head Approach Displays and Alignment

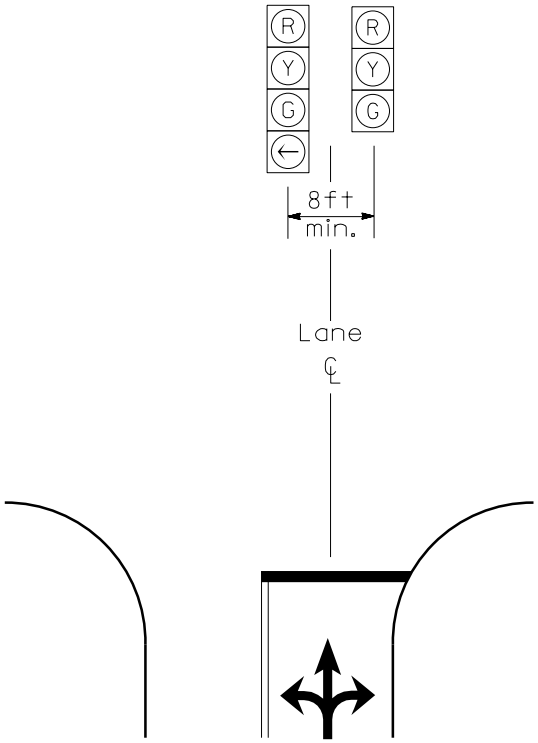
SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

7-21

STD. NO.
3.2
SHEET 19 OF 29

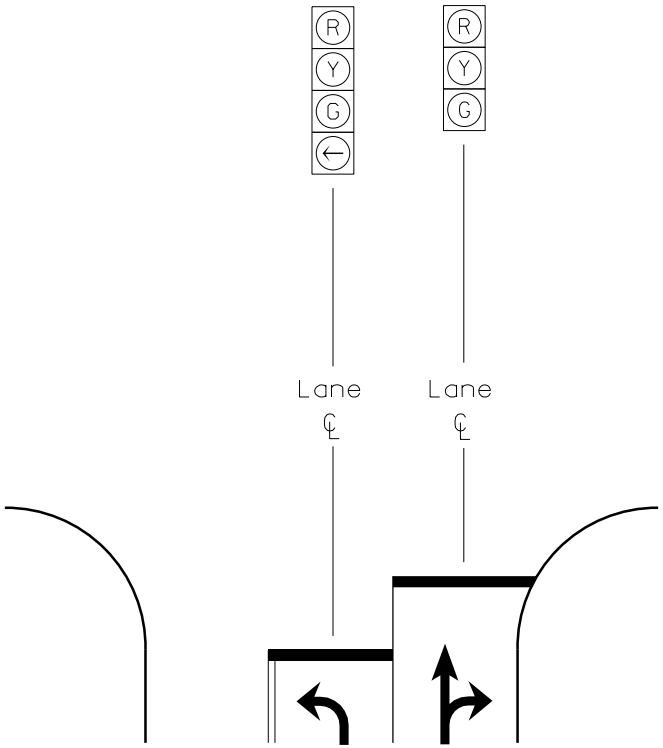
CASE 23

Split Phasing
Signal Head Configuration



CASE 24

Split Phasing
Signal Head Configuration



Signal Head Approach Displays and Alignment

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

7-21

STD. NO.
3.2
SHEET 20 OF 29

CASE 25

Split Phasing
Signal Head Configuration

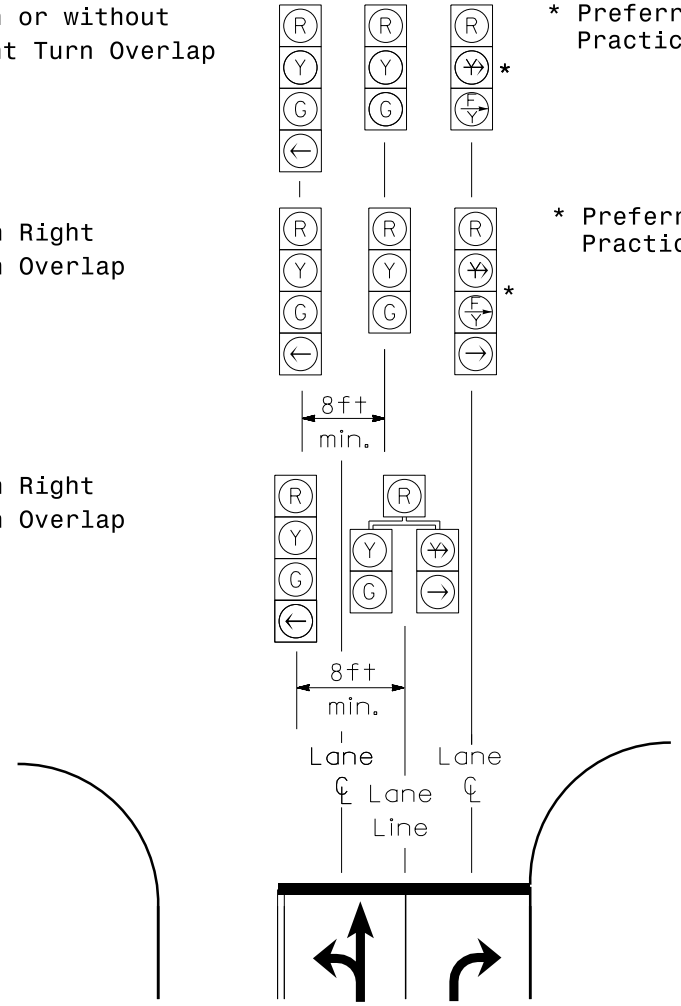
25CF - with or without Right Turn Overlap

* Preferred Practice

25CP - with Right Turn Overlap

* Preferred Practice

25CR - With Right Turn Overlap



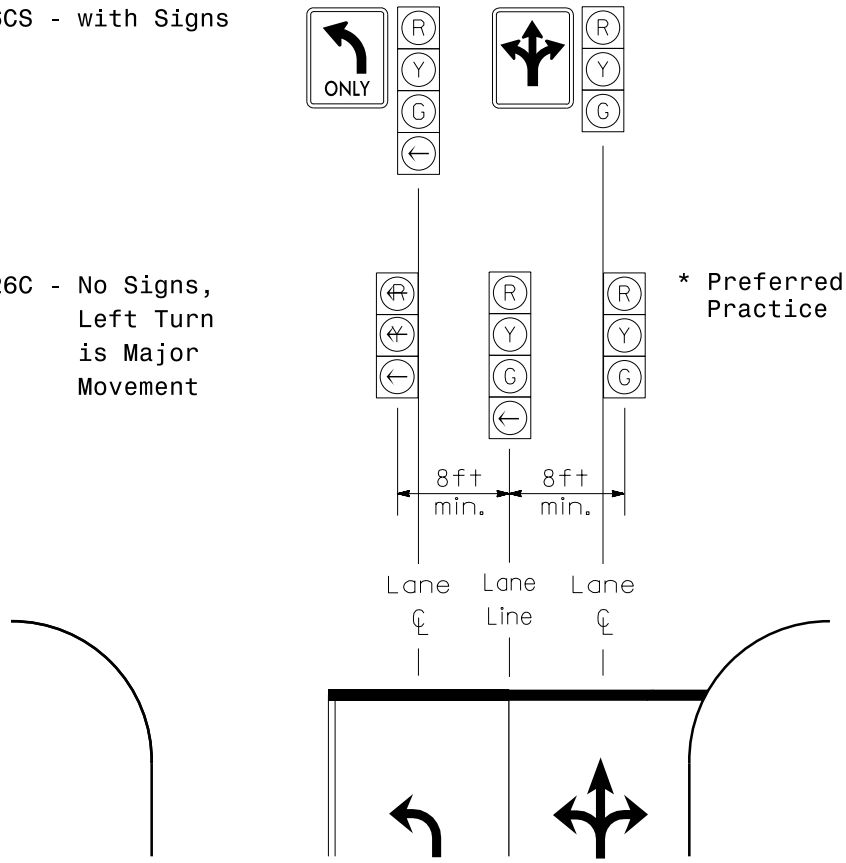
CASE 26

Split Phasing
Signal Head Configuration

26CS - with Signs

26C - No Signs, Left Turn is Major Movement

* Preferred Practice



Signal Head Approach Displays and Alignment

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

CASE 27

Split Phasing
Signal Head Configuration

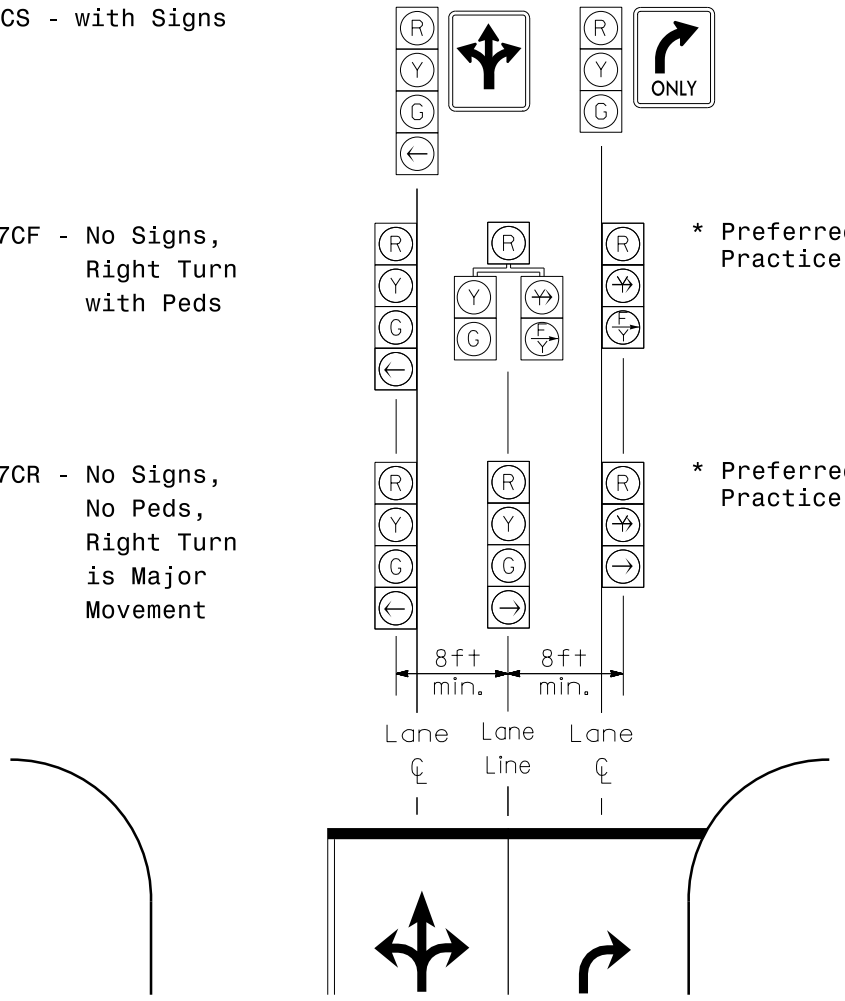
27CS - with Signs

27CF - No Signs, Right Turn with Peds

27CR - No Signs, No Peds, Right Turn is Major Movement

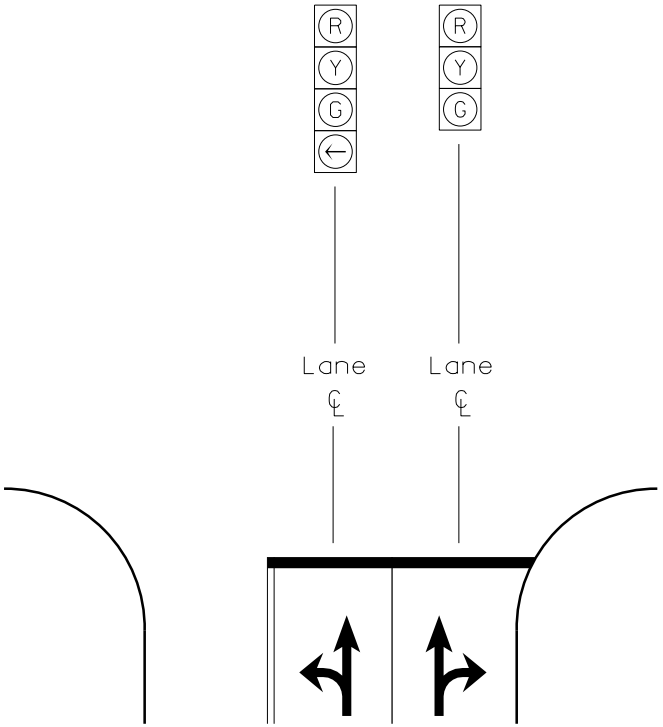
* Preferred Practice

* Preferred Practice



CASE 28

Split Phasing
Signal Head Configuration



Signal Head Approach Displays and Alignment

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

CASE 29

Split Phasing
Signal Head Configuration

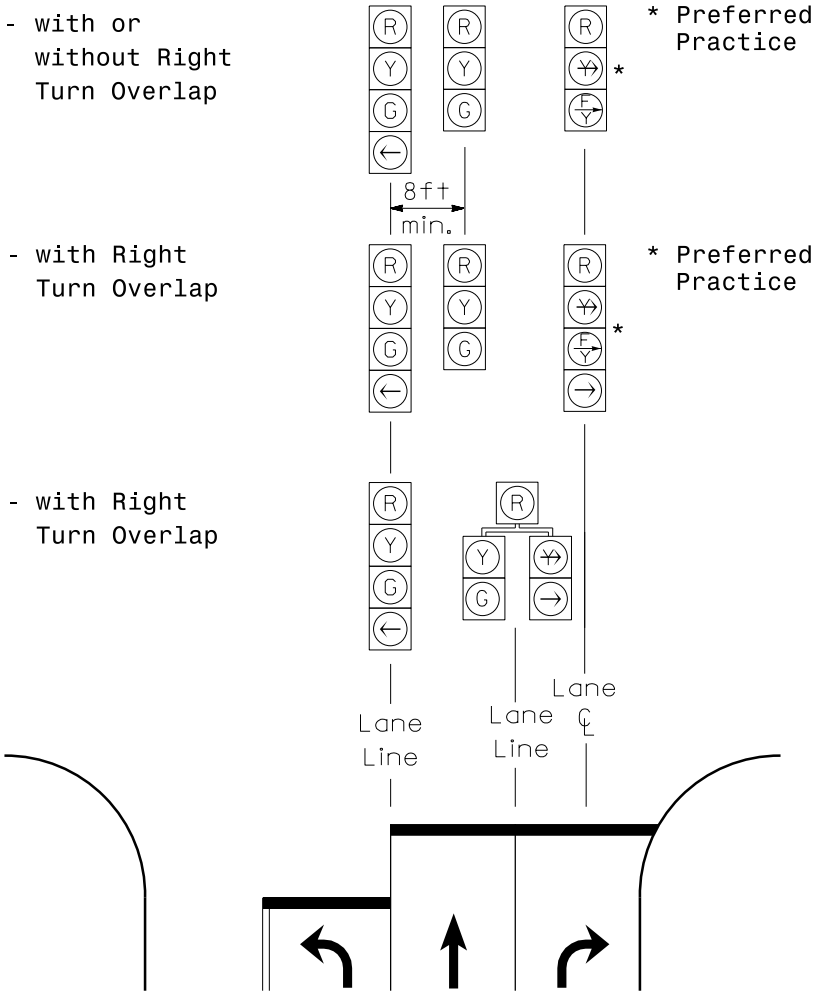
29CF - with or without Right Turn Overlap

29CP - with Right Turn Overlap

29CR - with Right Turn Overlap

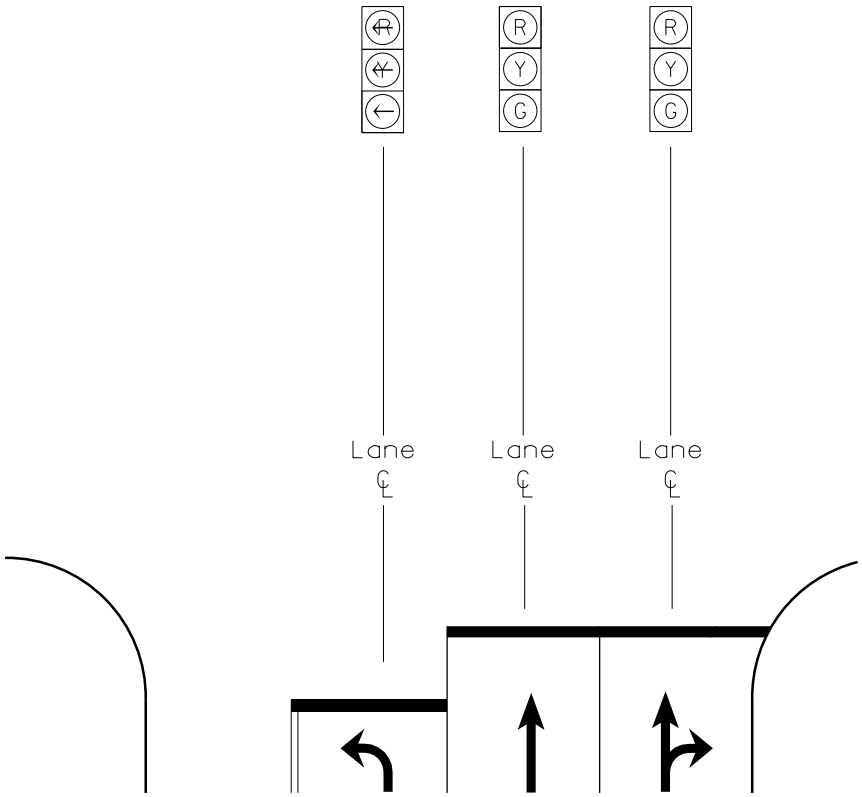
* Preferred Practice

* Preferred Practice



CASE 30

Split Phasing
Signal Head Configuration



Signal Head Approach Displays and Alignment

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

CASE 31

Split Phasing
Signal Head Configuration

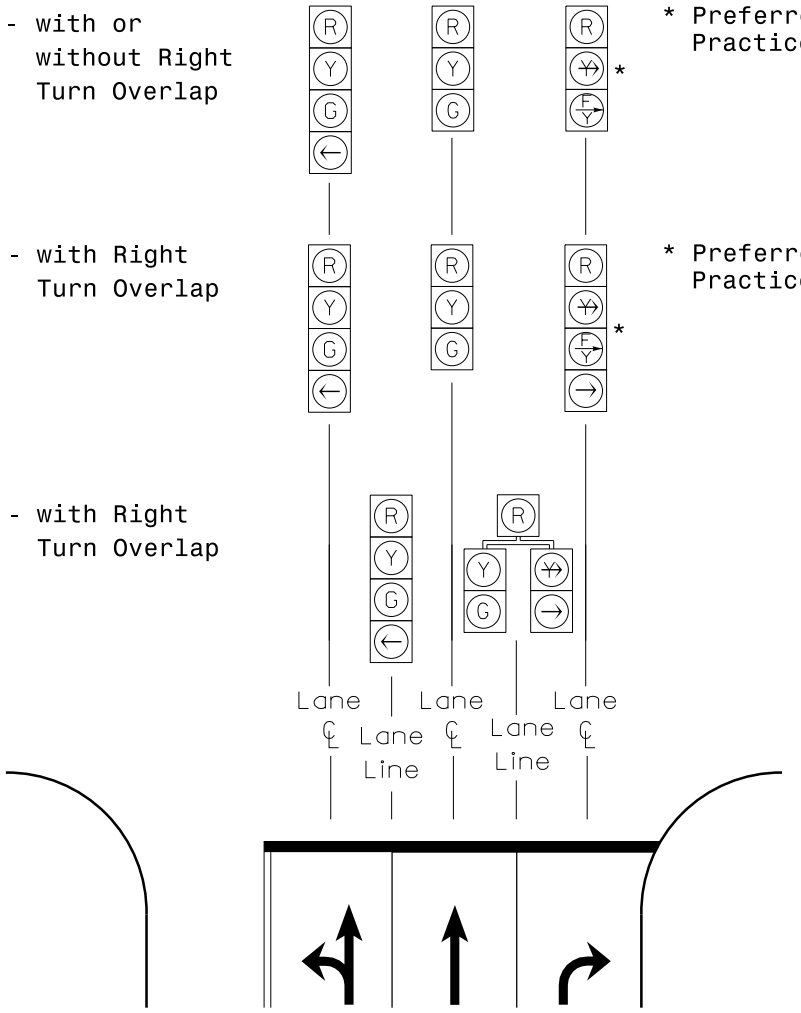
31CF - with or without Right Turn Overlap

* Preferred Practice

31CP - with Right Turn Overlap

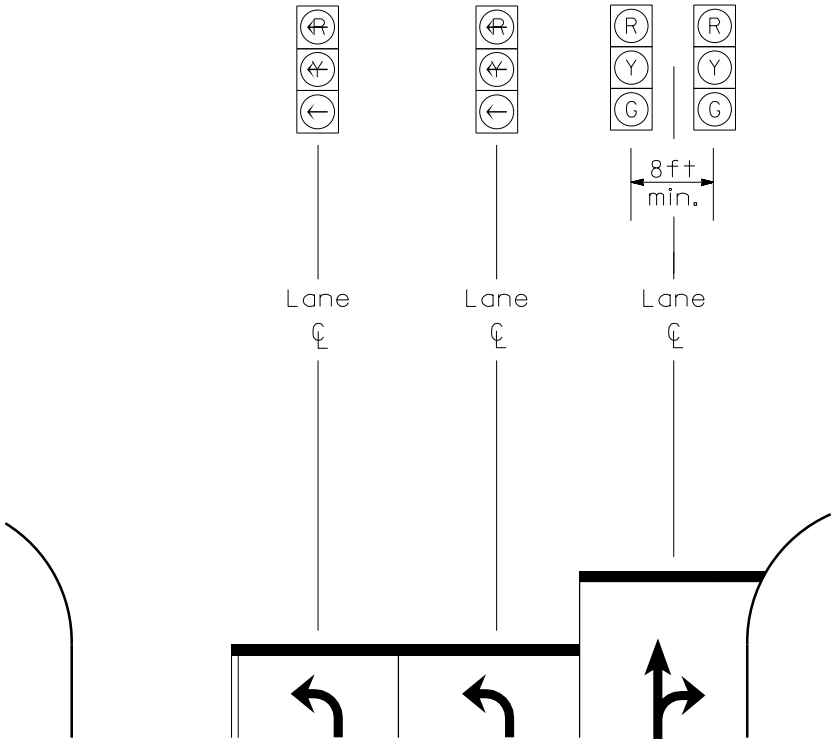
* Preferred Practice

31CR - with Right Turn Overlap



CASE 32

Split Phasing
Signal Head Configuration



Signal Head Approach Displays and Alignment

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

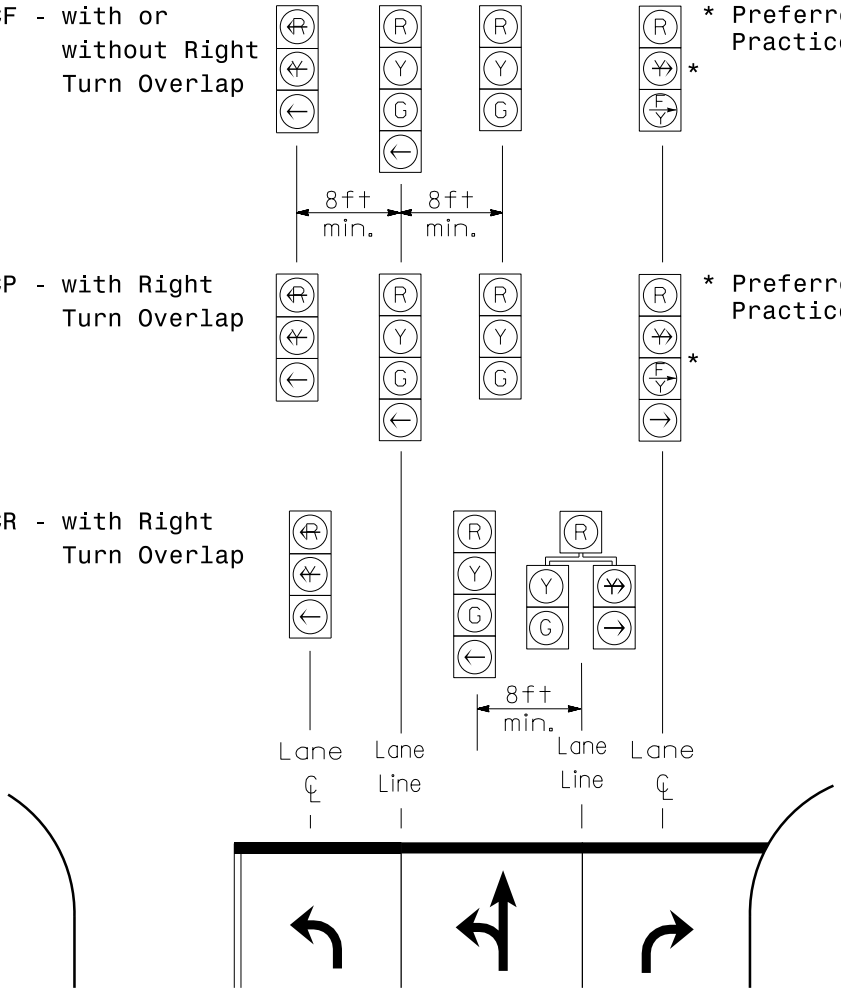
CASE 33

Split Phasing
Signal Head Configuration

33CF - with or without Right Turn Overlap

33CP - with Right Turn Overlap

33CR - with Right Turn Overlap

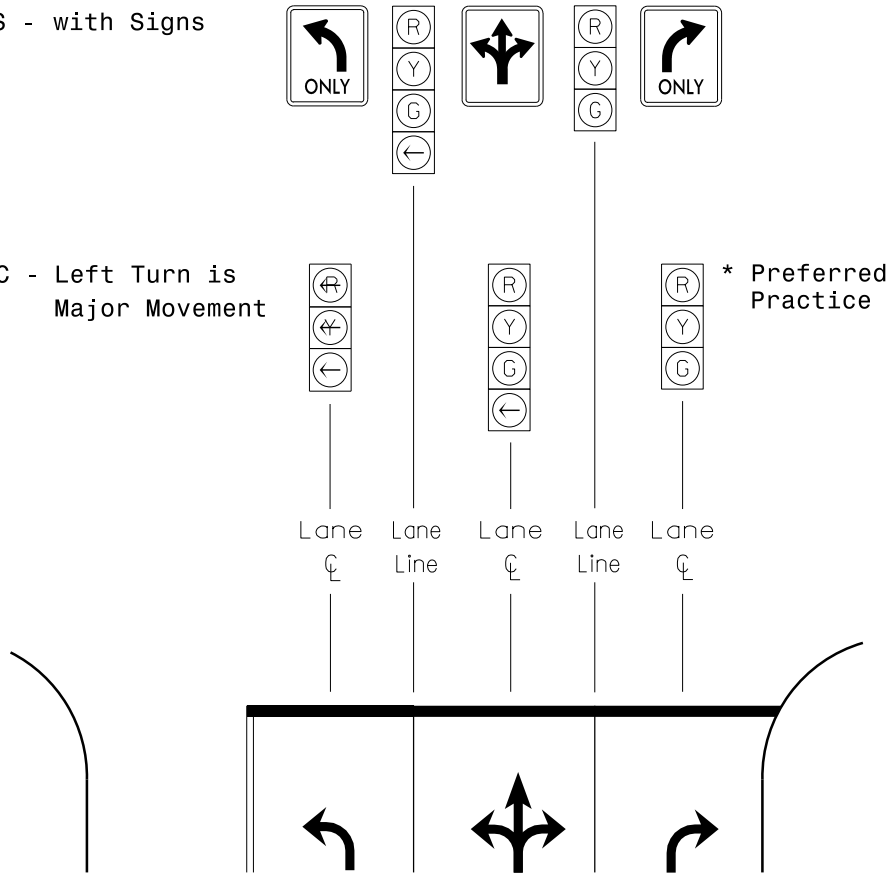


CASE 34

Split Phasing
Signal Head Configuration

34CS - with Signs

34C - Left Turn is Major Movement



Signal Head Approach Displays and Alignment

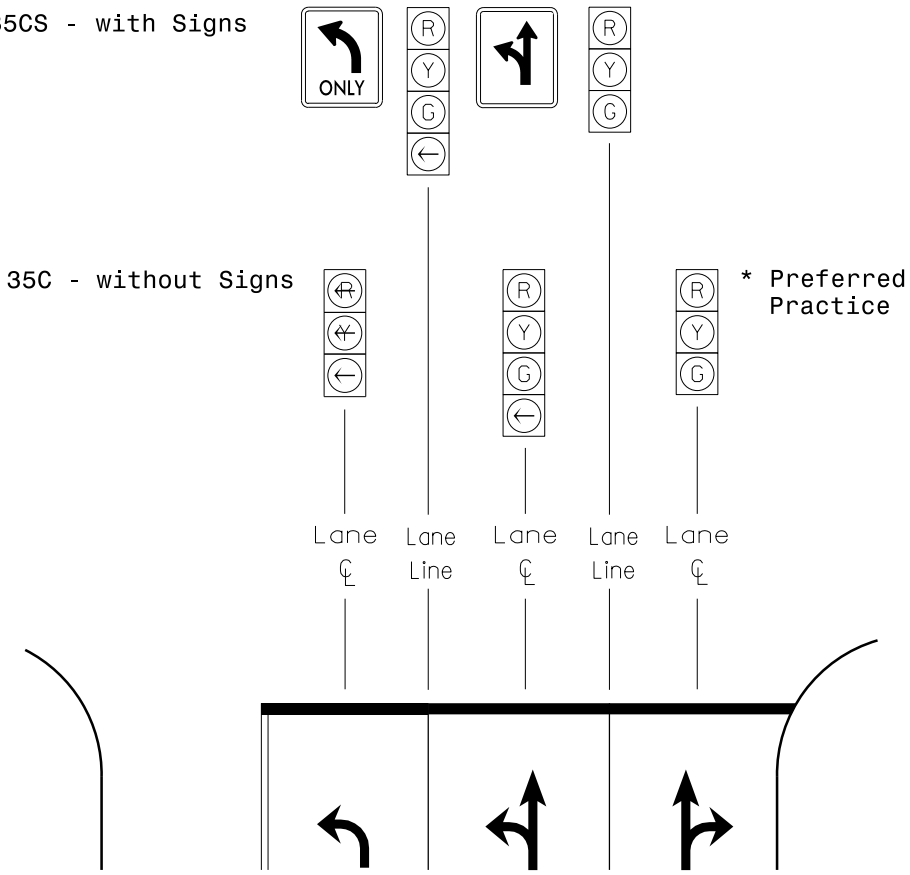
SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

CASE 35

Split Phasing
Signal Head Configuration

35CS - with Signs

35C - without Signs



* Preferred Practice

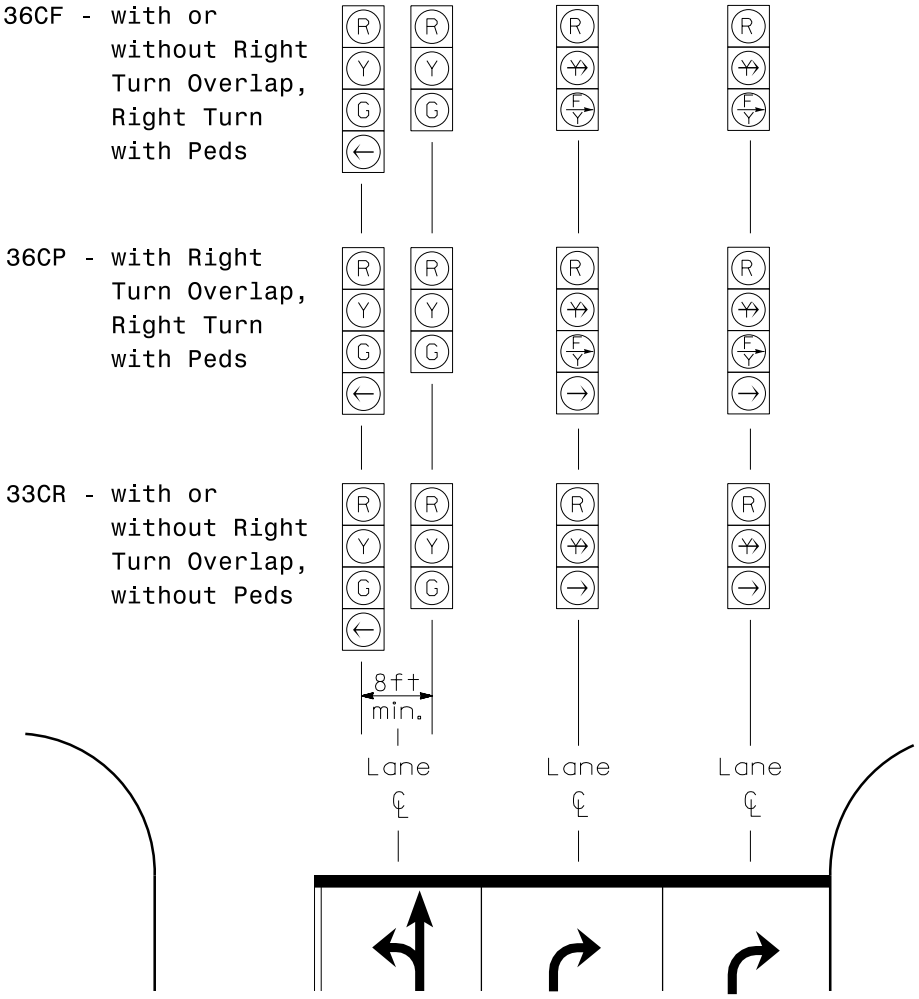
CASE 36

Split Phasing
Signal Head Configuration

36CF - with or without Right Turn Overlap, Right Turn with Peds

36CP - with Right Turn Overlap, Right Turn with Peds

33CR - with or without Right Turn Overlap, without Peds



Signal Head Approach Displays and Alignment

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

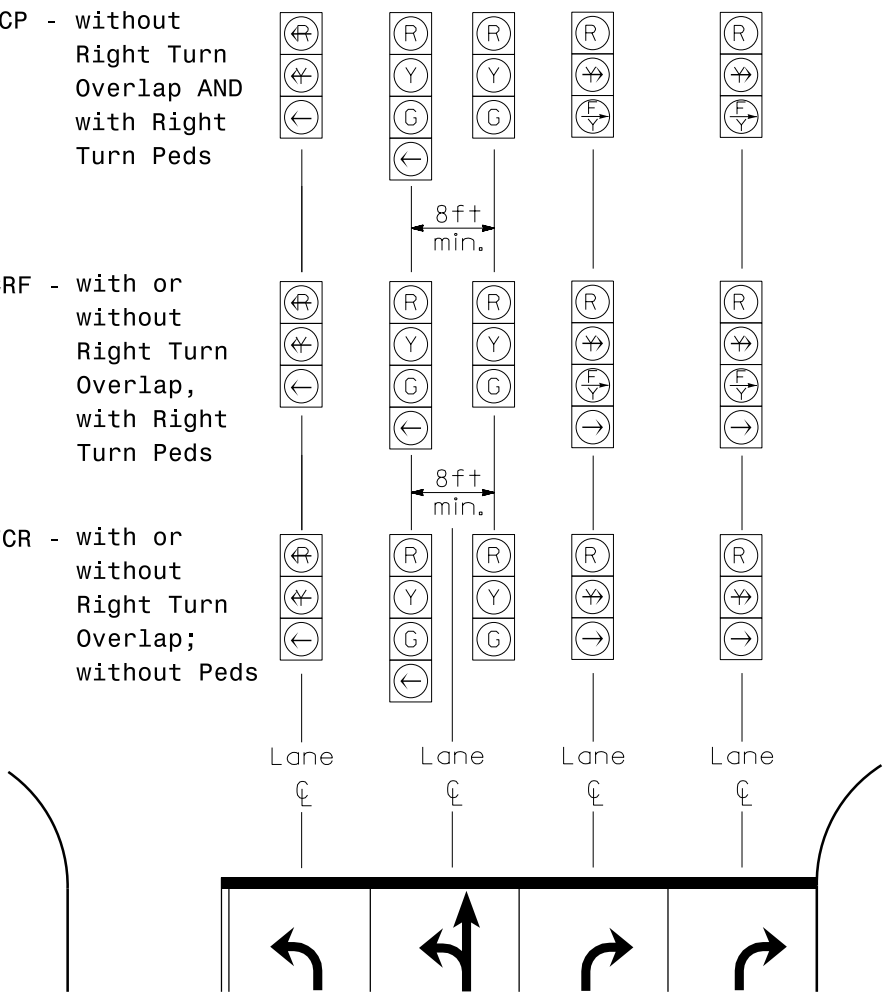
CASE 37

Split Phasing
Signal Head Configuration

37CP - without Right Turn Overlap AND with Right Turn Peds

37CRF - with or without Right Turn Overlap, with Right Turn Peds

37CR - with or without Right Turn Overlap; without Peds



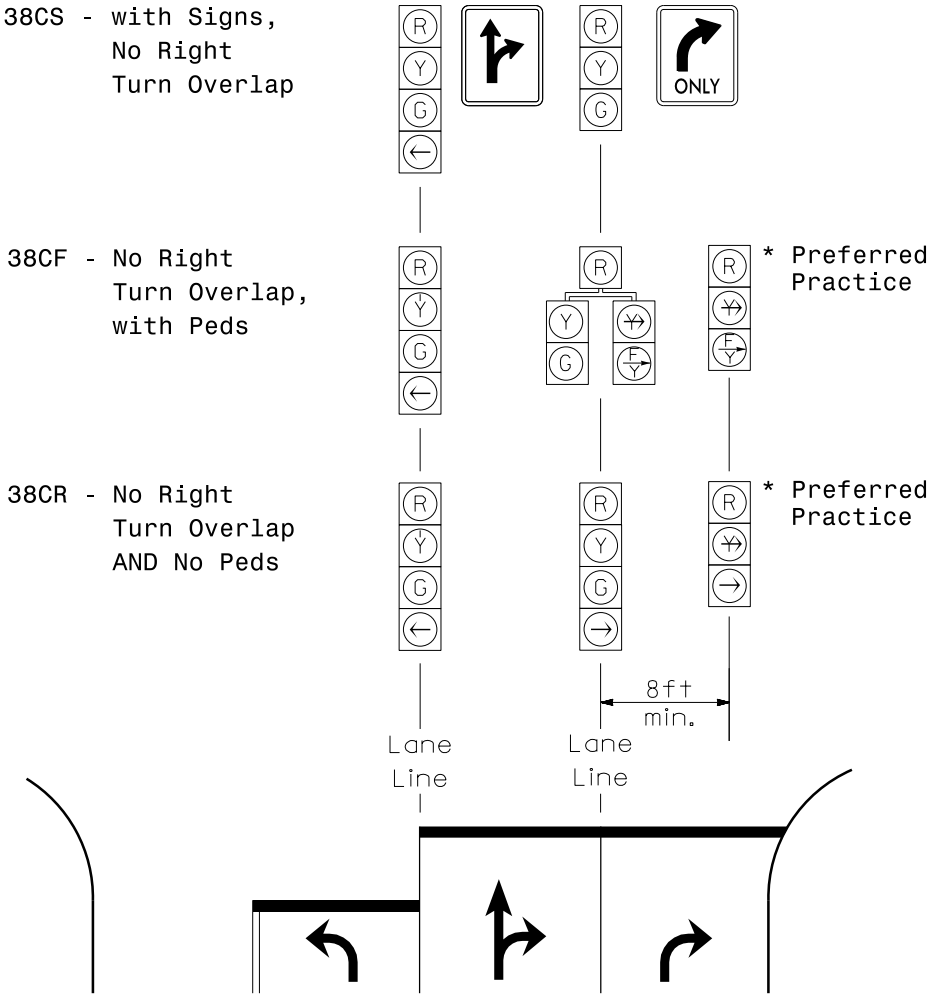
CASE 38

Split Phasing
Signal Head Configuration

38CS - with Signs, No Right Turn Overlap

38CF - No Right Turn Overlap, with Peds

38CR - No Right Turn Overlap AND No Peds



Signal Head Approach Displays and Alignment

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

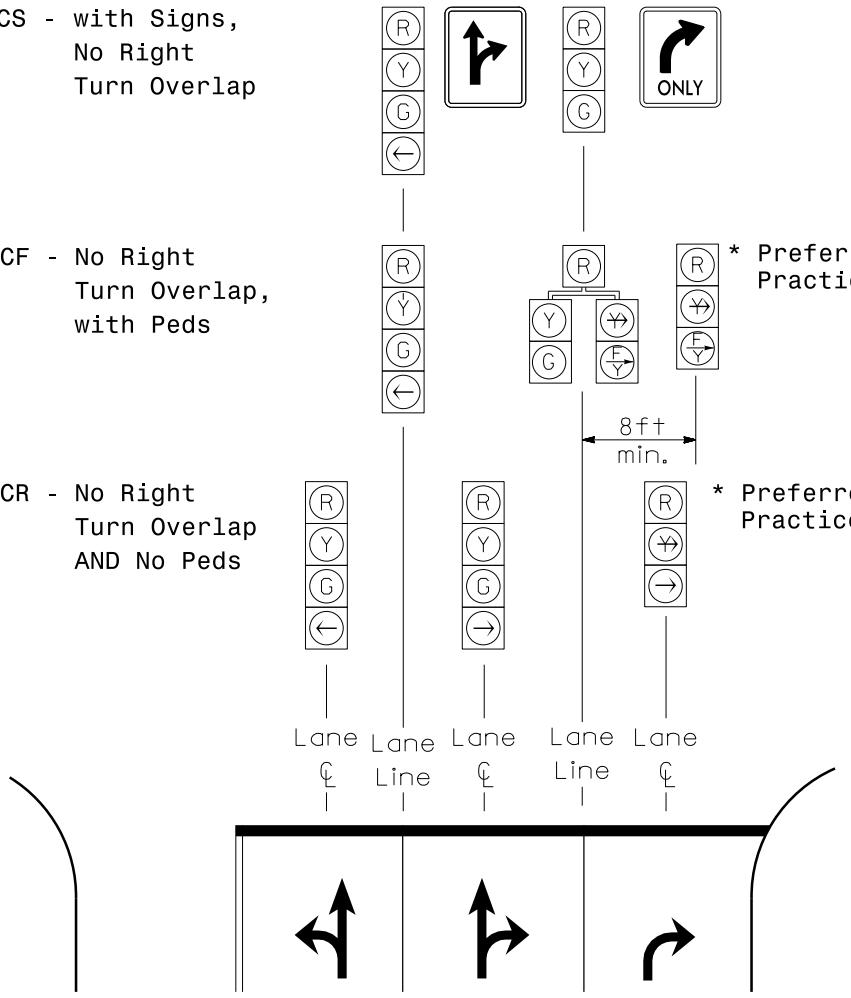
CASE 39

Split Phasing
Signal Head Configuration

39CS - with Signs, No Right Turn Overlap

39CF - No Right Turn Overlap, with Peds

39CR - No Right Turn Overlap AND No Peds



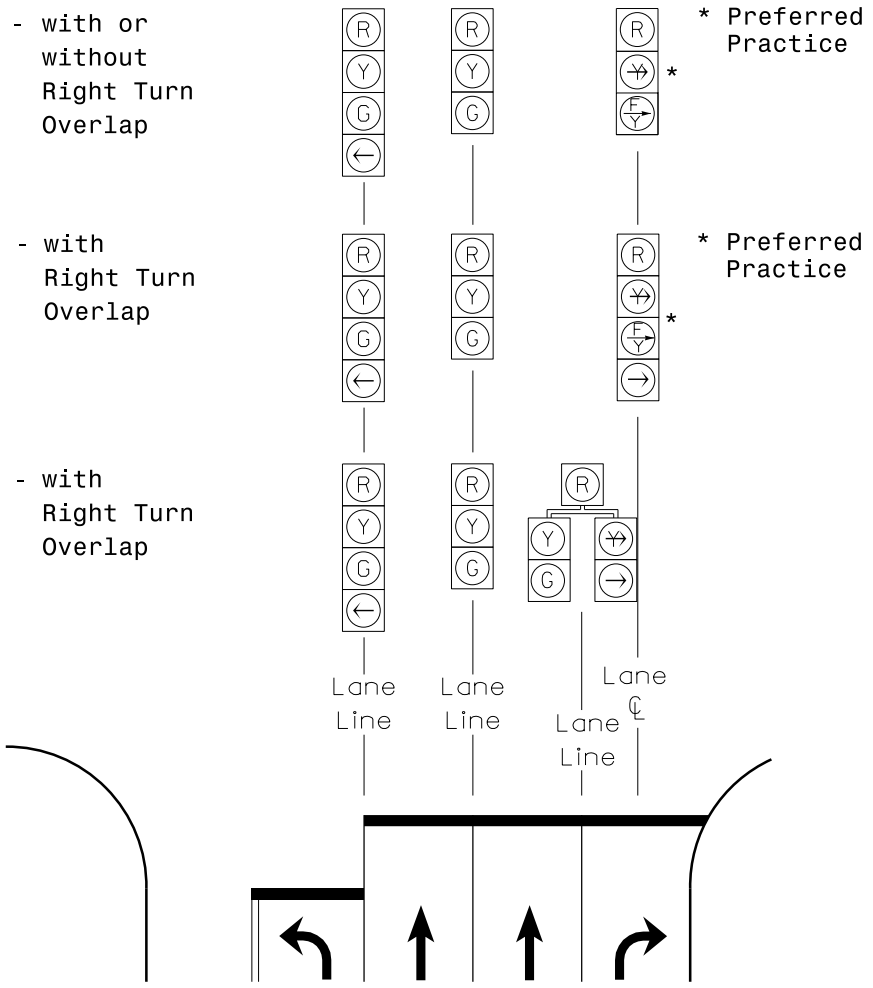
CASE 40

Split Phasing
Signal Head Configuration

40CF - with or without Right Turn Overlap

40CP - with Right Turn Overlap

40CR - with Right Turn Overlap



Signal Head Approach Displays and Alignment

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

CASE 41

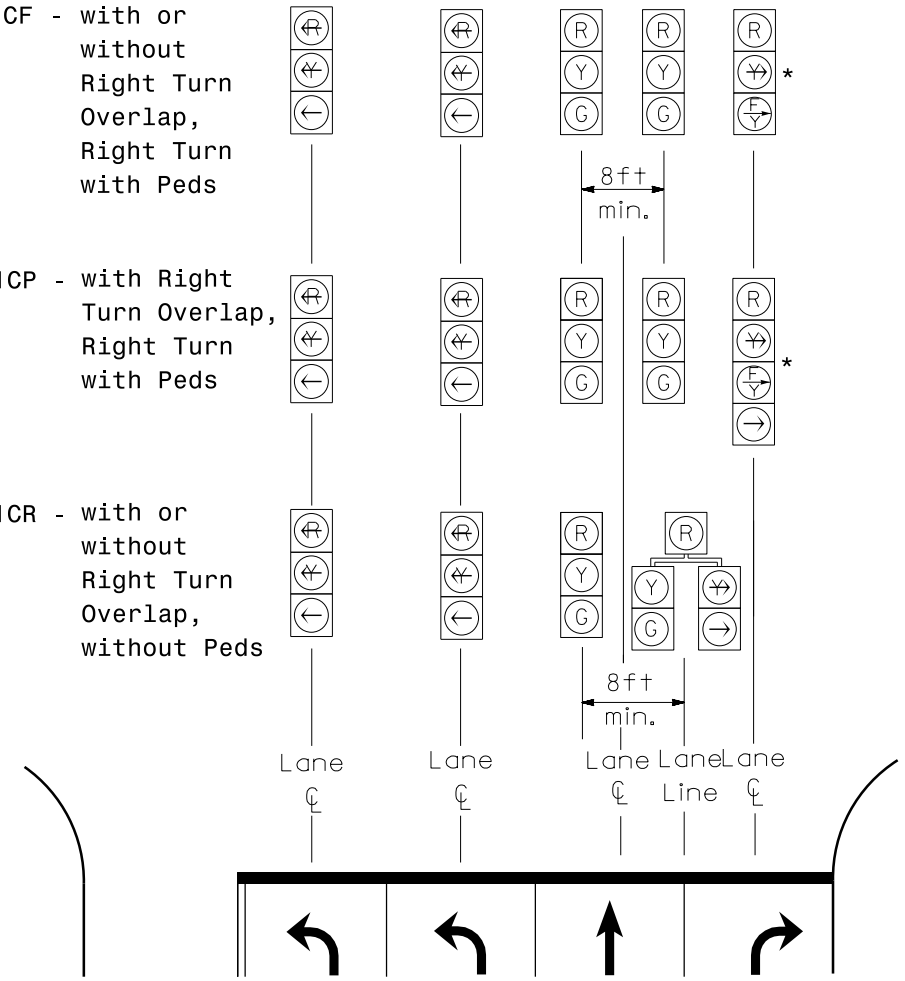
Split Phasing
Signal Head Configuration

* Preferred Practice

41CF - with or without Right Turn Overlap, Right Turn with Peds

41CP - with Right Turn Overlap, Right Turn with Peds

41CR - with or without Right Turn Overlap, without Peds



CASE 42

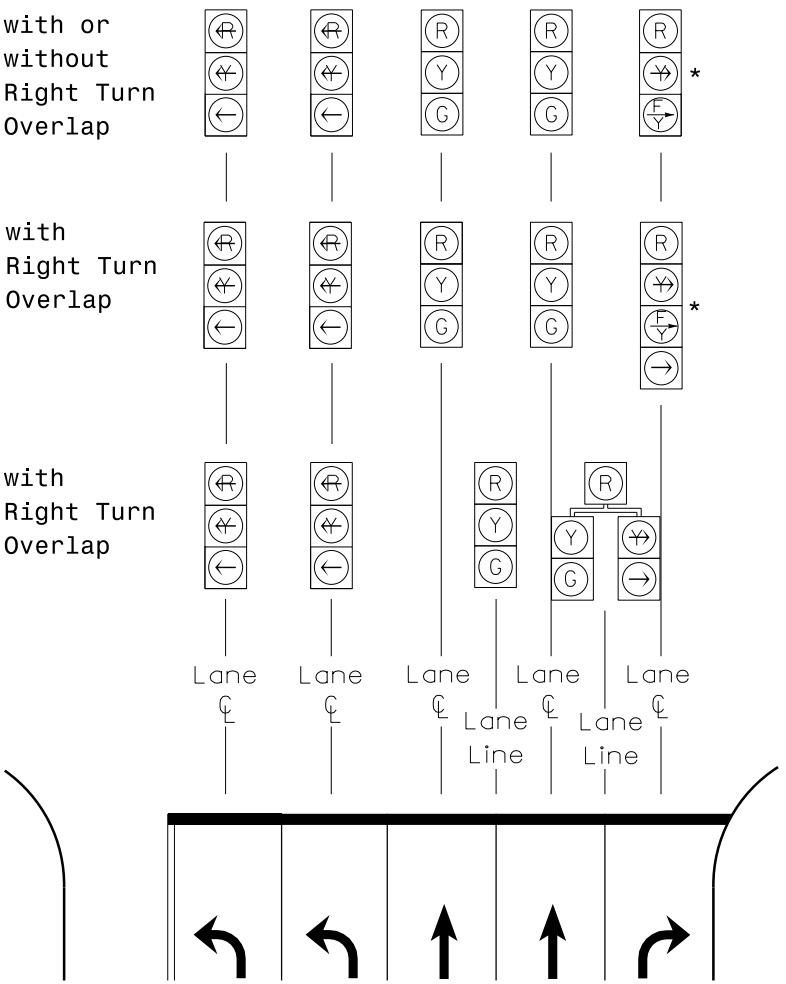
Split Phasing
Signal Head Configuration

* Preferred Practice

42CF - with or without Right Turn Overlap

42CP - with Right Turn Overlap

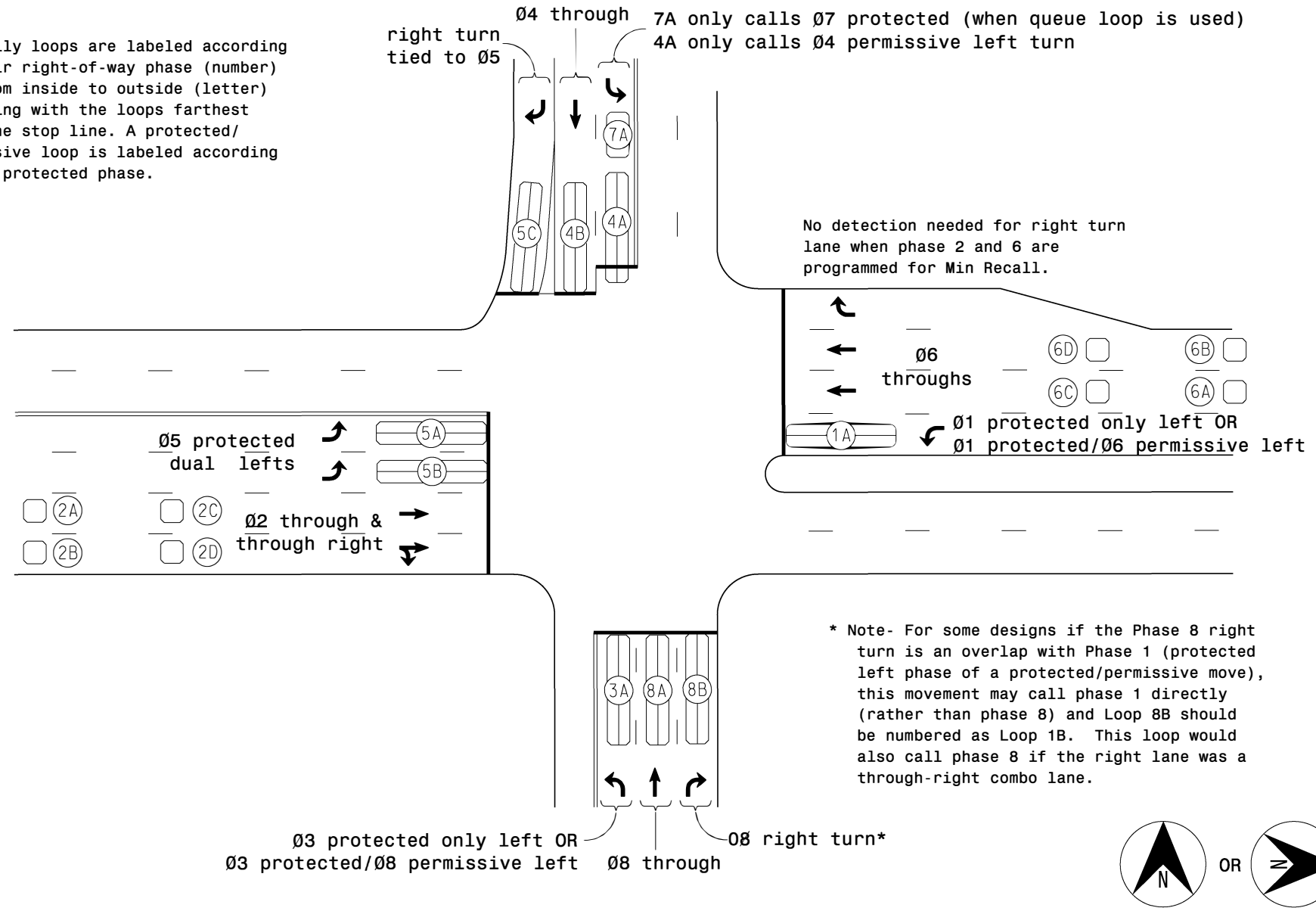
42CR - with Right Turn Overlap



Signal Head Approach Displays and Alignment

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

Typically loops are labeled according to their right-of-way phase (number) and from inside to outside (letter) beginning with the loops farthest from the stop line. A protected/ permissive loop is labeled according to its protected phase.



* Note- For some designs if the Phase 8 right turn is an overlap with Phase 1 (protected left phase of a protected/permissive move), this movement may call phase 1 directly (rather than phase 8) and Loop 8B should be numbered as Loop 1B. This loop would also call phase 8 if the right lane was a through-right combo lane.

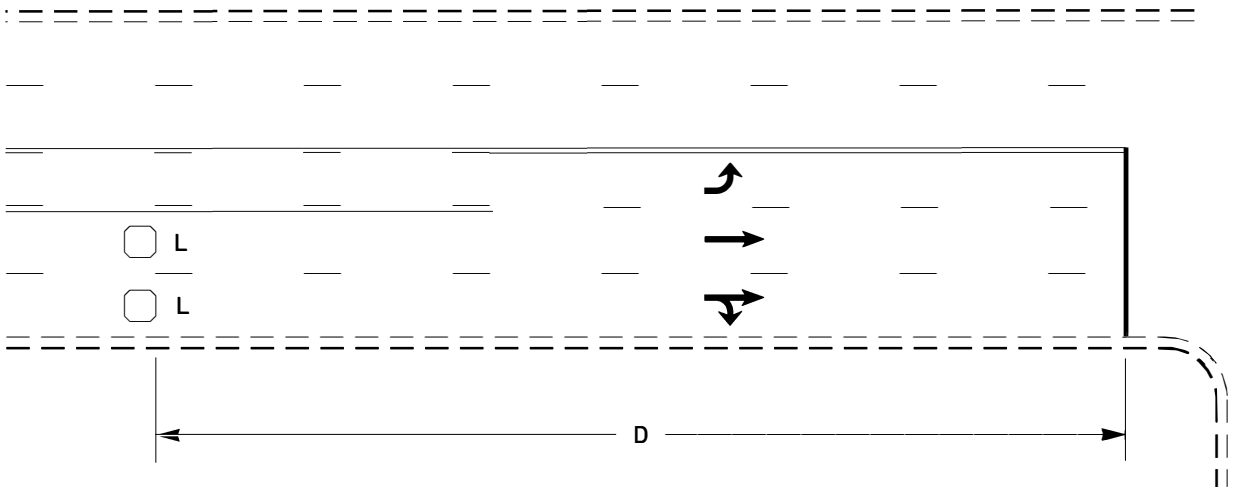
Typical Numbering of Loops/Detection Zones

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

7-21

STD. NO.
4.0
SHEET 1 OF 1

Volume Density Operation



Design Speed (MPH)	Loop Distance D (feet)	Extension/ Gap Time (sec.)	Min. Gap Time (sec.)
35	200	5.0	3.0
40	250	6.0	3.0
45	300	6.0	3.0
50	355	6.0	3.0
55	420	6.0	3.4
60	475	6.0	3.4
65	550	6.5	3.4

L = 6ft X 6ft
- -Presence loop
- -Wired to separate detectors/channels for 2070 Controllers

Design Considerations:

- -High speed [≥40 MPH]
- -Preferred option for cost and efficiency
- -Coordinate with Division and/or Municipality for use on 35 MPH approaches

Notes:

- -Set vehicle call memory to "LOCK"
- -Not appropriate for use with out-of-street detection
- -Volume density loops can double as system detectors when wired separately.

Loop Placement for Main Street Through Movements

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

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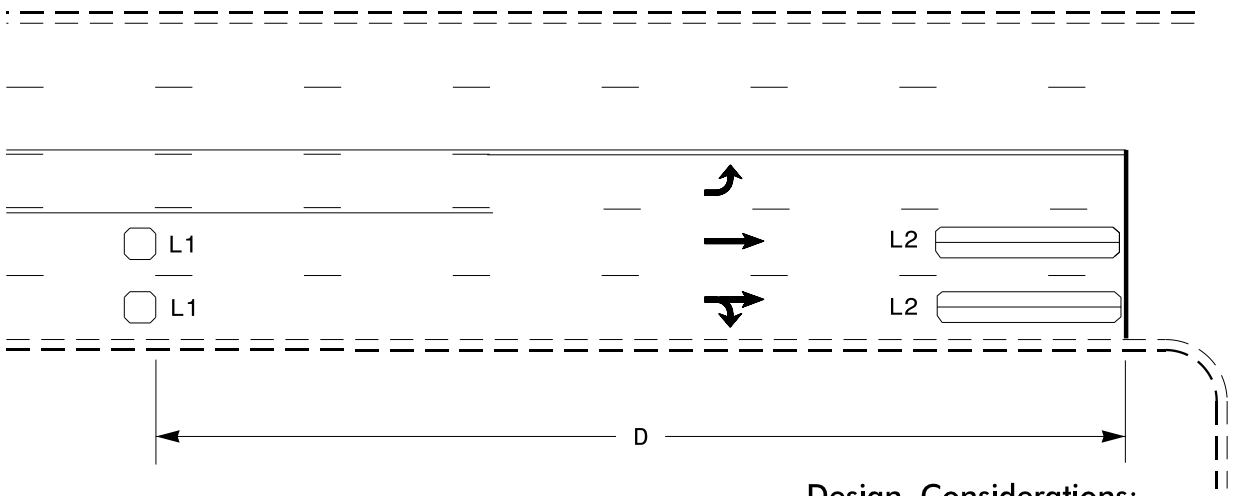
STD. NO.
4.1.1
SHEET 1 OF 4

Volume Density Operation with DC/EC

(Delayed Call/Extended Call)



L1 = 6ft X 6ft
Presence loop
Wired to separate detectors/channels
for 2070 Controllers

L2 = 6ft X 40ft
Quadrupole loop
Wired to separate
detectors/channels

Design Speed (MPH)	D (feet)	L2	
		Delay (sec.)	Extend (sec.)
35	200	5	2.0
40	250	5	2.0
45	300	5	2.0
50	355	5	2.0
55	420	5	2.0
60	475	5	2.0
65	550	5	2.0

Delay times are shown in whole seconds
Extend times are shown in intervals of .1 second

Design Considerations:

-High speed [≥40 MPH]
-High volume driveways between L1 and L2
-Single lane approach with left turns
-High truck traffic with steep positive grades
-Out-of-street detection
-More efficient than standard "stretch" detection,
but more costly to install and maintain
-Coordinate with Division and/or Municipality for
use on 35 MPH approaches

Notes:

-Do not program "ACTUATIONS B4 ADD" (not applicable for 2070 controllers), "SEC. PER ACTUATION" and "MAX. INITIAL"
-Delay on loops L2 must be FULL TIME delay
-Do not program "Vehicle Call Memory" (LOCK) for phases 2 & 6
-Loops L1 can double as system detectors when wired separately

Loop Placement for Main Street Through Movements

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

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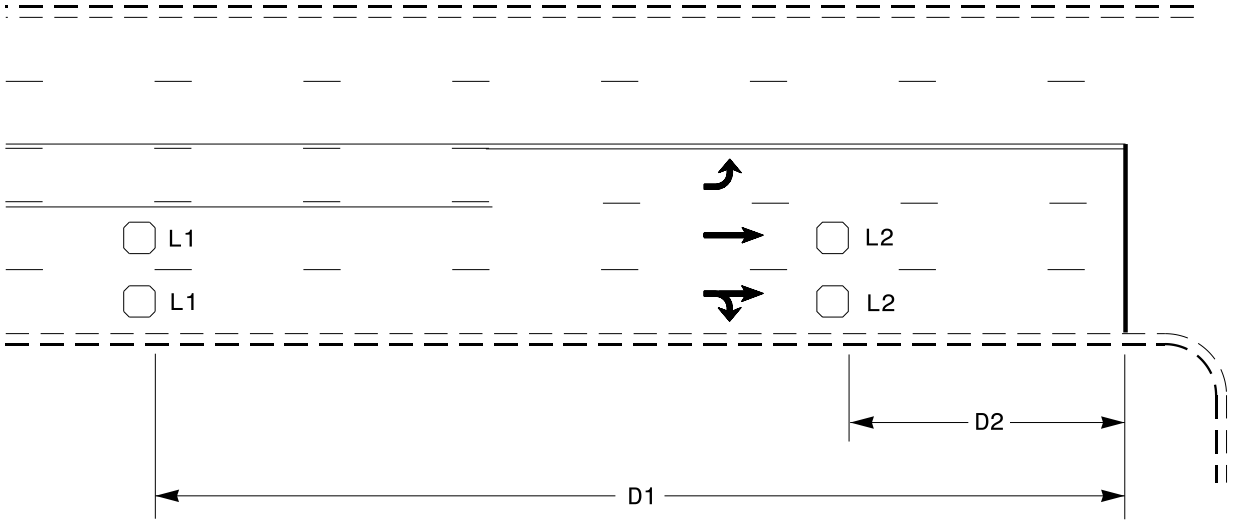
STD. NO.
4.1.1
SHEET 2 OF 4

Extend (Stretch) Detection



L1 = 6ft X 6ft
Presence loop
Wired in series

L2 = 6ft X 6ft
Presence loop
Wired in series

Design Speed (MPH)	D1 (feet)	D2 (feet)	Extend (sec.)
40	250	80	1.3
45	300	90	1.6
50	355	100	1.9
55	420	110	2.2
60	475	120	2.5
65	550	130	2.8

Design Considerations:

-High speed [≥40 MPH]
-High volume driveways between L1 and L2

Notes:

-Appropriate for use with out-of-street detection
-Loops L1 can double as system detectors, IF wired to separate detectors/ channels
-Gap time typically 2.0 seconds
-Loop placement may be varied due to design constraints such as bridges or poor pavement, or non-standard placement of existing loops. In such cases, recalculate Extend times for L1.

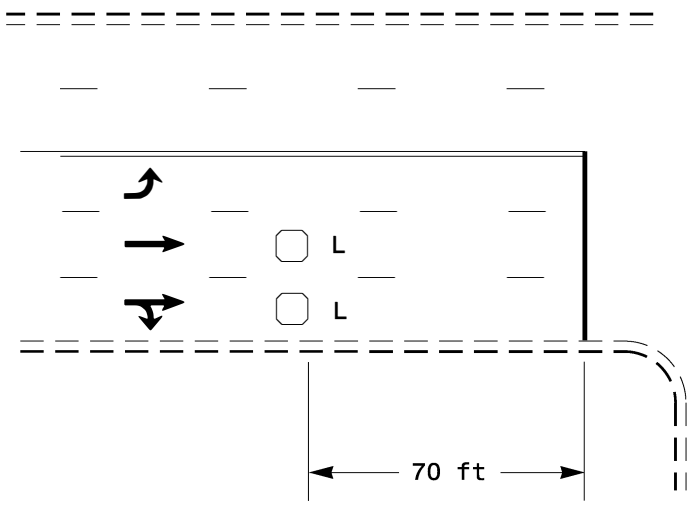
$$\text{Extend time (sec)} = \left(\frac{\text{(D1-D2) feet}}{\text{(Design Speed -5) mph}} \times \frac{\text{3600 sec/hr}}{\text{5280 ft/mi}} \right) - \text{Gap time}$$

Loop Placement for Main Street Through Movements

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.
4.1.1

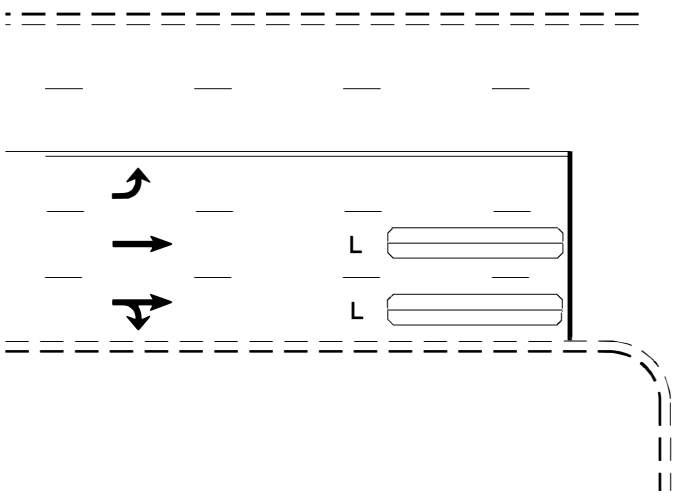
Low Speed Detection



L = 6ft X 6ft
Presence loop, wired in series

Design Considerations:

-Low speed [≤35 MPH]
-Gap time typically 3.0 seconds
-Preferred option
-Program "Vehicle Call Memory" (LOCK)
-May be used on 35 MPH single lane approaches; coordinate with Division and/or Municipality



L = 6ft X 40ft
Quadrupole loop, wired to separate detectors/channels

Design Considerations:

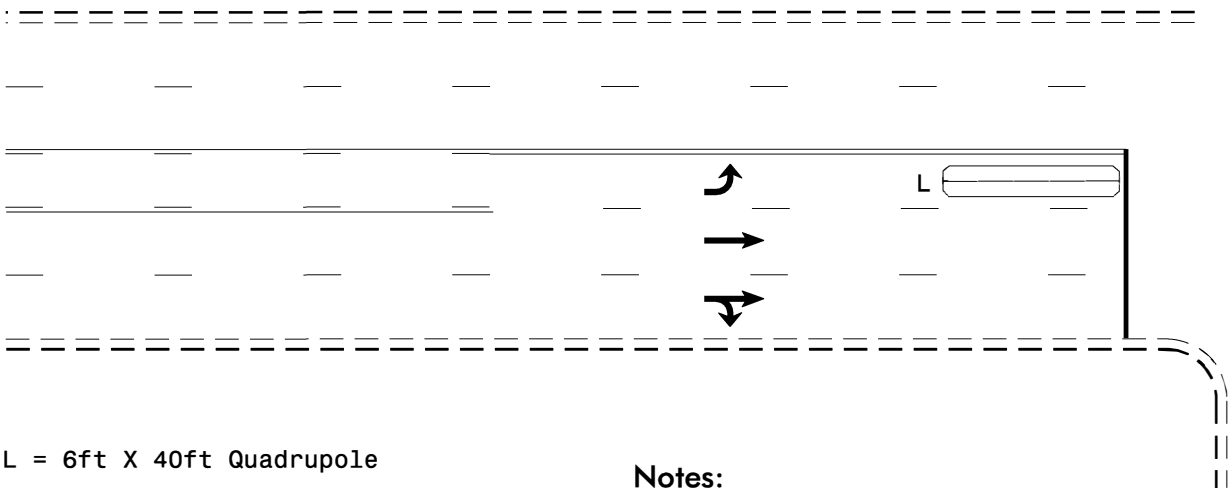
-Low speed [≤35 MPH]
-Gap time typically 0-2 seconds
-Appropriate for use with soft recall
-Do not program "Vehicle Call Memory" (LOCK)

Loop Placement for Main Street Through Movements

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.
4.1.1

Presence Detector



L = 6ft X 40ft Quadrupole

or, if longer detection area is needed:

6ft X 50ft Quadrupole
or
6ft X 60ft Quadrupole

Notes:

- Loops may not be required for all main street permissive turns
- Option to use 6ft X 6ft loop to wire in series with 70′ through loops.

Loop Type	Delay time	Full Time Delay
Left Turn Loop on Main Street with Low Speed or Stretch Detection	0 sec	N/A
Left Turn Loop on Main Street with Volume Density Detection	3-5 sec	Yes
Left Turn Loop on Side Street	2-3 sec if "clipping" prevention is desired; 0 sec otherwise	No

Loop Placement for Permissive Left Turns

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

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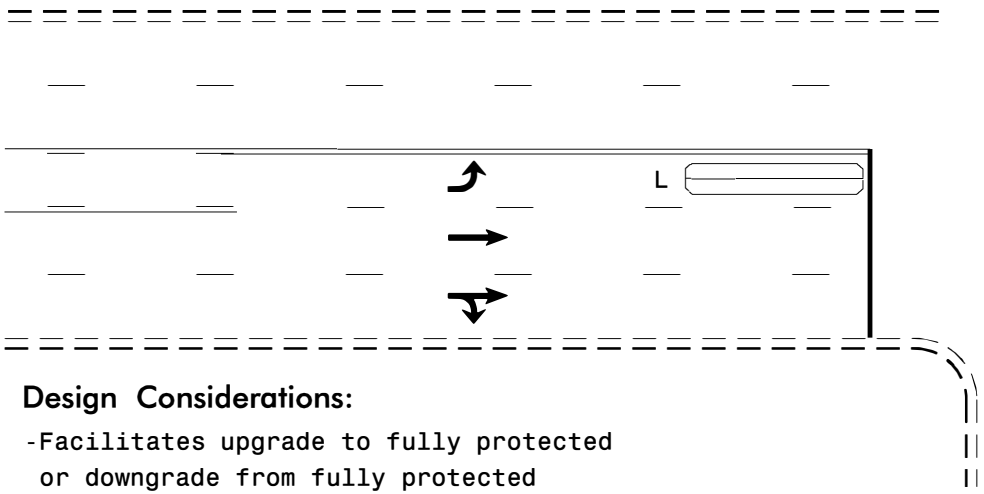
STD. NO.
4.1.2
SHEET 1 OF 1

Presence Loop with 2 Channel Detector



L = 6ft X 40ft Quadrupole loop

or, if longer detection area is needed:

6ft X 50ft Quadrupole loop

or

6ft X 60ft Quadrupole loop

Design Considerations:

- Facilitates upgrade to fully protected or downgrade from fully protected
- Calls up arrow when 1 or 2 cars waiting to turn
- Consider queue loop (Std. No. 4.1.3:2) for light left turn traffic or for light opposing through traffic

Note:

- Calling/extending the permissive phase may not be required for main street loops
- Gap time typically 1-3 seconds

Loop Type	Detector Channel	Phase	Delay Time	Full Time Delay
Left Turn Loop on Main Street with Low Speed or Stretch Detection	1	Protected Phase	10-30 sec (15 Typical)	No
	2	Permissive Phase	0 sec	N/A
Left Turn Loop on Main Street with Volume Density Detection	1	Protected Phase	10-30 sec (15 Typical)	No
	2	Permissive Phase	3-5 sec (3 Typical)	Yes
Left Turn Loop on Side Street	1	Protected Phase	10-30 sec (15 Typical)	No
	2	Permissive Phase	3 sec if "clipping" prevention is desired; 0 sec otherwise	No

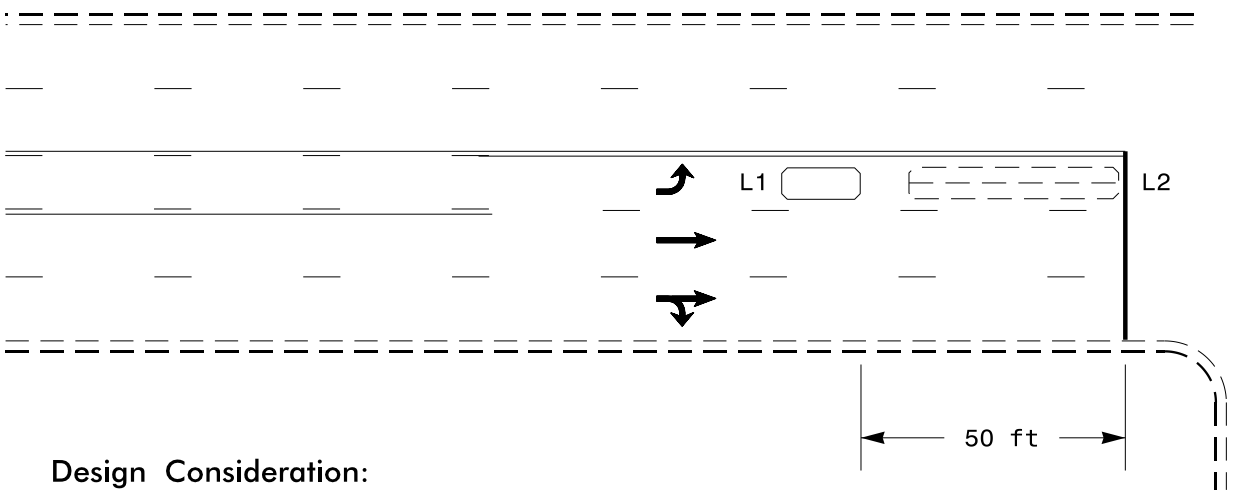
Loop Placement for Protected/Permissive Left Turns

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.

4.1.3

Queue Detector Loop



L1 = 6ft X 15ft
Presence loop (Queue detector) with Call delay

L2 = 6ft X 40ft
Quadrupole loop

Design Consideration:

-Calls up arrow when 3 or more cars waiting to turn
-Consider for side street left turns

Notes:

-L2 is optional when permitted phase has minimum recall
-L1 min green typically 8 seconds
-L1 gap time typically 2-4 seconds
-L2 gap time typically 1-3 seconds

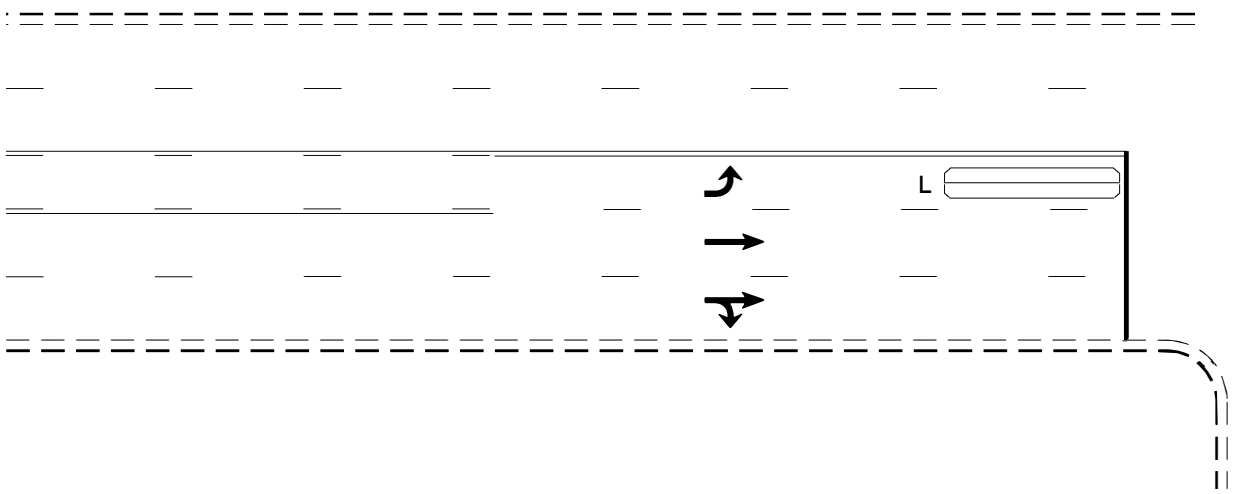
Loop Type	Phase	Delay Time	Full Delay Time
L1: Queue Detector	Protected Phase	5-15 sec	No
L2: Left Turn Loop on Main Street with Low Speed or Stretch Detection	Permissive Phase	0 sec	N/A
L2: Left Turn Loop on Main Street with Volume Density Detection	Permissive Phase	3-5 sec	Yes
L2: Left Turn Loop on Side Street	Permissive Phase	3 sec if "clipping" prevention is desired; 0 sec otherwise	No

Loop Placement for Protected/Permissive Left Turns

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.
4.1.3

Presence Detector



L = 6ft X 40ft Quadrupole

or, if longer detection area is needed:

6ft X 50ft Quadrupole

or

6ft X 60ft Quadrupole

Notes:

-Gap time typically 1-3 seconds
-A short (2 or 3 sec) call delay may be used if turning vehicles are able to "clip" loop L
-If call delay is used, do not program full time delay

Loop Placement for Protected Left Turns

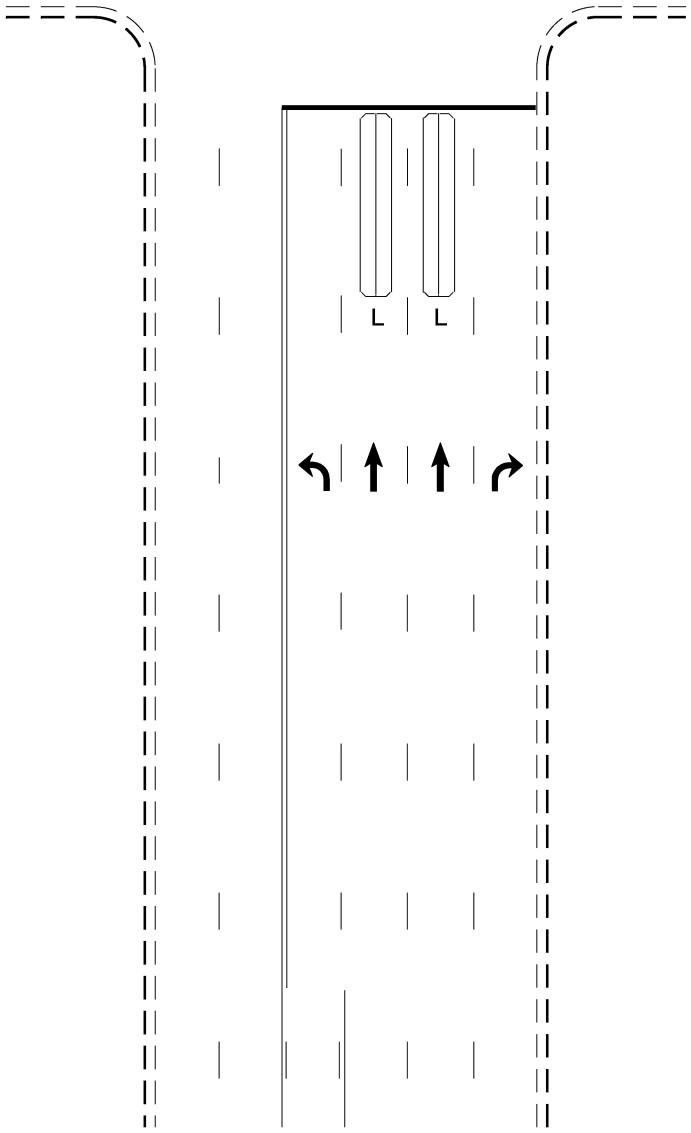
SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

7-21

STD. NO.

4.1.4

SHEET 1 OF 1



Typical Presence Detection

L = 6ft X 40ft
Quadrupole loop
Wired to separate detectors/channels

or, if longer detection area is needed:

6ft X 50ft Quadrupole
or
6ft X 60ft Quadrupole

Notes:

- Consider delay (NOT full time) if through lane is shared with a right-turn move, except where right turn on red is prohibited
- Gap time typically 1-3 seconds
- Do not program "Vehicle Call Memory" (LOCK)
- Consider higher gap time or longer detection area under the following circumstances:
  - Steep positive approach grade
  - High truck volumes

Loop Placement for Side Street Through Movements

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

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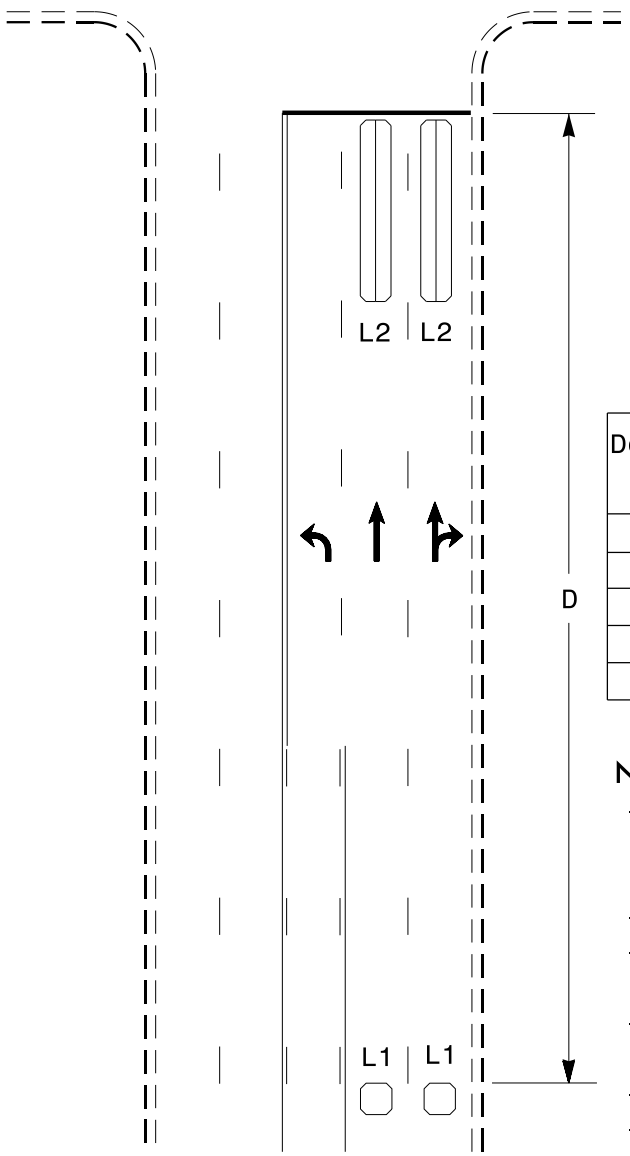
STD. NO.
4.1.5
SHEET 1 OF 3

Volume Density Operation with DC/EC
(Delayed Call/Extended Call



L1 = 6ft X 6ft Presence loop
Wired to separate detectors/channels
for TS2 and 2070 Controllers

L2 = 6ft X 40ft Quadrupole loop
Wired to separate detectors/channels

Design Speed (MPH)	D (feet)	L2	
		Delay (sec.)	Extend (sec.)
35	200	5	2.0
40	250	5	2.0
45	300	5	2.0
50	355	5	2.0
55	420	5	2.0

Design Considerations:

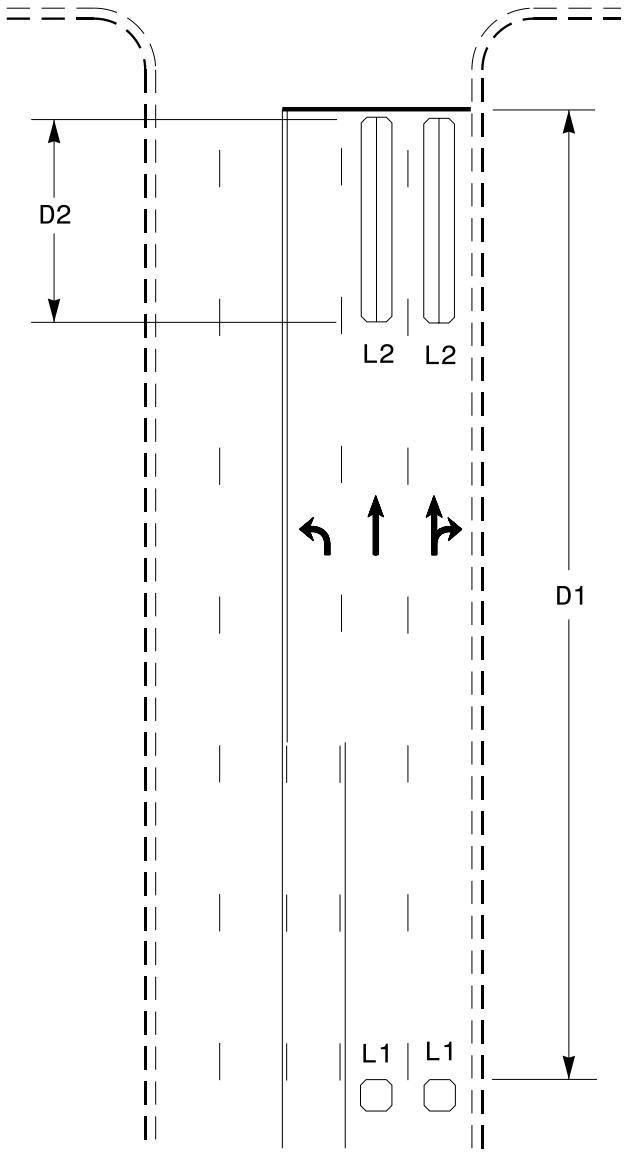
-Cross intersection AND
-Good horizontal and vertical alignment
-High speed [≥40 MPH]
-In some cases can provide better efficiency than "stretch" detection
-May be used on 35 MPH approaches; coordinate with Division and/or Municipality

Notes:

-Do not program "ACTUATIONS B4 ADD" (not applicable for 2070 controllers), "SEC. PER ACTUATION" and "MAX. INITIAL."
-Delay on loops L2 must be FULL TIME delay
-Do not program "Vehicle Call Memory" (LOCK) for phases 4 & 8.
-Loops L1 should be programmed for "EXTENSION" but NOT "CALLING."
-Delay times are shown in whole seconds
-Extend times are shown in intervals of .1 second
-For TS2 controllers, loops L1 must be programmed with 100 second delay (INHIBIT DELAY DURING GREEN = YES) to ensure that the loop acts to extend the phase only.
-Loops L1 can double as system detectors if wired separately.
-See Std. 4.1.1, Sheet 1 for Min and Max Gap (Extension) times

Loop Placement for Side Street Through Movements

Extend (Stretch) Detection



L1 = 6ft X 6ft
Presence loop, Wired in series

L2 = 6ft X D2 Quadrupole loop
Wired to separate detectors/channels

Design Speed (MPH)	D1 (feet)	D2 (feet)	Gap Time (sec.)	L1 Extend (sec.)
35	200	40	2.0	1.7
		60	1.0	2.2
40	250	40	2.0	2.1
		60	1.0	2.7
45	300	40	2.0	2.4
		60	1.0	3.1
50	355	40	2.0	2.8
		60	1.0	3.5
55	420	40	2.0	3.2
		60	1.0	3.9

Design Considerations:

- Cross Intersection AND Good Horizontal and Vertical Alignment
- High speed [≥40 MPH]
- May be used on 35 MPH approaches; coordinate with Division and/or Municipality

Notes:

- Loops L1 should be programmed for "EXTENSION" but NOT "CALLING."
- Do not program "Vehicle Call Memory" (LOCK)
- Loop placement may be varied due to design constraints such as bridges or poor pavement, or non-standard placement of existing loops. In such cases, recalculate Extend times for L1

$$\text{Extend time (sec)} = \left(\frac{\text{(D1-D2) feet}}{\text{(Design Speed -5) mph}} \times \frac{\text{3600 sec/hr}}{\text{5280 ft/mi}} \right) - \text{Gap time}$$

- For TS2 controllers, in addition to appropriate extend time, loops L1 must be programmed with 100 second delay (INHIBIT DELAY DURING GREEN = YES) to ensure that the loop acts to only extend the phase.
- Loops L1 can double as system detectors, if wired separately.

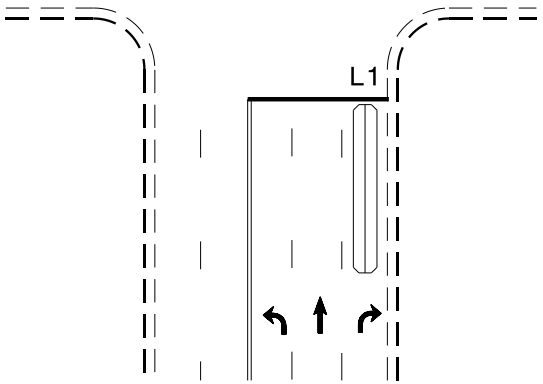
Loop Placement for Side Street Through Movements

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.
4.1.5
SHEET 3 OF 3

Typical Detector Layouts

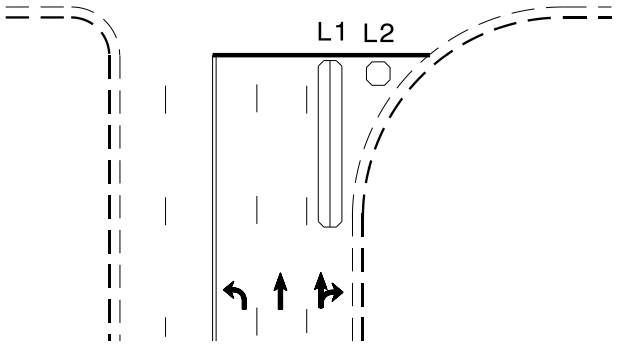
Standard Turn



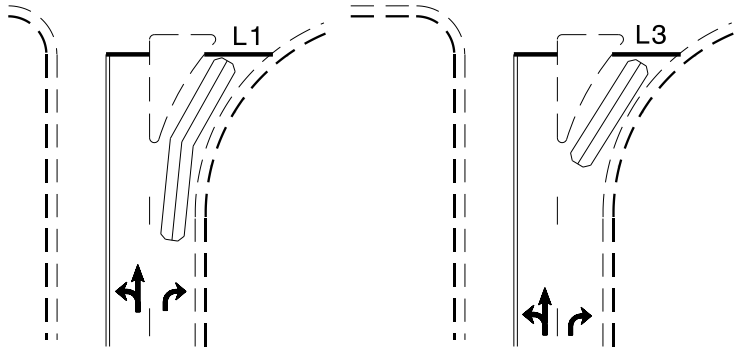
L1 = 6ft X 40ft Quadrupole loop
L2 = 6ft X 6ft [Minimum] Presence loop
Wired to separate detector/channel
L3 = 6ft X 40ft Quadrupole loop

Notes:
-Call delay appropriate for right turn loops unless right turn on red is prohibited.
-Suggestions for delay:
-Exclusive right turn lane: 15 sec
-Right turn lane shared with through or through/left movement: 10 sec or greater
-Do not program full time delay.

Wide Radius Turn



Channelized Turn

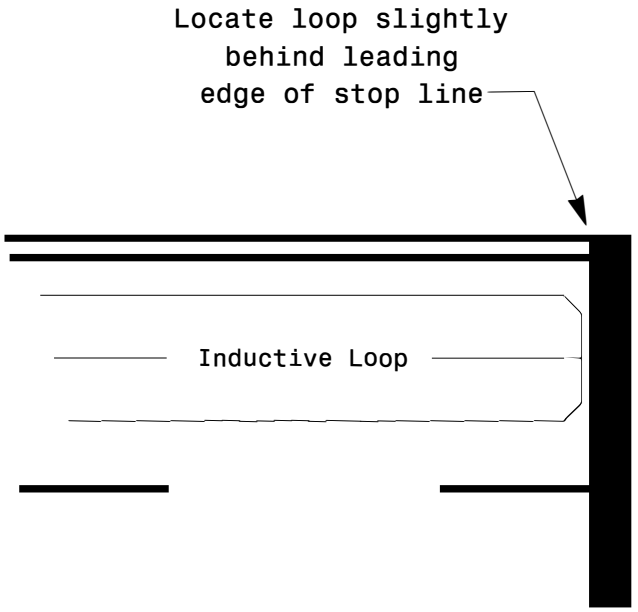


Detection is usually deleted for Yield condition

Loop Placement for Side Street Right Turns

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.
4.1.6
SHEET 1 OF 1



Note:

Loop may be located in advance of stop line when stop line is greater than 15′ from edge of intersecting roadway, or when loop detects a permissive or protected/permissive left turn.

However, this practice should be kept to a minimum as it also encourages drivers to stop beyond the stop line and still be detected, in effect, negating the purpose of the stop line.

Placement of Presence Loops

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

7-21

STD. NO.
4.1.7
SHEET 1 OF 1

Loop Dimension (feet)	Turns	Inductance (µh)	Loop Wire feet	Sealant (gal)*	Sawcut (feet)
6 X 6	3	72	72	0.8	24
	4	120	96		
	5	180	120		
	6	252	144		
6 X 15	2	63	84	1.3	42
	3	126	126		
	4	210	168		
6 X 25	2-4-2	218	224	2.7	87
6 X 30	2-4-2	258	264	3.1	102
6 X 40	2-4-2	338	344	4.0	132
6 X 50	2-4-2	418	424	5.0	162
6 X 60	2-4-2	498	504	5.9	192

* Amount of sealant is rounded up to nearest tenth of a gallon

Amount of Inductance, Loop Wire, Sealant and Sawcut for Inductive Loops

Calculate additional loop wire or sawcut for loop wire tail section by measuring length of tail section from loop to edge of pavement.

OR

$$L\ (ft) = 6+(N-1)12$$

Where: L = Length of loop wire or sawcut
N = Number of lanes crossed by tail section

To calculate additional sealant for loop wire tail section:

$$S\ (gal) = L\ (ft) / 33$$

Where: S = Amount of sealant
L = Length of sawcut required for tail section

Loop Wire and Lead–In Calculations

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.
4.2

Loop Inductance Notes

-Loop inductance should be equal to or greater than the lead-in inductance. A 2-to-1 ratio is preferable.

-Average lead-in cable inductance is .22 μh/ft

-The minimum total inductance on a single digital detector (channel) is 50 uμ, the maximum is 1000 μh.

-The maximum number of turns is 6.

-If the loop (excluding quadrupoles) will have more than 2″ of cover, add 1 turn to the loop over the normal calculated number of turns.

-Loops connected in series

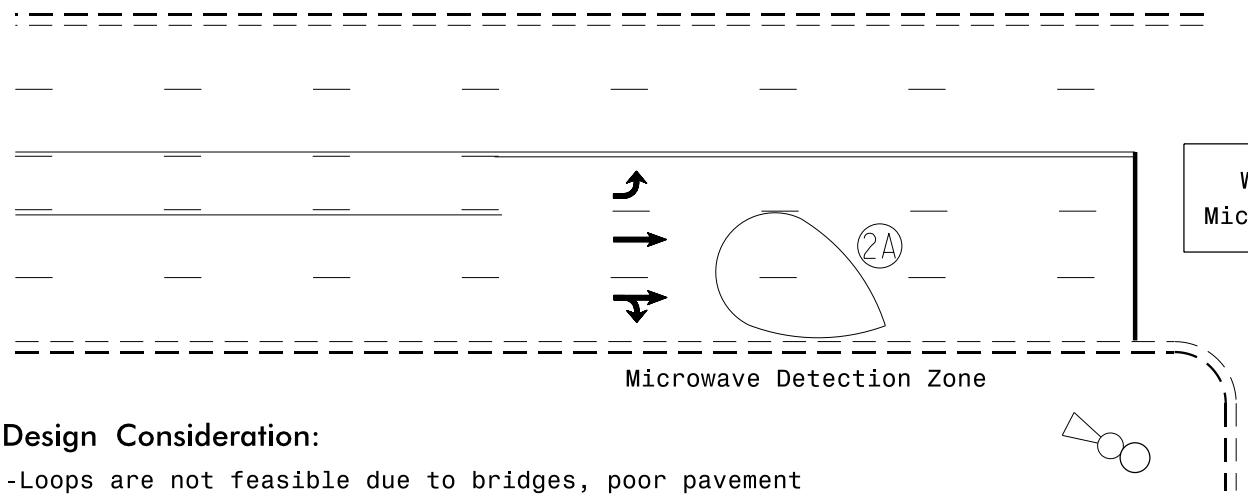
$L_{Total} = L_1 + L_2 + \ldots + L_N$

Where: N = Number of loops in series
L = Loop inductance (μh)

-Recommended number of turns for a single 6′ X 6′ loop:

Length of Lead-in (feet)	Number of Turns
< 250	3
250-375	4
375-525	5
> 525	6

Microwave Vehicle Detector



When used, include Note L 135 for Microwave Detection in the Plan Notes.

Design Consideration:

-Loops are not feasible due to bridges, poor pavement or anywhere loop lead-in can not be reasonably maintained such as constructions zones, etc.
-Typically used for only one to two detection areas, or one approach of an intersection.
-Consult with Division and/or Municipality

Notes:

-Requires one microwave detector unit per detection zone.
-Some units can detect multiple zones.
-Microwave detector needs to face traffic.
-Some microwave detectors have specific detection zone size parameters based on mounting height and distance from zone.
-Generally detects only in pulse mode; can't be used for presence detection.
-Cannot be used for system detection or vehicle counting.

2070 LOOP & DETECTOR INSTALLATION

INDUCTIVE LOOPS					DETECTOR PROGRAMMING							
LOOP	SIZE (FT)	TURNS	DISTANCE FROM STOP LINE (FT)	NEW LOOP	PHASE	CALLING	EXTENSION	FULL TIME DELAY	SYSTEM LOOP	STRETCH TIME	DELAY TIME	NEW CARD
2A	*	*	70	Y	2	Y	Y	-	-	-	-	*

*Microwave Detection Zone

Out–of–Street Detection

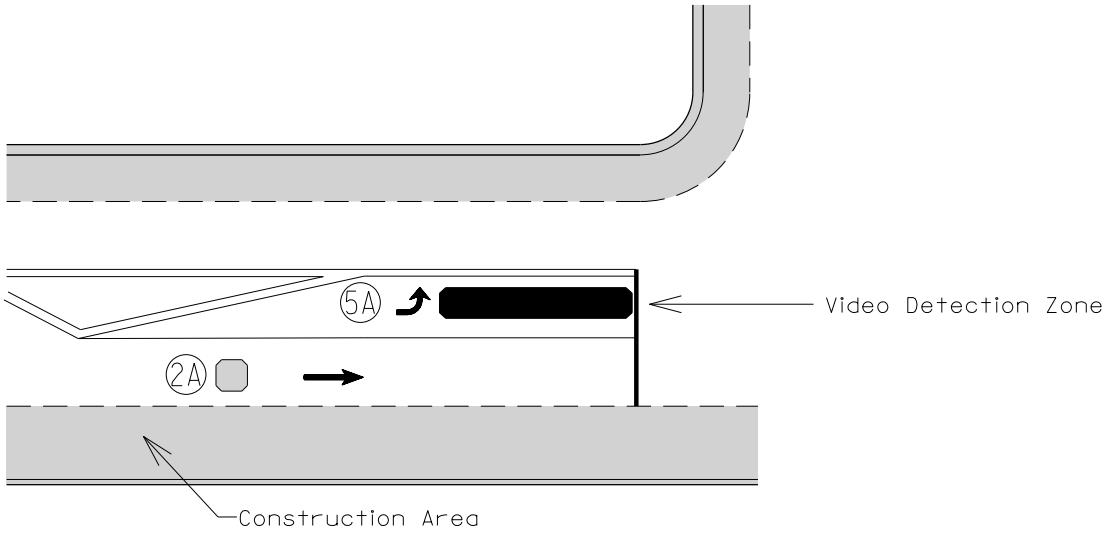
SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

7-21

STD. NO.
4.3
SHEET 1 OF 2

Video Detection Systems
(Loop Emulator, ITS Plus)

When used, include Note L 134 for Video Detection in the Plan Notes.



Design Consideration:

-Loops are not feasible due to bridges, poor pavement, or anywhere loop lead-in can not be reasonably maintained such as constructions zones, etc.
-Flexibility is desired in detection areas due to traffic shifts associated with construction phasing.
-Function similar to inductive loops.
-Consult with Division if video detection is desired for Final Design or permanent detection.

Notes:

-Cannot be used for vehicle counting.
-Cannot be used for system detection.

2070 LOOP & DETECTOR INSTALLATION

INDUCTIVE LOOPS					DETECTOR PROGRAMMING							
LOOP	SIZE (FT)	TURNS	DISTANCE FROM STOP LINE (FT)	NEW LOOP	PHASE	CALLING	EXTENSION	FULL TIME DELAY	SYSTEM LOOP	STRETCH TIME	DELAY TIME	NEW CARD
2A	6X6	*	70	*	2	Y	Y	-	-	-	-	*
5A	6X40	*	0	*	5	Y	Y	-	-	-	15	*
					2	Y	Y	-	-	-	-	*

*Video Detection Zone

NOTES		WHEN TO USE	
L 01	Refer to "Roadway Standard Drawings NCDOT" dated January 2018 and "Standard Specifications for Roads and Structures" dated January 2018.	**H 01**	All Plans except Developer Plans
L 03	Refer to "Roadway Standard Drawings NCDOT" dated January 2018, "Standard Specifications for Roads and Structures" dated January 2018, and all applicable sections of the latest version of the generic Project Special Provisions. The PSP can be accessed at the following website: https://connect.ncdot.gov/resources/safety/Pages/ITS-Design-Resources.aspx	**H 03**	Developer/Private Plans
L 05	Do not program signal for late night flashing operation unless otherwise directed by the Engineer.	**H 05**	For locations without railroad preemption
L 06	This location contains railroad preemption phasing. Do not program signal for late night flashing operation.	**H 06**	For locations with railroad preemption
L 10	Omit phase 1 during phase 2 on.	**H 10**	Phase omit note for NEMA and 2070 operation
L 12	Omit phase 5 during phase 6 on.	**H 12**	Phase omit note for NEMA and 2070 operation
L 14	Omit phase 3 during phase 4 on.	**H 14**	Phase omit note for NEMA and 2070 operation
L 16	Omit phase 7 during phase 8 on.	**H 16**	Phase omit note for NEMA and 2070 operation
L 19	Program controller to clear from phase # to phase # by progressing through phase # (see Electrical Details).	**H 19**	Additional note for omit situations for NEMA and 2070 operation
L 20	Enable Backup Protect (Prevent) to allow the controller to clear from phase # to phase # by progressing through an all red display.	**H 20**	Alternate to Phase Omits for Red Revert. Use Protect for OASIS and Prevent for ASC/3 Software
L 21	Disable Backup Protect (Prevent) for phase #.	**H 21**	Use for plans with existing 2070 controllers where backup protection exists but is no longer needed. Use Protect for OASIS and Prevent for ASC/3 Software
L 22	Phase 1 and/or phase 5 may be lagged.	**H 22**	Use for exclusive left turns or Flashing Yellow Arrows
L 23	Phase 3 and/or phase 7 may be lagged.	**H 23**	Use for exclusive left turns or Flashing Yellow Arrows
L 24	The order of phase 3 and phase 4 may be reversed.	**H 24**	Use for split side streets

Plan Notes

Signal Design Section
Transportation Mobility and Safety Division
North Carolina Department of Transportation

Std. No. 5.0

2-23

NOTES		WHEN TO USE	
L 25	The order of phase 1 and phase 5 may be reversed, but phase 1 and phase 5 shall not operate simultaneously.	**H 25**	Use with required lead/lag phasing where opposing left turns cannot safely operate together
L 26	The order of phase 3 and phase 7 may be reversed, but phase 3 and phase 7 shall not operate simultaneously.	**H 26**	Use with required lead/lag phasing where opposing left turns cannot safely operate together
L 27	Program phase 4 and phase 8 for dual entry.	**H 27**	For use with NEMA equipment
L 30	Remove existing signal heads numbered #.	**H 30**	Use when removing an existing signal head, blank out sign, or sign that is not being replaced on the plan.
L 31	Reposition existing signal heads numbered #.	**H 31**	Use when head is "slid" on same span
L 32	Install backplates for signal heads numbered #.	**H 32**	As needed
L 33	Tether signal heads numbered #.	**H 33**	As needed
L 40	Run all lead-in cable overhead on existing utility poles where possible.	**H 40**	Urban projects with many driveways
L 41	Abandon existing loops #.	**H 41**	As needed, usually by contracts
L 43	Set all detector units to presence mode.	**H 43**	All Plans with actuated loops
L 44	In the event of loop replacement, refer to the current ITS and Signals Design Manual and submit a Plan of Record to the Signal Design Section.	**H 44**	Use when not replacing “old style” loops
L 50	Locate new cabinet so as not to obstruct sight distance of vehicles turning right on red.	**H 50**	All plans with new cabinets
L 51	The cabinet should be designed to include an Auxiliary Output File for future use.	**H 51**	Use on plans with new 2070 cabinets and no FYA
L 52	Program controller to operate using FYA compact mode.	**H 52**	Use for Pole Mounted Cabinets operating FYAs
L 60	Omit "WALK" and flashing "DON'T WALK" with no pedestrian calls.	**H 60**	Use for pedestrian-activated signals (pushbuttons)
L 61	Program pedestrian heads to countdown the flashing "Don't Walk" time only.	**H 61**	Use with countdown peds
L 62	This intersection features accessible pedestrian signals utilizing percussive tone walk indications and/or speech messages.	**H 62**	Use with Accessible Pedestrian Signals

NOTES		WHEN TO USE	
L 63	Phase # pedestrian timing is designed as a 2 stage crossing. The FDW time shown is only intended to get a pedestrian to/from the median during a single crossing. Install R10-3d signs as appropriate.	**H 63**	Use with a 2 stage pedestrian crossing
L 70	Flash beacon # continuously.	**H 70**	Actuated flasher plan
L 71	Flash beacons # when actuated by loop #.	**H 71**	Actuated flasher plan
L 80	Thirty days after implementation of the revised signal operation, signs # and/or orange flags may be removed at the discretion of the Regional Traffic Engineer.	**H 80**	Use on plans being revised from fully protected or split side street phasing to protected-permissive phasing
L 81	Remove existing "Left Turn Signal" sign(s)-(R10-10L) and/or existing "Right Turn Signal" sign(s)-(R10-10R).	**H 81**	As needed
L 82	Existing "Left Turn Yield on Green" ball sign(s)-(R10-12) may be removed at the discretion of the Regional Traffic Engineer.	**H 82**	As needed
L 90	Pavement markings are existing.	**H 90**	Signal upgrades
L 91	Repaint stop lines and/or crosswalks.	**H 91**	As needed
L 92	Install pavement markings to designate lane separations for **APPROACH**.	**H 92**	As needed
L 120	Locate emergency vehicle preemption switch in **LOCATION**.	**H 120**	Emergency vehicle preemption (pushbutton actuated)
L 121	The Division Traffic Engineer will determine the Delay Time and Preempt Dwell Min Time for the emergency vehicle preemption timing.	**H 121**	Emergency vehicle preemption (pushbutton actuated)
L 122	This intersection features an optical preemption system. Shown locations of optical detectors are conceptual only.	**H 122**	Optical preemption
L 123	This intersection features a GPS preemption system.	**H 123**	GPS preemption
L 124	Program signal heads numbered # to clear to all red before going into preempt.	**H 124**	Use in place of dummy phase for emergency vehicle preemption
L 125	Ensure flashing operation does not alter operation of blankout signs.	**H 125**	Standard with RR preemption with blank-out signs
L 126	Clear signal heads numbered # from flashing 8" yellow to steady 12" yellow during interval 1 and steady red during interval 2.	**H 126**	RR preemption plans with advance flashing heads (for non-standard clearance)

NOTES	WHEN TO USE
L 127 Program parent phases for Overlap "P" for all phases used in normal operation.	**H 127** Most signal plans with Advance Railroad Preemption that have a Track Clearance phase
L 128 Ensure overlap "P" is terminated prior to entering preemption.	**H 128** All ASC/3 Plans with Advanced Railroad Preemption
L 129 Upon completion of Railroad (or Emergency Vehicle) Preemption, controller returns to normal operation based on vehicle demand.	**H 129** RR or EV Preemption plan when an exit phase (first normal phase served after preemption) is not or cannot be designated
L 130 The Division (City) Traffic Engineer will determine the hours of use for each phasing plan.	**H 130** Flashing Yellow Arrow plans designed with multiple or time of day phasing options
L 132 These loops serve as queue backup detectors. After # seconds of constant actuation, the detector unit places a call to the controller to preempt normal operation to clear out the storage lanes.	**H 132** Backup queue detectors
L 133 Existing Yellow Change Interval for phase # may be decreased by # seconds per week until the required value is reached.	**H 133** Major adjustments to clearance times
L 134 This intersection uses video detection. Install detectors according to the manufacturer's instructions to achieve the desired detection.	**H 134** Video detection
L 135 This intersection uses multi-zone microwave detection. Install detectors according to the manufacturer's instructions to achieve the desired detection.	**H 135** Microwave detection
L 136 Maximum times shown in timing chart are for free-run operation only. Coordinated signal system timing values supersede these values.	**H 136** Standard with coordination
L 137 Program phase 2 as a dummy phase for Ring 1.	**H 137** Use with SE-PAC software when only phase 6 is used in phasing, such as a one way street
L 138 Program phase 4 as a dummy phase for Ring 1.	**H 138** Use with SE-PAC software when only phase 8 is used in phasing, such as a one way street or tee intersection
L 139 Closed loop system data: Master Asset #, Controller Asset #.	**H 139** Use with any plan in a Closed loop signal system that is not connected to the statewide central server

MAXTIME with 170 Cabinet

MAXTIME DETECTOR INSTALLATION CHART

List All Loops in Ascending Alpha Numeric Order

	DETECTOR					PROGRAMMING							
	LOOP	SIZE (FT)	DISTANCE FROM STOP LINE (FT)	TURNS	NEW LOOP	CALL PHASE	DELAY TIME	EXTEND TIME	EXTEND	ADDED INITIAL	CALL	DELAY DURING GREEN	NEW CARD
Protected/Permissive Left Turn Calling 2 Phases (w/Stretch or Low Speed Detection on phase 6)	1A	6X40	0	2–4–2	–	1	15	–	X	–	X	–	–
						6	–	–	X	–	X	–	–
Volume Density Loop (Combined System Loop Not Used in Kinetic System)	2A	6X6	420	5	X	2	–	–	X	X	X	–	–
Volume Density with DC/EC for Side Street	4A	6X6	300	5	X	4	–	–	X	X	–	–	X
	4B	6X40	0	2–4–2	X	4	5	2.0	X	–	X	X	X
Protected/Permissive Left Turn Calling 2 Phases (with Volume Density on phase 2)	5A	6X40	0	2–4–2	X	5	15	–	X	–	X	–	–
						2	3	–	X	–	X	X	–
Side Street Right Turn Overlap Loop	5B	6X40	0	2–4–2	X	5	15	–	X	–	X	–	X
Stretch Loops	6A, 6B	6X6	300	EXISTING	–	6	–	1.6	X	–	X	–	–
	6C, 6D	6X6	90	4	–	6	–	–	X	–	X	–	–
Protected Only Left Turn Loop	7A	6X40	0	2–4–2	X	7	3	–	X	–	X	–	X
Permissive Only Left Turn Loop	8A	6X40	0	2–4–2	X	8	3	–	X	–	X	–	X
Side Street Through–Right Turn Combo Lane Loop	8B	6X40	0	2–4–2	X	8	10	–	X	–	X	–	X
System Loop	S3	6X6	+120	4	–	–	–	–	–	–	–	–	–

(Use X for Yes or –for No)

Enter Delay times as Whole seconds

Enter Extend times in intervals of 0.1 second

Detector Programming Attributes

Extend - Select to extend the green time by Passage time in Timing Chart; resets after each call. (Usually selected)

Added Initial - Enable when Volume Density is Used for Loop

Call - Select to place call during yellow or red. (Usually selected)

Delay During Green- Select to delay during red, yellow, and green (full time delay). If not selected, controller will time delay during red and yellow only. Normally used only with Volume Density.

Loop Chart Typicals

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO. 5.1

OASIS with 170 Cabinet

OASIS 2070 LOOP & DETECTOR INSTALLATION CHART

List All Loops in Ascending Alpha Numeric Order

	INDUCTIVE LOOPS					DETECTOR PROGRAMMING							
	LOOP	SIZE (FT)	DISTANCE FROM STOP LINE (FT)	TURNS	NEW LOOP	PHASE	CALLING	EXTENSION	FULL TIME DELAY	STRETCH TIME	DELAY TIME	SYSTEM LOOP	NEW CARD
Protected/Permissive Left Turn Calling 2 Phases (w/Stretch or Low Speed Detection on phase 6)	1A	6X40	0	2–4–2	–	1	Y	Y	–	–	15	–	–
						6	Y	Y	–	–	–	–	–
Volume Density Loop Combined w/System Loop (Combined Loop Not Used in Centracs Systems)	2A/S1	6X6	420	5	Y	2	Y	Y	–	–	–	Y	–
Volume Density with DC/EC for Side Street	4A	6X6	300	5	Y	4	–	Y	–	–	–	–	Y
	4B	6X40	0	2–4–2	Y	4	Y	Y	Y	2.0	5	–	Y
Protected/Permissive Left Turn Calling 2 Phases (with Volume Density on phase 2)	5A	6X40	0	2–4–2	Y	5	Y	Y	–	–	15	–	–
						2	Y	Y	Y	–	3	–	–
Side Street Right Turn Overlap Loop	5B	6X40	0	2–4–2	Y	5	Y	Y	–	–	15	–	Y
Stretch Loops	6A, 6B	6X6	300	EXISTING	–	6	Y	Y	–	1.6	–	–	–
	6C, 6D	6X6	90	4	–	6	Y	Y	–	–	–	–	–
Protected Only Left Turn Loop	7A	6X40	0	2–4–2	Y	7	Y	Y	–	–	3	–	Y
Permissive Only Left Turn Loop	8A	6X40	0	2–4–2	Y	8	Y	Y	–	–	3	–	Y
Side Street Through–Right Turn Combo Lane Loop	8B	6X40	0	2–4–2	Y	8	Y	Y	–	–	10	–	Y
System Loop	S3	6X6	+120	4	–	–	–	–	–	–	–	Y	–

(Use Y for Yes or – for No; Do not use X)

Enter Stretch times in intervals of 0.1 second

Delay times are Whole seconds

Detector Programming Attributes

Calling - Select to place call during yellow or red.

Extension - Select to extend the green time. Gap resets after each call. Must be selected whenever Vehicle Extension Time is entered in the timing chart. (Usually selected)

Full Time Delay - Select to delay during red, yellow, and green. If not selected, controller will time delay during red and yellow only. Normally used only with Volume Density.

Stretch Time - Enter times in intervals of .1 second

ASC/3 with 170 Cabinet

List All Loops in Ascending Alpha Numeric Order

ASC/3 DETECTOR INSTALLATION CHART

	DETECTOR					PROGRAMMING							
	LOOP	SIZE (FT)	DISTANCE FROM STOP LINE (FT)	TURNS	NEW LOOP	PHASE	CALLING	EXTEND TIME	DELAY TIME	USE ADDED INITIAL	TYPE	SYSTEM LOOP	NEW CARD
Protected/Permissive Left Turn Calling 2 Phases (w/Stretch or Low Speed Detection on phase 6)	1A	6X40	0	2–4–2	–	1	Yes	–	15.0	–	N	–	–
						6	Yes	–	–	–	N	–	–
Volume Density Loop combined w/System Loop	2A/S1	6X6	420	5	X	2	Yes	–	–	X	N	X	–
Volume Density with DC/EC for Side Street	4A	6X6	300	5	X	4	No	–	–	X	N	–	X
	4B	6X40	0	2–4–2	X	4	Yes	2.0	5.0	–	G	–	X
Protected/Permissive Left Turn Calling 2 Phases (with Volume Density on phase 2)	5A	6X40	0	2–4–2	X	5	Yes	–	15.0	–	N	–	–
						2	Yes	–	3.0	–	G	–	–
Side Street Right Turn Overlap Loop	5B	6X40	0	2–4–2	X	5	Yes	–	15.0	–	N	–	X
Stretch Loops	6A, 6B	6X6	300	EXISTING	–	6	Yes	1.6	–	–	N	–	–
	6C, 6D	6X6	90	4	–	6	Yes	–	–	–	N	–	–
Protected Left Turn Loop	7A	6X40	0	2–4–2	X	7	Yes	–	3.0	–	N	–	X
Permissive Only Left Turn Loop	8A	6X40	0	2–4–2	X	8	Yes	–	3.0	–	N	–	X
Side Street Through–Right Turn Combo Lane Loop	8B	6X40	0	2–4–2	X	8	Yes	–	10.0	–	N	–	X
System Loop	S3	6X6	+120	4	–	0	No	–	–	–	N	X	–

Enter Extend times in intervals of 0.1 second

Enter Delay times in intervals of 0.1 second from 0.0 to 255.0

Detector Programming Attributes

Delay - As Needed for Clipping or to reduce immediate call to serve phase, to allow for permissive turns or right on red when allowed

Extend (Stretch) - Enter times in intervals of .1 second

Use Added Initial: Use Only with Volume Density

ASC/3 Detector Type:

S = Standard Loop, W/ Extend and Delay
N = NTCIP (Used for Counting)
G = Full Time Delay
C = Call Phase only when Phase is NOT Green (Typically Not Used)
B = Enables Bike Min Green when Phase is served (Typically Not Used)

Loop Chart Typicals

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO. 5.1

ASC/3 with NEMA Cabinets: Use with Cary Signal System

List All Loops in Ascendng Alpha Numeric Order

LOOP & DETECTOR INSTALLATION CHART

ASC/3-2070LXN2 CONTROLLER w/ TS-2 CABINET

	INDUCTIVE LOOPS						DETECTOR UNITS						
	LOOP NO.	SIZE (ft)	DIST. FROM STOP LINE (ft)	TURNS	NEW	EXISTING	NEMA PHASE	NEW	EXISTING	TIMING		USE ADDED INITIAL	DET. TYPE
										FEATURE	TIME		
Protected/Permissive Left Turn Calling 2 Phases (w/Stretch or Low Speed Detection on phase 6)	1A	6X40	0	2–4–2	–	X	1	–	X	DELAY	15.0	–	N
							6	–	X	–	–	–	N
Volume Density Loop combined w/System Loop	2A/S1	6X6	300	4	X	–	2	–	X	–	–	X	N
							0	–	X	SYSTEM DETECTOR			N
Volume Density with DC/EC for Side Street	4A	6X6	300	4	X	–	4	X	–	–	–	X	N
	4B	6X40	0	2–4–2	X	–	4	X	–	DC/EC	5.0/2.0	–	G
Protected/Permissive Left Turn Calling 2 Phases (with Volume Density on phase 2)	5A	6X40	0	2–4–2	X	–	5	–	X	DELAY	15.0	–	N
							2	–	X	DELAY	3.0	–	G
Side Street Right Turn Overlap Loop	5B	6X40	0	2–4–2	X	–	5	X	–	DELAY	15.0	–	N
Stretch Loops	6A, 6B	6X6	300	EXISTING	–	X	6	–	X	EXTEND	1.6	–	N
	6C, 6D	6X6	90	4	–	X	6	–	X	–	–	–	N
Protected Left Turn Loop	7A	6X40	0	2–4–2	X	–	7	X	–	DELAY	3.0	–	N
Permissive Only Left Turn Loop	8A	6X40	0	2–4–2	X	–	8	X	–	DELAY	3.0	–	N
Side Street Through–Right Turn Combo Lane Loop	8B	6X40	0	2–4–2	X	–	8	X	–	DELAY	10.0	–	N
System Loop	S3	6X6	+120	4	–	X	0	–	X	SYSTEM DETECTOR			N

Enter Extend times in intervals of 0.1 second

Enter Delay times in intervals of 0.1 second from 0.0 to 255.0

Detector Programming Attributes

Delay - As Needed for Clipping or to reduce immediate call to serve phase, to allow for permissive turns or right on red when allowed

Extend (Stretch) - Enter times in intervals of .1 second

Use Added Initial: Use Only with Volume Density

ASC/3 Detector Type:

S = Standard Loop, W/ Extend and Delay
N = NTCIP (Used for Counting)
G = Full Time Delay
C = Call Phase only when Phase is NOT Green (Typically Not Used)
B = Enables Bike Min Green when Phase is served (Typically Not Used)

Loop Chart Typicals

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO. 5.1

SE-PAC: Use with Hickory and Raleigh Signal Systems

SE-PAC 2070 LOOP & DETECTOR UNIT INSTALLATION CHART

List All Loops in Ascendng Alpha Numeric Order

	INDUCTIVE LOOPS						DETECTOR PROGRAMMING															
								TIMING		OPERATION MODE											STATUS	
										0	1	2	3	4	5	6	7				
	LOOP NO.	SIZE (ft)	TURNS	DIST. FROM STOP LINE (ft)	NEW	EXISTING	ASSIGNED PHASE	DELAY	EXTEND (STRETCH)	VEHICLE	PEDESTRIAN	1 CALL	STOP A	STOP B	PROT/PER LEFT	PROT/PER THROUGH	AND	SWITCH	SYSTEM LOOPS	NEW	EXISTING
* Left Turn Loop for Alternate Phasing	1A	6X40	2–4–2	0	–	X	1	5.0 SEC.	– SEC.	X	–	–	–	–	–	–	–	–	–	–	X
Volume Density Loop combined w/System Loop	2A/S1	6X6	5	300	X	–	2	– SEC.	– SEC.	X	–	–	–	–	–	–	–	–	–	–	X
Volume Density with DC/EC for Side Street	4A	6X6	5	300	X	–	4	100.0 SEC.	– SEC.	X	–	–	–	–	–	–	–	–	–	X	–
	4B	6X40	2–4–2	0	X	–	4	5.0 SEC.	2.0 SEC.	X	–	–	–	–	–	–	–	–	–	X	–
Protected/Permissive Left Turn Calling 2 Phases (Stretch or Volume Density on Main Street)	5A	6X40	2–4–2	0	X	–	5	15.0 SEC.	– SEC.	X	–	–	–	–	–	–	–	–	–	–	X
							2	– SEC.	– SEC.	X	–	–	–	–	–	–	–	–	–	–	X
Side Street Right Turn Overlap Loop	5B	6X40	2–4–2	0	X	–	5	15.0 SEC.	– SEC.	X	–	–	–	–	–	–	–	–	–	X	–
Stretch Loops	6A, 6B	6X6	EXISTING	300	–	X	6	– SEC.	1.6 SEC.	X	–	–	–	–	–	–	–	–	–	–	X
	6C, 6D	6X6	4	90	–	X	6	– SEC.	– SEC.	X	–	–	–	–	–	–	–	–	–	–	X
Protected Left Turn Loop	7A	6X40	2–4–2	0	X	–	7	3.0 SEC.	– SEC.	X	–	–	–	–	–	–	–	–	–	X	–
Permissive Only Left Turn Loop	8A	6X40	2–4–2	0	X	–	8	3.0 SEC.	– SEC.	X	–	–	–	–	–	–	–	–	–	X	–
Side Street Through–Right Turn Combo Lane Loop	8B	6X40	2–4–2	0	X	–	8	10.0 SEC.	– SEC.	X	–	–	–	–	–	–	–	–	–	X	–
System Loop	S3	6X6	4	+120	–	X	0	– SEC.	– SEC.	–	–	–	–	–	–	–	–	–	X	–	X

* When Alternate Phasing is used, the loop should only be programed to call and exend the left turn phase with a 5 second delay.

Detector Programming Attributes

Vehicle- Vehicle detector operates as standard vehicle detector

Pedestrian - Vehicle detector operates as standard pedestrian detector (Not Used)

Switch - List an alternate phase that could be extended when green by loop detection while the assigned primary phase is red (Not Normally Used)

Extend (Stretch) - Enter times in intervals of .1 second

Features Typically Not Used:
- 1 Call
- Stop A
- Stop B
- Prot/Per Left
- Prot/Per Through
- And

SE-PAC detectors cannot be programmed for Full Time Delay or variable operation Alternate (Time of Day) Phasing

Enter Extend times in intervals of 0.1 second

Enter Delay times in intervals of 0.1 second from 0.0 to 255.0

Trafficware Apogee: Use with Greensboro Signal System

List All Loops in Ascendng Alpha Numeric Order

LOOP & DETECTOR UNIT INSTALLATION CHART
TRAFFICWARE APOGEE SOFTWARE 2070 CONTROLLER

	INDUCTIVE LOOPS					DETECTOR PROGRAMMING								
	LOOP	SIZE (FT)	DISTANCE FROM STOP LINE (FT)	TURNS	NEW LOOP	PHASE	SWITCH (PHASE)	DELAY TIME	STRETCH TIME	CALLING	EXTENSION	ADDED INIT.	SYSTEM LOOP	NEW CARD
* Left Turn Loop for Alternate Phasing	1A	6X40	0	2–4–2	–	1	–	5.0	–	X	X	–	–	–
Volume Density Loop combined w/System Loop	2A/S1	6X6	300	5	X	2	–	–	–	X	X	X	X	–
Stretch Detection for Side Street	4A	6X6	300	5	X	4	–	100.0	–	–	X	–	–	X
	4B	6X40	0	2–4–2	X	4	–	5.0	2.0	X	X	–	–	X
Protected/Permissive Left Turn Calling 2 Phases (Stretch or Volume Density on Main Street)	5A	6X40	0	2–4–2	X	5	2	15.0	–	X	X	–	–	X
Side Street Right Turn Overlap Loop	5B	6X40	0	2–4–2	X	5	–	15.0	–	X	X	–	–	X
Stretch loops	6A, 6B	6X6	300	EXISTING	–	6	–	–	1.6	X	X	–	–	–
	6C, 6D	6X6	90	4	–	6	–	–	–	X	X	–	–	–
Protected Left Turn Loop	7A	6X40	0	2–4–2	X	7	–	3.0	–	X	X	–	–	X
Permissive Only Left Turn Loop	8A	6X40	0	2–4–2	X	8	–	3.0	–	X	X	–	–	X
Side Street Through–Right Turn Combo Lane Loop	8B	6X40	0	2–4–2	X	8	–	10.0	–	X	X	–	–	X
System Loop	S3	6X6	+120	4	–	–	–	–	–	–	–	–	X	–

2070 Controller w/Trafficware Apogee Software (Formerly Naztec)

Enter Delay times in intervals of 0.1 second from 0.0 to 255.0

Enter Stretch times in intervals of 0.1 second

* Trafficware Apogee loops cannot be programmed for variable phasing. When Alternate Phasing is used, the loop should only be programed for the left turn phase with a 5 second delay.

Detector Programming Attributes

Switch (Phase) - Typically used with protected/permitted left turns to call and extend switched phase when it's green. In example above, phase 2 is left is extended after phase 5 terminates.

Calling - Select to place call during red. (Usually selected)

Extension - Select to extend the green time. (Usually selected)

Added Initial: Use Only with Volume Density Operation

Trafficware Apogee detectors cannot be programmed for Full Time Delay or variable operation Alternate (Time of Day) Phasing

MAXTIME Timing Chart (Part 1)

For All Plans

- Typically 7 seconds when Pedestrian Phase used
- Pedestrian Clear (See STD. 6.0)
- Main Street:
  ≥ 50 MPH = 14 sec
  40-45 MPH = 12 sec
  ≤ 35 MPH = 10 sec

  Side Streets, Left Turns, and Main Street
  Stop Line Detection: Set to 4-8 sec
  Typically 7 sec.
- Main Street - Typically 2.0 sec for stretch detection, 3.0 sec for low speed detection. For Volume Density, amount of time required to get vehicle traveling 5 MPH under the speed limit from upstream loop to stop line, generally 6.0 sec.
  Side Street - Typically 1.0-3.0 sec. Adjust for size of detection area, grade, truck traffic, etc.
  (Left) Turning Phase - Typically 2.0 seconds for 6X40 loops at stop line.
- Maximum green times may be determined with the help of a software package. Alternately, a hand calculation may be suitable:

  $$\text{Max Green} = 4 + 2\left(\frac{\text{Heaviest PHV per lane}}{3600/\text{est cycle length}}\right)$$ PHV = Peak hour volume
- See STD. NO. 5.2.2
- Leading Pedestrian Interval (See STD. 6.0)
- Default is for detector to Lock call. Use X to set detector on Non Lock for stop line detection (most phases other than 2+6)
- NONE, MIN RECALL, MAX RECALL, SOFT RECALL, or PED RECALL
- ON or not selected (see Definitions)

MAXTIME TIMING CHART

FEATURE	PHASE		
	2	4	5
Walk *	7	7	–
Ped Clear *	13	22	–
Min Green *	12	7	7
Passage *	6.0	2.0	2.0
Max 1 *	75	30	20
Yellow Change	4.2	3.7	3.0
Red Clear	1.9	2.1	3.2
Added Initial *	2.5	-	-
Maximum Initial *	34	-	-
Time Before Reduction *	15	-	-
Time To Reduce *	30	-	-
Minimum Gap	3.0	-	-
Advance Walk *	3	3	-
Non Lock Detector	-	X	X
Vehicle Recall	MIN RECALL	-	-
Dual Entry	-	X	-

* These values may be field adjusted. Do not adjust Min Green and Extension times for phases 2 and 6 lower than what is shown. Min Green for all other phases should not be lower than 4 seconds.

Note: For Pre-Timed Signal, set Passage to 0.0 and Recall Position to MAX RECALL.
25.5 = Default time for normal phase time

Note: The default entry for many features in the controller is 0. If a value is not changing on the signal plan (such as no pedestrian phase is used), show a dash (-) in the Timing Chart to show that the value does not change.

MAXTIME Timing Chart (Part 2)

For Volume Density Plans (See 5.2.3 Sheet 1)

Variable Initial Features (Time only during non–green portion of phase)

- Amount added to Variable Initial Time (starting at 0) for each actuation of detector loops. Typical values:
  2.5 secs. for single through lane
  1.5-1.8 sec. for two through lanes
  1.0-1.5 sec. for three through lanes
  When traffic is more evenly distributed over multiple lanes, use lower number. Increase for high truck traffic.

- Time needed to service a queue reaching from detector loop to stop line. Calculated by:

$$\text{Maximum Variable Initial} = 4 + 2\left\langle \frac{\text{Distance to loop}}{\text{Std veh length} = 20' \text{ (6m)}} \right\rangle$$

Gap Reduction Features (Time only during green portion of phase)

- Time that expires before gap reduction begins. Prevents premature transfer of green. Typically 15-30 secs., but never less than the minimum green.
  For sidestreet Volume Density, may use 0 or 5 sec.
- Amount of time over which gap time will reduce from initial value (Extension 1) to minimum value (Minimum Gap). Typically 30-60 secs.
  For side street Volume Density, may use 15 or 20 sec.
- Set equal to lowest gap time that allows vehicle to clear dilemma zone. Typically 3.0 sec. - 4.0 sec., but no lower than 3.4 sec. for 55 MPH (See STD. 4.1.1, Sheet 1)

Notes:
- -The sum of the Time Before Reduction and the Time to Reduce should not exceed the Max Green 1 time.
- -The Extension 1 resets to the initial value if the serviceable conflicting call is removed (eg. Turns right on red).

MAXTIME TIMING CHART

FEATURE	PHASE		
	2	4	5
Walk *	7	7	–
Ped Clear *	13	22	–
Min Green *	12	7	7
Passage *	6.0	2.0	2.0
Max 1 *	75	30	20
Yellow Change	4.2	3.7	3.0
Red Clear	1.9	2.1	3.2
• Added Initial *	2.5	-	-
• Maximum Initial *	34	-	-
• Time Before Reduction *	15	-	-
• Time To Reduce *	30	-	-
• Minimum Gap	3.0	-	-
Advance Walk *	3	3	-
Non Lock Detector	-	X	X
Vehicle Recall	MIN RECALL	-	-
Dual Entry	-	X	-

* These values may be field adjusted. Do not adjust Min Green and Extension times for phases 2 and 6 lower than what is shown. Min Green for all other phases should not be lower than 4 seconds.

Note: For Pre-Timed Signal, set Passage to 0.0 and Recall Position to MAX RECALL.
25.5 = Default time for normal phase time

Note: The default entry for many features in the controller is 0. If a value is not changing on the signal plan (such as no pedestrian phase is used), show a dash (-) in the Timing Chart to show that the value does not change.

OASIS Timing Chart

For All Plans

- See Sheet 1, Min Green 1
- See Sheet 1, Passage
- See Sheet 1, Max Green 1
- See STD. NO. 5.2.2
- Minimum Red used during Backup Protection. Typically set to 5.0 for phase(s) used, otherwise default is 2.0 sec. (See Std. 2.3)
- See Sheet 1, Walk 1
- See Sheet 1, Don't Walk 1
- See Sheet 1, Advance Walk

For Volume Density Plans

- See Sheet 2, Seconds per Actuation
- See Sheet 2, Maximum Variable Initial
- See Sheet 2, Time Before Reduction
- See Sheet 2, Time to Reduce
- See Sheet 2, Minimum Gap

For All Plans

- NONE, MIN RECALL, MAX RECALL, SOFT RECALL, or PED RECALL
- NONE, RED, or YELLOW (See Definitions)
- ON or not selected (see Definitions)
- ON or not selected, usually selected (see Definitions)

OASIS 2070 TIMING CHART

FEATURE	PHASE 2	PHASE 4	PHASE 5
Min Green 1*	12	7	7
Extension 1*	6.0	2.0	2.0
Max Green 1*	75	30	20
Yellow Clearance	4.2	3.7	3.0
Red Clearance	1.9	2.1	3.2
Red Revert	5.0	2.0	2.0
Walk 1*	7	7	-
Don't Walk 1	13	22	-
Advanced Walk *	3	3	-
Seconds Per Actuation*	2.5	-	-
Max Variable Initial*	34	-	-
Time Before Reduction*	15	-	-
Time To Reduce*	30	-	-
Minimum Gap	3.0	-	-
Recall Mode	MIN RECALL	-	-
Vehicle Call Memory	YELLOW	-	-
Dual Entry	-	ON	-
Simultaneous Gap	ON	ON	ON

* These values may be field adjusted. Do not adjust Min Green and Extension times for phases 2 and 6 lower than what is shown. Min Green for all other phases should not be lower than 4 seconds.

Note: For Pre-Timed Signal, set Extension 1 to 0.0 and Recall Position to MAX RECALL. Enter N/A for Vehicle Call Memory.
0 = Default time for normal phase time

Note: The default entry for many features in the controller is 0. If a value is not changing on the signal plan (such as no pedestrian phase is used), show a dash (-) in the Timing Chart to show that the value does not change.

ASC/3 (170) Timing Chart

For All Plans

- See Sheet 1, Min Green 1
- See Sheet 1, Advance Walk
- See Sheet 1, Walk 1
- See Sheet 1, Don't Walk 1
- See Sheet 1, Passage
- See Sheet 1, Max Green 1
- See STD. NO. 5.2.2
- Minimum Red used during Backup Protection. Typically set to 5.0 for phase(s) used, otherwise default is 2.0 sec. (See Std. 2.3)

For Volume Density Plans

- Actuations Before Add: Number of vehicles that arrive that will not count toward Maximum Initial value. For most controllers, this value is zero.
- See Sheet 2, Seconds per Actuation
- See Sheet 2, Maximum Variable Initial
- See Sheet 2, Time Before Reduction
- See Sheet 2, Time to Reduce
- See Sheet 2, Minimum Gap

For All Plans

- LOCK or NON-LOCK (See Definitions)
- NONE, VEH RECALL, MAX RECALL, SOFT RECALL, or PED RECALL
- ON or not selected (see Definitions)
- ON or not selected, usually selected (see Definitions)

ASC/3 TIMING CHART

FEATURE	PHASE 2	PHASE 4	PHASE 5
Min Green *	12	7	7
Delayed Green *	3	3	–
Walk *	7	7	–
Ped Clear	13	22	–
Veh. Extension *	6.0	2.0	2.0
Max 1 *	75	30	20
Yellow	4.2	3.7	3.0
Red Clear	1.9	2.1	3.2
Red Revert	5.0	2.0	2.0
Actuations B4 Add *	–	–	–
Seconds /Actuation *	2.5	-	-
Max Initial *	34	-	-
Time Before Reduction *	15	-	-
Time to Reduce *	30	-	-
Minimum Gap	3.0	-	-
Locking Detector	X	-	-
Recall Position	VEH. RECALL	-	-
Dual Entry	–	X	-
Simultaneous Gap	X	X	X

* These values may be field adjusted. Do not adjust Min Green and Extension times for phases 2 and 6 lower than what is shown. Min Green for all other phases should not be lower than 4 seconds.

Note: For Pre-Timed Signal, set Vehicle Extension to 0.0 and Recall Position to MAX RECALL. 25.5 = Default time for normal phase time

Note: The default entry for many features in the controller is 0. If a value is not changing on the signal plan (such as no pedestrian phase is used), show a dash (-) in the Timing Chart to show that the value does not change.

ASC/3 (NEMA) Timing Chart (For Cary 2070 Signal System)

For All Plans

- See Sheet 1, Min Green 1
- See Sheet 1, Advance Walk
- See Sheet 1, Passage
- See STD. NO. 5.2.2
- See Sheet 1, Max Green 1
- NONE, MIN RECALL, MAX RECALL, SOFT RECALL or PED RECALL
- Lock - ON or OFF
- See Sheet 1, Walk 1
- See Sheet 1, Don't Walk 1

For Volume Density Plans

- See Sheet 3, Actuations Before Add
- See Sheet 2, Seconds per Actuation
- See Sheet 2, Maximum Variable Initial
- See Sheet 2, Time Before Reduction
- See Sheet 2, Time to Reduce
- See Sheet 2, Minimum Gap

For All Plans

- ON or not selected (see Definitions)
- ON or not selected, usually selected (see Definitions)

Note: For Pre-Timed Signal, set Vehicle Extension to 0.0 and Recall Position to MAX RECALL.

TIMING CHART
ASC/3-2070LXN2 CONTROLLER

FEATURE	PHASE 2	PHASE 4	PHASE 5
MINIMUM GREEN *	12	7	7
DELAYED GREEN *	3	3	–
VEHICLE EXT. *	6.0	2.0	2.0
YELLOW CHANGE INT	4.2	3.7	3.0
RED CLEARANCE	1.9	2.1	3.2
MAX 1 *	75	30	20
RECALL POSITION	MIN RECALL	NONE	NONE
LOCK DET.	ON	OFF	OFF
WALK *	7	7	–
PED CLEAR	13	22	–
ACTUATION B4 ADD *	–	–	–
SEC PER ACTUATION *	2.5	–	–
MAXIMUM INITIAL *	34	–	–
TIME B4 REDUCTION *	15	–	–
TIME TO REDUCE *	30	–	–
MINIMUM GAP	3.0	–	–
DUAL ENTRY	OFF	ON	OFF
SIMULTANEOUS GAP	ON	ON	ON

* These values may be field adjusted. Do not adjust Min Green and Extension times for phases 2 and 6 lower than what is shown. Min Green for all other phases should not be lower than 4 seconds.

25.5 = Default time for normal phase time

Note: The default entry for many features in the controller is 0. If a value is not changing on the signal plan (such as no pedestrian phase is used), show a dash (-) in the Timing Chart to show that the value does not change.

SE–PAC Timing Chart
(Hickory and Raleigh Signal Systems)

For All Plans

- See Sheet 1, Min Green 1
- See Sheet 1, Passage
- See Sheet 1, Max Green 1
- See STD. NO. 5.2.2
- See Sheet 1, Walk 1
- See Sheet 1, Don't Walk 1
- See Sheet 1, Advance Walk

For Volume Density Plans

- See Sheet 2, Seconds per Actuation
- See Sheet 2, Maximum Variable Initial
- See Sheet 2, Time Before Reduction
- See Sheet 2, Time to Reduce
- See Sheet 2, Minimum Gap

For All Plans

- NONE, MIN RECALL, MAX RECALL, SOFT RECALL, or PED RECALL
- LOCK or NON-LOCK (See Definitions)
- ON or not selected (see Definitions)
- ON or not selected, usually selected (see Definitions)

Notes:
-SE-PAC Software cannot use Red Revert for backup protection. Phase omits must be used.
-For Pre-Timed Signal, set Pasasge Gap to 0.0 and Recall Position to MAX RECALL. Enter NON-LOCK for Vehicle Call Memory.

SE-PAC 2070 TIMING CHART

FEATURE	PHASE 2	PHASE 4	PHASE 5
Min Green *	12	7	7
Passage Gap *	6.0	2.0	2.0
Maximum Green *	75	30	20
Yellow Change	4.2	3.7	3.0
Red Clear	1.9	2.1	3.2
Walk *	7	7	–
Pedestrian Clear	13	22	–
Advance Walk *	3	3	–
Added Initial *	2.5	–	–
Maximum Initial *	34	–	–
Time Before Reduction *	15	–	–
Time To Reduce *	30	–	–
Minimum Gap	3.0	–	–
Recall Mode	MIN RECALL	–	–
Vehicle Call Memory	LOCK	NON–LOCK	NON–LOCK
Dual Entry	–	ON	–
Simultaneous Gap	ON	ON	ON

* These values may be field adjusted. Do not adjust Min Green and Extension times for phases 2 and 6 lower than what is shown. Min Green for all other phases should not be lower than 4 seconds.

25.5 = Default time for normal phase time

Note: The default entry for many features in the controller is 0. If a value is not changing on the signal plan (such as no pedestrian phase is used), show a dash (-) in the Timing Chart to show that the value does not change.

Trafficware Apogee Timing Chart
(Greensboro Signal System)

For All Plans

- See Sheet 1, Min Green 1
- See Sheet 1, Passage
- See Sheet 1, Max Green 1
- See STD. NO. 5.2.2
- See Sheet 1, Walk 1
- See Sheet 1, Don't Walk 1
- See Sheet 1, Advance Walk

For Volume Density Plans

- See Sheet 2, Seconds per Actuation
- See Sheet 2, Maximum Variable Initial
- See Sheet 2, Time Before Reduction
- See Sheet 2, Time to Reduce
- See Sheet 2, Minimum Gap

For All Plans

- NONE, MIN RECALL, MAX RECALL, SOFT RECALL, or PED RECALL
- YES or NO (See Definitions)
- ON or not selected (see Definitions)
- ON or not selected, usually selected (see Definitions)

Notes:
-For Pre-Timed signal, set Gap, Extension to 0.0 and Recall Position to MAX RECALL. Enter NO for Lock Calls.
-Trafficware Apogee Software cannot use Red Revert for backup protection. Phase omits must be used.

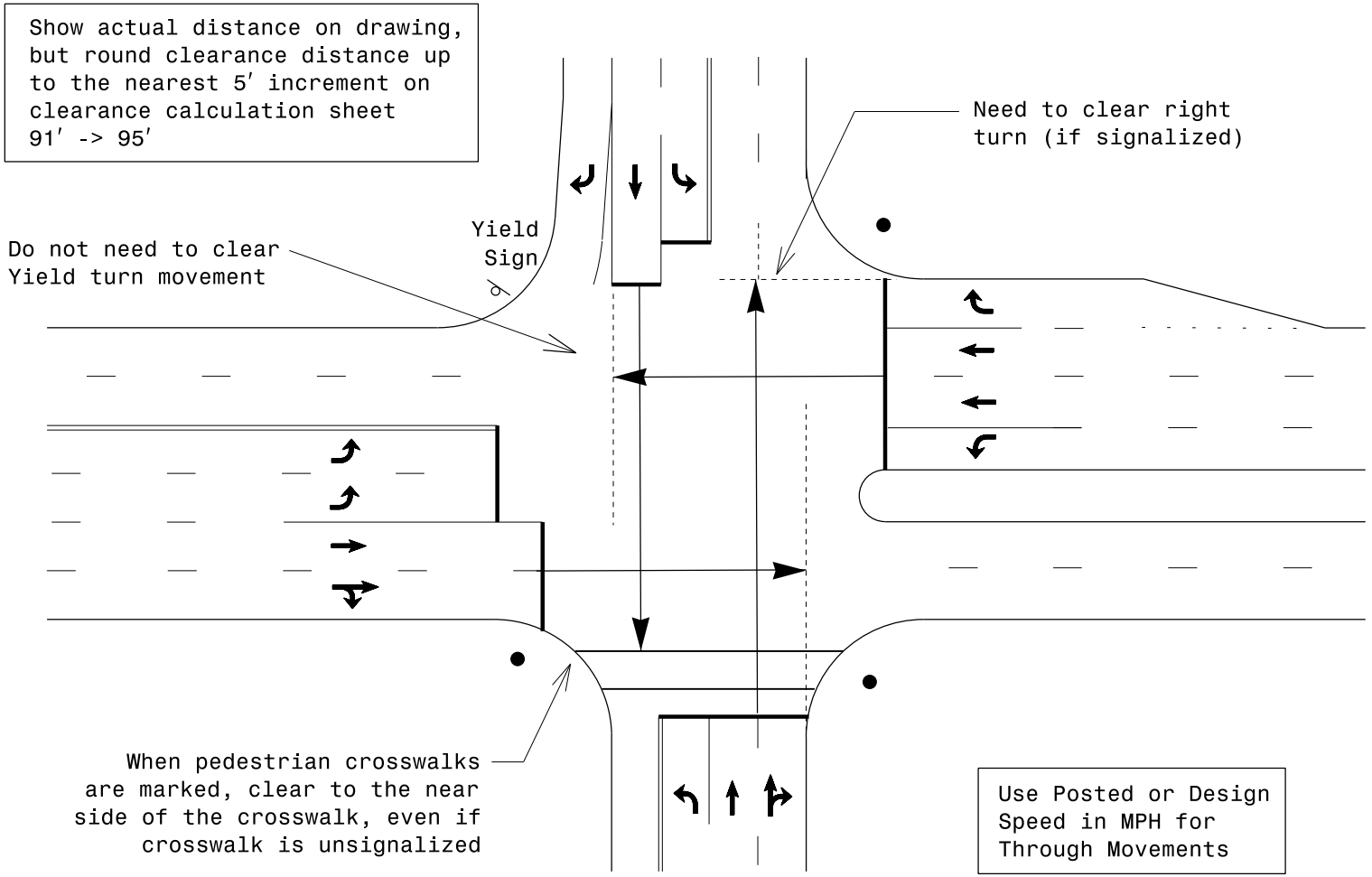
TRAFFICWARE APOGEE 2070 TIMING			
	PHASE		
FEATURE	2	4	5
Min Green *	12	7	7
Gap, Extension *	6.0	2.0	2.0
Maximum Green 1 *	75	30	20
Maximum Green 2 *	110	25	25
Yellow Clear	4.2	3.7	3.0
Red Clear	1.9	2.1	3.2
Walk *	7	7	–
Pedestrian Clear	13	22	–
Green/Ped Delay	3	3	–
Added Initial *	2.5	–	–
Maximum Initial *	34	–	–
Time Before Reduction *	15	–	–
Time To Reduce *	30	–	–
Minimum Gap	3.0	–	–
Recall Mode	MIN RECALL	–	–
Lock Calls	YES	NO	NO
Dual Entry	–	ON	–
Simultaneous Gap	ON	ON	ON

* These values may be field adjusted. Do not adjust Min Green and Extension times for phases 2 and 6 lower than what is shown. Min Green for all other phases should not be lower than 4 seconds.

25.5 = Default time for normal phase time

Note: The default entry for many features in the controller is 0. If a value is not changing on the signal plan (such as no pedestrian phase is used), show a dash (-) in the Timing Chart to show that the value does not change.

Through Movement Clearance Distances

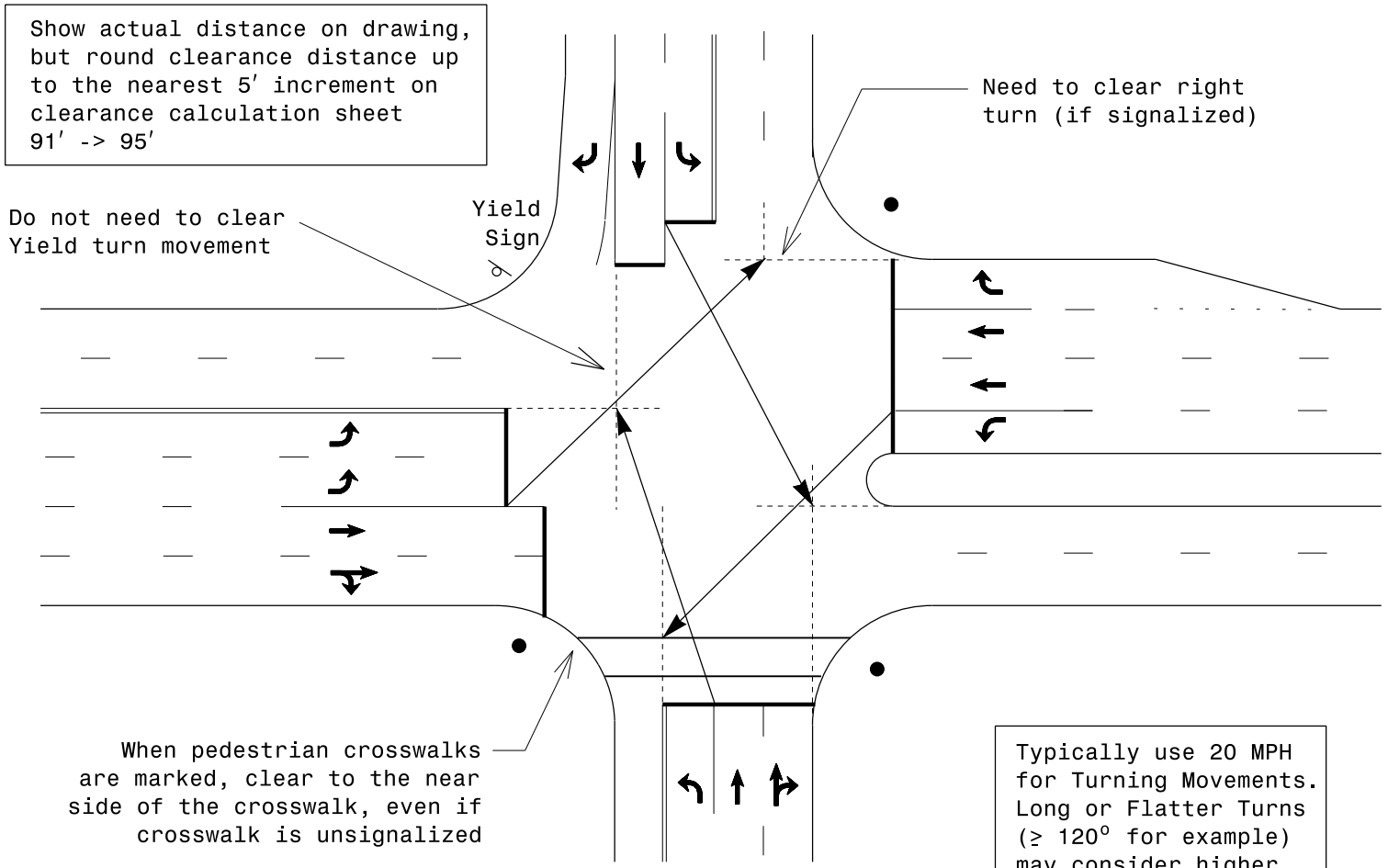


Change and Clearance Intervals

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.
5.2.2

Standard Left Turn Movement Clearance Distances
Median, Dual Left, Setback, Yield, Crosswalks

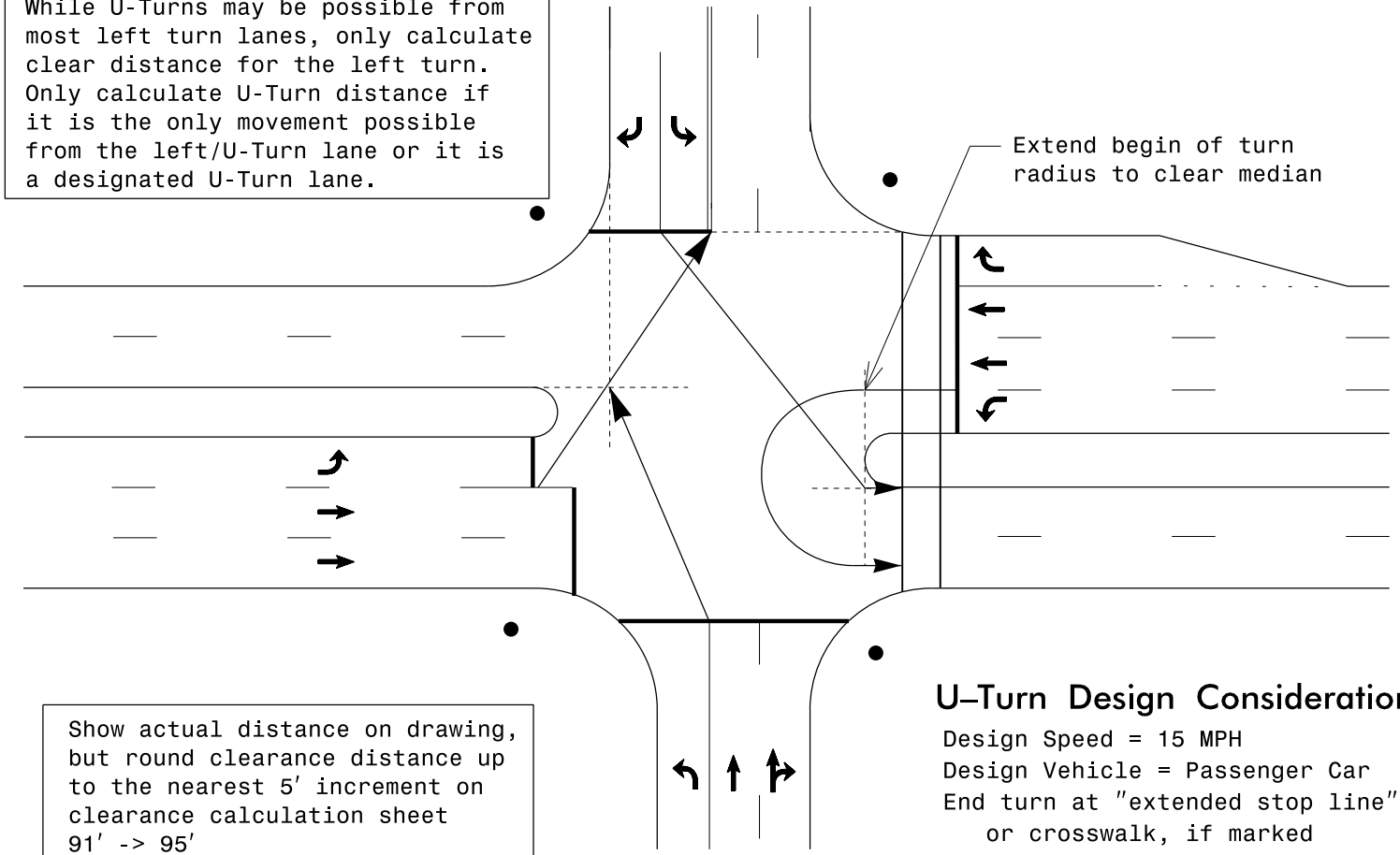


Change and Clearance Intervals

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

Other Left Turn Movement Clearance Distances
Median, Dual Left, Setback, One Way, Crosswalks

While U-Turns may be possible from most left turn lanes, only calculate clear distance for the left turn. Only calculate U-Turn distance if it is the only movement possible from the left/U-Turn lane or it is a designated U-Turn lane.



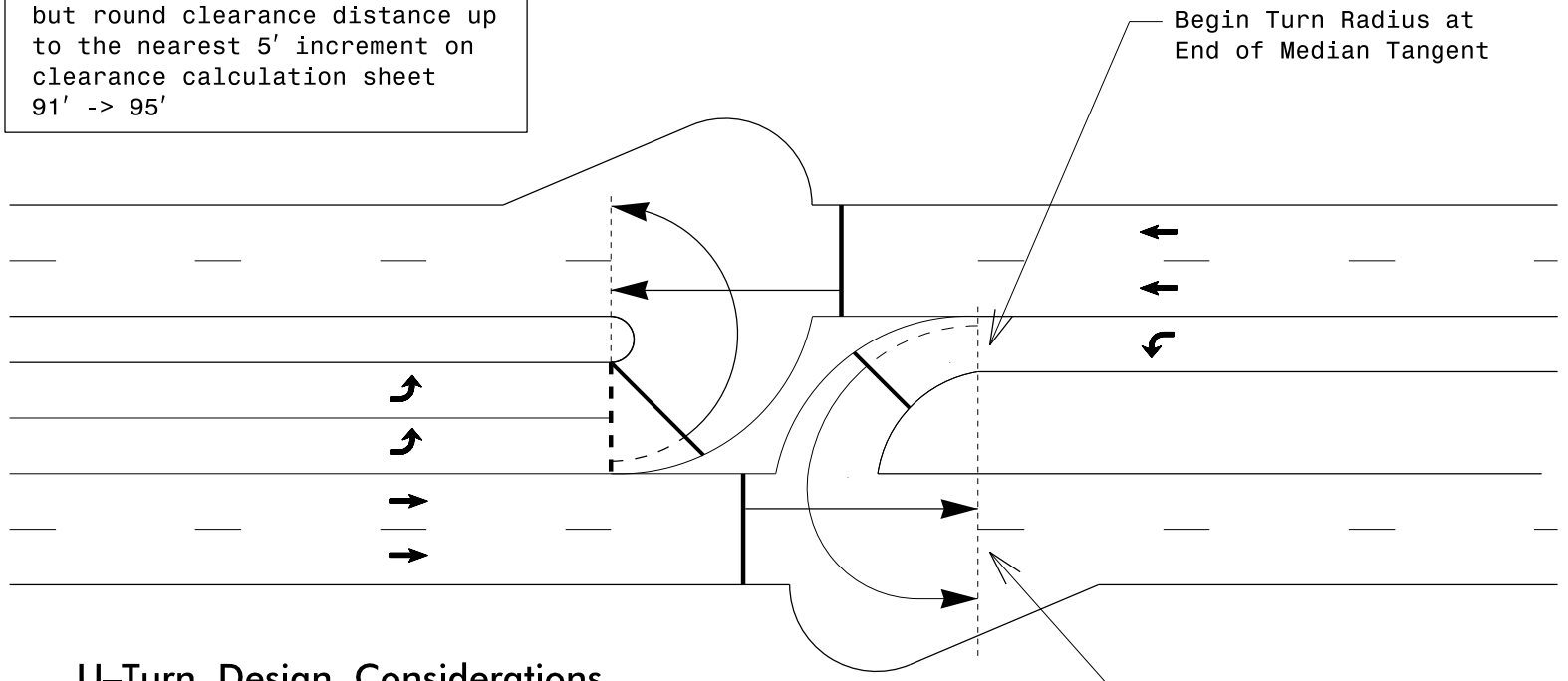
Show actual distance on drawing, but round clearance distance up to the nearest 5′ increment on clearance calculation sheet
91′ -> 95′

U–Turn Design Considerations

Design Speed = 15 MPH
Design Vehicle = Passenger Car
End turn at "extended stop line"
or crosswalk, if marked
Calculate u-turn clearance if it is the only move possible (no left turn)

U–Turn Movement Clearance Distances
Single and Dual Lanes

Show actual distance on drawing, but round clearance distance up to the nearest 5′ increment on clearance calculation sheet
91′ -> 95′



U–Turn Design Considerations

Design Speed = 15 MPH
Design Vehicle = Passenger Car
End turn at "extended stop line" or
line perpendicular (90°) to edge
of median tangent
Calculate u-turn clearance if it is the
only move possible (no left turn)

Determination of Yellow Change and Red Clearance Intervals

Yellow Change Interval

$$\text{Yellow interval} = t + \frac{v}{2a + 64.4g}$$

t = perception reaction time, typically 1.5 seconds
v = design speed*, in ft/sec
a = deceleration rate, typically 11.2 ft/sec^2
g = grade

Round up to nearest 0.1 second.

Minimum yellow change interval is 3.0 seconds.

Hold stakeholder discussion** when calculated yellow change interval is longer than 6.0 seconds.

Red Clearance Interval

$$\text{Red interval} = \frac{w}{v}$$

w = width of intersection, in feet
v = design speed*, in ft/sec

If the initial calculation results in an all red time longer than 3.0 seconds, recalculate the red time as follows:

$$\text{Recalculated red interval} = \frac{1}{2}\left(\frac{w}{v} - 3\right) + 3$$

Round up to nearest 0.1 second.

Minimum red clearance interval is 1.0 seconds.

Hold stakeholder discussion** when recalculated red clearance interval is longer than 4.0 seconds.

Notes

* Design speed is the speed limit unless a speed study determines that the 85th percentile speed is faster or intersection geometrics compel vehicles to traverse the intersection slower.

** The purpose of a stakeholder discussion is to provide advance notification and involvement to stakeholders and provide an opportunity to consider possible countermeasures.

For most left turn lanes, assume a speed of 20 MPH to 30 MPH. For locations with unusual conditions a higher or lower spreed may be appropriate.

For separate (protected or P/P) left turn phases, calculate yellow and red intervals for the left turn movement.

For left turns without a separate phase (permitted or split), calculate yellow and red times for both the through movement and left turn movement. Use the highest yellow and enough red to equal the highest total time.

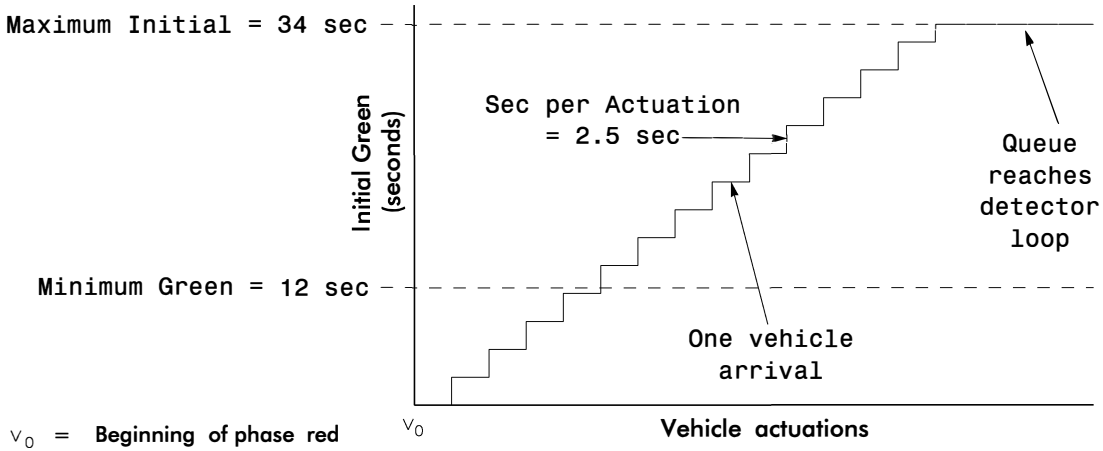
Where existing times are higher than calculated times, use the calculated values unless there is a documented history of the need for higher times. If approach is high speed and existing times are significantly higher than the calculated times, use the calculated values but consider adding a note to the plan to direct field forces to reduce the time incrementally. Include in the note how much and how often to reduce time until the final value is reached. (Ex. Existing Yellow Change Interval for phase 2 may be decreased by 0.2 seconds per week until the required value is reached.)

When using a Flashing YELLOW ARROW (FYA) for one or both left turns on a street, the through movements shall be equal using the highest yellow and highest red required for each phase.

Sources:
Traffic Engineering Handbook, Fifth Edition, Institute of Transportation Engineers, 1999.

A Policy on Geometric Design of Highways and Streets, Fourth Edition, American Association of State Highway and Transportation Officials, 2001.

Variable Initial Parameters



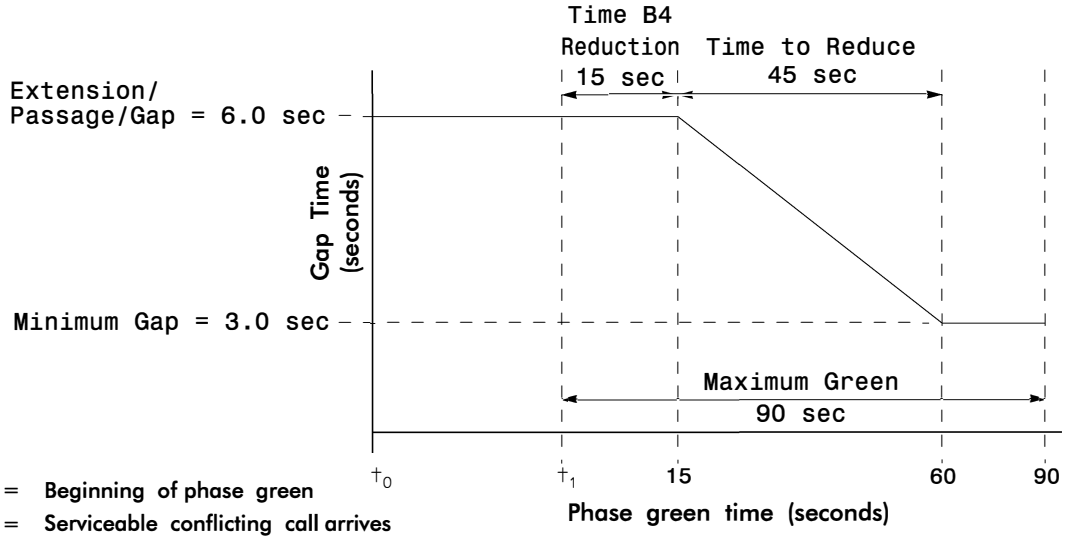
v_0 = Beginning of phase red with no vehicles waiting

Variable initial operation increases the MIN Green interval in a manner dependent upon the number of vehicle actuations placed on the phase while it is in the Yellow or Red interval. The variable initial interval is calculated as a function of the vehicle actuations and the MIN Green, Seconds Per Actuation, and MAX Variable Initial settings. The following relationship calculates the variable initial interval:

Initial Interval = (# of Vehicle Actuations) X (Seconds Per Actuation Setting)

If the calculated initial interval is less than the MIN Green setting, the MIN Green time will be used as the initial interval. If the calculated initial interval is greater than the MAX Variable initial setting, the MAX Variable initial will be used as the initial interval.

Gap Reduction Parameters



t_0 = Beginning of phase green

t_1 = Serviceable conflicting call arrives

Gap Reduction reduces the allowable gap between successive vehicle actuations by dynamically decreasing the extension time. The rate of reduction is based on the setting of the Extension, Minimum Gap, and Time to Reduce settings. Using this method, the gap will be reduced by the following relationship:

$$\text{Reduction} = \frac{\text{Extension} - \text{Minimum Gap}}{\text{TTR}} \times (\text{Current Green Interval Time} - \text{TBR})$$

This reduction begins when the Green interval has timed the Time Before Reduction (TBR) setting. Reduction of the allowable gap will continue until the gap reaches a value equal to or less than the Minimum Gap In the presence of continual vehicle actuations, the phase will not gap out, even if the gap has been reduced to zero.

Volume Density Timing Example – 2070 Controllers

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.
5.2.3
SHEET 1 OF 1

Standard Signal Plan Legend

(This basic Legend should apper on every signal plan, even if not all items are shown or used on the plan. Additional symbols [shown to the right] may be added as needed.)

LEGEND

PROPOSED		EXISTING
	Traffic Signal Head	
	Modified Signal Head	N/A
	Sign	
	Pedestrian Signal Head With Push Button & Sign	
	Signal Pole with Guy	
	Signal Pole with Sidewalk Guy	
	Inductive Loop Detector	
	Controller & Cabinet	
	Junction Box	
	2-in Underground Conduit	
N/A	Right of Way	
	Directional Arrow	

Note:

Symbols for utilities, hydrology, property lines, etc. should mirror standards set by NCDOT's Roadway Design Unit.

Other Common Symbols

PROPOSED		EXISTING
	Metal Strain Pole	
	Metal Pole with Mastarm	
	Type I Pushbutton Post	
	Type II Signal Pedestal	
	Type III Signal Pedestal	
DD	Directional Drill	N/A
	Out of Pavement (Also Optical) Detector	
	Video Detection Area	
	Out of Pavement Detection Area	
M	Master Controller & Cabinet	M
N/A	Railroad Cantilever	
N/A	Railroad Gate and Flasher	
N/A	Railroad Tracks	
	Construction Zone Drums	
	Construction Zone	
	New Pavement	N/A
N/A	Curb Ramp	
A	Sign I.D.	A

Common Drawing Symbols

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
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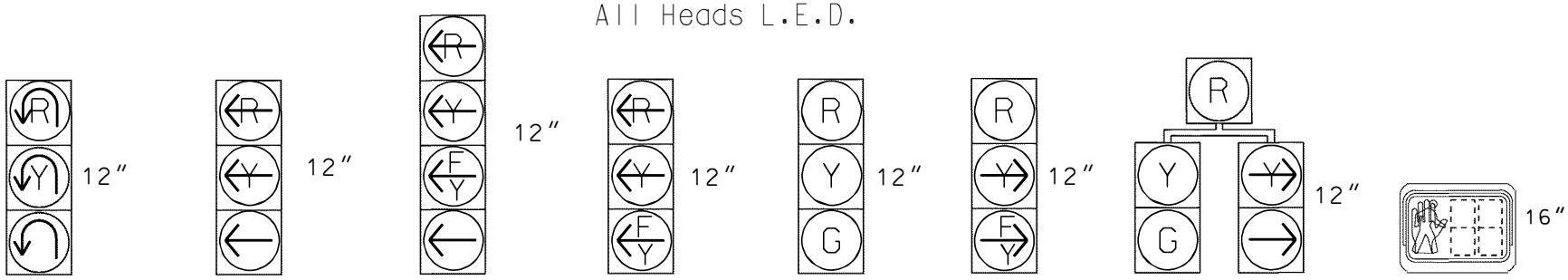
7-21

STD. NO.
5.3
SHEET 1 OF 1

Typical Appearance of Signal Face I.D.

SIGNAL FACE I.D.

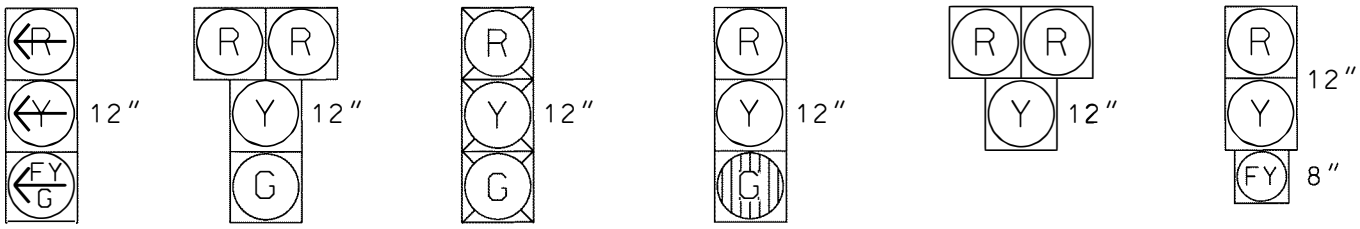
All Heads L.E.D.



31 | 11, 12 | 51 | 41 | 21, 22, 42, 61, 62, 81, 82 | 63 | 43 | P61, P62, P81, P82

Signal heads should appear from left to right in a manner similar to order they would be seen as mounted in the field.

Signal Faces/Heads with Special Characteristics



In general, do not try to minimzie the visibility of the steady Yellow and Red display unless required.

Signal Face I.D. Details

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

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STD. NO.
5.4
SHEET 1 OF 1

File Naming

Signal files should be named in accordance with the chart below:

Plan Type	.pdf Name	CADD FIle Name
Signal Design (Geometric)	051234-20200515g.pdf	051234_sig_dsn_20200515.dgn
Mutiple Sheet Signal Design	051234-20200515g#.pdf	All sheets in one file as above
Temporary Signal Plan	051234-20200515g-t#.pdf	051234T#_sig_dsn_20200515.dgn
Temporary Signal Plan Revision	051234-20200515g-r#-t#.pdf	051234T#_sig_rev#_20200515.dgn
Single Metal Pole Loading Sheet	051234-20200515m#.pdf	051234_sig_m#_20200515.dgn
Multiple Metal Pole Loading Sheet	051234-20200515m#&#.pdf	All sheets in one file as above
Signal Revision	051234-202005155g-r#.pdf	051234_sig_rev#_20200515.dgn
Plan of Record (POR)	051234-20200515g-por.pdf	051234_sig_por_20200515.dgn
Plan of Record with Revision	051234-20200515g-r#-por.pdf	051234_sig_por_20200515.dgn
Project Title Sheet (TIP)	Z-6789 tsh.pdf	Z-6789_sig_tsh_20200515.dgn
Electrical Programing Details	051234-20200515e.pdf	051234_sm_ele_20200515.dgn
Multiple Sheet Electrical Detail	051234-20200515e#.pdf	All sheets in one file as above
Signal Communication Plans (SCP)	Z-6789scp#.pdf	Z-6789scp.dgn (All sheets in one file)
Project Special Provisions (PSP)	Z-6789 Signal PSP.pdf	Z-6789_Signal_PSP.docx

051234 = Signal Inventory Number without the Dash (05-1234)
Date plan was sealed in Year, Month, and Day format, no slashes (5/15/2020 = 20200515)
Signal Plan = g/sig_dsn; Electrical Detail = e/sm_ele; Metal Pole = m/sig_mp; Revision = r/sig_rev
= Sheet or Temporary Number, as needed with multiple sheets or designs; do not number if only 1 is used
Z-6789 = TIP Project Number

NOTE: Signal Communication Plans are not the same as ITS plans; they are separate documents.

Sheet Numbering

All Sheets should be numbered within the CADD file. Standalone signals may have all sheets numbered in sequence: 1, 2, etc. For multi-signal projects, each design, temporary and final, should be numbered:

Sig. 1.0 = Project Titlesheet (When used. If N/A, Sig. 1.0 can be first signal plan)
Sig. 1.1 - 1.2 = 2018 Standard Plate Sheets (each sheet as needed)
Sig. 2.0 = First Signal Plan
Sig. 2.1 - 2.x = Electrical Detail for First Signal Plan (multiple sheets if needed)
Sig. 2.x+1 = Metal Pole Loading Detail (if needed); x = Last Electrical Detail sheet
Sig. 3.0 = Second Signal Plan Signal (use x.1 if a second sheet is required)
Sig. 3.1 - 3.x = Electrical Detail for 2nd Signal Plan (multiple sheets if needed)
Subsequent Sheets will follow the same pattern - 4.0, 5.0, etc.
M1 through M8 = Standard Metal Pole Sheets (When necessary; include all 8 sheets when used)
SCP 1, SCP 2, SCP 3,.....= Signal Communication Plans

Naming Plans for Letting

Signal PSP shall be preceded by m: m_Z-6789 Signals PSP.pdf

All sheets in the Signal Plan package shall be preceded by the prefix 260 then a sequential 3 digit number (with leading zeros if needed) to ensure correct order of plans. The prefix should be followed by the file name as shown above. The sequential numbers need not be consecutive, and gaps should be left to allow for insertion of additional/revised plans in the future as needed. It is suggested to use multiples of 5 for the sequence when feasible.

260_001_Z-6789 tsh.pdf	Project Title Sheet
260_005_Z-6789 Std Plate Sheet.pdf	Standard Plate Sheet(s)
260_010_051234-20200515g.pdf	1st Signal Plan
260_015_051234-20200518e1.pdf	Electrical Programming Detail Sheet 1
260_020_051234-20200518e2.pdf	Electrical Programming Detail Sheet 2
260_025_051234-20200515m.pdf	Metal Pole Loading Detail (as needed)
260_030_051678-20200515g.pdf	2nd Signal Plan
↓	Standard Metal Pole Sheets (as needed)
260_225_Z-6789scp1.pdf	Signal Communication Plans

Project Type

Indicate whether 'New Installation,' 'Signal Upgrade,' or 'Temporary Signal.'

Graphic Scale

Include a graphic scale on all plans. Signal plans should be 20, 40, or 50 scale. Use the scale that allows for the most clarity of detail on the signal plan, trying to keep the plan to one sheet if possible. The scale does not need to match the scale of the corresponding roadway plans on a TIP project.

Plan Description

Description should include:

- # Phases
- Type of Actuation
- w/ Special Features (if any)
- Isolated or System (including name and type)
- Signal System #: (Usually same as master #)

Text and Lettering

-Letter sizes should approximate the following:
Title block street names and title heads...3/16 in
All other lettering.....1/8 in

-List the routes in the title block using the word "at", not "and", as follows:

SR XXXX (Tree Avenue) at SR XXXX (Stump Drive)

-OR-

SR XXXX (Tree Avenue) at SR XXXX (Stump Drive)/NC 123 (Branch Street)

When listing the intersection, the main street (phases 2+6) should be listed first followed by (at) the minor street(s).

North Arrow

For general projects, align the main street to run horizontally across the plan where possible. For TIP & Contract projects, align the plan in the same general direction as the roadway plans.

Address

For plans prepared in house, include the Department logo with the Signal Design Section's address in the title block.

For plans prepared by Private Engineering Firms, include the Department logo with the Signal Design Section's address in the title block and the firm's name with address on the plan sheet beside the title block.

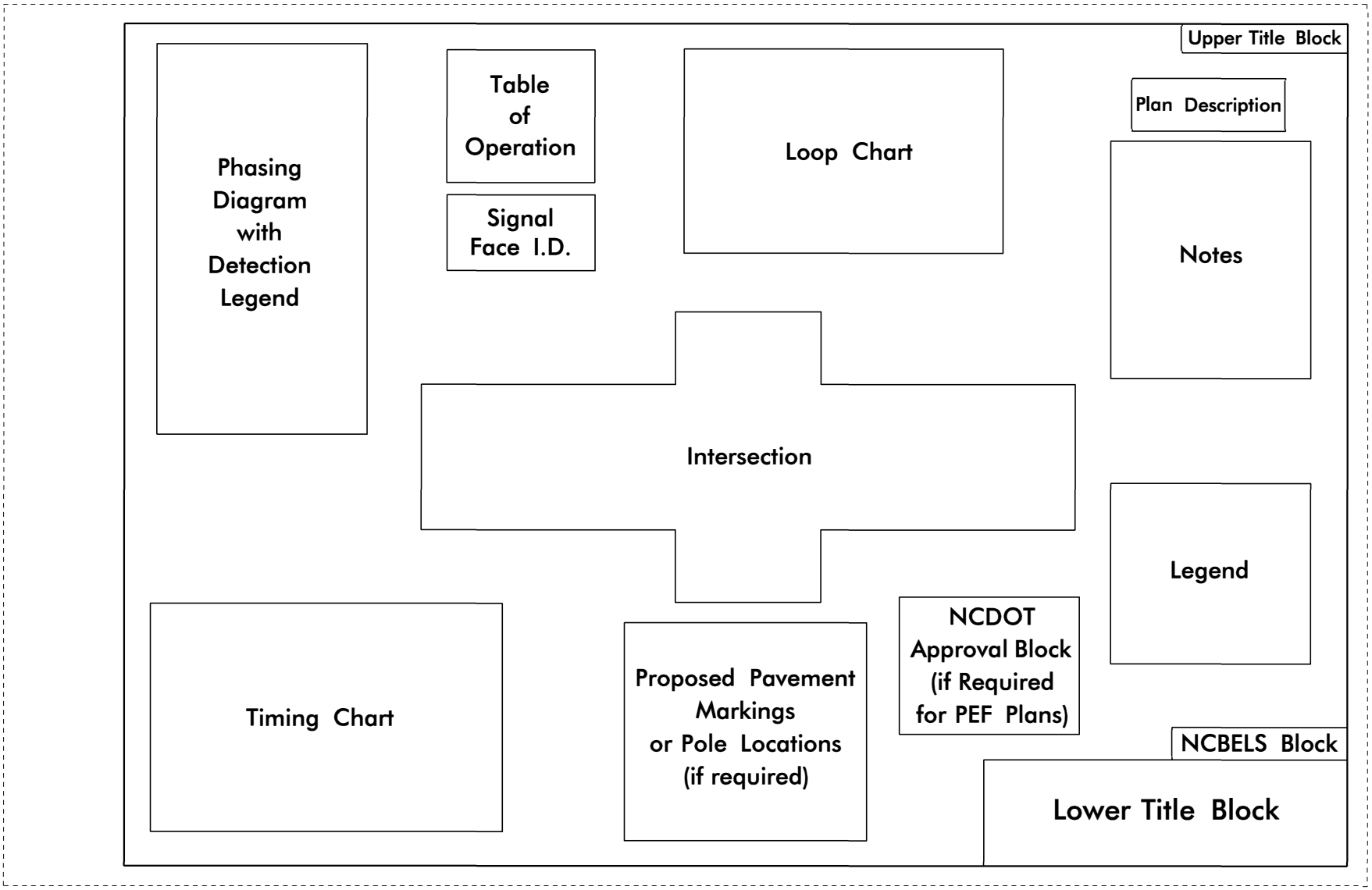
For plans prepared by municipalities, include the department logo with the Signal Design Section's address in the title block and the municipality's name with address on the plan sheet beside the title block.

Private engineering firms and municipalities are responsible for placing their name with address on the plan sheets. Company or municipal logos are permitted providing they do not detract from the plan.

NCBELS Block

The NC Board of Engineers and Land Surveyors requires a block reading "Document Not Considered Final Unless All Signatures Completed" directly adjacent to the seal block for all plans that are sealed electronically or transmitted electronically with a seal on it.

Typical Signal Plan Layout

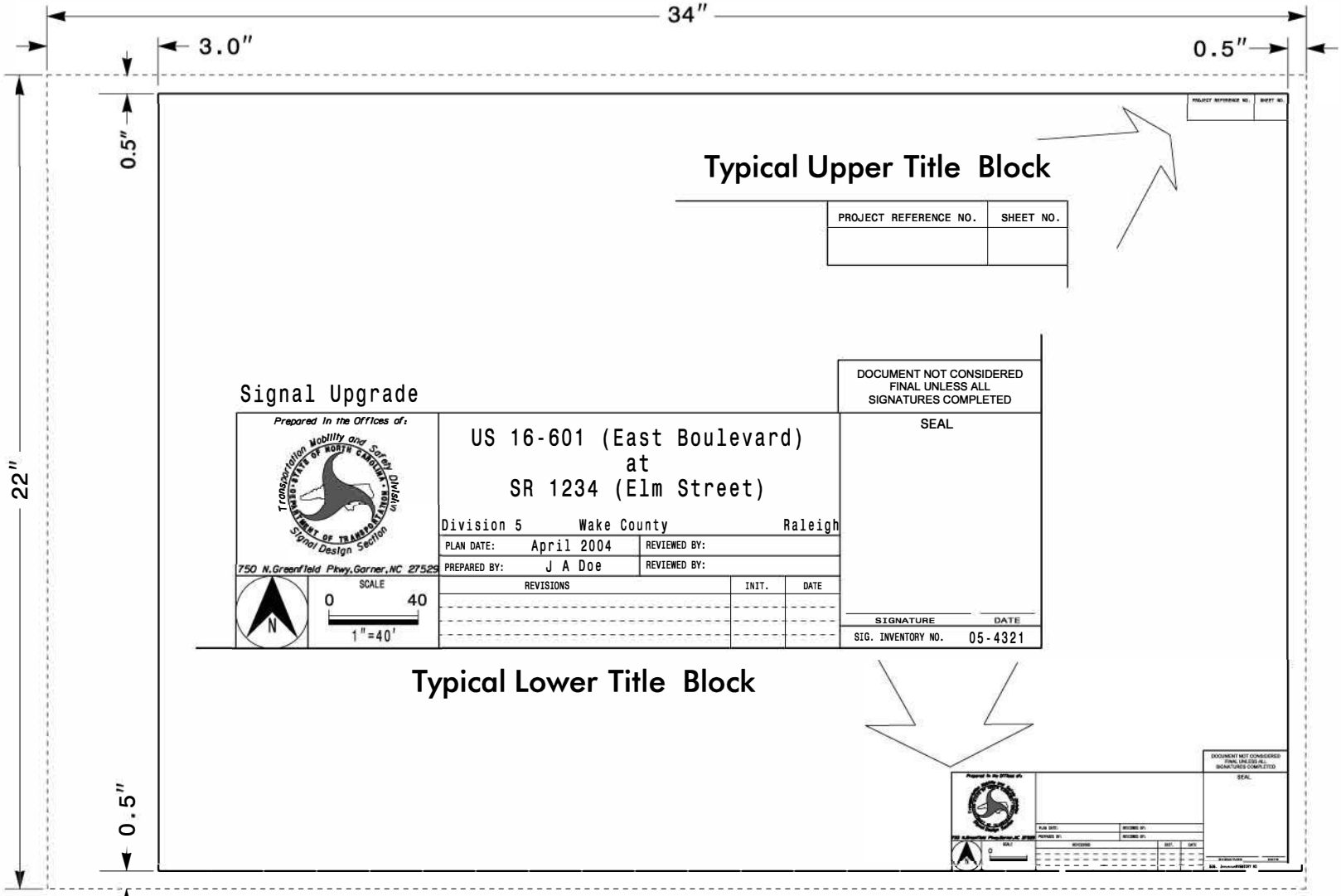


Drawing Format Items

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.
5.5.2
SHEET 2 OF 5

Typical Border Sheet with Dimensions



A Half Size Plan should be 11" X 17" and be a true half scale of the plan scale shown.

Drawing Format Items

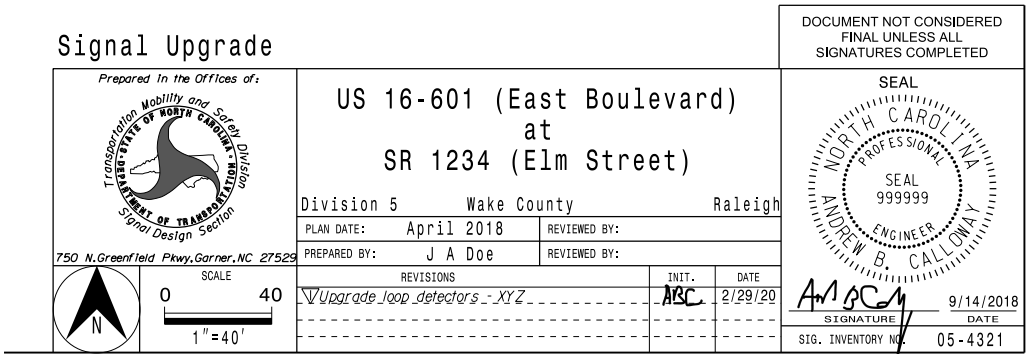
SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO. 5.5.2

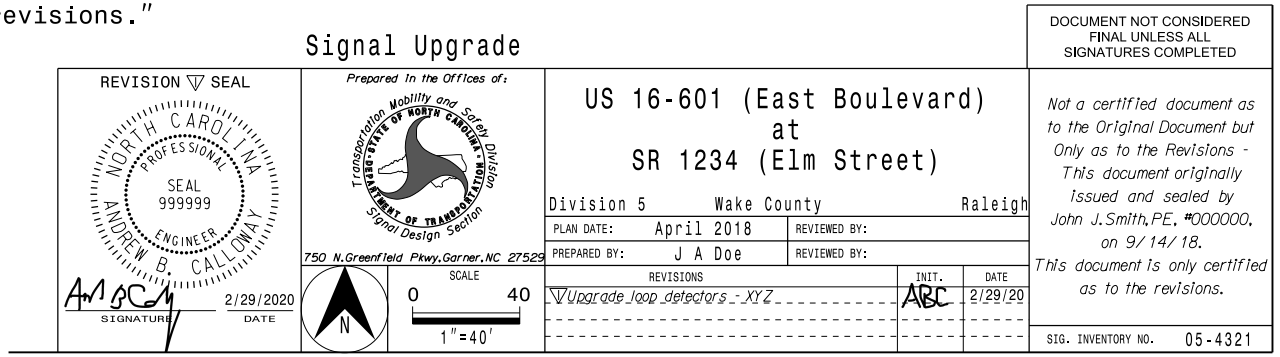
Revisions

When revising an existing traffic signal plan, include the revision number, date, and revision description. Additionally, enclose the revision number in a triangle and place the triangle on the plans near the affected area if needed for clarity.

When the PE making the revision is the same PE who sealed the original plan, the PE initials and dates the revision block and reseals the original plan with the original date.



When the PE making the revision is different than the PE who sealed the original plan, then a "Revision Seal" block needs to be added to the title block to the left (preferred) or just above the title block on the original plans. In addition, add the text "Not a certified document as to the Original Document but only as to the Revisions - This document originally issued and sealed by 'name,' 'PE number,' on 'date.' This document is only certified as to the revisions."



Supersede Plans

A Supersede may be used when a plan replaces a plan previously issued for a project and the plan has not yet been implemented. It can be for any type of project, but the supersede plan should be for the same project. The supersede plan may sealed by a different Engineer than the Engineer who sealed the original plan for the project. The name of the previous Engineer of Record does not need to be shown on the plan, just the date the original plan was sealed.

This plan supersedes the plan signed and sealed on 2/12/09.

NCDOT Plan Approval Block

The NCDOT Approval Block should be included on all electronically sealed plans prepared by Private Engineering Firms for a Third Party, such as a municipality or private development, for any project that NCDOT is not letting, administering, or has direct oversight of the Contract, even if it is participating in funding the project. The block will be electronically signed by the Regional Signal Engineer (or designee) once the plan set is officially reviewed, approved, and ready for Transmittal to the Division. The block should appear on every plan sheet sealed by the Private Engineering Firm.

The Approval Block is not needed on signal plans prepared by Private Engineering Firms under contract to NCDOT. The Contract may be with Project Management Unit, Transportation System Management & Operations Unit, or a Highway Division for a TIP project in preparation for let, or as part of a Design Build Contract. The Approval Block is also not needed for any Standard Sheets the sealed by the Department for inclusion in a bid a package, such as Standard Metal Pole sheets (M Sheets).

NC Dept of Transportation
Division of Highways

Final Drawing Date: _____

_____
NCDOT Approval

Signal Cable Calculations

Signal Cable

There is only one pay item for signal cable; combine measurements for 16-4 and 16-7 cable. Route cable to minimize the length of cable used. Add 3′ extra in cabinets. Add 3′ extra at each signal head. Assume 30′ down poles. Note: Use 2 separate cable runs if there are more than 6 heads on a phase.

Example (See sheet 2)

Heads 61 & 62:
3′ (beside head) + 12′ + 3′ (beside head) + 270′ + 30′ (down pole) + 10′ (to cabinet) + 3′ (in cabinet) = 331′

Head 11
3′ (beside head) + 256′ + 30′ (down pole) + 10′ (to cabinet) + 3′ (in cabinet) = 302′

Heads 41 & 42:
3′ (beside head) + 15′ + 3′ (beside head) + 105′ + 30′ (down pole) + 10′ (to cabinet) + 3′ (in cabinet) = 169′

Head 43:
3′ (beside head) + 220′ + 30′ (down pole) + 10′ (to cabinet) + 3′ (in cabinet) = 266′

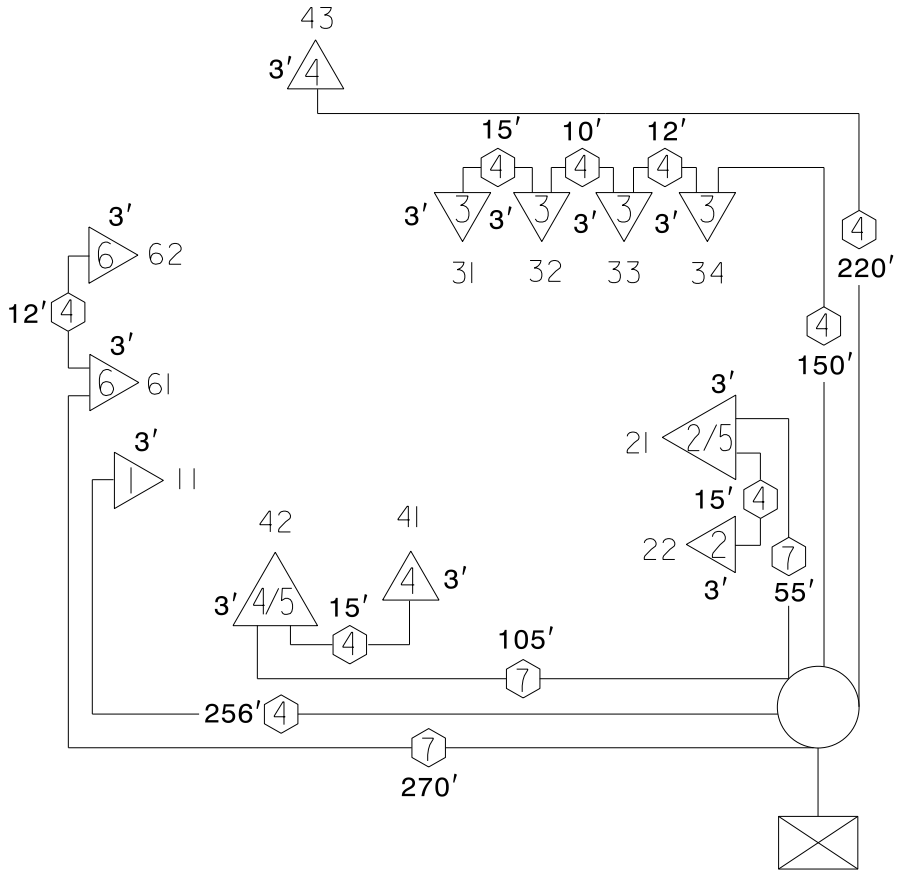
Heads 31, 32, 33 & 34:
3′ (beside head) + 15′ + 3′ (beside head) + 10′ + 3′ (beside head) + 12′ + 3′ (beside head) + 150′
+ 30′ (down pole) + 10′ (to cabinet) + 3′ (in cabinet) = 242′

Heads 21 & 22:
3′ (beside head) + 15′ + 3′ (beside head) + 55′ + 30′ (down pole) + 10′ (to cabinet) + 3′ (in cabinet) = 119′

Total: 331′ + 302′ + 169′ + 266′ + 242′ + 119′ = 1429′

Round up to nearest 10′ = 1430′

Signal Cable Example Diagram



Legend

- 4 — 16–4 Conductor
- 7 — 16–7 Conductor
- 4 — Phase/Overlap
- 22 — Signal Face I.D.
- 15′ — Segment Distance

Plan Quantity Calculations

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

7-09

STD. NO.
5.6
SHEET 2 OF 4

Messenger Cable & Loop Lead–In Calculations

Messenger Cable (Spanwire)

Example (See sheet 4)

Note: Do not add any length for guys as they are included as a pay item for guy assemblies.

145′ + 170′ + 110′ + 172′ = 597′

Round up to nearest 10′ = 600′

Loop Lead–In Cable

Each loop lead-in wire connects 1 loop to the cabinet if the is wired separately. Quadrupole and volume density (counting) loops need to be wired separately. If multiple loops are wired together, 1 lead-in connects the group to the cabinet. Low speed and extend (stretch) loops may be wired together. Include lead-in for pedestrian pushbuttons and microwave detectors. Assume 30′ up or down poles.

Example (See sheet 4)

Loops 2A & 2B (together) and 5A (separate):
25′ + 30′ (up pole) + 172′ + 30′ (down pole) + 10′ (to cabinet)

= 267′ X 2 = 534′

Loop 6A and 6B (each separate):
250′ + 25′ + 30′ (up pole) + 110′ + 30′ (down pole) +10′ (to cabinet)

= 455′ X 2 = 910′

Loop 1A:
25′ + 30′ (up pole) + 110′ + 30′ (down pole) + 10′ (to cabinet)

= 205′

Loops 3A, 3B, and 3C (each separate): 15′

= 15′ X 3 = 45′

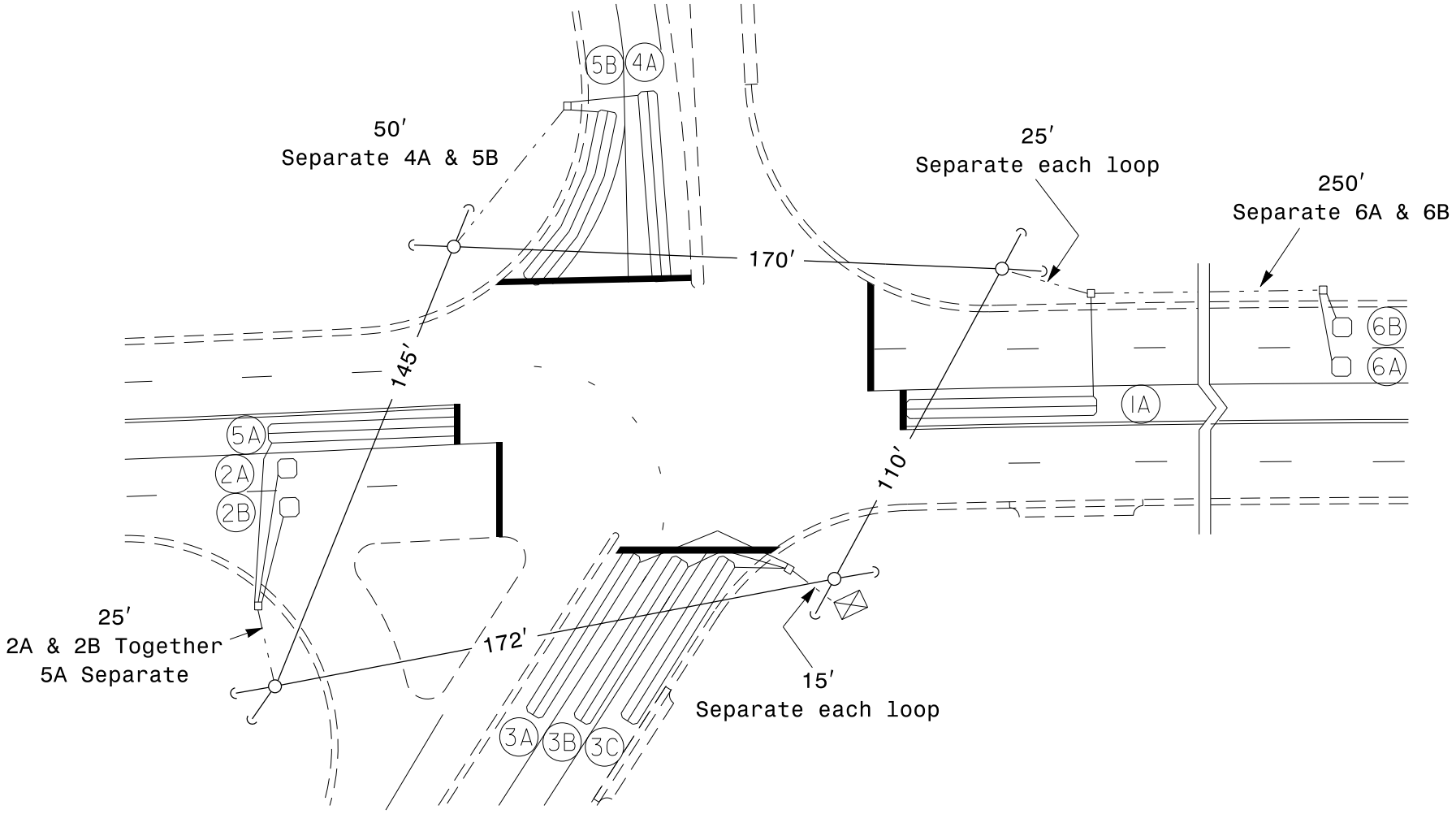
Loop 4A and 5B (each separate):
50′ + 30′ (up pole) + 170′ + 110′ + 30′ (down pole) +10′ (to cabinet)

= 400′ X 2 = 800′

Total: 534′ + 910′ + 205′ + 45′ + 800′ = 2494′

Round up to nearest 10′ = 2500′

Loop Lead–In & Messenger Cable Example Diagram



Plan Quantity Calculations

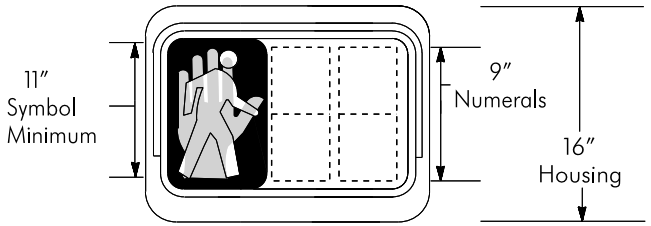
SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

7-09

STD. NO.
5.6
SHEET 4 OF 4

Typical Pedestrian Signal

Countdown Pedestrian Head



Person = WALK
Flashing Hand = Flashing DON'T WALK (FDW)
(Pedestrian Clearance Time)
Steady Hand = DON'T WALK
Numbers/Timer = FDW Time Remaining

Pedestrian Head Guidelines

-Countdown pedestrian heads shall be used for new and upgraded installations.
-When possible, avoid pedestrian movements with simultaneous parallel dual (right or left) turn vehicle movements. Consider phasing alternatives for pedestrians to safely cross the dual turn movements.
-With pre-timed operation, use "Ped Recall" when pushbuttons are not used.
-Also with pre-timed operation, vehicle "Max Time" (maximum Green) should not be less than the total of "Walk" and "Flashing Don't Walk" times. [MAX Green < W + FDW]
-When a pedestrian phase is activated by a pushbutton, use the "Omit WALK..." note (L60) to prevent pedestrian phase and timing being served if no pedestrian calls are activated.

Pedestrian Timing

-"WALK" Time: Minimum of 4 to 7 seconds; 7 seconds should be used when possible.
-In urban and suburban areas, when practical, use a Leading Pedestrian Interval (LPI) of at least 3 seconds. An LPI should allow a pedestrian to cross at least one travel lane during the LPI. If APS is not used with an LPI, there should be at least 4 seconds between WALK and LPI times. If APS is used, LPI time may be equal to but not exceed the programmed WALK time (LPI ≤ W).
-"Flashing DON'T WALK" Time (FDW): Enough time to get from curb or shoulder to far side of the farthest traveled lane (D). Use 3.5 feet per second (S), minus the concurrent yellow change interval (YC). A slower walking speed may be used if appropriate at specific locations only with Division Traffic Engineer, Regional Traffic Engineer, and Signal Design approval.

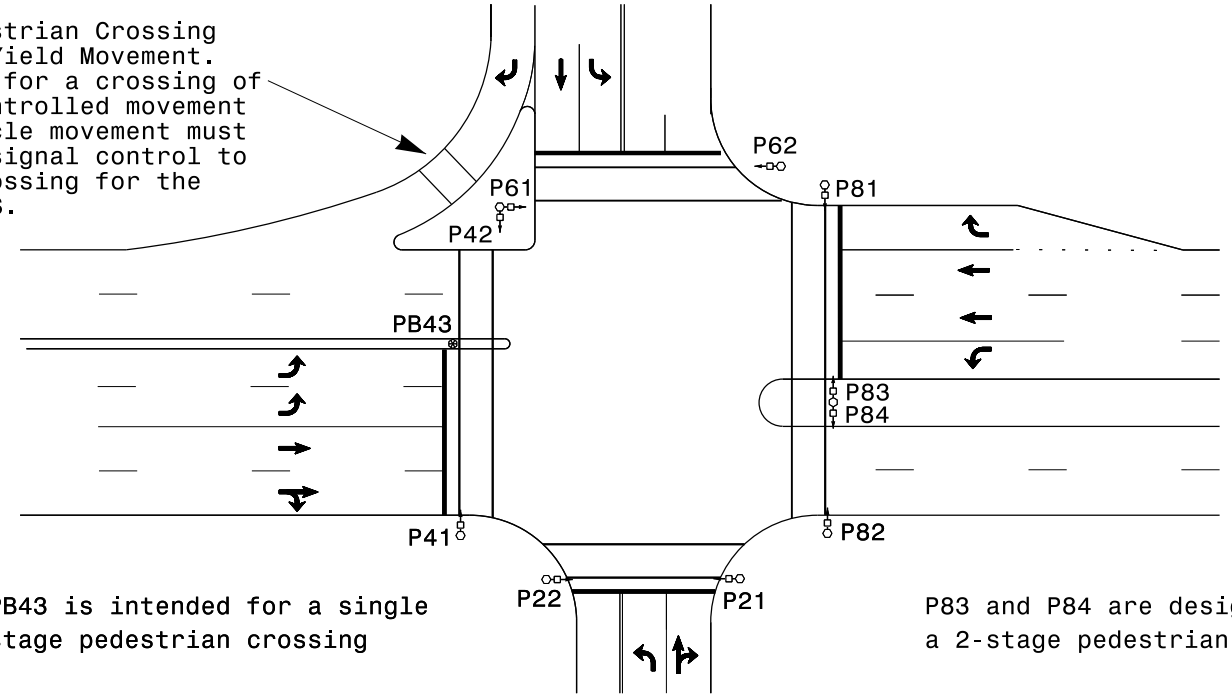
$$FDW = \frac{D}{S} - YC$$

Pedestrian Signal Heads & Timing

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.
6.0
SHEET 1 OF 1

Uncontrolled Pedestrian Crossing
Across a Vehicle Yield Movement.
If APS is desired for a crossing of an otherwise uncontrolled movement or lane, the vehicle movement must be brought under signal control to provide a safe crossing for the crosswalk with APS.



PB43 is intended for a single stage pedestrian crossing

P83 and P84 are designed for a 2-stage pedestrian crossing

-Pedestrian signal heads should be installed for every marked crosswalk at a signalized intersection.
-Refer to Design Manual Std. No. 3.0:1 for pedestrian signal head numbering.
-See Standard Roadway Drawing 1705.02 for pedestrian signal head and pushbutton assembly location guidelines.
-Pedestrian pushbuttons should be separated by at least 10 feet on each quadrant when possible.
-Pushbuttons do not need to be labeled if they are associated with a pedestrian signal head.
-If a pedestrian pushbutton only is installed on a pedestal with no accompanying pedestrian signal head, such as in a median or island, it should be labeled "PB" in sequence with the corresponding phase.
-Pedestrian movements should not be signalized across Yield or free flowing vehicle movements.
-If APS is desired for a crossing of an otherwise uncontrolled movement or lane, the vehicle movement must be brought under signal control to provide a safe crossing for the crosswalk with APS.
-Dual turn vehicle movements concurrent with pedestrian crossings should be avoided, or mitigated if necessary.
-If a median or island is at least 6 feet in width, consider installing a pushbutton on the island or median if there is potential for a pedestrian to be stranded while crossing.
-It is recommended that a median or island be at least 10 feet to designated as a pedestrian refuge.

References: 2009 MUTCD Section 4E.08 and NCDOT Roadway Standard Drawings 1705.02 and 1705.04

Pedestrian Pedestals & Pushbuttons

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

7-21

STD. NO.
6.1
SHEET 1 OF 2

Single Stage Crossing

-It is preferred that a pedestrian crossing be designed as a single stage crossing whenever practical. During a single stage crossing, a pedestrian completely crosses a street from one quadrant to another.
-If there is a roadway median or island at least 6 feet in width and it is capable of providing an optional pedestrian refuge, a single pushbutton should be installed in the median or island. Do not install a pedestrian signal head in the median for a single stage crossing. Despite the presence of a pushbutton in the median, it is intended that a pedestrian cross the entire street at one time and not stop part way.
-If only a pedestrian pushbutton is installed on a pedestal in a median or island with no pedestrian head(s), it should be labeled "PB" in sequence with the corresponding phase.
-The pedestrian clearance time should be calculated to completely cross the street from one quadrant to the other, even if an optional pedestrian refuge in the median or island is provided.
-Pushbuttons for a single stage crossing should be accompanied by a R10-3E sign.

2–Stage Crossing

-In some cases, it may be preferred or necessary to provide a 2-stage crossing, allowing pedestrians to only cross between one quadrant and the median or island during a single signal cycle. While not the only factor, a pedestrian crossing requiring more than 40 seconds of clearance should be considered for mulitple stages if possible.
-A minimum width of 10 feet for the median or island is recommended to serve as a refuge for a 2 stage crossing.
-When a 2-stage crossing is required, a single pedestrian pushbutton and 2 pedestrian signal heads shall be installed in the median or island.
-When the individual stages or a pedestrian crossing are designed to operate during the same phase, the longest crossing distance among the multiple stages should be used to calculate the pedestrian clearance time.
-Pushbuttons intended to allow crossing only to the median or island shall be accompanied by a R10-3D sign.
-Median pushbuttons should be accompanied by a R10-3E sign.
-A 2-stage crossing should only be used after discussion with the Division Traffic Engineer, Regional Traffic Engineer, municipal Traffic Engineer (if appropriate), and the Signal Design Section.

Accessible Pedestrian Signal (APS)

ACCESSIBLE PEDESTRIAN SIGNAL OPERATION				
SIGNAL FACE	VOICE	TONES	INTERVAL	SPEECH MESSAGE
P21	-	X	Walk	(Percussive Tone)
	X	-	Flashing Don't Walk / Don't Walk	Wait. Wait to cross Central.
P22	X	-	Walk	Central. Walk sign is on to cross Central.
	X	-	Flashing Don't Walk / Don't Walk	Wait. Wait to cross Central.
P41	X	-	Walk	Main. Walk sign is on to cross Main.
	X	-	Flashing Don't Walk / Don't Walk	Wait. Wait to cross Main.
P42	X	-	Walk	Main. Walk sign is on to cross Main.
	X	-	Flashing Don't Walk / Don't Walk	Wait. Wait to cross Main
PB43	-	X	Walk	(Percussive Tone)
	X	-	Flashing Don't Walk / Don't Walk	Wait. Wait to cross Main.
P61	X	-	Walk	Central. Walk sign is on to cross Central.
	X	-	Flashing Don't Walk / Don't Walk	Wait. Wait to cross Central.
P62	-	X	Walk	(Percussive Tone)
	X	-	Flashing Don't Walk / Don't Walk	Wait. Wait to cross Central.
P81	-	X	Walk	(Percussive Tone)
	X	-	Flashing Don't Walk / Don't Walk	Wait. Wait to cross Main.
P82	-	X	Walk	(Percussive Tone)
	X	-	Flashing Don't Walk / Don't Walk	Wait. Wait to cross Main.

Do not program street name directions (North, East, South, West) or name descriptions (Street, Road, Drive, Avenue, etc.) in the speech message unless it is necessary for clarity to the pedestrian at the individual intersection (such as 1st Street at 2nd Ave.).

NOTE: For this example, the pushbuttons for signal heads P22 and P41 are less than 10 feet apart within the same quadrant, as are the pushbuttons for signal heads P61 and P42.

Note: PB43 refers to a pushbutton in the median on a Type I post with no pedestrian signal head.

- The type of APS used is based on location of the pushbutton. It is on a quadrant basis, not based on the crosswalk. It is acceptable to use a percussive tone on one end of a crosswalk and a speech message on the other.
- APS is not required for all crossings at an intersection. If requested, it may be used only on designated crossings.
- Pushbuttons should be at least 10 feet apart when possible. This may not be possible in all applications.
- If the pushbuttons in a quadrant are at least 10 feet apart, a percussive tone shall be used during the WALK display. A speech message shall not be used when pushbuttons are at least 10 feet apart.
- If the pushbuttons in a quadrant are less than 10 feet apart, a speech message shall be used during the WALK display.
- A speech message should be used upon pushbutton actuation during the Flashing DON'T WALK and DON'T WALK display for all crossings where APS is used.
- When APS is used with a median pushbutton, it should also be shown in the chart. In most cases, the median pushbutton will use a percussive tone.

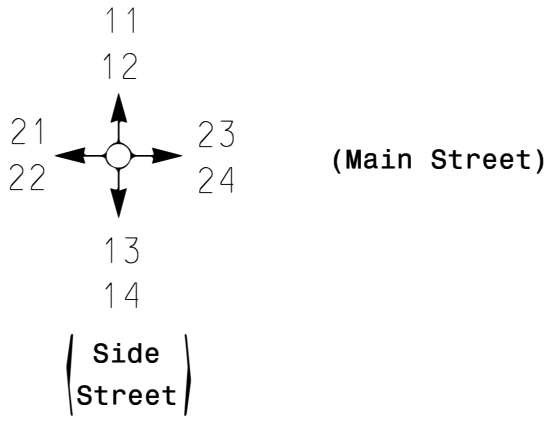
Reference: Sections 4E.09 thru 4E.11 of the 2009 MUTCD

Accessible Pedestrian Heads & Pushbuttons

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO. 6.2

Typical Numbering for Beacons



SIGNAL FACE I.D.

All Heads L.E.D.

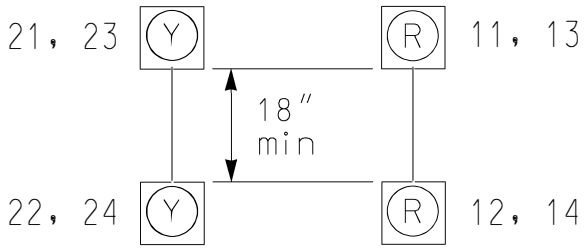


Table of Operation for Beacons

TABLE OF OPERATION

SIGNAL FACE	INTERVAL 1	INTERVAL 2
	ON	OFF
	OFF	ON
	ON	OFF
	OFF	ON

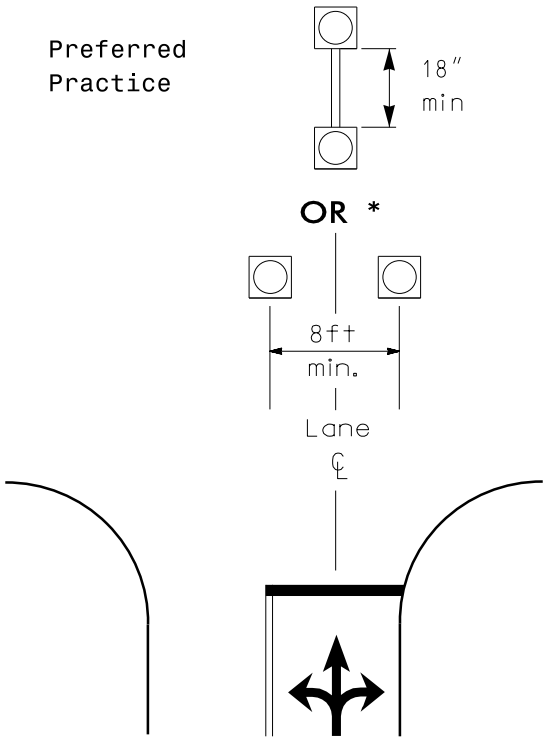
Intersection Beacons

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.
7.0
SHEET 1 OF 3

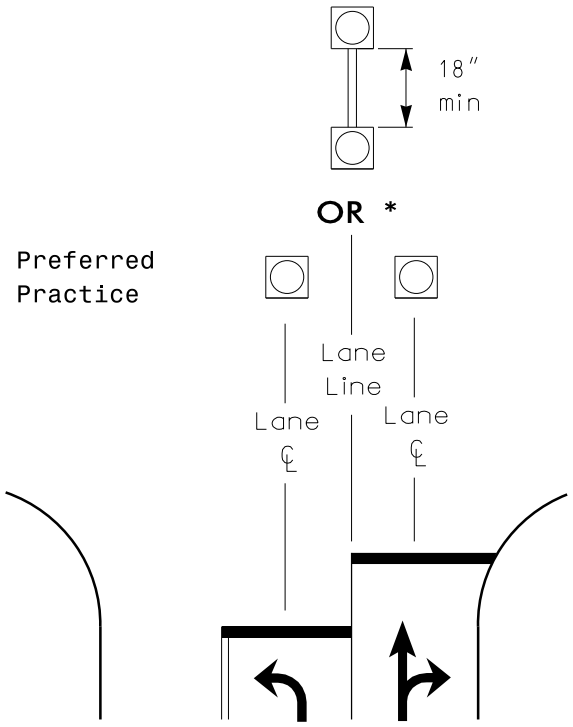
Signal Head Approach Display and Alignment

Single Lane Approach



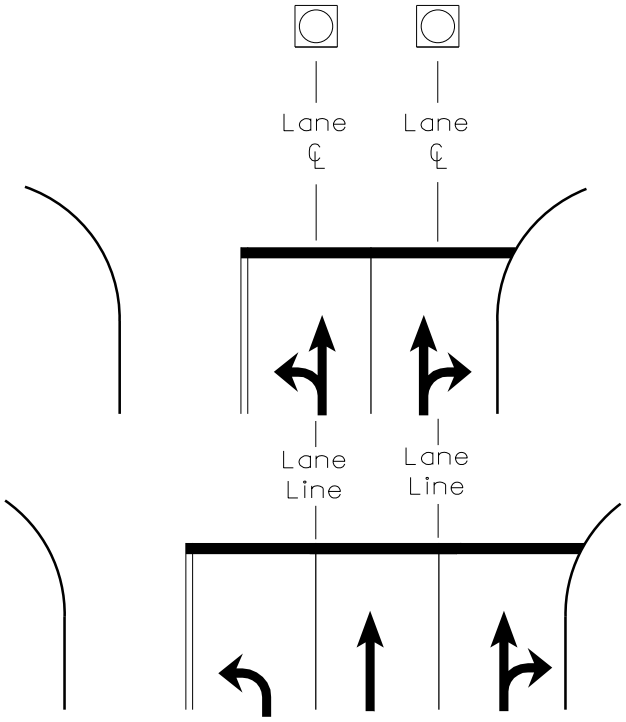
* Engineer to determine based on site specific characteristics

Single Through Lane Approach with Turning Lane



* Engineer to determine based on site specific characteristics

Multi-Lane Approach



General Guidelines

- Flash vertically mounted beacons alternatively
- Flash horizontally mounted beacons concurrently

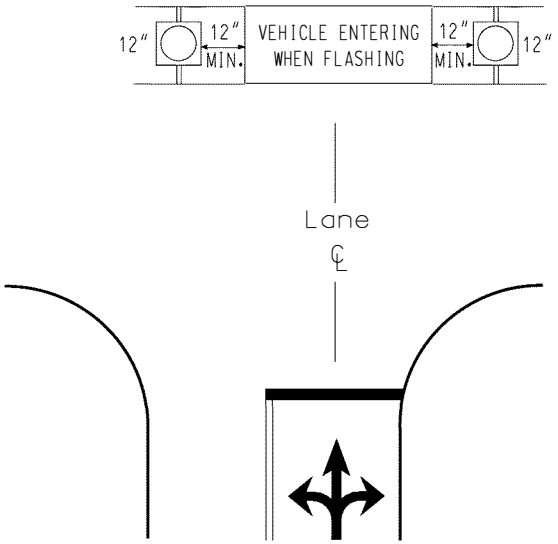
Intersection Beacons

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

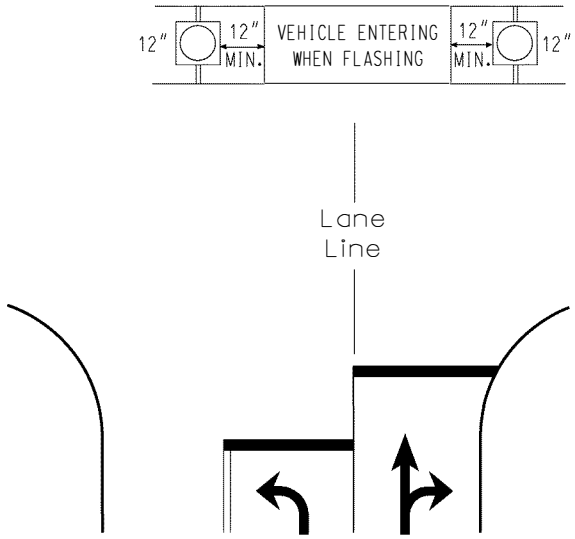
STD. NO.
7.0

Actuated Beacon with Overhead Sign

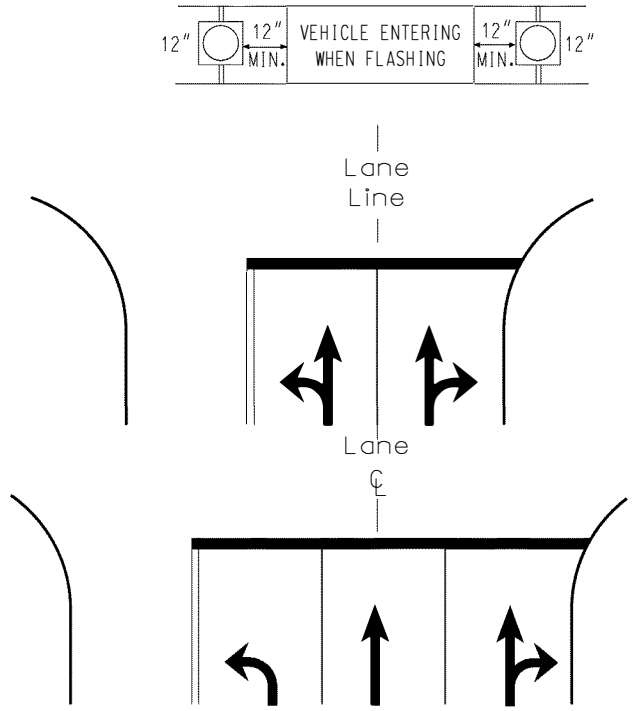
Single Lane Approach



Single Through Lane Approach with Turning Lane



Multi-Lane Approaches



General Guidelines

–Sign may be installed at intersection or in advance of intersection, at Engineer's discretion.

–Unless mounted directly adjacent to a STOP or YIELD sign, all advance warning or intersection beacons shall be Yellow.

–Typical sign size: 114"x36"

–Lettering size: 8"D

–See Drawing Notes (Std. No. 5.0) for notes specific to actuated beacons

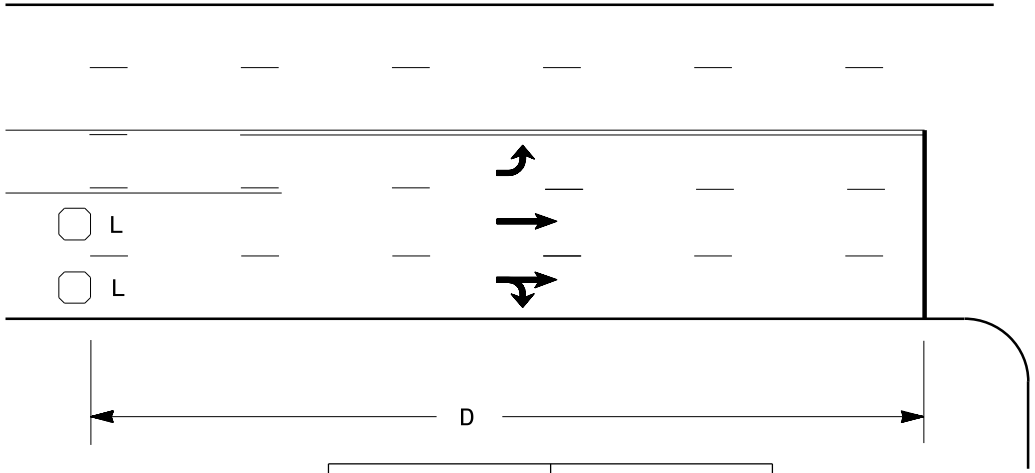
Intersection Beacons

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

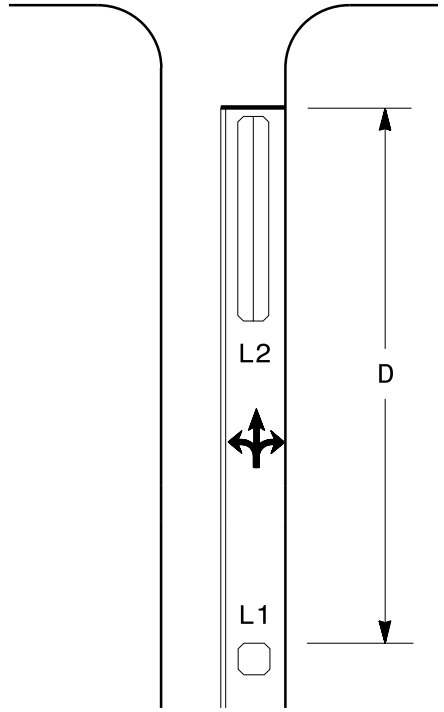
STD. NO.
7.0
SHEET 3 OF 3

Loop Placement for Actuated Beacons

Main Street Loop Placement
(Single or Multilane)



Side Street Loop Placement



Design Speed (MPH)	D (ft)
35	200
40	250
45	300
50	355
55	420
60	475
65	550

L = 6ft X 6ft, Presence loop

L1 = 6ft X 6ft, Presence loop (Loop L1 is optional)

L2 = 6ft X 40ft To 60ft Quadruple loop

Warning Beacons

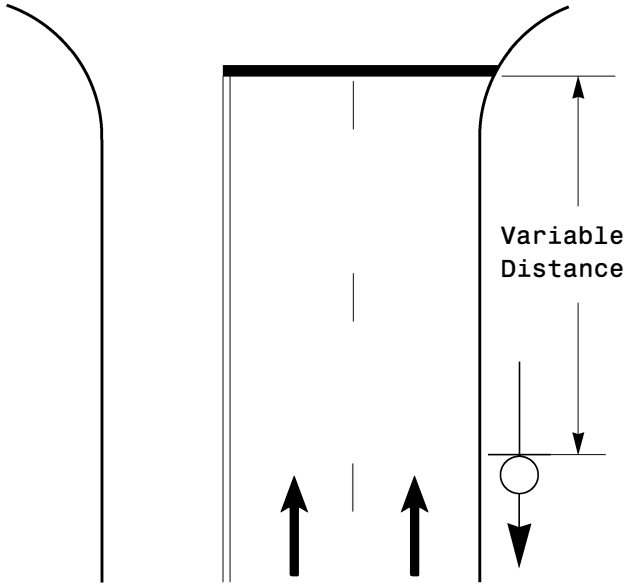
SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

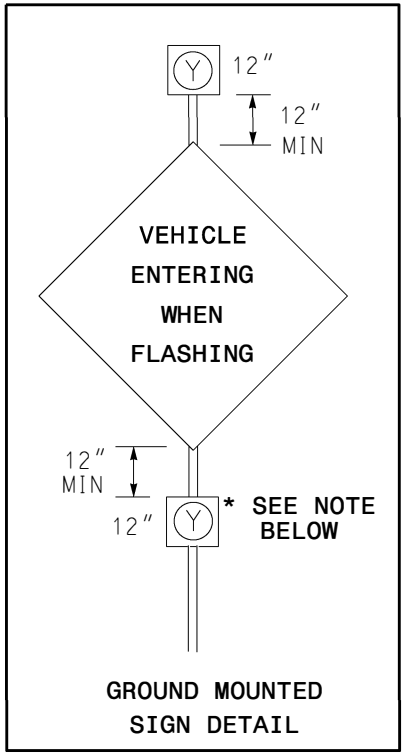
12-21

STD. NO.
7.1
SHEET 1 OF 3

Actuated Beacon with Ground–Mounted Sign

Single or Multi-Lane Approaches





GROUND MOUNTED
SIGN DETAIL

Recommended Minimum Placement of Sign and Advance Warning Beacon From Stop Line (or Condition if no Stop Line)	
Design Speed (MPH)	D (feet)
<35	100
40	125
45	175
50	250
55	325
60	400
65	475

If a warning sign is used with an actuated Beacon to warn divers of an impending changing condition, a WHEN FLASHING Plaque (W16-13P) shall be used below the warning sign and within the beacon structure unless it otherwise included in the text of the warning sign.

* BOTTOM BEACON IS RECOMMENDED, BUT NOT REQUIRED. IF USED, IT SHALL FLASH ALTERNATELY WITH THE TOP BEACON.

General Guidelines

- For multi–lane divided roadways with medians dual ground mounted signs should be installed
- See Drawing Notes (Std. No. 5.0) for notes specific to actuated flashers
- Distances for Advance Placement of signs from MUTCD Table 2C–4

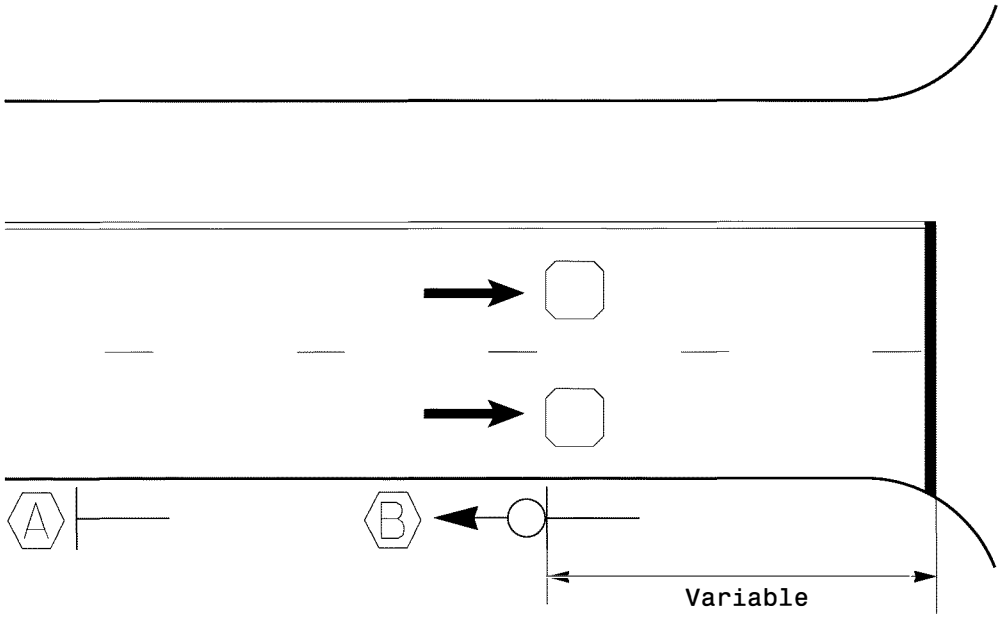
Warning Beacons

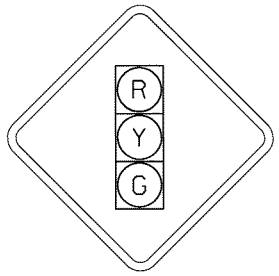
SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.
7.1

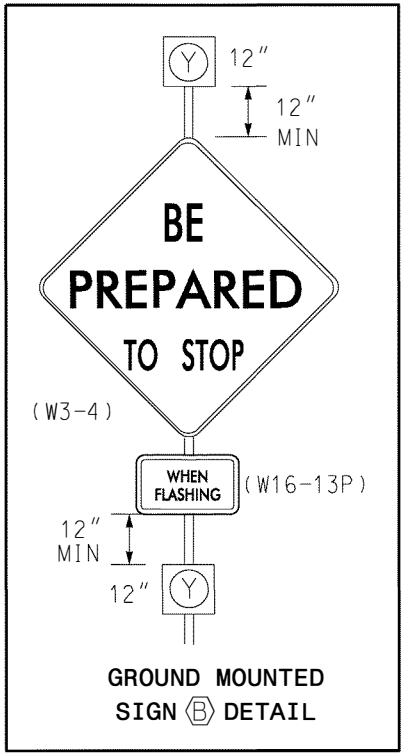
Actuated Beacon with Ground-Mounted Sign

Single or Multi-Lane Approaches





(A) Signal Ahead Sign (W3-3)



GROUND MOUNTED SIGN (B) DETAIL

- "BE PREPARED TO STOP" (W3-4) signs and Beacons (if used) should be placed at the back detection loops for the approach and mounted on Type III Pedestal when possible.
- For multi-lane divided roadways with medians, dual ground mounted signs should be installed.
- Beacons should start to flash at least 3 seconds prior to end of vehicle Green phase.
- Beacons shall be Yellow and flash alternately.

When a BE PREPARED TO STOP (W3-4) warning sign is used (with or without actuated Beacons) is used in advance of a traffic control signal, a Signal Ahead (W3-3) is also required in advance of the BE PREPARED TO STOP sign.

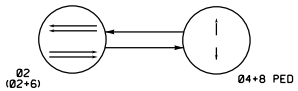
Reference: 2009 MUTCD Section 2C.36

Warning Beacons

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO. 7.1

PHASING DIAGRAM



PHASING DIAGRAM DETECTION LEGEND

- DETECTED MOVEMENT
- UNDETECTED MOVEMENT (OVERLAP)
- UNSIGNALIZED MOVEMENT
- PEDESTRIAN MOVEMENT

SIGNAL FACE I.D.

All Heads L.E.D.

21, 22
23, 24
(61, 62)

P41
P81

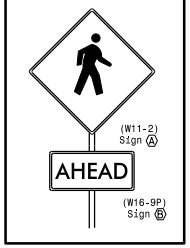
TABLE OF OPERATION

SIGNAL FACE	PHASE Ø2 DARK	Ø2 ACTIVATION	Ø2 STEADY YELLOW	Ø2 ALL RED	Ø4+8 PED WALK	Ø4+8 PED CLEAR	FLASH
21, 22	DRK	FY	Y	R	R	FR*	Y
23, 24	DRK	FY	Y	R	R	FR*	Y
P41	DW	DW	DW	DW	W	FDW	DRK
P81	DW	DW	DW	DW	W	FDW	DRK

* ALTERNATING FLASH

Y- STEADY YELLOW
FY- FLASHING YELLOW
R- STEADY RED
FR- FLASHING RED
W- WALK
DW- DON'T WALK
FDW- FLASHING DON'T WALK
DRK- DARK

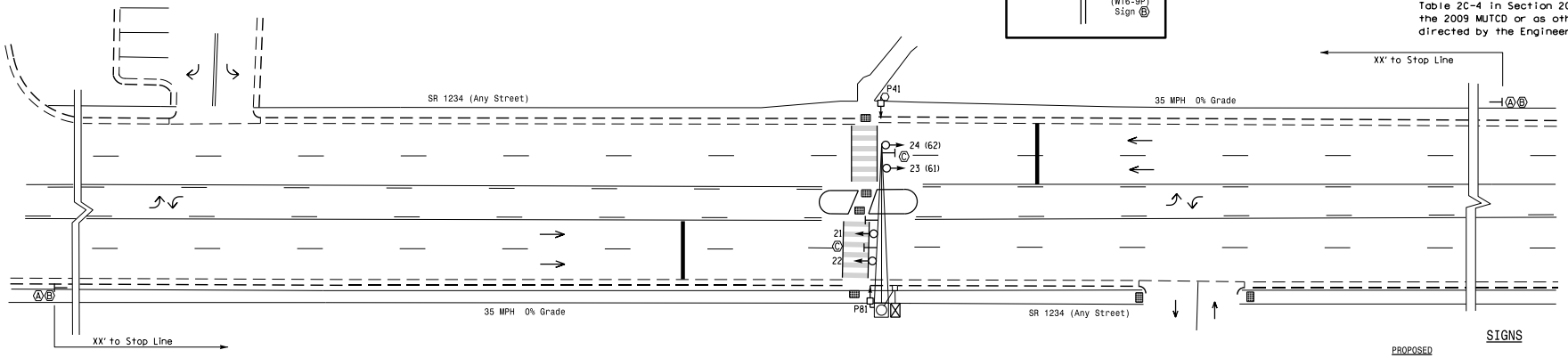
Figure 1



2 Phase
Semi-Actuated
Pedestrian Hybrid Beacon
Anytown Signal System

NOTES

1. Refer to "Roadway Standard Drawings NCDOT" dated January 2018 and "Standard Specifications for Roads and Structures" dated January 2018.
2. Program pedestrian heads to countdown the flashing "Don't Walk" time only.
3. Enable Ped Yellow Clear for phase 4 + 8.
4. Maximum times shown in timing chart are for free-run operation only. Coordinated signal system timing values supersede these values.
5. Locate Pedestrian and Crosswalk advance signs in accordance with Table 2C-4 in Section 2C.05 of the 2009 MUTCD or as otherwise directed by the Engineer.



SIGNS

PROPOSED		EXISTING
Ⓐ	Pedestrian Crossing Sign (W11-2) See Figure 1	Ⓐ
Ⓑ	"AHEAD" Plaque (W16-9P) See Figure 1	Ⓑ
Ⓒ	"CROSSWALK-STOP ON RED" Ball Sign (R10-23)	Ⓒ

OASIS 2070 TIMING CHART

FEATURE	PHASE 2	4 PED	8 PED	OLA
Min Green 1 *	10	7	7	5
Extension 1 *	0.0	0.0	0.0	
Max Green 1 *	30	0	0	
Yellow Clearance	5.0	3.0	3.0	3.8
Red Clearance	2.0	0.0	0.0	5.0
Walk 1 *	-	7	7	
Don't Walk 1	-	19	19	
Seconds Per Actuation *	-	-	-	
Max Variable Initial *	-	-	-	
Time Before Reduction *	-	-	-	
Time To Reduce *	-	-	-	
Minimum Gap	-	-	-	
Recall Mode	MAX RECALL	-	-	
Vehicle Call Memory	-	-	-	
Dual Entry	-	-	-	
Simultaneous Gap	ON	ON	ON	

Serves as Flashing Yellow Time

Serves as Steady Yellow Clearance Time

Serves as All Red Clearance Time

* These values may be field adjusted. Do not adjust Min Green and Extension times for phase 2 lower than what is shown. Min Green for all other phases should not be lower than 4 seconds.

-Vehicle Phase should be phase 2 for OASIS and SE-PAC software; use phases 2+6 for ASC/3 software.
-For monitoring purposes, pedestrian equipment on one side of the crosswalk is phase 4 and the other side is phase 8.
-Unless needed for coordination, vehicle detection is not required for phase 2 (2+6 for ASC/3 software). The initial Flashing Yellow display provides additional warning that the signal is changing.
-APS may be used in conjunction with a hybrid beacon.
-Signs W11-2 and W16-9P (as shown in Figure 1) are not required, but should be installed in advance of a pedestrian hybrid beacon based on roadway speed.
-A warning beacon may be provided to supplement the W11-2 sign.
-Notes as shown above should be used on the signal plan.

Pedestrian Hybrid Beacon ("HAWK")

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.
7.2.1

2-23

SHEET 1 OF 1

OASIS 2070 Timing Chart

- See STD. NO. 5.2.1 for Vehicle Phase
  Use 7 sec. for Ped Phases
  Use 5 sec. for Overlap
- Unless vehicle phase is detected, set to 0
- See STD. NO. 5.2.1
- Phase 2 Yellow Serves as Flashing Yellow Time. Use default 3.0 seconds for Ped phases.

Serves as Flashing Yellow Time

- Use 2.0 sec for Phase 2 Red. Use 0.0 for Ped Phases.
- Typically 4-7 seconds
- See STD. NO. 6.0
- Volume Density Timing
  Normally Not Used
  If used, see STD. 5.2.1
- MAX RECALL if no vehicle detection used
- None (-) or YELLOW
- Usually not selected
- ON or not selected, usually selected

OASIS 2070 TIMING CHART

FEATURE	PHASE 2	4 PED	8 PED	OLA
Min Green 1 *	10	7	7	5
Extension 1 *	0.0	0.0	0.0	
Max Green 1 *	30	0	0	
Yellow Clearance	5.0	3.0	3.0	3.8
Red Clearance	2.0	0.0	0.0	5.0
Walk 1 *	-	7	7	
Don't Walk 1	-	19	19	
Seconds Per Actuation *	-	-	-	
Max Variable Initial *	-	-	-	
Time Before Reduction *	-	-	-	
Time To Reduce *	-	-	-	
Minimum Gap	-	-	-	
Recall Mode	MAX RECALL	-	-	
Vehicle Call Memory	-	-	-	
Dual Entry	-	-	-	
Simultaneous Gap	ON	ON	ON	

* These values may be field adjusted. Do not adjust Min Green and Extension times for phase 2 lower than what is shown. Min Green for all other phases should not be lower than 4 seconds.

- OLA Min Green must be the same as Phase 2 Yellow clearance time (Flashing Yellow Time)
- OLA Yellow is vehicle steady Yellow clearance time as calulated in STD. 5.2.2
- Serves as Steady Yellow Clearance Time
- Serves as All Red Clearance Time
- OLA Red should be at least time calculated in STD. 5.2.2, but may be increased up to 5.0

Advance Walk (LPI) is not typically used with Pedestrian Hybrid "HAWK" Signal

All Time parameters entered for Phase 4 PED and Phase 8 PED should be identical

Pedestrian Hybrid Beacon ("HAWK") Timing Charts

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO. 7.2.2

ASC/3 Timing Chart w/170 Cabinet

- See STD. NO. 5.2.1 for Vehicle Phase
  Use 7 for Ped Phases
  Use 5 for Overlap
- Typically 4-7 seconds
- See STD. NO. 6.0
  Serves as Flashing Yellow Time
- Unless vehicle phase is detected, set to 0 sec
- See STD. NO. 5.2.1
- Yellow clearance time as calulated in STD. 5.2.2
  Use default 3.0 seconds for Ped phases.
  Serves as Steady Yellow Clearance Time
  Serves as All Red Clearance Time
- Red Clear should be calculated as in STD. 5.2.2,
  but may be increased up to 5.0. Use 0.0 sec.
  for Ped Phases.
- Volume Density Timing Normally Not Used
  If used, see STD. 5.2.1
- None if no vehicle detection
- PED RECALL if no vehicle detection
- Usually not selected
- ON or not selected, usually selected

ASC/3 TIMING CHART

FEATURE	PHASE 2	PHASE 4 PED	PHASE 6	PHASE 8 PED
Min Green *	10	7	10	7
Walk *	7	7	7	7
Ped Clear *	5	19	5	19
Veh. Extension *	0.0	0.0	0.0	0.0
Max 1 *	30	7	30	7
Yellow	3.8	3.0	3.8	3.0
Red Clear	5.0	0.0	5.0	0.0
Actuations B4 Add *	-	-	-	-
Seconds /Actuation *	-	-	-	-
Max Initial *	-	-	-	-
Time Before Reduction *	-	-	-	-
Time To Reduce *	-	-	-	-
Minimum Gap	-	-	-	-
Locking Detector	-	-	-	-
Recall Position	PED RECALL	-	PED RECALL	-
Dual Entry	-	-	-	-
Simultaneous Gap	ON	ON	ON	ON

* These values may be field adjusted. Do not adjust Min Green and Extension times for phases 2 and 6 lower than what is shown. Min Green for all other phases should not be lower than 4 seconds.

Advance Walk (LPI) is not typically used with Pedestrian Hybrid "HAWK" Signal

All Time parameters entered for Phase 2 and Phase 6 must be identical.

All Time parameters entered for Phase 4 PED and Phase 8 PED must be identical.

ASC/3 NEMA Timing Chart (For Cary 2070LXN2 Signal System)

- See STD. NO. 5.2.1 for Vehicle Phases
  Use 7 for Ped Phases
- Unless vehicle phase is detected, set as dash
- Yellow clearance time as calulated in STD. 5.2.2
  Use default 3.0 seconds for Ped phases.
  (1) Serves as Steady Yellow Clearance Time
  (2) Serves as All Red Clearance Time
- Red Clear should be calculated as in STD. 5.2.2,
  but may be increased up to 5.0. Use 0.0 sec
  for Ped Phases.
- See STD. NO. 5.2.1
- MAX RECALL if no vehicle detection
- OFF if no vehicle detection
  (3) Serves as Flashing Yellow Time
- Typically 4-7 seconds
- See STD. NO. 6.0 For Ped Clear Times. Set to
  Flashing Yellow Time for Vehicle Phases
- Volume Density Timing Normally Not Used
  If used, see STD. 5.2.1
- Usually not selected
- ON or not selected, usually selected

TIMING CHART
ASC/3-2070LXN2 CONTROLLER

PHASE	Ø2	Ø4 PED	Ø6	Ø8 PED
MINIMUM GREEN *	10 SEC.	7 SEC.	10 SEC.	7 SEC.
VEHICLE EXT *	- SEC.	- SEC.	- SEC.	- SEC.
YELLOW CHANGE INT*	3.8 SEC.	3.0 SEC.	3.8 SEC.	3.0 SEC.
RED CLEARANCE *	5.0 SEC.	0.0 SEC.	5.0 SEC.	0.0 SEC.
MAX 1 *	30 SEC.	7 SEC.	30 SEC.	7 SEC.
RECALL POSITION	PED RECALL	-	PED RECALL	-
LOCK DET.	OFF	OFF	OFF	OFF
WALK*	7 SEC.	7 SEC.	7 SEC.	7 SEC.
PED CLEAR	5 SEC.	19 SEC.	5 SEC.	19 SEC.
ACTUATION B4 ADD*	- VEH.	- VEH.	- VEH.	- VEH.
SEC PER ACTUATION *	- SEC.	- SEC.	- SEC.	- SEC.
MAXIMUM INITIAL *	- SEC.	- SEC.	- SEC.	- SEC.
TIME B4 REDUCTION *	- SEC.	- SEC.	- SEC.	- SEC.
TIME TO REDUCE *	- SEC.	- SEC.	- SEC.	- SEC.
MINIMUM GAP	- SEC.	- SEC.	- SEC.	- SEC.
DUAL ENTRY	-	-	-	-
SIMULTANEOUS GAP	ON	ON	ON	ON

(1) (2) (3)

* These values may be field adjusted. Do not adjust Min Green and Extension times for phases 2 and 6 lower than what is shown. Min Green for all other phases should not be lower than 4 seconds.

Advance Walk (LPI) is not typically used with Pedestrian Hybrid "HAWK" Signal

All Time parameters entered for Phase 2 and Phase 6 must be identical

All Time parameters entered for Phase 4 PED and Phase 8 PED must be identical

Pedestrian Hybrid Beacon ("HAWK") Timing Charts

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.
7.2.2

SE–PAC 2070 Timing Chart
(Hickory and Raleigh Signal Systems)

(Based on SE-PAC Version 5)

- See STD. NO. 5.2.1 for Vehicle Phase. Use 7 for Ped Phase(s).
- Unless vehicle phase is detected, set to 0.0.
- See STD. NO. 5.2.1 for Vehicle Phase. Use Total of Walk and Pedestrian Clear Time (W+PC) for Ped Phase(s).
- Yellow clearance time as calculated in STD. 5.2.2. Use default 3.0 seconds for Ped phase(s).
- Red clearance time as calculated in STD. 5.2.2. Use 0.0 seconds for Ped phase(s).
- Typically 4-7 seconds for 2 PED
- See STD. NO. 6.0 for 2 PED
- Volume Density Timing Normally Not Used If used, see STD. 5.2.1
- Program for MIN/PED RECALL if no vehicle detection used
- None ("-") or YELLOW
- Usually not selected
- ON or not selected, usually selected

SE-PAC 2070 TIMING CHART

FEATURE	PHASE 1 PED	PHASE 2 PED
Min Green *	10	7
Passage Gap *	0.0	0.0
Maximum Green *	30	26
Yellow Change	5.0	3.0
Red Clear	2.0	0.0
Walk *	10	7
Pedestrian Clear	5	19
Added Iniitial *	-	-
Maximum Initial *	-	-
Time Before Reduction *	-	-
Time To Reduce *	-	-
Minimum Gap	-	-
Recall Mode	MIN/PED RECALL	-
Vehicle Call Memory	-	-
Dual Entry	-	-
Simultaneous Gap	ON	ON

- Yellow Change → Serves as Steady Yellow Clearance Time
- Red Clear → Serves as All Red Clearance Time
- Walk → Minimum Dark Time Between Activations
- Pedestrian Clear → Serves as Flashing Yellow Time

* These values may be field adjusted. Do not adjust Min Green and Extension times for phases 1 and 2 lower than what is shown. Min Green for all other phases should not be lower than 4 seconds.

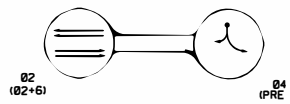
Advance Walk (LPI) is not typically used with Pedestrian Hybrid "HAWK" Signal

Pedestrian Hybrid Beacon ("HAWK") Timing Charts

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO. 7.2.2

PHASING DIAGRAM



PHASING DIAGRAM DETECTION LEGEND

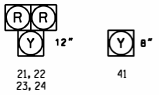
- DETECTED MOVEMENT
- UNDETECTED MOVEMENT (OVERLAP)
- UNSIGNALIZED MOVEMENT
- PEDESTRIAN MOVEMENT

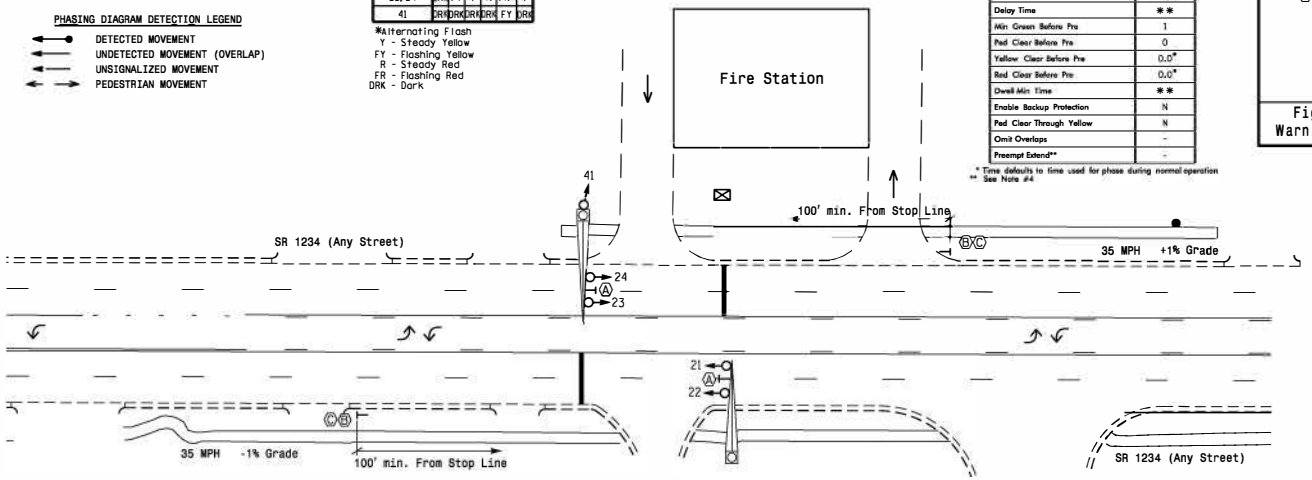
TABLE OF OPERATION						
SIGNAL FACE	PHASE					
	Ø2 (DARK)	ACTIVATION	STEADY YELLOW	STEADY RED	Ø4 PRE 2	FLASH
21, 22	DRK	FY	Y	R	FR*	Y
23, 24	DRK	FY	Y	R	FR*	Y
41	DRK	DRK	DRK	DRK	FY	DRK

*Alternating Flash
Y - Steady Yellow
FY - Flashing Yellow
R - Steady Red
FR - Flashing Red
DRK - Dark

SIGNAL FACE I.D.

All Heads L.E.D.





OASIS 2070 EV PREEMPT	
FUNCTION	PRE 2
Interval 1 – Dwell Green	255
Interval 1 – Dwell Yellow	0.0*
Interval 1 – Dwell Red	0.0*
Interval 5 – Exit Green	1
Interval 5 – Yellow	0.0
Interval 5 – Red	0.0
Exit Phase(s)	2
Priority	MED
Delay Time	**
Min Green Before Pre	1
Ped Clear Before Pre	0
Yellow Clear Before Pre	0.0*
Red Clear Before Pre	0.0*
Dwell Min Time	**
Enable Backup Protection	N
Ped Clear Through Yellow	N
Omit Overlaps	-
Preempt Extend**	-

* Time defaults to time used for phase during normal operation
** See Note #4

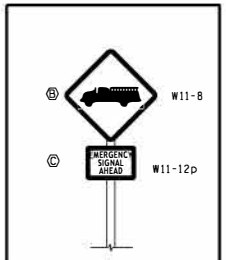


Figure 1: Advance Warning Sign Assembly

2 Phase
Semi-Actuated
Emergency Hybrid Beacon
(Anytown Signal System)

NOTES

1. Refer to "Roadway Standard Drawings NCDOT" dated January 2018 and "Standard Specifications for Roads and Structures" dated January 2018.
2. Locate new cabinet so as not to obstruct sight distance of vehicles turning right on red.
3. Locate emergency vehicle preemption switch in Fire Station.
4. The Division Traffic Engineer will determine the Delay Time and Dwell Min time for the emergency vehicle preemption timing.
5. Signal head 41 shall remain Dark except during the phase 4 green interval (flashing yellow display).
6. Maximum times shown in timing chart are for free-run operation only. Coordinated signal system timing values supersede these values.
7. Locate advance signs in accordance with Table 2C-4 in Section 2C.05 of the 2009 MUTCD or as otherwise directed by the Engineer.

SIGNS

PROPOSED		EXISTING
A	"EMERGENCY SIGNAL STOP ON FLASHING RED" Sign (R10-14A)	A
B	Emergency Vehicle Sign (W11-8)	B
C	"EMERGENCY SIGNAL AHEAD" Sign (W11-12p)	C

OASIS 2070 TIMING CHART			
FEATURE	PHASE 2	PHASE 4 (PRE 2)	OLA
Min Green 1 *	10	7	5
Extension 1 *	0.0	0.0	
Max Green 1 *	30	30	
Yellow Clearance	5.0	3.0	3.8
Red Clearance	2.0	3.6	5.0
Walk 1 *	-	-	
Don't Walk 1	-	-	
Seconds Per Actuation *	-	-	
Max Variable Initial *	-	-	
Time Before Reduction *	-	-	
Time To Reduce *	-	-	
Minimum Gap	-	-	
Recall Mode	MAX RECALL	-	
Vehicle Call Memory	-	-	
Dual Entry	-	-	
Simultaneous Gap	ON	ON	

Serves as Flashing Yellow Time

Serves as Steady Yellow Clearnace Time

Serves as All Red Clearnace Time

* These values may be field adjusted. Do not adjust Min Green and Extension times for phase 2 lower than what is shown. Min Green for allother phases be lower than 4 seconds.

-EV Preempt Phase should be programmed as PRE 2.
-Vehicle Phase should be phase 2 for OASIS and SE-PAC software; use phases 2+6 for ASC/3 software.
-Vehicle detection is not required for phase 2 (2+6 for ASC/3 software). The initial Flashing Yellow display provides additional warning that the beacon is activating.
-Signs W11-8 and W11-12P (shown in Figure 1) are required and should be installed in advance of an emergency vehicle hybrid beacon based on roadway speed as recommended in the MUTCD.
-A steady all red interval should follow the steady yellow interval and precede the alternating flashing red display.
-Signal head 41 may be either a 8" or 12" yellow beacon; its location may vary so that it is most visible to the exiting emergency vehicle.
-An emergency vehicle beacon may be combined for use with with a pedestrian hybrid beacon.

Emergency Vehicle Hybrid Beacon ("HAWK")

SIGNAL DESIGN SECTION
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STD. NO.
7.3.1

OASIS 2070 Timing Chart

- See STD. NO. 5.2.1 for Vehicle Phase
  Use 7 sec. for EV Phase
  Use 5 sec. for Overlap
- Unless vehicle phase is detected, set to 0.
- See STD. NO. 5.2.1
- Phase 2 Yellow Serves as Flashing Yellow Time. Use STD. 5.2.2 to calculate Yellow Clear time for phase 4.
- Use 2.0 sec for Phase 2 Red. Use STD. 5.2.2 to calculate Red Clear time for phase 4.
- Typically not used with EVP
- See STD. NO. 6.0 Typically not used with EVP
- Volume Density Timing
  Normally Not Used
  If used, see STD. 5.2.1
- MAX RECALL if no vehicle detection used
- None (-) or YELLOW
- Usually not selected (-)
- ON or not selected, usually selected

Serves as Flashing Yellow Time

OASIS 2070 TIMING CHART

FEATURE	PHASE 2	PHASE 4 (PRE 2)	PHASE OLA
Min Green 1 *	10	7	5
Extensian 1 *	0.0	0.0	
Max Green 1 *	30	30	
Yellaw Clearance	5.0	3.0	3.8
Red Clearance	2.0	3.6	5.0
Walk 1 *	-	-	
Dan't Walk 1	-	-	
Seconds Per Actuation *	-	-	
Max Variable Initial *	-	-	
Time Befare Reductian *	-	-	
Time Ta Reduce *	-	-	
Minimum Gap	-	-	
Recall Made	MAX RECALL	-	
Vehicle Call Memary	-	-	
Dual Entry	-	-	
Simultaneous Gap	ON	ON	

* These values may be field adjusted. Do not adjust Min Green and Extension times for phase 2 lower than what is shown. Min Green for all other phases should not be lower than 4 seconds.

- OLA Min Green must be the same as Phase 2 Yellow clearance time (Flashing Yellow Time)
- OLA Yellow is vehicle steady Yellow clearance time as calulated in STD. 5.2.2
- Serves as Steady Yellow Clearance Time
- Serves as AllRed Clearance Time
- OLA Red should be at least time calculated in STD. 5.2.2, but may be increased up to 5.0

Emergency Vehicle Hybrid Beacon ("HAWK") Timing Charts

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STD. NO. 7.3.2

ASC/3 Timing Chart w/170 Cabinet

- See STD. NO. 5.2.1 for Vehicle Phase; Use 7 for EV Phase.
- Typically not used with EVP
- See STD. NO. 6.0 Typically not used with EVP

Serves as Flashing Yellow Time

- Unless vehicle phase is detected, set to 0 sec
- See STD. NO. 5.2.1
- Yellow clearance time as calulated in STD. 5.2.2 for all phases.

Serves as Steady Yellow Clearance Time

Serves as All Red Clearance Time

- Red Clear should be calculated as in STD. 5.2.2 for all phases, but may be increased up to 5.0.
- Volume Density Timing Normally Not Used If used, see STD. 5.2.1
- None (-) if no vehicle detection
- MAX RECALL if no vehicle detection
- Usually not selected (-)
- ON or not selected, usually selected

ASC/3 TIMING CHART

FEATURE	PHASE 2	PHASE 4 (PRE 2)	PHASE 6
Min Green *	10	7	10
Walk *	-	-	-
Ped Clear *	5	-	5
Veh. Extension *	0.0	0.0	0.0
Max 1 *	30	30	30
Yellow	3.8	3.0	3.8
Red Clear	5.0	3.6	5.0
Actuations B4 Add *	-	-	-
Seconds /Actuation *	-	-	-
Max Initial *	-	-	-
Time Before Reduction *	-	-	-
Time To Reduce *	-	-	-
Minimum Gap	-	-	-
Locking Detector	-	-	-
Recall Position	MAX RECALL	-	MAX RECALL
Dual Entry	-	-	-
Simultaneous Gap	ON	ON	ON

* These values may be field adjusted. Do not adjust Min Green and Extension times for phases 2 and 6 lower than what is shown. Min Green for all other phases should not be lower than 4 seconds.

All Time parameters entered for Phase 2 and Phase 6 must be identical.

ASC/3 NEMA Timing Chart (For Cary 2070LXN2 Signal System)

- See STD. NO. 5.2.1 for Vehicle Phases; Use 7 for EV Phase.
- Unless vehicle phase is detected, set as dash
- Yellow clearance time as calulated in STD. 5.2.2 for all phases.

Serves as Steady Yellow Clearance Time

Serves as All Red Clearance Time

- Red Clear should be calculated as in STD. 5.2.2 for all phases, but may be increased up to 5.0.
- See STD. NO. 5.2.1
- MAX RECALL if no vehicle detection
- OFF if no vehicle detection

Serves as Flashing Yellow Time

- Typically not used with EVP
- Typically not used with EVP. Set to Flashing Yellow Time for Vehicle Phases
- OFF if Volume Density Timing Not Used
- Volume Density Timing Normally Not Used If used, see STD. 5.2.1.
- Usually not selected (-)
- ON or not selected, usually selected

TIMING CHART
ASC/3-2070LXN2 CONTROLLER

PHASE	Ø2	Ø4 (PRE 2)	Ø6
MINIMUM GREEN *	10 SEC.	7 SEC.	10 SEC.
VEHICLE EXT *	- SEC.	- SEC.	- SEC.
YELLOW CHANGE INT*	3.8 SEC.	3.0 SEC.	3.8 SEC.
RED CLEARANCE *	5.0 SEC.	3.6 SEC.	5.0 SEC.
MAX 1 *	30 SEC.	30 SEC.	30 SEC.
RECALL POSITION	MAX RECALL	-	MAX RECALL
LOCK DET.	OFF	OFF	OFF
WALK*	- SEC.	- SEC.	- SEC.
PED CLEAR	5 SEC.	- SEC.	5 SEC.
VOLUME DENSITY	OFF	OFF	OFF
ACTUATION B4 ADD*	- VEH.	- VEH.	- VEH.
SEC PER ACTUATION *	- SEC.	- SEC.	- SEC.
MAXIMUM INITIAL *	- SEC.	- SEC.	- SEC.
TIME B4 REDUCTION *	- SEC.	- SEC.	- SEC.
TIME TO REDUCE *	- SEC.	- SEC.	- SEC.
MINIMUM GAP	- SEC.	- SEC.	- SEC.
DUAL ENTRY	-	-	-
SIMULTANEOUS GAP	ON	ON	ON

* These values may be field adjusted. Do not adjust Min Green and Extension times for phases 2 and 6 lower than what is shown. Min Green for all other phases should not be lower than 4 seconds.

All Time parameters entered for Phase 2 and Phase 6 must be identical

Emergency Vehicle Hybrid Beacon ("HAWK") Timing Charts

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.
7.3.2

SE–PAC 2070 Timing Chart
(Hickory and Raleigh Signal Systems)

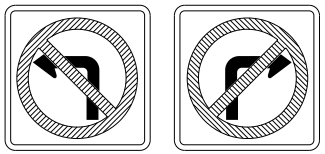
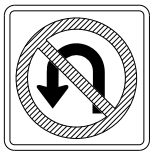
(Based on SE-PAC Version 5)

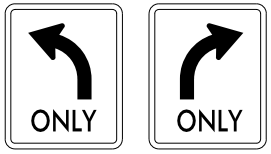
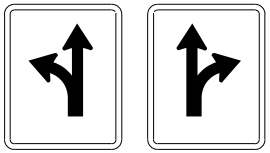
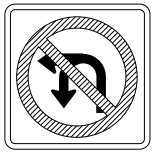
- See STD. NO. 5.2.1 for Vehicle Phase. Use 7 for Ped Phase(s).
- Unless vehicle phase is detected, set to 0.0.
- Set for same as MIN GREEN. Controller rests in Phase 1 until preempt activation.
- Yellow clearance time as calculated in STD. 5.2.2 for each phase.
- Red clearance time as calculated in STD. 5.2.2 for Phase 1 PED. Use 0.0 for 2 PED (not used).
- Since preempt activated, this value generally not used. Preempt will begin immediately unless a delay time is used. Use 1.
- Flashing Yellow Time for 1 PED. For 2 PED, this is the Preempt Dwell time, which is usually field adjusted.
- Volume Density Timing Not Used
- Program for MIN/PED RECALL if no vehicle detection used
- None ("-") or YELLOW
- Usually not selected
- ON or not selected, usually selected

SE-PAC 2070 TIMING CHART		
	PHASE	
FEATURE	1 PED	2 PED
Min Green	10	7
Passage Gap	0.0	0.0
Maximum Green	10	7
Yellow Change	5.0	3.0
Red Clear	2.0	0.0
Walk	1	1
Pedestrian Clear	5	10#
Added Iniitial	-	-
Maximum Initial	-	-
Time Before Reduction	-	-
Time To Reduce	-	-
Minimum Gap	-	-
Recall Mode	MIN/PED RECALL	-
Vehicle Call Memory	-	-
Dual Entry	-	-
Simultaneous Gap	ON	ON

See Note X. This value may be field adjusted. No other values should be field adjusted.

- Yellow Change → Serves as Steady Yellow Clearance Time
- Red Clear → Serves as All Red Clearance Time
- Pedestrian Clear → Serves as Preempt Dwell Time
- Pedestrian Clear → Serves as Flashing Yellow Time

Sign No.	Description	Graphic
R1-1	"STOP" Sign	
R1-2	"YIELD" Sign	
R3-1 R3-2	No Right Turn Sign No Left Turn Sign	
R3-3	"NO TURNS" Sign	
R3-4	No U Turn Sign	

Sign No.	Description	Graphic
R3-5a	Through Arrow "ONLY" Sign	
R3-5L R3-5R	Left Arrow "ONLY" Sign Right Arrow "ONLY" Sign	
R3-6L R3-6R	Combined Through and Left Arrow Sign Combined Through and Right Arrow Sign	
R3-18	No U-Turn/No Left Turn Sign	
R3-27	No Straight Through Sign	

Commonly Used Signs

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
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STD. NO.
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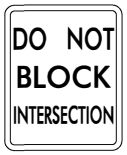
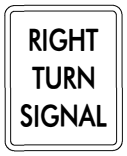
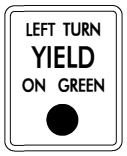
Sign No.	Description	Graphic
R8-8	"DO NOT STOP ON TRACKS" Sign	
R10-6	"STOP HERE ON RED" Sign	
R10-7	"DO NOT BLOCK INTERSECTION" Sign	
R10-10R	"RIGHT TURN SIGNAL" Sign	
R10-11 R10-11a R10-11b	"NO TURN ON RED" ● Sign "NO TURN ON RED" Sign "NO TURN ON RED" Sign	 
R10-12	"LEFT TURN YIELD ON GREEN" ● Sign	

Sign No.	Description	Graphic
R10-13	"EMERGENCY SIGNAL" Sign	
R10-14 R10-14a	"EMERGENCY SIGNAL STOP ON FLASHING RED" Sign	
R10-15L R10-15R	Left (Right) "TURNING VEHICLES" Yield "TO" Pedestrians Sign	 
R10-16	"U-TURN YIELD TO RIGHT TURN" Sign	
R10-22	Bicycle Signal Actuation "TO REQUEST GREEN WAIT ON SYMBOL" Sign	
R10-23	"CROSSWALK STOP ON RED" ● Sign	

Commonly Used Signs

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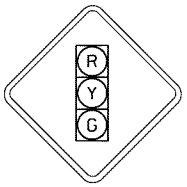
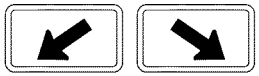
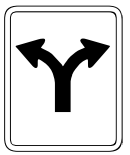
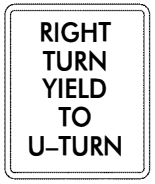
Sign No.	Description	Graphic
W3-3	Signal Ahead Sign	
W3-4	"BE PREPARED TO STOP" Sign	
W11-2	Pedestrian Crossing Sign	
W11-8	Emergency Vehicle Sign	
W11-12p	"EMERGENCY SIGNAL AHEAD" Plaque	
W16-7pL W16-7pR	Left (Right) Downward Diagonal Arrow Plaque	
W16-9p	"AHEAD" Plaque	

Sign No.	Description	Graphic
W25-1	"ONCOMING TRAFIC HAS EXTENDED GREEN" Sign	
W25-2	"ONCOMING TRAFIC MAY HAVE EXTENDED GREEN" Sign	
	Dual Turn Arrows Sign	
	Dual Turn and Through Arrows Sign	
	"RIGHT TURN YIELD TO U-TURN" Sign	
	Bus "SIGNAL" Sign	

Commonly Used Signs

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TRANSPORTATION MOBILITY AND SAFETY DIVISION
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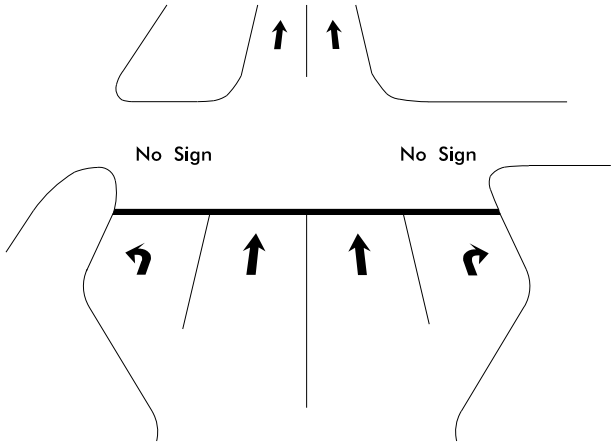
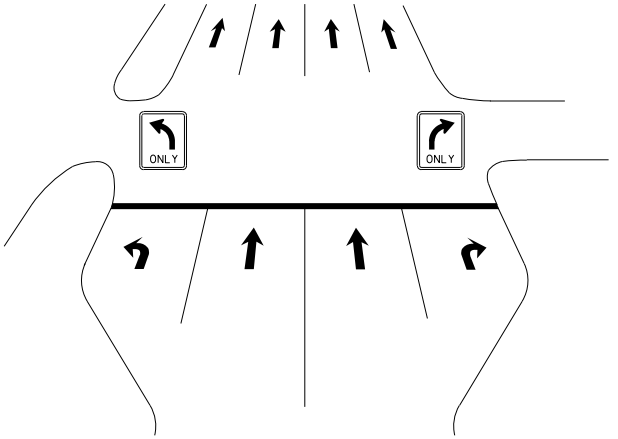
1) In general, lane-use control signs are not required when a vehicle must shift into a turning bay to make a turning movement (Example 1).

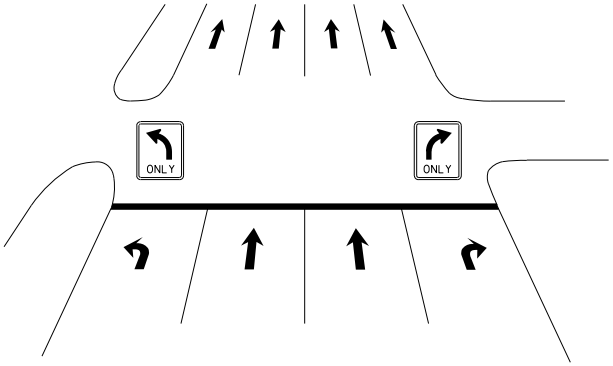
2) In general, lane-use control signs should be used when:
   A) Lane geometrics allow a through movement, but a mandatory turn is required (Examples 2 and 3).
   B) A lane without a turn bay ends abruptly (Example 4).



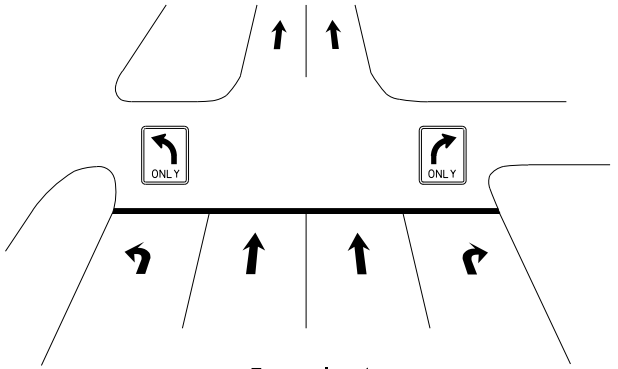
Example 1



Example 2



Example 3



Example 4

Application of Lane–Use Control Signs

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TRANSPORTATION MOBILITY AND SAFETY DIVISION
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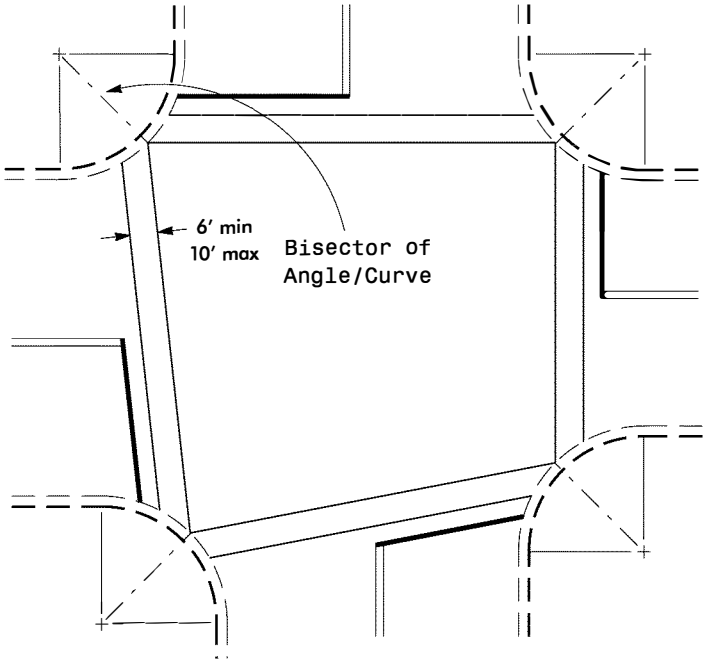
SHEET 1 OF 1

CASE 1

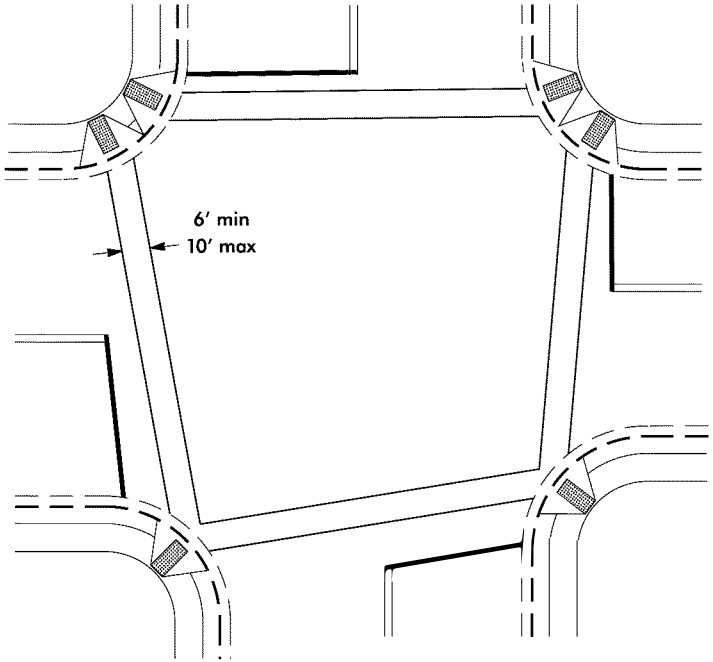
Locate Crosswalks from Center of Curve



Per Division and/or municipal agreement, crosswalk markings may be transverse or high visibility.

CASE 2

Connect Curb Ramps



When practical, it is preferred to have 2 curb ramps per quadrant.

Reference: Roadway Standard Drawing 1205.07

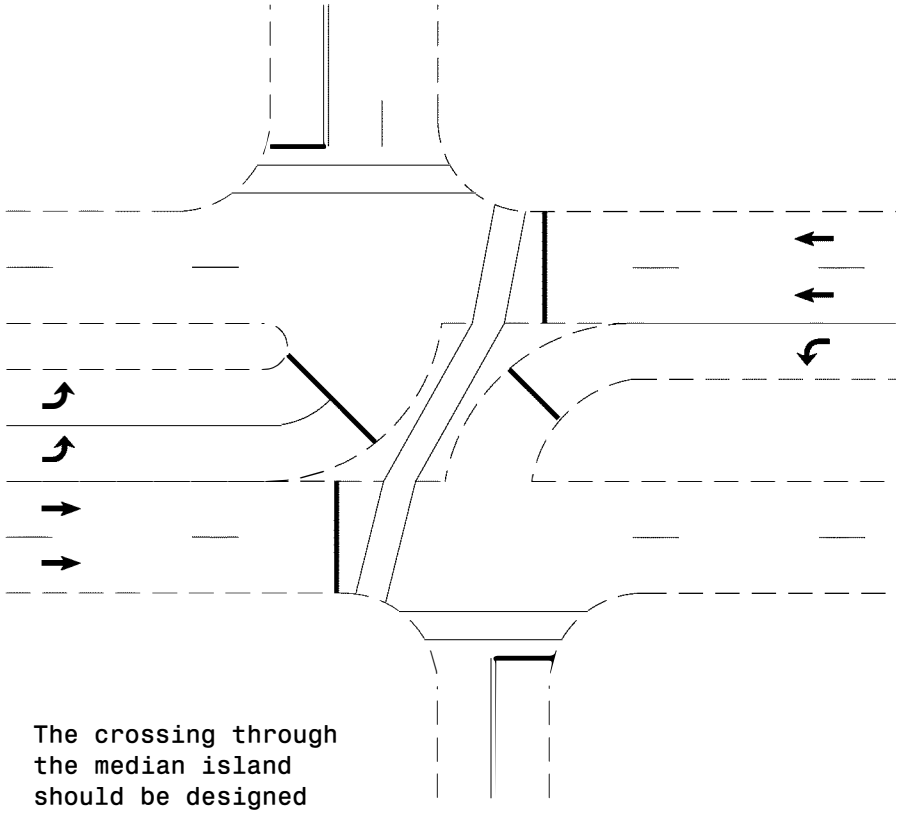
Crosswalks

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

7-21

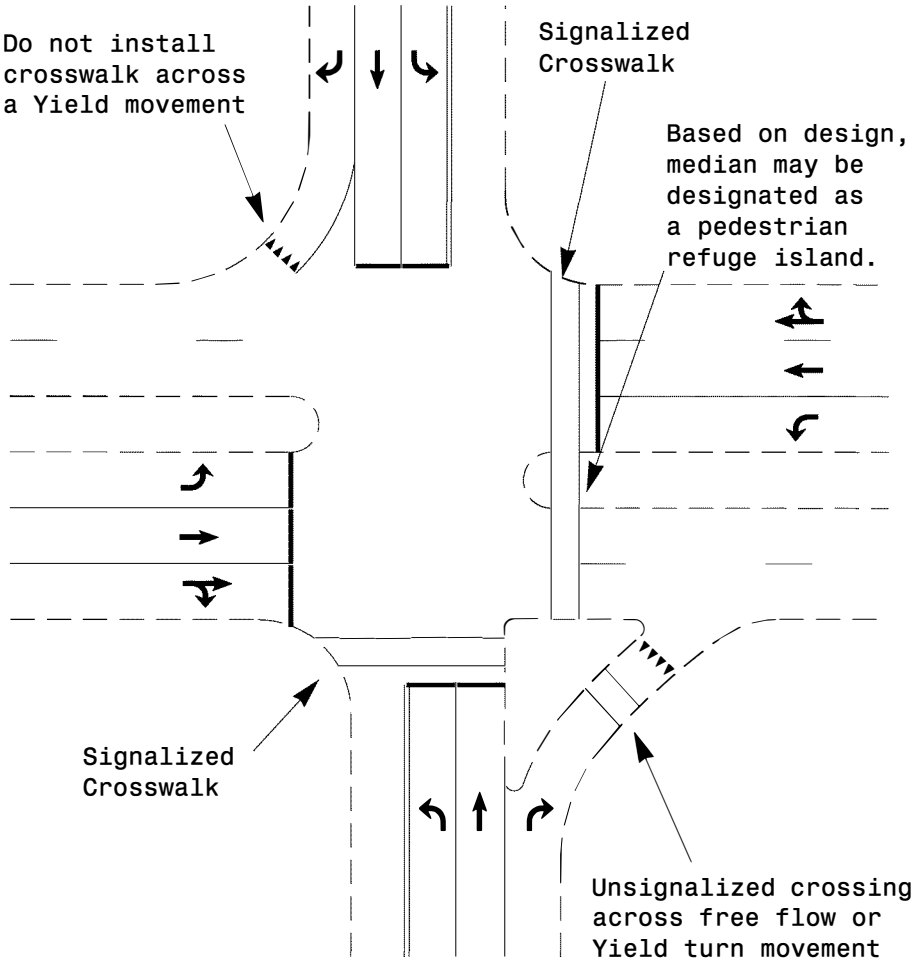
STD. NO.
9.0
SHEET 1 OF 2

Crosswalk Across Superstreet



The crossing through the median island should be designed as a 2 stage crossing.

Intersection with Median and/or Pork Chop Island



Reference: Roadway Standard Drawing 1205.07

Crosswalks

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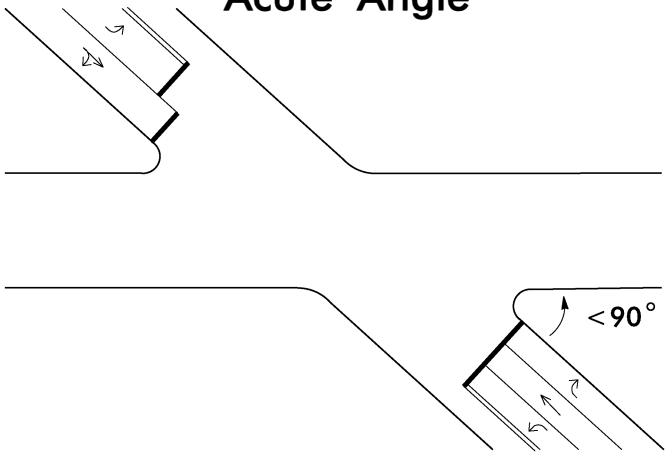
7-21

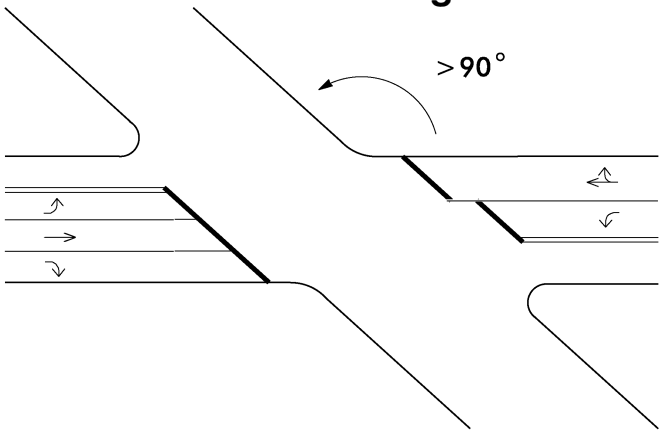
STD. NO.
9.0
SHEET 2 OF 2

CASE 1
Acute Angle



For approaches with intersection angles less than 90 degrees, place stop lines perpendicular to the centerline of the approach.

CASE 2
Obtuse Angle



For approaches with intersection angles greater than 90 degrees, place stop lines parallel to the edge of the intersecting roadway.

Notes

- "Intersection angle" is defined as the angle between the approach in question and the intersection roadway to the right.
- Typically, place stop lines no more than 30 feet nor less than 4 feet from the nearest edge of the intersecting travel way.
- The offset (stagger) of a stop line between adjacent lanes should be no more than 20 feet.
- For stop line locations at crosswalks, locate stop line 4 feet behind and parallel to the nearest crosswalk line, but not within the area of a curb ramp.
- When practical, locate stop lines to allow for installation of a future crosswalk based on guidelines above.

Reference: Roadway Standard Drawings 1205.04 and 1205.07

Stop Lines

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

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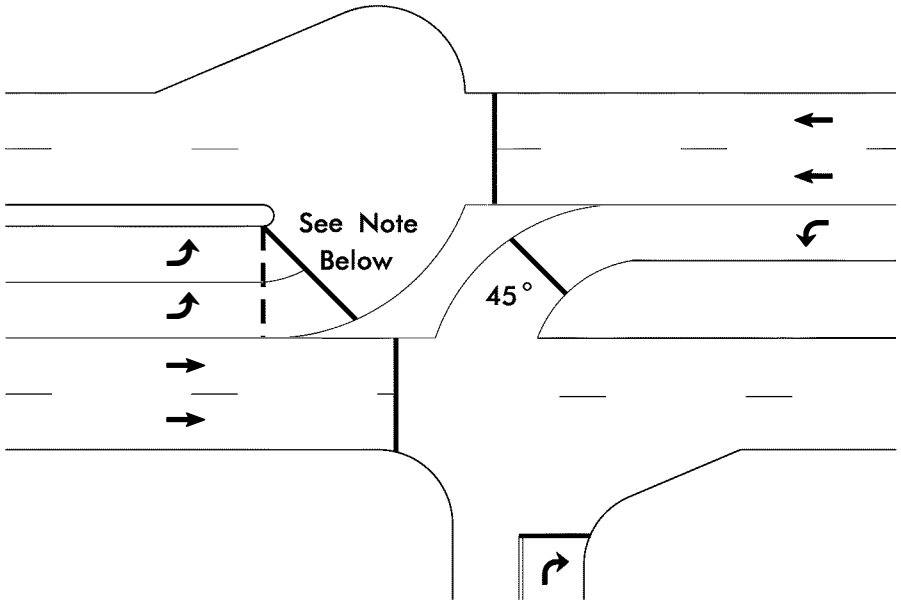
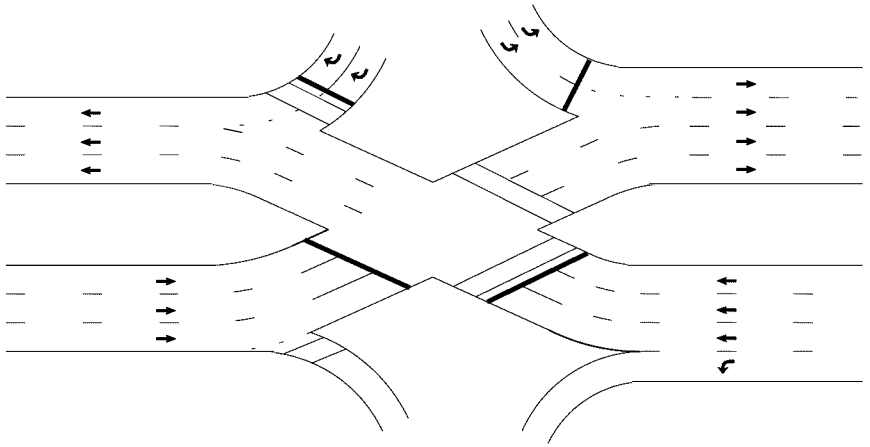
STD. NO.
9.1
SHEET 1 OF 2

CASE 3
Superstreet Left and/or U–Turn



-As many superstreet U-turns and left turns operate in a protected/permissive or variable phasing mode, stop line should be located to allow vehicle to be at stop line, still be on detection loop, and have visual clearance to make a permissive turn.
-Angle stop lines for U-Turns and left turns to be at 45° angle, so they are approximately halfway around the radius of the turn.
-Stop line should still be angled so it is perpendicular to vehicle as it is turning in lane.
-If dual turn lanes are present and the signal will only allow the movement in a protected mode, the stop line may extend perpendicular from the edge of the tangent island rather than at an angle.

CASE 4
Diverging Diamond Interchange



Notes

- Stop line should be a straight line across all lanes, not staggered or offset for each lane, that maintains at least a 40 foot distance to the overhead signal heads for all lanes.
-Where a crosswalk exists, locate stop lines 4 feet from and parallel to the crosswalk crossing travel lanes.
-When there is no crosswalk, locate stop line parallel to the tangent edge of travel for the intersecting lanes, or if needed to maintain a 40 foot distance to the signal heads, perpendicular to the travel lanes.
-For left turns off ramps, locate stop line perpendicular across travel lanes.

Reference: Roadway Standard Drawings
1205.04, 1205.07, and 1205.15

Stop Lines

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TRANSPORTATION MOBILITY AND SAFETY DIVISION
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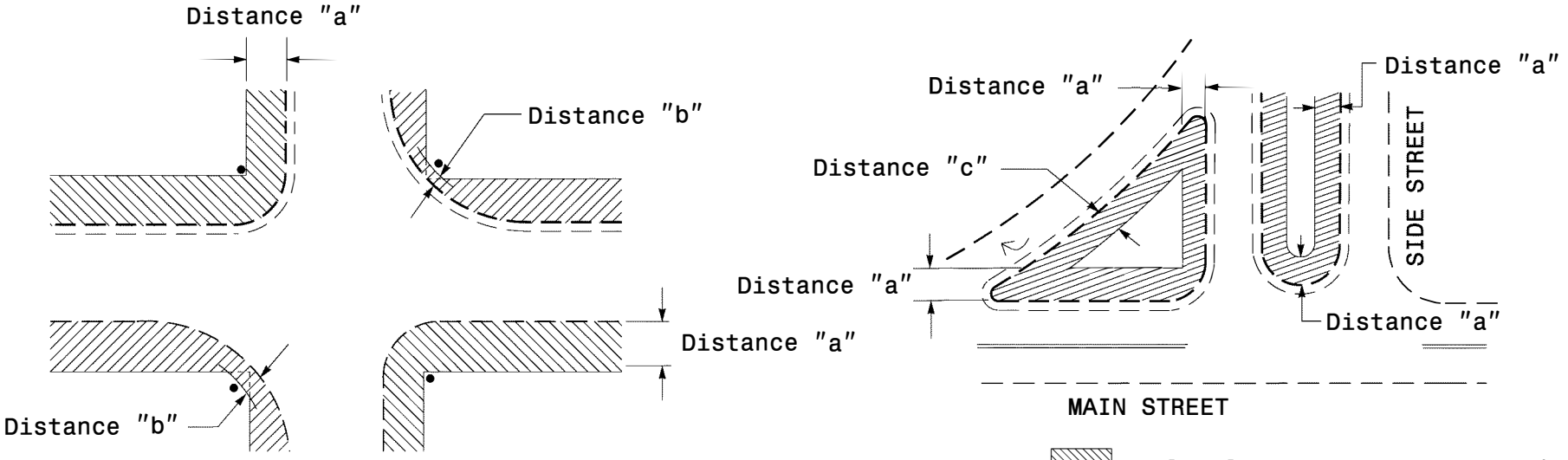
STD. NO.
9.1
SHEET 2 OF 2

Pole Placement Guidelines



Design Speed MPH	Distance "a"		Distance "b"		Distance "c"		
	Distance from Face of Curb feet	Distance from EOP feet	Face of Curb feet	EOP feet	Side St. Speed MPH	Distance from Face of Curb feet	Distance from EOP feet
≤40	12	14	7	10	≤40	7	7
					45-50	7	7
					≥55	10	12
45-50	16	18			≤40	7	7
					45-50	10	12
					≥55	12	14
≥55	22	22			≤40	7	7
					45-50	10	12
					≥55	12	14

Note 1: The signal supports should be placed as far away from the roadway as practical.

Note 2: Painted islands should not be used for pole locations unless a method of protection is provided (such as a guardrail).

Distances are the desired minimum from the face of pole

Reference: AASHTO "Roadside Design Guide", 4th Edition, 2011

Recommended Pole Placement

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

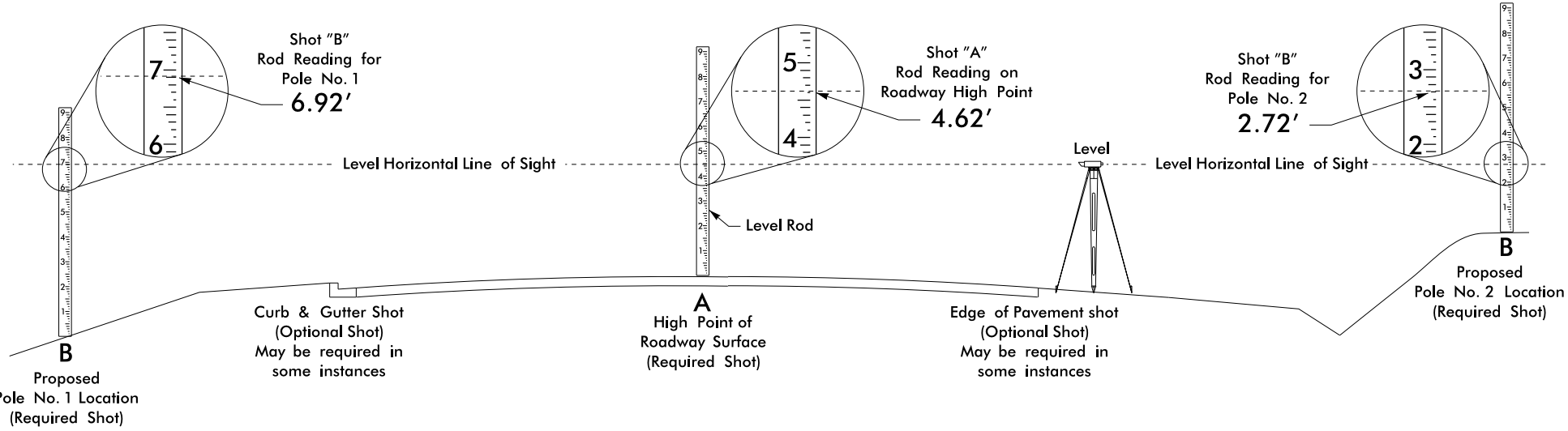
7-21

STD. NO.
10.0
SHEET 1 OF 1

Survey Level With Rod Method

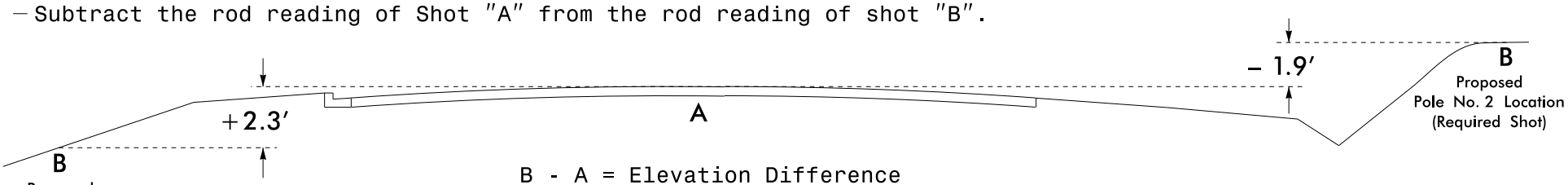
Step 1: Using a standard Survey Level and Level Rod:

– Take elevation shots on high point of roadway (shot "A") and at proposed pole foundation centerline (Shot "B").



Find the elevation difference between the proposed foundation and the high point of the roadway

– Subtract the rod reading of Shot "A" from the rod reading of shot "B".



B - A = Elevation Difference

(Do not round up)

Elevation difference for Pole No. 1: 6.92′-4.62′ = +2.3′
Elevation difference for Pole No. 2: 2.72′-4.62′ = -1.9′

Determining Elevation Difference for Metal Poles

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
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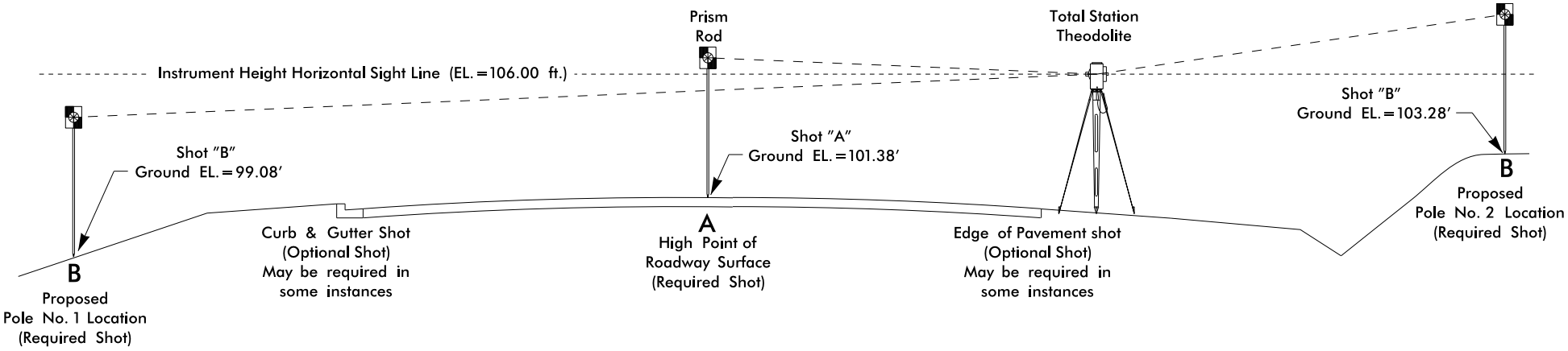
7-04

STD. NO.
10.1.1
SHEET 1 OF 2

Total Station And Data Collector With Prism Rod Method

Step 1: Using a Total Station and Data collector with Prism Rod:

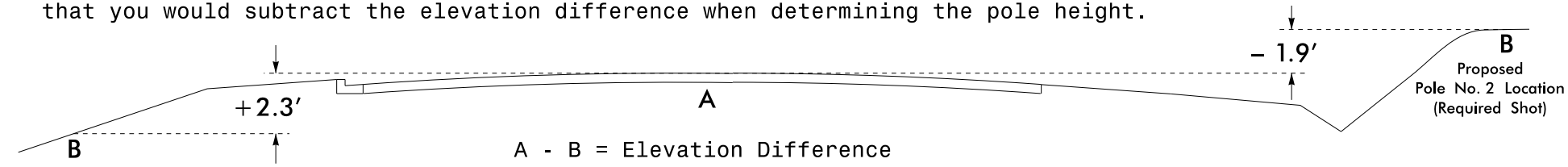
– Take elevation shots on high point of roadway (shot "A") and at proposed pole foundation centerline (Shot "B").



Step 2: Find the elevation difference between Shot "A" and Shot "B"

– Subtract the ground elevation of Shot "B" from the roadway elevation of shot "A".

Notice the difference in the equation when different survey methods are used. A positive number should reflect that you would add the elevation difference to the pole height, where a negative number would mean that you would subtract the elevation difference when determining the pole height.



A - B = Elevation Difference

(Do not round up)

{ Elevation difference for Pole No. 1: 101.38'-99.08' = +2.3'
{ Elevation difference for Pole No. 2: 101.38'-103.28' = -1.9'

Determining Elevation Difference for Metal Poles

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
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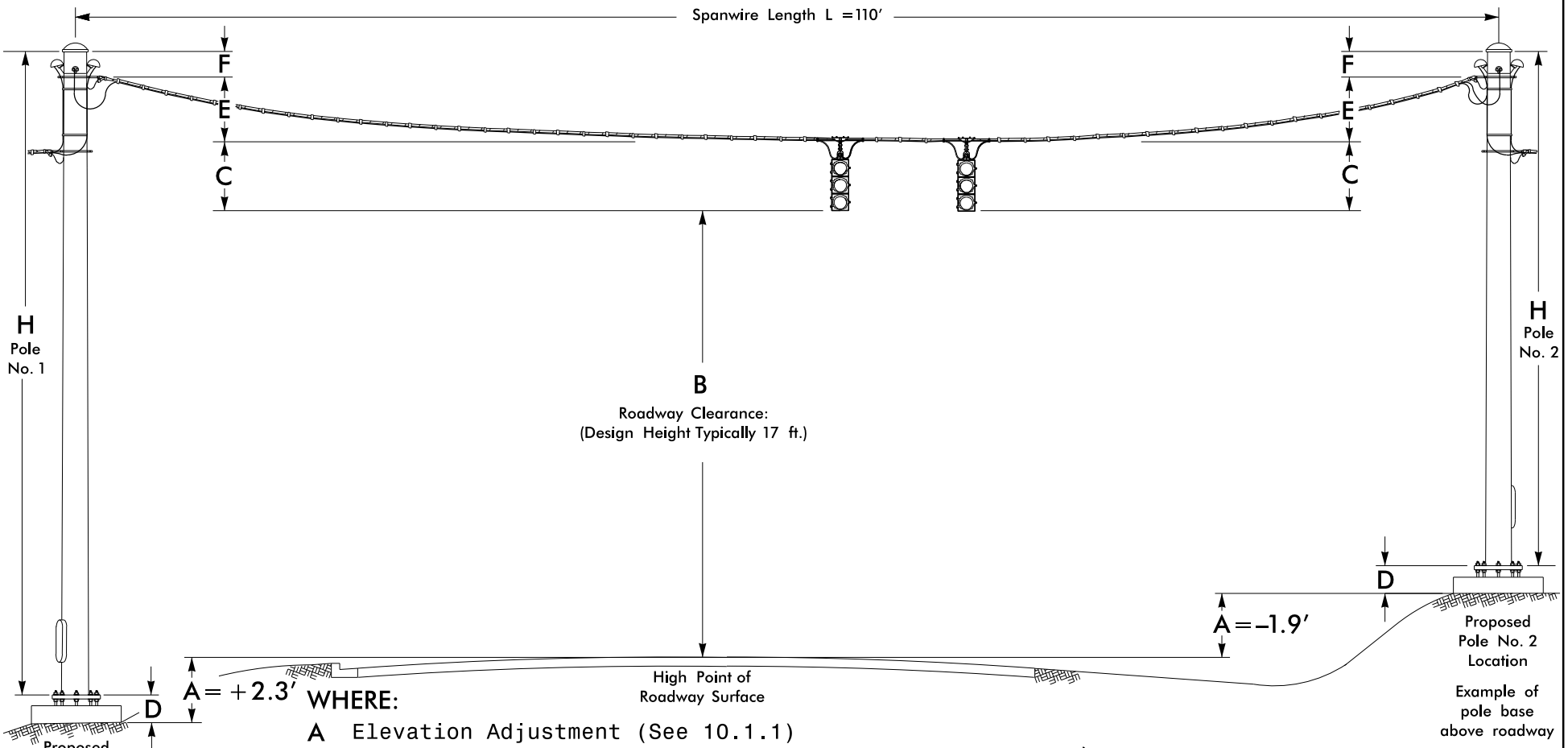
7-04

STD. NO.
10.1.1
SHEET 2 OF 2

MINIMUM STRAIN POLE HEIGHT (H) = A + B + C − D + E + F



WHERE:

- A Elevation Adjustment (See 10.1.1)
- B Roadway Clearance Distance (Design Height typically 17′)
- C Signal Head Height for Spanwire Mounting (See 10.1.3)
- D Top of pole base above ground = 0.75′
- E Spanwire Sag = 4% of total Spanwire Length "L"
- F Spanwire Attachment Point (Minimum) = 1.5′ Below Top of Pole

Calculating H
(Round up to .5 ft.)

Pole height for pole No. 1 (H): +2.3′+17′+4.25′-.75′+4.4′+1.5′ = 28.7′ => 29.0 ft.

Pole height for pole No. 2 (H): -1.9′+17′+4.25′-.75′+4.4′+1.5′ = 24.5′ => 24.5 ft.

Pole Height Determination – Strain Poles

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TRANSPORTATION MOBILITY AND SAFETY DIVISION
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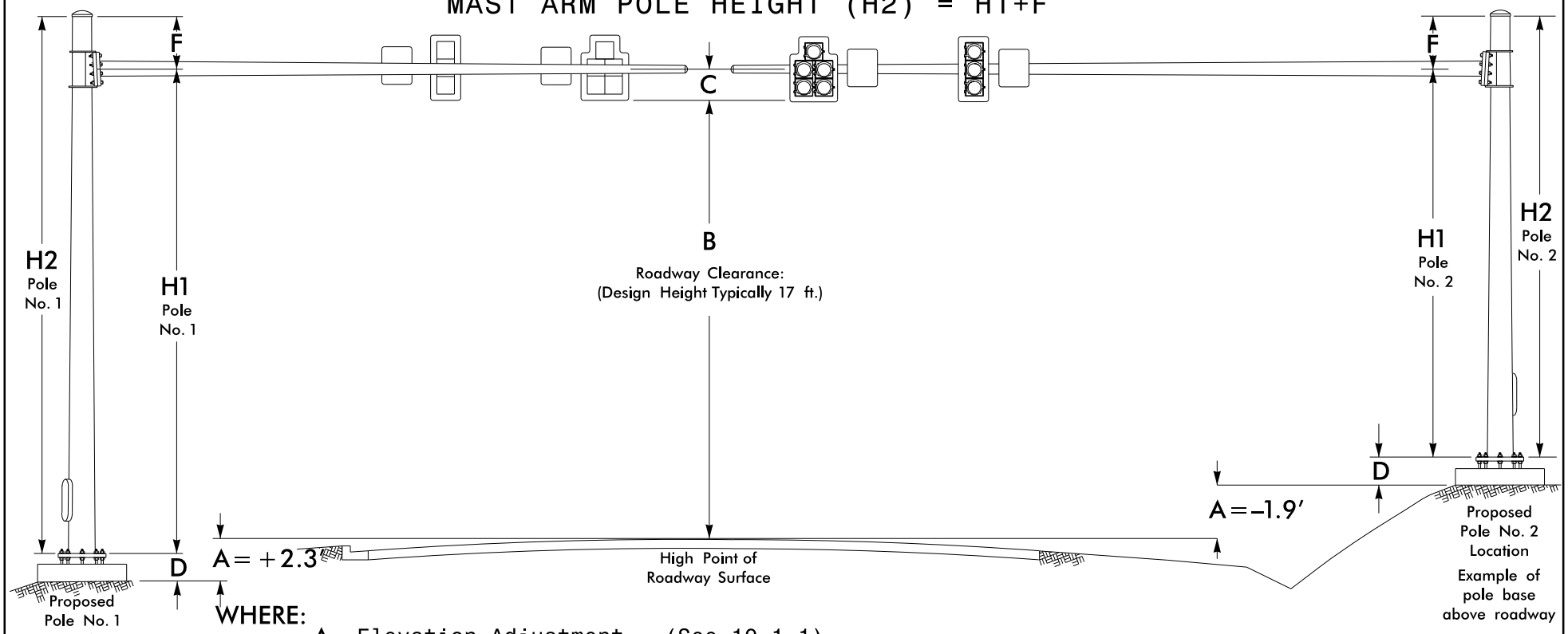
7-04

STD. NO.
10.1.2
SHEET 1 OF 3

MAST ARM ATTACHMENT HEIGHT (H1) =A+B+C−D
MAST ARM POLE HEIGHT (H2) = H1+F



WHERE:

- A Elevation Adjustment - (See 10.1.1)
- B Roadway Clearance Distance (Design Height typically 17′)
- C ½ Signal Head Height for Mast Arm Mounting (See 10.1.3)
- D Top of Pole base above ground = 0.75′
- F ℄ Arm Attachment Point to Top of Pole = 2′

EXAMPLES:

Calculating H1 (Round up to .1 ft.)

Mast Arm attachment height for pole No. 1 (H1): +2.3′+17′+(4.67′/2)-.75′ = 20.885′ => 20.9 ft.

Mast Arm attachment height for pole No. 2 (H1): -1.9′+17′+(4.67′/2)-.75′ = 16.685′ => 16.7 ft.

Calculating H2 (Round up to .5 ft.)

Pole height for pole No. 1 (H2): 20.9′+2′ = 22.9′ => 23.0 ft.

Pole height for pole No. 2 (H2): 16.7′+2′ = 18.7′ => 19.0 ft.

Pole Height Determination – Straight Mast Arms

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
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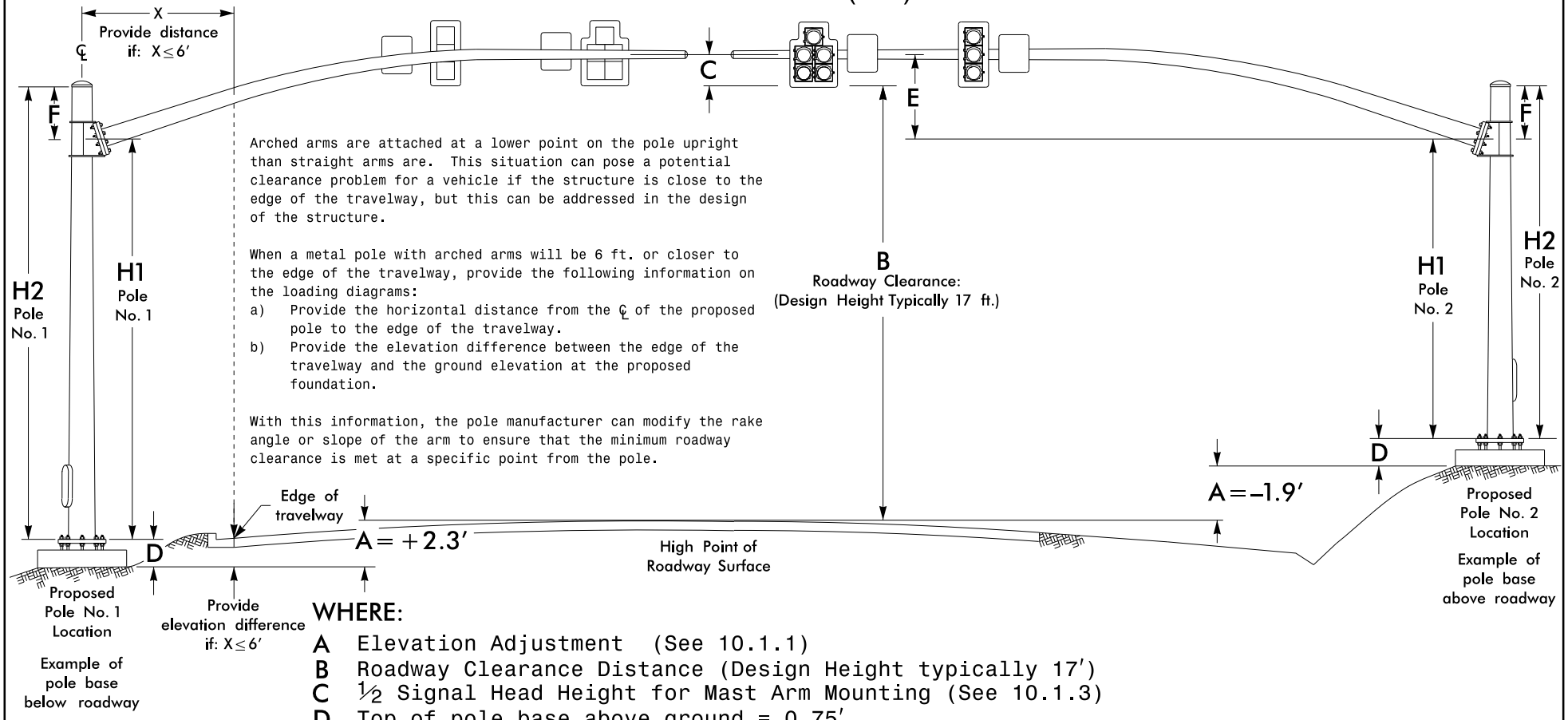
7-04

STD. NO.
10.1.2
SHEET 2 OF 3

MAST ARM ATTACHMENT HEIGHT (H1) =A+B+C−D−E
MAST ARM POLE HEIGHT (H2) = H1+F



Arched arms are attached at a lower point on the pole upright than straight arms are. This situation can pose a potential clearance problem for a vehicle if the structure is close to the edge of the travelway, but this can be addressed in the design of the structure.

When a metal pole with arched arms will be 6 ft. or closer to the edge of the travelway, provide the following information on the loading diagrams:

a) Provide the horizontal distance from the ℄ of the proposed pole to the edge of the travelway.
b) Provide the elevation difference between the edge of the travelway and the ground elevation at the proposed foundation.

With this information, the pole manufacturer can modify the rake angle or slope of the arm to ensure that the minimum roadway clearance is met at a specific point from the pole.

WHERE:

- A Elevation Adjustment (See 10.1.1)
- B Roadway Clearance Distance (Design Height typically 17′)
- C ½ Signal Head Height for Mast Arm Mounting (See 10.1.3)
- D Top of pole base above ground = 0.75′
- E Nominal Rise in Mast Arm = 5′
- F ℄ Arm Attachment Point to Top of Pole = 2′

EXAMPLES:

Calculating H1 (Round up to .1 ft.)
- Mast Arm attachment height for pole No. 1 (H1): +2.3′+17′+(4.67′/2)-.75′-5.0′ = 15.885′ => 15.9 ft.
- Mast Arm attachment height for pole No. 2 (H1): -1.9′+17′+(4.67′/2)-.75′-5.0′ = 11.685′ => 11.7 ft.

Calculating H2 (Round up to .5 ft.)
- Pole height for pole No. 1 (H2): 15.9′+2′ = 17.9′ => 18.0 ft.
- Pole height for pole No. 2 (H2): 11.7′+2′ = 13.7′ => 14.0 ft.

Pole Height Determination – Curved /Arched Mast Arms

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
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STD. NO.
10.1.2
SHEET 3 OF 3

LOADING SCHEDULE FOR STRAIN POLES

DESCRIPTION	AREA	SIZE	WEIGHT
SIGNAL HEAD 12"-3 SECTION-WITH BACKPLATE, HANGER, AND BALANCE ADJUSTER	9.5 S.F.	25.5" W x 53.5" L	56 LBS
SIGNAL HEAD 12"-3 SECTION (T-TYPE HYBRID BEACON)-WITH BACKPLATE, HANGER, AND BALANCE ADJUSTER	10.5 S.F.	39.0" W x 39.0" L	58 LBS
SIGNAL HEAD 12"-4 SECTION (T-TYPE)-WITH BACKPLATE, HANGER, AND BALANCE ADJUSTER	14.0 S.F.	39.0" W x 52.0" L	83 LBS
SIGNAL HEAD 12"-4 SECTION (VERTICAL)-WITH BACKPLATE, HANGER, AND BALANCE ADJUSTER	11.75 S.F.	25.5" W x 65.5" L	69 LBS
SIGNAL HEAD 12"-5 SECTION-WITH BACKPLATE, HANGER, AND BALANCE ADJUSTER	16.5 S.F.	42.0" W x 56.5" L	95 LBS
SIGNAL HEAD 8"-3 SECTION-WITH BACKPLATE, HANGER, AND BALANCE ADJUSTER	6.75 S.F.	22.0" W x 40.5" L	43 LBS
LED BLANKOUT SIGN WITH HANGER	6.0 S.F.	24.0" W x 36.0" L	110 LBS
SIGN WITH HANGER	5.0 S.F.	24.0" W x 30.0" L	11 LBS
SIGN WITH HANGER	7.5 S.F.	30.0" W x 36.0" L	14 LBS
STREET NAME SIGN, WITH HANGER	16.0 S.F.	24.0" W x 96.0" L	36 LBS
PEDESTRIAN SIGNAL HEAD WITH MOUNTNG HARDWARE	2.2 S.F.	18.5" W x 17.0" L	21 LBS
LUMINAIRE	0.87 S.F.	13.25" W x 26.25" L	35 LBS

LOADING SCHEDULE FOR MAST ARM POLES

DESCRIPTION	AREA	SIZE	WEIGHT
SIGNAL HEAD RIGID MOUNTED 12"-3 SECTION-WITH BACKPLATE	9.3 S.F.	25.5" W x 52.5" L	60 LBS
SIGNAL HEAD RIGID MOUNTED 12"-3 SECTION (T-TYPE HYBRID BEACON)- WITH BACKPLATE	10.5 S.F.	39.0" W x 39.0" L	62 LBS
SIGNAL HEAD RIGID MOUNTED 12"-4 SECTION (T-TYPE)-WITH BACKPLATE	14.0 S.F.	39.0" W x 52.0" L	83 LBS
SIGNAL HEAD RIGID MOUNTED 12"-4 SECTION (VERTICAL)-WITH BACKPLATE	11.7 S.F.	25.5" W x 66.0" L	74 LBS
SIGNAL HEAD RIGID MOUNTED 12"-5 SECTION-WITH BACKPLATE	16.3 S.F.	42.0" W x 56.0" L	103 LBS
SIGNAL HEAD RIGID MOUNTED 8"-3 SECTION-WITH BACKPLATE	6.75 S.F.	24.0" W x 40.5" L	43 LBS
LED BLANKOUT SIGN RIGID MOUNTED	6.0 S.F.	24.0" W x 36.0" L	110 LBS
SIGN RIGID MOUNTED	5.0 S.F.	24.0" W x 30.0" L	11 LBS
SIGN RIGID MOUNTED	7.5 S.F.	30.0" W x 36.0" L	14 LBS
STREET NAME SIGN, RIGID MOUNTED	16.0 S.F.	24.0" W x 96.0" L	36 LBS
PEDESTRIAN SIGNAL HEAD WITH MOUNTNG HARDWARE	2.2 S.F.	18.5" W x 17.0" L	21 LBS
LUMINAIRE	0.87 S.F.	13.25" W x 26.25" L	35 LBS

Loading Schedules For Metal Poles

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

7-21

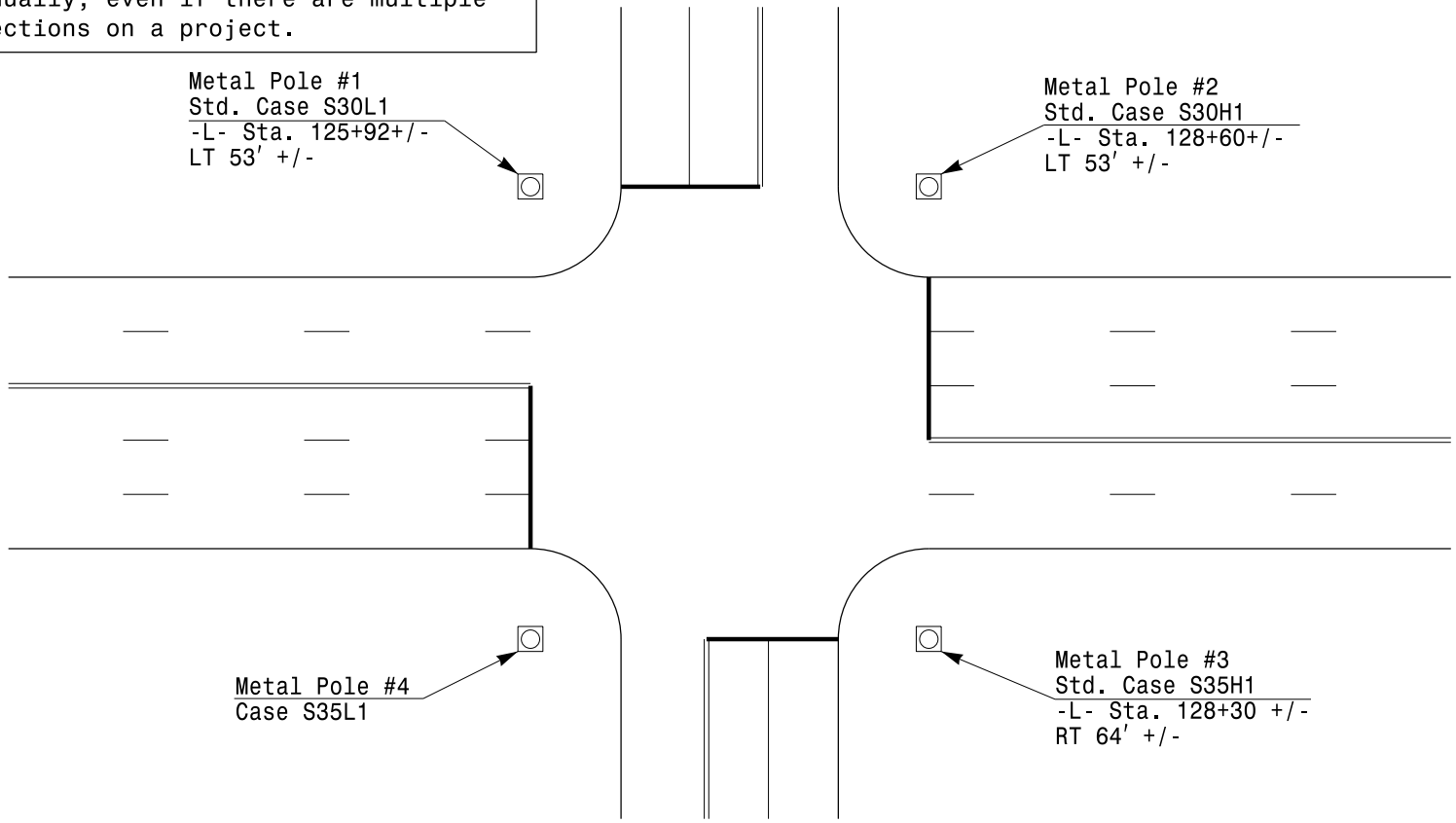
STD. NO.
10.1.3
SHEET 1 OF 1

Metal Pole Numbers and Locations

Number metal poles clockwise starting from the upper left quadrant of the signal plan. Signal pedestals do not need numbered.

Each intersection should be numbered individually, even if there are multiple intersections on a project.

Include the pole number and standard case number, if available, for all new or existing metal poles and metal poles with mastarms on signal plan.



Metal Pole Numbering and Labeling

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

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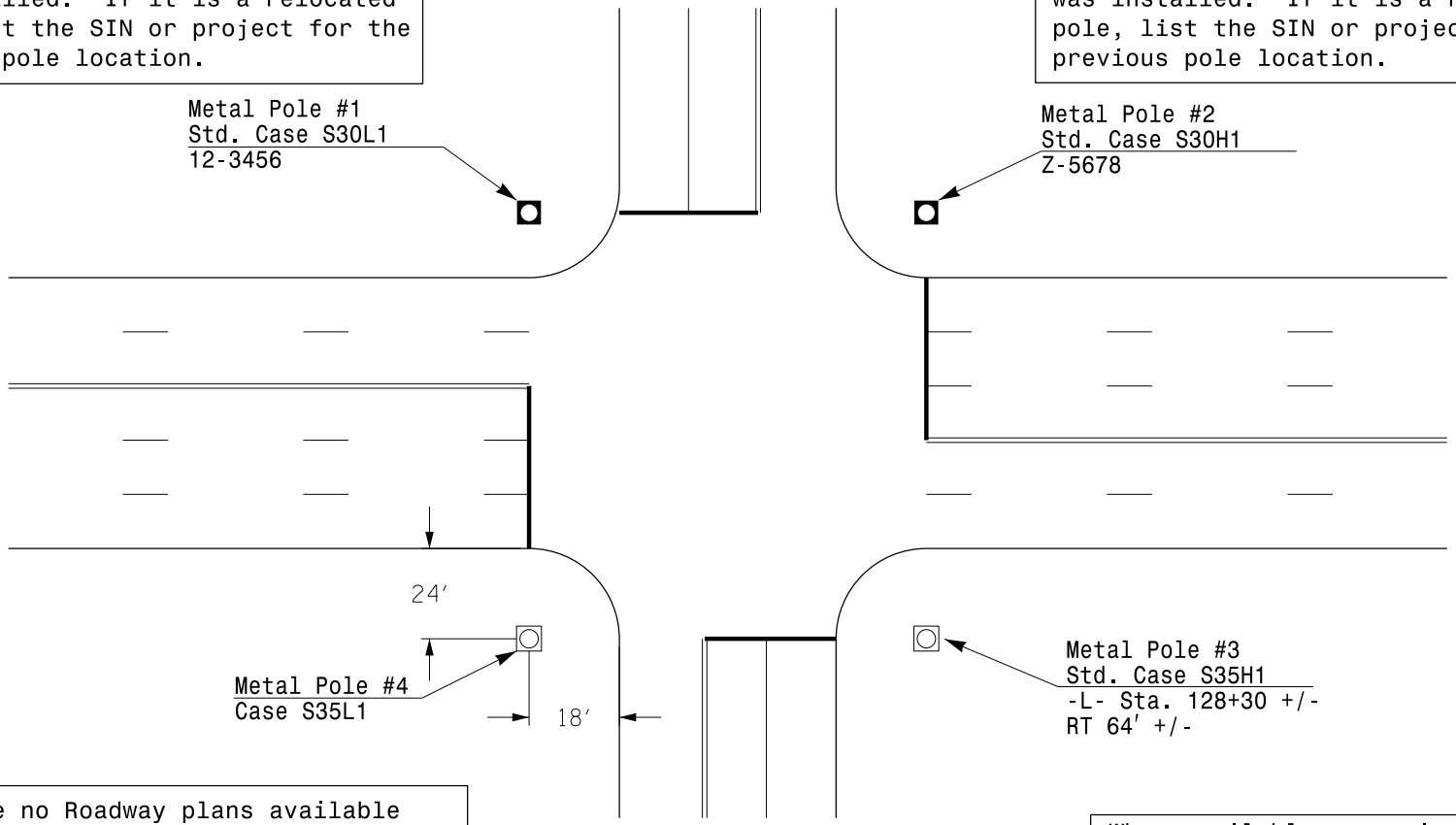
STD. NO.
10.2
SHEET 1 OF 3

Metal Pole Numbers and Locations

When known, include the metal pole number, standard case number (if applicable), and project that pole was installed. If it is a relocated pole, list the SIN or project for the previous pole location.

When known, include the metal pole number, standard case number (if applicable), and project that pole was installed. If it is a relocated pole, list the SIN or project for the previous pole location.



If there are no Roadway plans available for stations and offsets, in a plan Inset (preferably) dimension pole locations from edge of pavement, back of curb, or some other definitive reference point.

When available on projects, use Roadway plan station and offsets for pole locations. Round locations to the nearest foot.

Metal Pole Numbering and Labeling

SIGNAL DESIGN SECTION
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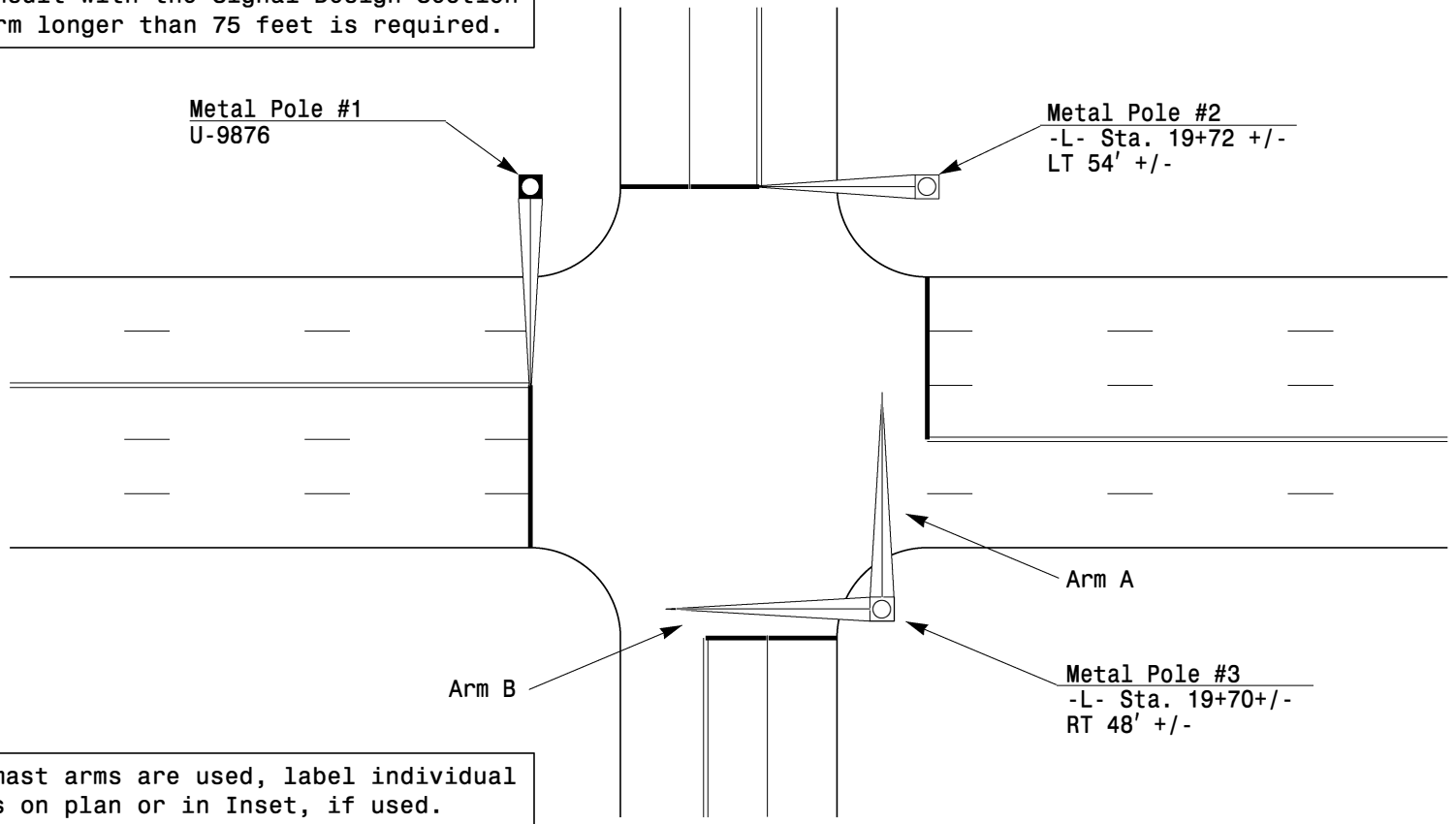
STD. NO.
10.2
SHEET 2 OF 3

Metal Pole with Mastarms

Mast arms should be a maximum of 75 feet in length. Consult with the Signal Design Section if a mast arm longer than 75 feet is required.



If Dual mast arms are used, label individual mast arms on plan or in Inset, if used. Arm A should be over the major street, and Arm B should be over the minor street. Do not show dimensions of mast arms on plans.

Metal Pole Numbering and Labeling

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
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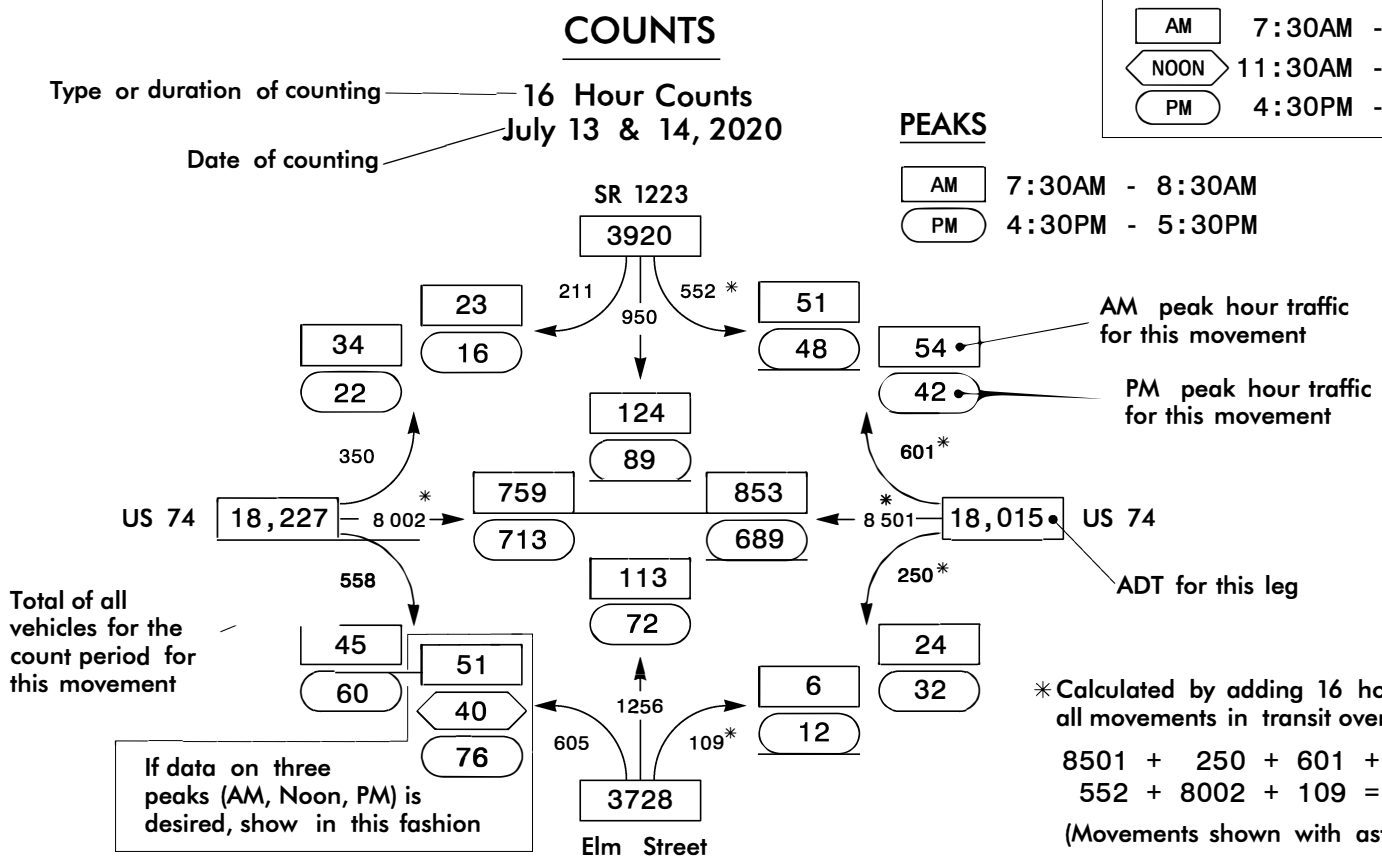
STD. NO.
10.2
SHEET 3 OF 3

Typical Count Diagram
Complete Traffic Counts

If a "Noon" (between 10:30AM and 2:30PM) peak occurs, show in this fashion:

PEAKS

AM	7:30AM - 8:30AM
NOON	11:30AM - 12:30PM
PM	4:30PM - 5:30PM



Traffic Counts

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

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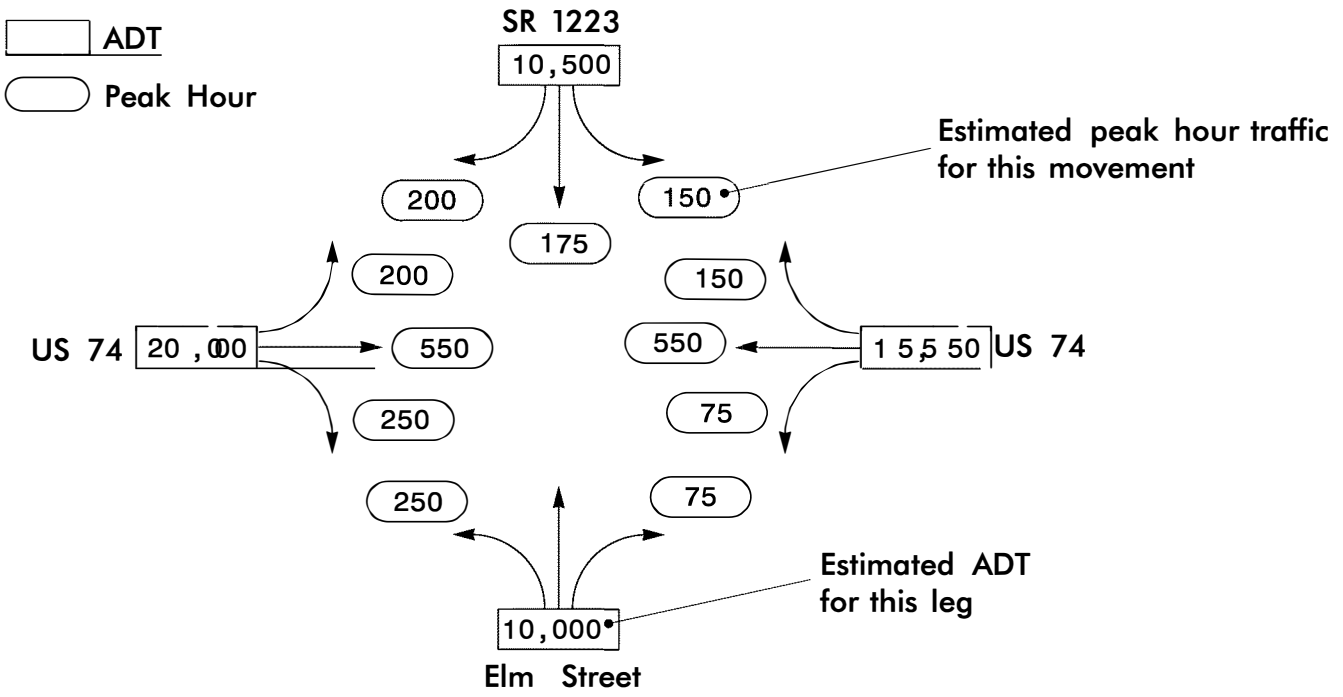
STD. NO.
11.0
SHEET 1 OF 3

Typical Count Diagram
Estimated Traffic Counts

Year 2050 Projected Volumes



Traffic Counts

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TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

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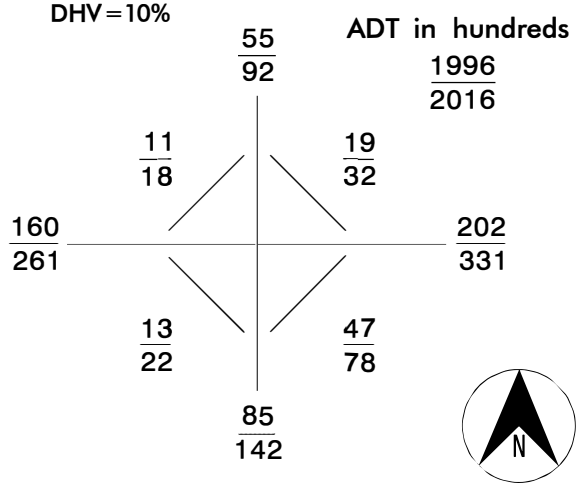
11.0

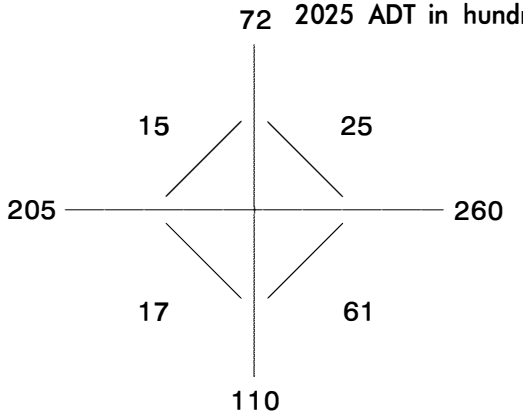
Conversion from Estimated ADT to Estimated DDHV – Example

GIVEN Project Letting Date = 2025
Design Year = Letting Date + 5 years = 2030
D = 60%
DHV = 10%



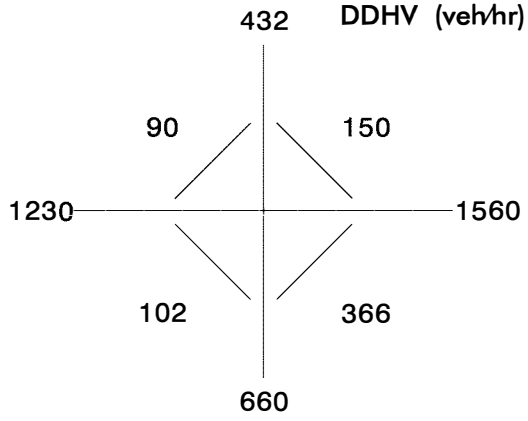
STEP 1 Interpolate to find 2025 ADT.

For the north leg, 55 + (92-55)(9/20) = 72



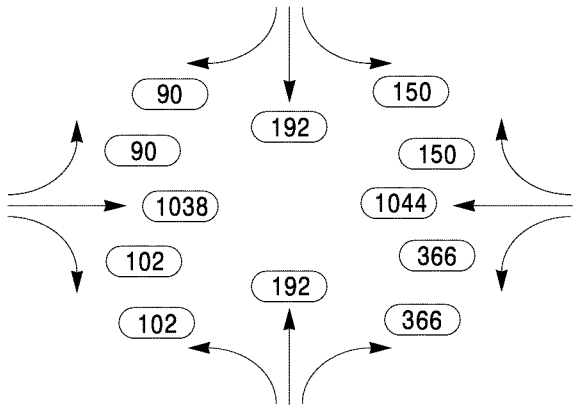
STEP 2 Convert to DDHV: (ADT)(DHV)(D) = DDHV.

For the north leg, (7200)(.10)(.60) = 432

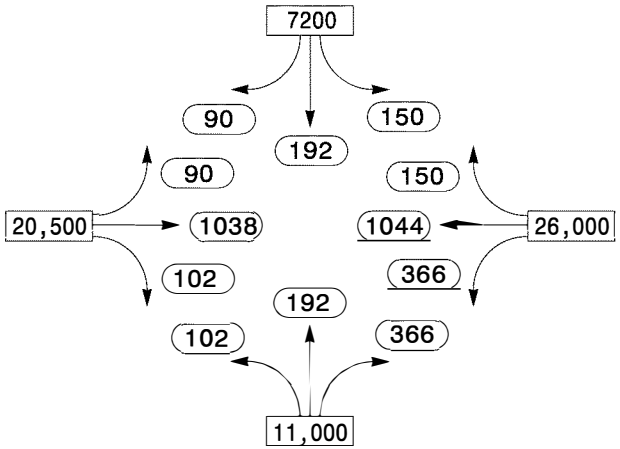


STEP 3 Determine through volumes by subtracting turning volume from total volume.

For the north leg, 432 - 90 - 150 = 192



STEP 4 Complete count diagram.



NOTES

-ADT = Average Daily Traffic

-DHV = Design Hour Volume

-DDHV = Directional Design Hour Volume

-D = Directional Split

-Use the highest directional split for each movement. Do not attempt to determine the direction of the peak flow for both the morning and afternoon peak hours.

-Because of the uncertainty of the data, a peak hour factor of 1.0 should be used when these peak hour volumes are used for analysis.

Traffic Counts

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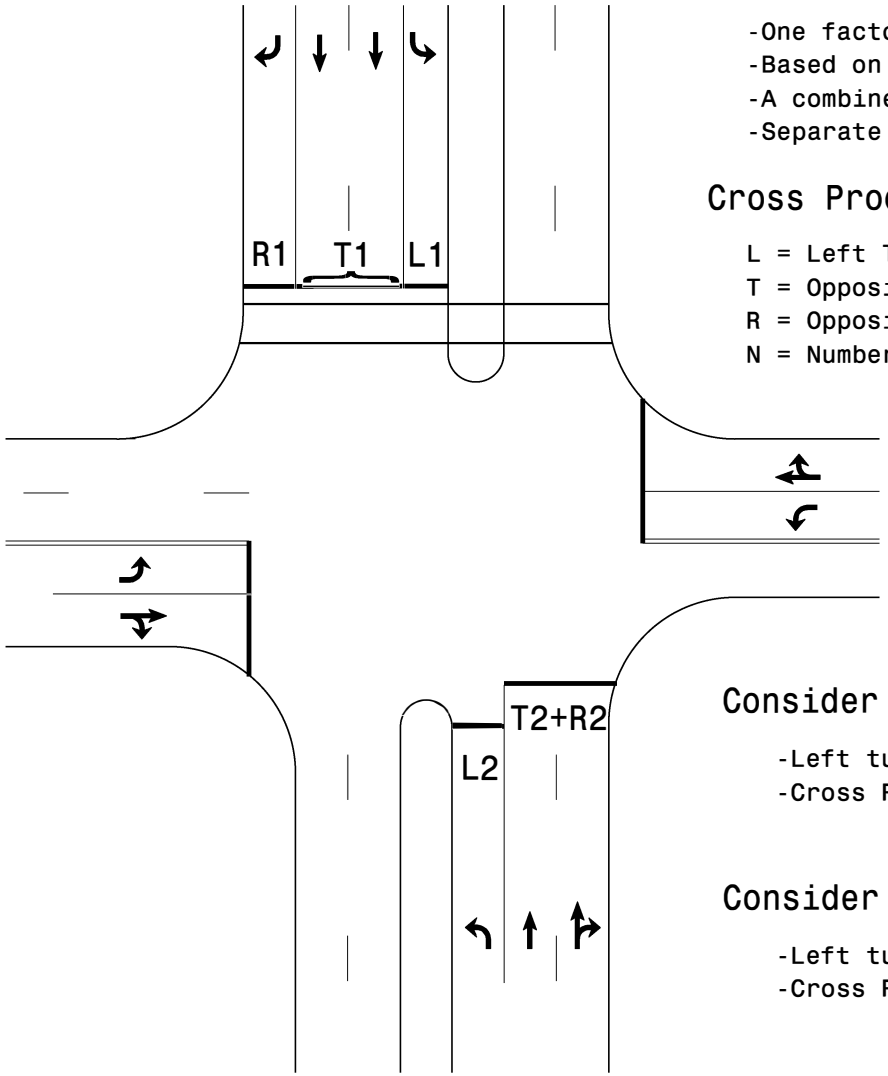
SHEET 3 OF 3

Cross Products



- One factor in determining left turn phasing treatment
- Based on Opposing Peak Hour Volumes per Lane
- A combined through and right movement is 1 lane
- Separate through and right lanes are 2 lanes

Cross Product = $L*(\frac{T+R}{N})$

L = Left Turn Volume (vph)
T = Opposing Through Volume (vph)
R = Opposing Right Turn Volume (vph)
N = Number of Opposing Through and Right Lanes

Northbound CP = L2 * ((T1 + R1)/3)
Southbound CP = L1 * ((T2 + R2)/2)

Consider Protected/Permissive Left Turn Phasing:

- Left turn volume > 125 vph
- Cross Product > 50,000 vph

Consider Protected Only Left Turn Phasing:

- Left turn volume > 125 vph
- Cross Product > 100,000 vph

Bus Transit Signals

Bus Transit Signals shall be used at intersections where it is desired to give transit vehicles priority movement by the display of separate signals heads. The priority movement given to a transit vehicle may be an exclusive phase movement or a movement concurrent with another nonconflicting vehicle phase.

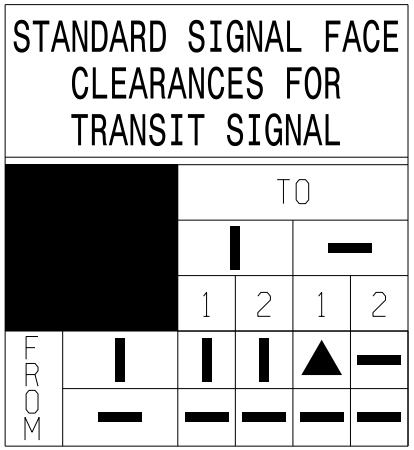
When used, the following guidelines should be used:

- At least two 3-section transit signal heads shall be displayed per approach where priority is desired.

- All transit signal displays shall be white in color:
  - Horizontal Bar = STOP
  - Solid Triangle = YELLOW CHANGE INTERVAL/PREPARE TO STOP
  - Vertical Bar = PROCEED

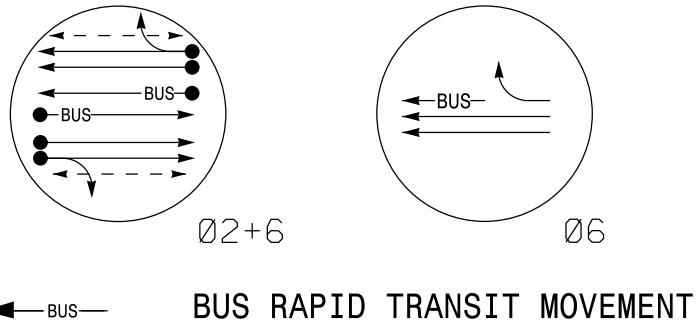
- A "Bus Signal" sign may be displayed adjacent to each transit signal head for clarity if the signal display is also visible to other traffic.

Standard Signal Face Clearance Chart



The Standard Signal Face Clearance For Transit Signals Chart (shown at left) should be included on every signal plan that uses bus transit signals. A chart showing the standard clearance display for traditional signal displays (Red, Yellow, and Green CIRCULAR and ARROWs, and Pedestrian displays) is included in the NCDOT Standard Drawings, however, that chart does not include displays for transit signals. The chart should be included on plans using bus transit signals until the NCDOT Roadway Standard Drawings is updated and the chart is modified to include the bus transit signal displays.

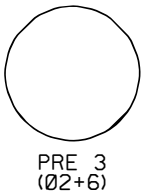
Phasing Diagram



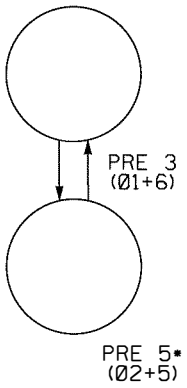
When exclusive transit lanes, movements, or phases are provided at an intersection, the movements need to be shown in the phasing diagram. For a bus (Bus Rapid Transit), the symbol is a solid line with an arrow and the word BUS in the solid line. This symbol should be used if the movement is an exclusive to the bus or the bus has an exclusive lane. It is not needed if the bus shares the same lanes and movements as regular traffic. The symbol should also be part of the Phasing Diagram Legend.

Emergency Vehicle Preemption (EVP) Phasing

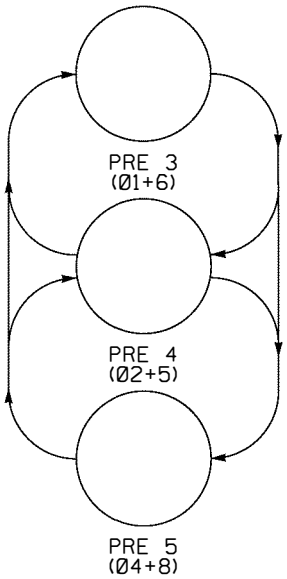
EV PREEMPT PHASES
(Medium Priority)



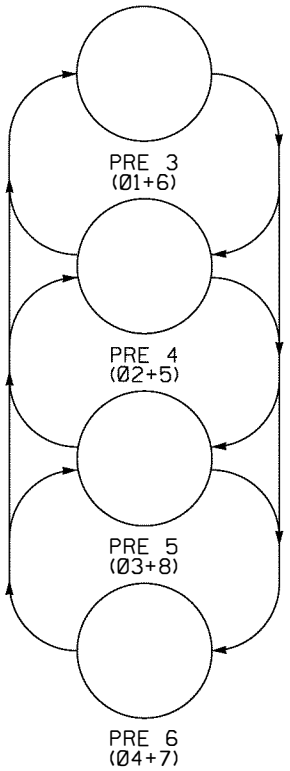
EV PREEMPT PHASES
(Medium Priority)



EV PREEMPT PHASES
(Medium Priority)



EV PREEMPT PHASES
(Medium Priority)



Phasing Design Considerations:

1) EV Preemption (EVP) is Medium Priority.
2) EVP Diagram is a separate diagram and should be independent of the main phasing diagram for normal (non-preempt) operation.
3) Pedestrian phases and movements are normally not active during EVP.
4) Right turn overlaps that operate with concurrent left turn phases during normal opeartion are omitted during EVP.
5) Alternate Phasing can impact the operation of signal heads during EVP. Alternate Preemption phasing programs may also be required.
6) If a preemption phase is intended for one direction only, it should incorporate backup protection and a GREEN ARROW for the left turn movement if appropriate.
7) Preemption phases should be labeled as "PRE #".
8) For pushbutton operation, use PRE 2.
9) For Optical and/or GPS type operation:
   For 1 preempt, use PRE 3.
   For 2 preempts, use PRE 3 and 5 (* For Cary Signal System, use PRE 3 and 4).
   For 3 preempts, use PRE 3, 4, and 5.
   For 4 preempts, use PRE 3, 4, 5, and 6.
10) Include corresponding regular phase numbers in the EVP phasing diagram.

2070 OASIS EV Preemption Chart (Part 1)

Used to designate this interval as the preemption Dwell interval. This interval will use Dwell Min. Time below and serve Dwell phase(s). Select 255 to indicate Dwell (HOLD) phase.

Clearance times for Dwell phase(s). Times entered here will override normal phase time if used. Only enter a time if the dwell phase is not a phase used in normal operation and is not in the Timing Chart. 0.0 is a default time and the controller will use corresponding phase times set for normal operation.

Amount of time signal is in exit phase before preemption ends. Select 0 for controller to return to next corresponding phase in normal operation after preemption. Select 1 to designate an exit phase and return controller to that phase for normal operation. If another time is entered, that is amount of time exit phase will be served before serving next phase in normal operation.

Clearance time not used when Interval 5 is exit interval. Enter 0.0.

Select Exit Phase(s) to be served after exiting EVP. Normally a concurrent through phase to the EVP movement. If EV Phase was on the main street, and proper signal heads for clearance exist, use 2+6. If EV Phase was on the minor street, and proper signal heads for clearance exist, use 4+8.

Select Priority of Preemption (OFF, LOW, MED, HIGH). This will determine the hierarchy of preempt phases served in the event there are simultaneous conflicting preempt calls. Most Emergency Vehicle Preempts are a Medium (MED) priority. In the event of conflicting preempt calls of the same priority, the lowest number preempt is served.

Delay between time Preempt call is received and Preempt sequence is activated. Usually 0 sec. for optical and GPS systems, but a delay (in seconds) may be used for pushbutton activated preemptions if desired.

OASIS 2070 EV PREEMPT				
FUNCTION	PRE 3	PRE 4	PRE 5	PRE 6
Interval 1 – Dwell Green	255	255	255	255
Interval 1 – Dwell Yellow	0.0*	0.0*	0.0*	0.0*
Interval 1 – Dwell Red	0.0*	0.0*	0.0*	0.0*
Interval 5 – Exit Green	1	1	1	1
Interval 5 – Yellow	0.0	0.0	0.0	0.0
Interval 5 – Red	0.0	0.0	0.0	0.0
Exit Phase(s)	2+6	2+6	4+8	4+8
Priority	MED	MED	MED	MED
Delay Time	0.0	0.0	0.0	0.0
Min Green Before Pre	1	1	1	1
Ped Clear Before Pre	0*	0*	0*	0*
Yellow Clear Before Pre	0.0*	0.0*	0.0*	0.0*
Red Clear Before Pre	0.0*	0.0*	0.0*	0.0*
Dwell Min Time	7	7	7	7
Dwell Max Time (min)	2	2	2	2
Enable Backup Protection	Y/N	Y/N	Y/N	Y/N
Ped Clear Through Yellow	Y	Y	Y	Y
Preempt Extend**	2	2	2	2

* Time defaults to time used for phase during normal operation
** Program Timing on Optical Detection Unit

Notes:
Unused phase columns should be removed from the chart.

Emergency Vehicle Preemption Timing Chart

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.
13.0.2
SHEET 1 OF 6

2070 OASIS EV Preemption Chart (Part 2)

Minimum green time assured for current normal phase in operation before transition into preempt sequence. Usually 1 sec., so as to begin preemption sequence immediately (if a Delay is desired, enter that in the Delay time) Entering 0 sec. will default to normal minimum green time for phase, which should be avoided.

Time provided to display Flashing "DON'T WALK" for pedestrians to clear intersection before beginning preemption sequence. Enter 0, which will use default (normal) time for phase if ped is used. Ped clearance may not be shortened when entering EVP.

Clearance times provided to clear current phase before transitioning into preemption. Using 0.0 sec. for each will allow controller to use times set in normal operation.

Minimum time preemption dwell phase will run. Optical and GPS systems typically use the same time as the phase in normal operation, but then preempt phase can be extended as needed; usually 7 seconds. Minimum time for pushbutton locations needs to be based on trial runs (typically by the Division).

Maximum time (in minutes) preemption dwell phase(s) will be serviced. After this time is reached, the preemption sequence will terminate and proceed to the exit phase(s). Usually 2 minutes or 120 seconds.

Select Y (YES) to clear to all red before going into preemption to prevent yellow trap. Select N (NO) if Flashing YELLOW ARROWs are present and/or there is no potential for a yellow trap when clearing into preempt phase. Yellow traps entering EVP should be avoided. This setting overrides programming for normal operation.

Y (Yes) will time the "Ped Clear Before Pre" and "Yellow Clear Before Pre" simultaneously, thereby reducing overall clearance time needed before preemption. Select N (No) to time "Ped Clear Before Pre" then full yellow clear and red clear before going into preempt. Usually select Y.

Time to extend preempt dwell phase after call is dropped (usually 2 sec.). Typically used for Optical and GPS systems.

OASIS 2070 EV PREEMPT

FUNCTION	PRE 3	PRE 4	PRE 5	PRE 6
Interval 1 – Dwell Green	255	255	255	255
Interval 1 – Dwell Yellow	0.0*	0.0*	0.0*	0.0*
Interval 1 – Dwell Red	0.0*	0.0*	0.0*	0.0*
Interval 5 – Exit Green	1	1	1	1
Interval 5 – Yellow	0.0	0.0	0.0	0.0
Interval 5 – Red	0.0	0.0	0.0	0.0
Exit Phase(s)	2+6	2+6	4+8	4+8
Priority	MED	MED	MED	MED
Delay Time	0.0	0.0	0.0	0.0
Min Green Before Pre	1	1	1	1
Ped Clear Before Pre	0*	0*	0*	0*
Yellow Clear Before Pre	0.0*	0.0*	0.0*	0.0*
Red Clear Before Pre	0.0*	0.0*	0.0*	0.0*
Dwell Min Time	7	7	7	7
Dwell Max Time (min)	2	2	2	2
Enable Backup Protection	Y/N	Y/N	Y/N	Y/N
Ped Clear Through Yellow	Y	Y	Y	Y
Preempt Extend**	2	2	2	2

* Time defaults to time used for phase during normal operation
** Program Timing on Optical Detection Unit

Notes:
Unused phase columns should be removed from the chart.

Emergency Vehicle Preemption Timing Chart

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
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STD. NO.
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ASC/3 170 Cabinet EV Preemption Chart

See Sheet 1, Exit Phase

Similar to Priority, this establishes a hierarchy of preempt phases served in the event there are conflicting preempt calls simultaneously. Normally OFF for EV Preempt. In the event of conflicting calls, the lowest number preempt has priority and is served first.

See Sheet 1, Delay Time

See Sheet 2, Ped Clear Thru Yellow

See Sheet 1, Enable Backup Protection
Select Y to clear to all red to avoid yellow trap or N if there is no potential yellow trap. This setting overrides programming for normal operation.

Similar to Min Green Before Pre, this is the Min Walk time displayed before preempt. Usually set to 1 second when ped phases are present at an intersection.

See Sheet 2, Ped Clear Before Pre
255 is a default time and the controller will use the corresponding phase times set for normal operation.

See Sheet 2, Min Green Before Pre

See Sheet 2, Yellow Clear Before Pre and Red Clear Before Pre. 25.5 is the default time and the controller will use corresponding phase times set for normal operation.

See Sheet 2, Min Dwell Time

See Sheet 2, Preempt Extend

See Sheet 2, Dwell Max Time (in seconds)

See Sheet 1, Dwell Yellow and Dwell Red
25.5 is a default time and the controller will use the corresponding phase times set for normal operation.

ASC/3 EV PREEMPT

FUNCTION	PRE 3	PRE 4	PRE 5	PRE 6
Exit Phase(s)	2+6	2+6	4+8	4+8
Preempt Override	OFF	OFF	OFF	OFF
Delay Time	0	0	0	0
Ped Clear Through Yellow	Y	Y	Y	Y
Terminate Phases	Y/N	Y/N	Y/N	Y/N
Entrance Walk	1	1	1	1
Entrance Ped Clear	255*	255*	255*	255*
Entrance Min Green	1	1	1	1
Entrance Yellow Change	25.5*	25.5*	25.5*	25.5*
Entrance Red Clear	25.5*	25.5*	25.5*	25.5*
Minimum Dwell Time	7	7	7	7
Preempt Input Extension Time **	2	2	2	2
Preempt Max Time	120	120	120	120
Exit Yellow Change	25.5*	25.5*	25.5*	25.5*
Exit Red Clear	25.5*	25.5*	25.5*	25.5*

* Allows normal phase times to be used.
** Program Timing on Optical Detection Unit

Notes:
Unused phase columns should be removed from the chart.

Emergency Vehicle Preemption Timing Chart

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TRANSPORTATION MOBILITY AND SAFETY DIVISION
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13.0.2

ASC/3 NEMA Cabinet EV Preemption Chart

See Sheet 1, Delay Time

Similar to Priority, this establishes a hierarchy of preempt phases served in the event there are conflicting preempt calls simultaneously. Normally OFF for EV Preempt. In the event of conflicting calls, the lowest number preempt has priority and is served first.

See Sheet 2, Ped Clear Thru Yellow

See Sheet 1, Enable Backup Protection
Select Y to clear to all red to avoid yellow trap or N if there is no potential yellow trap.

Similar to Min Green Before Pre, this is the Min Walk time displayed before preempt. Usually set to 1 second when ped phases are present at an intersection.

See Sheet 2, Ped Clear Before Pre
255 is a default time and the controller will use the corresponding phase times set for normal operation.

See Sheet 2, Min Green Before Pre

See Sheet 2, Yellow Clear Before Pre and Red Clear Before Pre. 25.5 is the default time and the controller will use corresponding phase times set for normal operation.

See Sheet 2, Min Dwell Time

See Sheet 2, Dwell Max Time (in seconds)

See Sheet 1, Exit Phase

See Sheet 1, Dwell Yellow and Dwell Red
25.5 is a default time and the controller will use the corresponding phase times set for normal operation.

See Sheet 2, Preempt Extend

EMERGENCY VEHICLE PREEMPTION

FUNCTION	PRE 3	PRE 4
DELAY BEFORE PREEMPT	0	0
PMT OVERRIDE	OFF	OFF
PED CLEAR THROUGH YELLOW	Y	Y
TERMINATE PHASES	Y/N	Y/N
ENTRANCE WALK	1	1
ENTRANCE PED CLEAR	255 *	255 *
ENTRANCE MIN GREEN	1	1
ENTRANCE YELLOW CLEAR	25.5*	25.5*
ENTRANCE RED CLEAR	25.5*	25.5*
MIN DWELL GREEN	7	7
MAX CALL TIME	120	120
EXIT PHASE(S)	2+6	2+6
EXIT YELLOW CLEAR	25.5*	25.5*
EXIT RED CLEAR	25.5*	25.5*
PREMPT EXTEND **	2	2

* Time defaults to time used for phase during normal operation.
** Program Timing on Optical Detection Unit

Notes:
Additional columns may be added to the chart as needed.
Unused phase columns should be removed from the chart.

Emergency Vehicle Preemption Timing Chart

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SE–PAC EV Preemption Chart

See Sheet 2, Min Green Before Pre and Min Walk time displayed before entering preempt. Usually set to 1 second.

See Sheet 1, Exit Phase

See Sheet 1, Delay Time

See Sheet 2, Dwell Max Time (in seconds)

See Sheet 2, Ped Clear Before Pre
Ped Clear Time can overlap with the Yellow Clear Before Pre, but this overlap is not an adjustable setting and must also be set for normal operation. When entering EVP, use the highest required FDW time of all ped phases used in normal operation. A default time cannot be entered for SE-PAC.

See Sheet 2, Yellow Clear Before Pre and Red Clear Before Pre. 0 (Zero) is the default time and the controller will use corresponding phase times set for normal operation. Times are entered as whole numbers which will be divided by 10 (40 = 4.0 seconds).

These entries are only used for Railroad Preemption, or if there is a multi-phase EV Preemption sequence. Usually 0 (Zero).

See Sheet 2, Min Dwell Time

Return Pedestrian Clean - Time to Clear a pedestrian (FDW) during a preempt Dwell phase. Usually 0 since pedestrian phases are normally not active during preemption phases.

See Sheet 1, Dwell Yellow and Dwell Red
0 (Zero) is a default time and the controller will use the corresponding phase times set for normal operation. Times are entered as whole numbers which will be divided by 10 (40 = 4.0 seconds).

SE-PAC Preemption

FUNCTION	PRE 3	PRE 4	PRE 5	PRE 6
MIN GRN / WLK	1	1	1	1
EXIT PHASES	2+6	2+6	4+8	4+8
DELAY	0	0	0	0
MXCALL	120	120	120	120
SEL PED CLR	22	22	22	22
SEL YEL / 10	0*	0*	0*	0*
SEL RED / 10	0*	0*	0*	0*
TRACK GREEN	0	0	0	0
TRK PED CLR	0	0	0	0
TRK YEL / 10	0	0	0	0
TRK RED / 10	0	0	0	0
DWELL GRN	7	7	7	7
RET PED CLR	0	0	0	0
RET YEL / 10	0*	0*	0*	0*
RET RED / 10	0*	0*	0*	0*

* Time defaults to time used for phase during normal operation.

Notes:
Unused phase columns should be removed from the chart.

Emergency Vehicle Preemption Timing Chart

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Trafficware Apogee EV Preemption Chart

See Sheet 1, Delay Time

Minimum duration that a preempt call is active. Begins at the end of any delay period and prevents an exit until mimimum time (in seconds) has elapsed.

See Sheet 2, Min Green Before Pre

See Sheet 3, Entrance Walk

See Sheet 2, Ped Clear Before Pre

See Sheet 2, Min Dwell Time

Time to Clear a pedestrian (FDW) during a preempt Dwell phase. Usually 0 since pedestrian phases are normally not active during preemption phases.

See Sheet 1, Dwell Yellow and Dwell Red Times entered here will override normal phase time if used. Only enter a time if the dwell phase is not a phase used in normal operation and is not in the Timing Chart. 25.5 is a default time and the controller will use the corresponding phase times set for normal operation.

See Sheet 2, Yellow Clear Before Pre and Red Clear Before Pre. 25.5 is the default time and the controller will use corresponding phase times set for normal operation.

See Sheet 1, Enable Backup Protection Select ON to clear to all red to avoid yellow trap or OFF if there is no potential yellow trap.

Ensures that Delay, Min Dwell, and Min Duration are served even if preempt call is removed before actual preempt sequence begins. Usually ON.

Similar to Priority, this establishes a hierarchy of preempt phases served in the event there are conflicting preempt calls simultaneously. Normally OFF for EV Preempt. Conflicting calls of the same priority are served in the order the call was received.

See Sheet 1, Exit Phase

EMERGENCY VEHICLE PREEMPTION

FUNCTION	PRE 3	PRE 5
DELAY BEFORE PREEMPT	0	0
MINIMUM DURATION	16	16
MIN GREEN BEFORE PREEMPT	1	1
MIN WALK BEFORE PREEMPT	1	1
PED CLEAR BEFORE PREEMPT	255*	255*
MINIMUM DWELL	7	7
EXIT PED CLEAR	0	0
EXIT YELLOW CHANGE	25.5*	25.5*
EXIT RED CLEAR	25.5*	25.5*
ENTER YELLOW CHANGE	25.5*	25.5*
ENTER RED CLEAR	25.5*	25.5*
ALL-RED B4 PREEMPT	OFF	OFF
LOCK INPUT	ON	ON
OVERRIDE HIGHER # PREEMPT	OFF	OFF
EXIT PREEMPT TO	Ø2+6	Ø2+6

* Time defaults to time used for phase during normal operation.

Notes:
Additional columns may be added to the chart as needed.
Unused phase columns should be removed from the chart.

Emergency Vehicle Preemption Timing Chart

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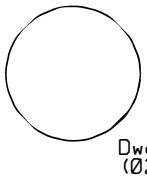
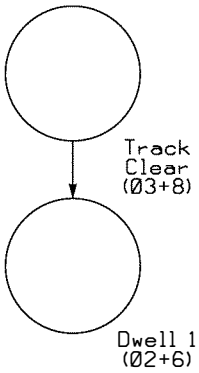
Railroad Preemption Phasing

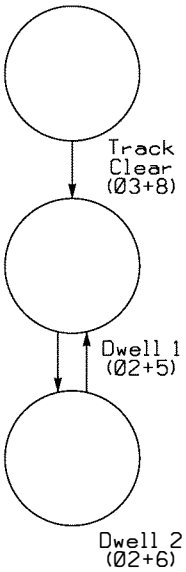
RAIL PREEMPT PHASES
(High Priority)



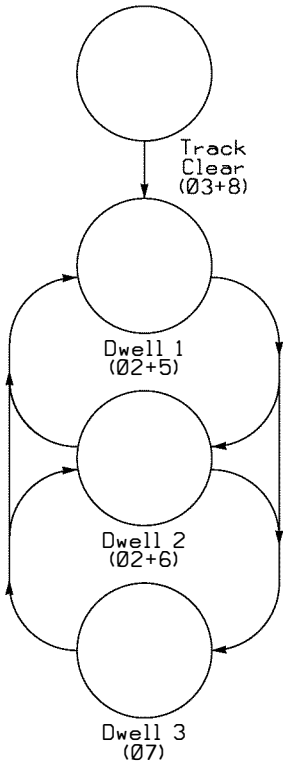
RAIL PREEMPT PHASES
(High Priority)



RAIL PREEMPT PHASES
(High Priority)



RAIL PREEMPT PHASES
(High Priority)



Phasing Design Considerations:

1) Railroad Preemption is High Priority.
2) Railroad Preemption Diagram is a separate diagram and should be independent of the main phasing diagram for normal (non-preempt) operation.
3) Pedestrian phases and movements are normally not active during Railroad Preemption.
4) Right turn overlap that may operate with concurrent left turn phase during normal opeartion is omitted during the Track Clearance Phase.
5) Alternate Phasing can impact the operation of signal heads during Railroad Preemption. Alternate Preemption phasing programs may also be required.
6) Railroad Preemption should be PRE 1.
7) A GREEN ARROW should be used for the left turn movement with the Track Clearance phase.
8) Backup protection is not required when entering Railroad Preemption. Yellow traps are allowed, however, signs (W25-1 or W25-2) and/or Flashing YELLOW ARROW displays should be used to minimize potential yellow traps as much as practical.
9) Include corresponding regular phase numbers in the Railroad Preemption phasing diagram.
10) Following the Track Clear phase, all Dwell phases will be served once regardless of demand, based on normal phasing order, unless the preemption call is terminated. If the preemption call continues, the Dwell phases will be served based on vehicle demand.
11) Depending on the individual characteristics of the intersection and railroad crossing, it may be necessary to have multiple track clearance phases or only a dwell phase during Railroad Preemption.

2070 OASIS Railroad Preemption Chart (Part 1)

Based on Greenshield's Formula, see STD. 13.1.5, Sheet 1. Typical minimum is 10 seconds. Time may be adjusted based on if Simultaneous or Advanced Preemption is used.

Times for Track Clearance Phase based on STD. 5.2.2. Should be the same times as if the phase(s) were used in normal operation.

Designates this interval as the preemption Dwell interval. This interval will use Dwell Min. Time below and serve Dwell phase(s). Select 255 to indicate Dwell (HOLD) phase.

Clearance times for Dwell phase(s). Times entered here will override normal phase time if used. Only enter a time if the Dwell phase is not a phase used in normal operation and is not in the Timing Chart. 0.0 is a default time and the controller will use corresponding phase times set for normal operation.

Amount of time signal is in Exit phase before preemption ends. Select 0 for controller to return to next corresponding phase in normal operation after preemption. Select 1 to designate an Exit phase and return controller to that phase for normal operation. If another time is entered, that is amount of time designated Exit phase will be served before serving next phase in normal operation.

Clearance time not used when Interval 5 is Exit interval. Enter 0.0.

Select Exit Phase(s) to be served after exiting Railroad Preemption. Normally it is a phase whose movement was blocked by the train. It may be a left turn phase or a through phase.

Select Priority of Preemption (OFF, LOW, MED, HIGH). This will determine the hierarchy of preempt phases served in the event there are conflicting preempt calls simultaneously. Railroad Preemption is a High (HIGH) priority.

Delay between time Preempt call is received and Preempt sequence is activated. Usually 0 sec. for Railroad Preempt.

OASIS 2070 RR PREEMPT	
FUNCTION	PRE 1
Interval 1 – Track Clearance Green	16
Interval 1 – Track Clearance Yellow	4.2
Interval 1 – Track Clearance Red	1.3
Interval 2 – Dwell Green	255
Interval 2 – Dwell Yellow	0.0*
Interval 2 – Dwell Red	0.0*
Interval 5 – Exit Green	1
Interval 5 – Yellow	0.0
Interval 5 – Red	0.0
Exit Phase(s)	4+8
Priority	HIGH
Delay Time	0.0
Min Green Before Pre	1
Ped Clear Before Pre	5
Yellow Clear Before Pre	4.9
Red Clear Before Pre	2.4
Dwell Min Time	10
Enable Backup Protection	N
Ped Clear Through Yellow	Y
Omit Overlaps	P

* Time defaults to time used for phase during normal operation

This signal was designed for simultaneous preemption.

Railroad Preemption Timing Chart

SIGNAL DESIGN SECTION
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2070 OASIS Railroad Preemption Chart (Part 2)

Minimum green time assured for current phase before transition into preempt phase. Usually 1 second. (Using 0 sec. will default to normal minimum green time).

Time provided to display Flashing "DON'T WALK" for pedestrians to clear intersection before beginning Railroad Preemption sequence. Due to variability of having to clear actuated pedestrian phases, this time is normally set to the rounded up integer of the Yellow Clear Before Pre time, as these times will overlap and clear simultaneously (4.1-4.9 => 5), etc.

Clearance times provided to clear current phase before transition into preemption. To ensure consistent signal operation with railroad warning devices, enter the highest Yellow Clear and Red Clear times among normal phases that are not Track Clearance phases. The Yellow Clear and Red Clear times may be from separate phases. These times also represent the time required to clear Overlap P prior to entering preemption.

Minimum Green Time for Dwell (hold) phase. Typically, same as time used for phase when in normal operation.

Select "N" (No) for Railroad Preemption. This will allow the signal to the track clearance phase immediately, including displaying a Yellow Trap if the potential exists. If the potential for a yellow trap exists, signs or alternative signal displays should be considered to reduce potential impacts.

Select "Y" (Yes) if any pedestrian phases exist at the signal, which will time the "Ped Clear Before Pre" (FDW) and "Yellow Clear Before Pre" simultaneously, thereby reducing overall clearance time needed before preemption. Select "N" only if there are no pedestrian phases at the signal.

List any overlaps that operate during normal operation that should not operate during Railroad Preemption. This also includes overlap P, which is a background timer during all normal phases and must clear prior to entering preemption.

Show if signal preemption timing is designed for Advance or Simultaneous Preemption to work with railroad equipment.

OASIS 2070 RR PREEMPT	
FUNCTION	PRE 1
Interval 1 – Track Clearance Green	16
Interval 1 – Track Clearance Yellow	4.2
Interval 1 – Track Clearance Red	1.3
Interval 2 – Dwell Green	255
Interval 2 – Dwell Yellow	0.0*
Interval 2 – Dwell Red	0.0*
Interval 5 – Exit Green	1
Interval 5 – Yellow	0.0
Interval 5 – Red	0.0
Exit Phase(s)	4+8
Priority	HIGH
Delay Time	0.0
Min Green Before Pre	1
Ped Clear Before Pre	5
Yellow Clear Before Pre	4.9
Red Clear Before Pre	2.4
Dwell Min Time	10
Enable Backup Protection	N
Ped Clear Through Yellow	Y
Omit Overlaps	P

* Time defaults to time used for phase during normal operation

This signal was designed for advanced preemption.

Railroad Preemption Timing Chart

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.
13.1.2

ASC/3 170 Cabinet Railroad Preemption Chart

See Sheet 1, Exit Phase

Similar to Priority, this establishes a hierarchy of preempt phases served in the event there are conflicting preempt calls simultaneously. Usually ON for Railroad Preemption to indicate the highest priority. The lowest number preempt has priority in ASC/3.

See Sheet 1, Delay Time

See Sheet 2, Ped Clear Thru Yellow

See Sheet 2, Enable Backup Protection

Select Y (Yes). Allows preemptor to reservice the track clearance phase if the preempt call goes way and returns before the preemption sequence terminates.

Similar to Min Green Before Pre, this is the Min Walk time displayed before preempt. Usually set to 1 second when ped phases are present at an intersection.

See Sheet 2, Ped Clear Before Pre

See Sheet 2, Min Green Before Pre

See Sheet 2, Yellow Clear Before Pre and Red Clear Before Pre.

See Sheet 1, Track Clearance Green

See Sheet 1, Track Clearance Yellow and Track Clearance Red. Default times are 25.5.

See Sheet 2, Min Dwell Time

See Sheet 2, Dwell Yellow and Dwell Red. Default times are 25.5.

See Sheet 2, Advance or Simultaneous Preemption

ASC/3 RR PREEMPT

FUNCTION	PRE 1
Exit Phase(s)	4+8
Preempt Override	ON
Delay Time	0
Ped Clear Trough Yellow	Y
Terminate Phases	N
Track Clear Reservice	Y
Entrance Walk	1
Entrance Ped Clear	5
Entrance Min Green	1
Entrance Yellow Change	4.9
Entrance Red Clear	2.4
Track Clear Min Green	16
Track Clear Yellow Change	4.2
Track Clear Red Clear	1.3
Min Dwell Time	10
Exit Yellow Change	25.5*
Exit Red Clear	25.5*

* Allows normal phase times to be used.

This signal was designed for advanced preemption.

Railroad Preemption Timing Chart

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
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STD. NO.
13.1.2

ASC/3 NEMA Cabinet Railroad Preemption Chart

See Sheet 1, Delay Time

Similar to Priority, this establishes a hierarchy of preempt phases served in the event there are conflicting preempt calls simultaneously. Usually ON for Railroad Preemption to indicate the highest priority. The lowest number preempt has priority in ASC/3.

See Sheet 2, Ped Clear Thru Yellow

See Sheet 2, Enable Backup Protection

Select Y (Yes). Allows preemptor to reservice the track clearance phase if the preempt call goes way and returns before the preemption sequence terminates.

Similar to Min Green Before Pre, this is the Min Walk time displayed before preempt. Usually set to 1 second when ped phases are present at an intersection.

See Sheet 2, Ped Clear Before Pre

See Sheet 2, Min Green Before Pre

See Sheet 2, Yellow Clear Before Pre and Red Clear Before Pre.

See Sheet 1, Track Clearance Green

See Sheet 1, Track Clearance Yellow and Track Clearance Red. Default times are 25.5.

See Sheet 2, Min Dwell Time

See Sheet 1, Exit Phase

See Sheet 2, Dwell Yellow and Dwell Red. Default times are 25.5.

See Sheet 2, Advance or Simultaneous Preemption

RAILROAD PREEMPTION

FUNCTION	SECONDS
DELAY BEFORE PREEMPT	0
PMT OVERRIDE	ON
PED CLEAR THROUGH YELLOW	Y
TERMINATE PHASES	N
TRACK CLEAR RESERVICE	Y
ENTRANCE WALK	1
ENTRANCE PED CLEAR	5
ENTRANCE MIN GREEN	1
ENTRANCE YELLOW CLEAR	4.9
ENTRANCE RED CLEAR	2.4
TRACK CLEAR MIN GREEN	16
TRACK CLEAR YELLOW CLEAR	4.2
TRACK CLEAR RED CLEAR	1.3
MIN DWELL GREEN	10
EXIT PHASE(S)	4+8
EXIT YELLOW CLEAR	25.5*
EXIT RED CLEAR	25.5*

* Time defaults to time used for phase during normal operation.

This signal was designed for advanced preemption.

Railroad Preemption Timing Chart

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO. 13.1.2

SE–PAC Railroad Preemption Chart

See Sheet 2, Min Green Before Pre and Min Walk time displayed before entering preempt. Usually set to 1 second.

See Sheet 1, Exit Phase

See Sheet 1, Delay Time

Set to 0 for Railroad Preemption. Railroad Preemption call will operate for as long as necessary.

See Sheet 2, Ped Clear Before Pre. Ped Clear Time can overlap with the Yellow Clear Before Pre, but this overlap is not an adjustable setting and must also be set for normal operation.

See Sheet 2, Yellow Clear Before Pre and Red Clear Before Pre. 0 (Zero) is the default time and the controller will use corresponding phase times set for normal operation. Times are entered as whole numbers which will be divided by 10 (40 = 4.0 seconds)

See Sheet 1, Track Clearance Green

Usually 0. Pedestrian WALK phases are not active during Track Clear Green.

See Sheet 1, Track Clearance Yellow and Track Clearance Red. 0 (Zero) is a Default times. Times are entered as whole numbers which will be divided by 10 (40 = 4.0 seconds).

See Sheet 2, Min Dwell Time

Return Pedestrian Clean - Time to Clear a pedestrian (FDW) during a preempt Dwell phase. Usually 0 since pedestrian phases are normally not active during preemption phases.

See Sheet 1, Dwell Yellow and Dwell Red. 0 (Zero) is a default time and the controller will use the corresponding phase times set for normal operation. Times are entered as whole numbers which will be divided by 10 (40 = 4.0 seconds).

See Sheet 2, Advance or Simultaneous Preemption

SE-PAC Preemption

FUNCTION	PRE 1
MIN GRN / WLK	1
EXIT PHASES	2+6
DELAY	0
MXCALL	0
SEL PED CLR	5
SEL YEL / 10	49
SEL RED / 10	24
TRACK GREEN	16
TRK PED CLR	0
TRK YEL / 10	42
TRK RED / 10	13
DWELL GRN	7
RET PED CLR	0
RET YEL / 10	0*
RET RED / 10	0*

* Time defaults to time used for phase during normal operation.

This signal was designed for advanced preemption.

Railroad Preemption Timing Chart

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.
13.1.2

Trafficware Apogee Railroad Preemption Chart

See Sheet 1, Delay Time

Minimum duration that a preempt call is active. Begins at the end of any delay period and prevents an exit until mimimum time (in seconds) has elapsed.

See Sheet 2, Min Green Before Pre

See Sheet 3, Entrance Walk

See Sheet 2, Ped Clear Before Pre

See Sheet 1, Track Clearance Green

See Sheet 2, Min Dwell Time

Time to Clear a pedestrian (FDW) during a preempt Dwell phase. Usually 0 since pedestrian phases are normally not active during preemption phases.

See Sheet 1, Dwell Yellow and Dwell Red. 25.5 is the default to use normal phase timing.

See Sheet 2, Yellow Clear Before Pre and Red Clear Before Pre. 25.5 is the default to use normal phase timing.

See Sheet 1, Track Clearance Yellow and Track Clearance Red. 25.5 is the default to use normal phase timing.

See Sheet 1, Enable Backup Protection Select OFF for Railroad Preempiton, even if there is potential for a yellow trap when entering preemption.

Ensures that Delay, Min Dwell, and Min Duration are served even if preempt call is removed before actual preempt sequence begins. Usually ON.

Similar to Priority, this establishes a hierarchy of preempt phases served in the event there are conflicting preempt calls simultaneously. Normally ON for Railroad Preemption.

See Sheet 1, Exit Phase

See Sheet 2, Advance or Simultaneous Preemption

RAILROAD PREEMPTION	
FUNCTION	PRE 1
DELAY BEFORE PREEMPT	0
MINIMUM DURATION	20
MIN GREEN BEFORE PREEMPT	1
MIN WALK BEFORE PREEMPT	1
PED CLEAR BEFORE PREEMPT	5
TRACK GREEN	16
MINIMUM DWELL	10
EXIT PED CLEAR	0
EXIT YELLOW CHANGE	25.5*
EXIT RED CLEAR	25.5*
ENTER YELLOW CHANGE	4.9
ENTER RED CLEAR	2.4
TRACK YELLOW CHANGE	4.2
TRACK RED CLEAR	1.3
ALL-RED B4 PREEMPT	OFF
LOCK INPUT	ON
OVERRIDE HIGHER # PREEMPT	ON
EXIT PREEMPT TO	Ø2+6

* Time defaults to time used for phase during normal operation.

This signal was designed for advanced preemption.

Railroad Preemption Timing Chart

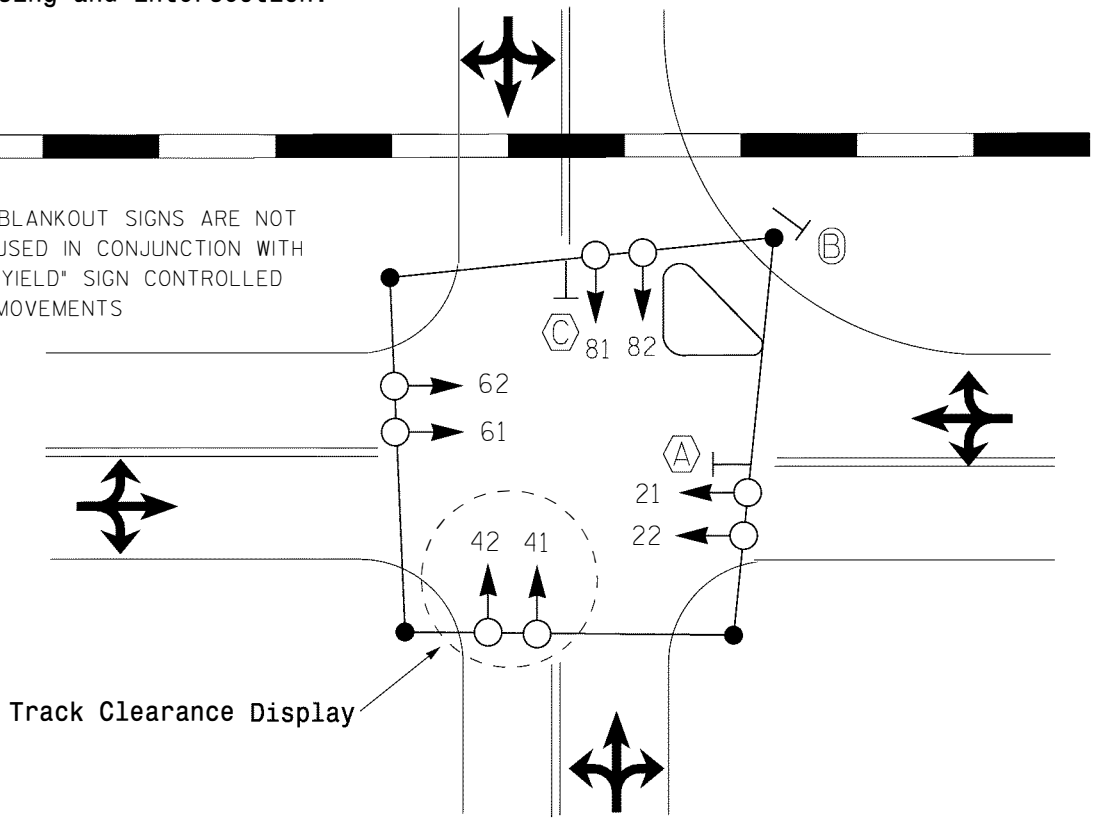
SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

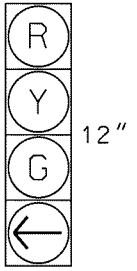
7-21

STD. NO.
13.1.2
SHEET 6 OF 6

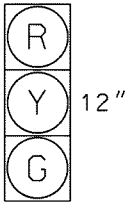
Permissive Only Displays without Flashing YELLOW ARROWs

NOTE: Pre-signal may be used to control vehicles prior to railroad crossing to address queuing between crossing and intersection.





41



21, 22
42
61, 62
81, 82

Ⓐ "NO LEFT TURN" L.E.D. Blankout Sign

Ⓑ "YIELD" Sign (R1-2)

Ⓒ "ONCOMING TRAFFIC MAY HAVE EXTENDED GREEN" Sign (W25-2)

TABLE OF OPERATION

SIGNAL FACE	PHASE RR CLR	PHASE RR DWELL	PHASE FLASH
21, 22	R	G	R
41	G ←	R	Y
42	G	R	Y
61, 62	R	G	R
81, 82	R	R	Y
SIGN A	ON	ON	*

* SEE NOTE X

Railroad Preemption: Use of Signal Heads and Blankout Signs

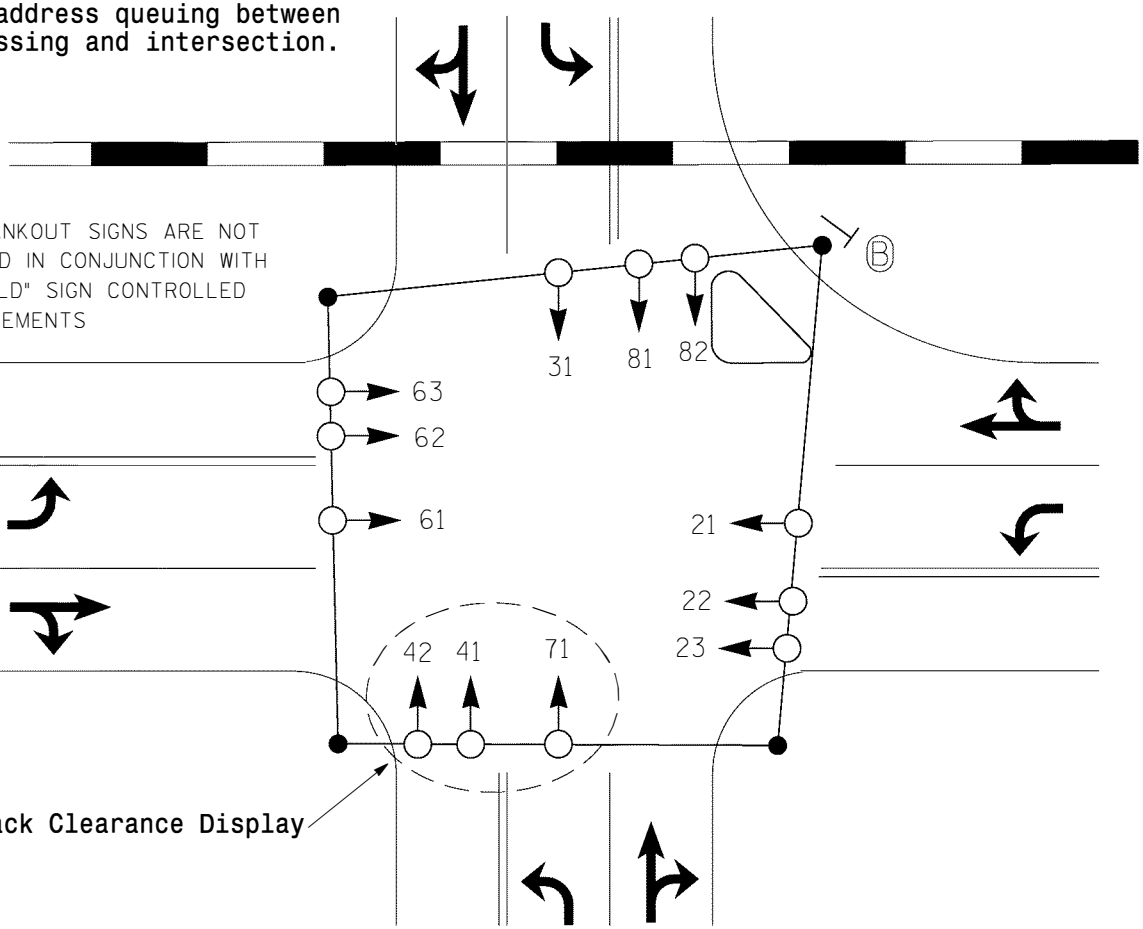
SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

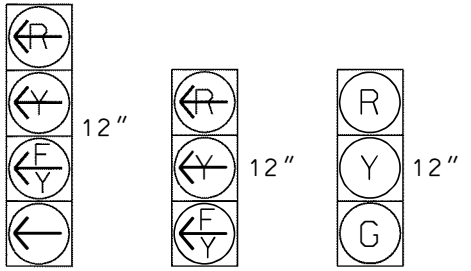
7-21

STD. NO. 13.1.3

Permissive Only Displays with Flashing YELLOW ARROWs

NOTE: Pre-signal may be used to control vehicles prior to railroad crossing to address queuing between crossing and intersection.





31
71

21
61

22, 23
41, 42
62, 63
81, 82

Ⓑ "YIELD" Sign (R1-2)

TABLE OF OPERATION

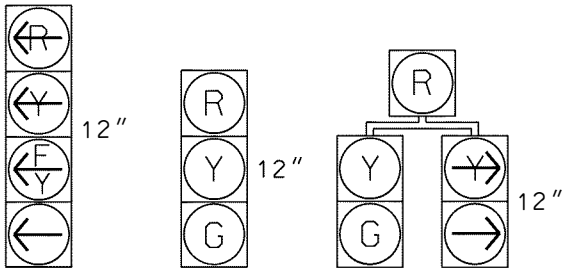
SIGNAL FACE	PHASE			
	RR CLR	RR DWL 1	RR DWL 2	FLASH
21	~~R~~	~~FY~~	~~R~~	~~R~~
22, 23	R	G	R	R
31	~~FY~~	~~R~~	~~←~~	~~Y~~
41, 42	G	R	R	Y
61	~~R~~	~~R~~	~~R~~	~~R~~
62, 63	R	G	R	R
71	~~←~~	~~R~~	~~R~~	~~Y~~
81, 82	R	R	R	Y

Railroad Preemption: Use of Signal Heads and Blankout Signs

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

Protected /Permissive Displays

NOTE: Pre-signal may be used to control vehicles prior to railroad crossing to address queuing between crossing and intersection.

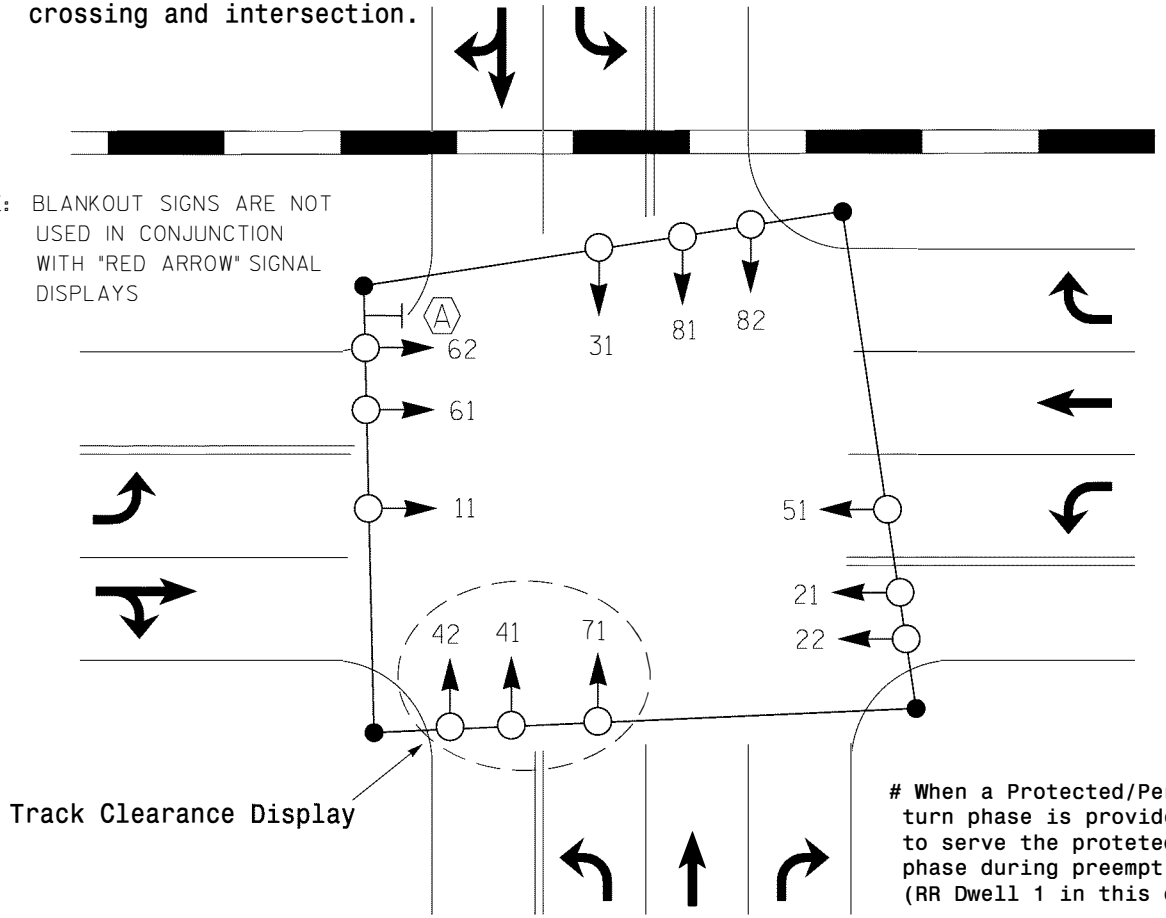


11
31
51
71

21, 22
41, 42
61
81

62
82

NOTE: BLANKOUT SIGNS ARE NOT USED IN CONJUNCTION WITH "RED ARROW" SIGNAL DISPLAYS



Ⓐ "NO RIGHT TURN" L.E.D. Blankout Sign

When a Protected/Permissive left turn phase is provided, programming to serve the proteted left turn phase during preempt may be optional (RR Dwell 1 in this example)

TABLE OF OPERATION

SIGNAL FACE	PHASE				
	RR CLR	RR DWL #1	RR DWL 2	RR DWL 3	FLASH
11	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~
21, 22	R	G	G	R	R
31	~~F Y~~	~~R~~	~~R~~	←	~~Y~~
41, 42	G	R	R	R	Y
51	~~R~~	←	~~F Y~~	~~R~~	~~R~~
61	R	R	G	R	R
62	R	R	G	R	R
71	←	~~R~~	~~R~~	~~R~~	~~Y~~
81	R	R	R	R	Y
82	R	R/→	R	R/→	Y
SIGN A	ON	ON	ON	ON	✳

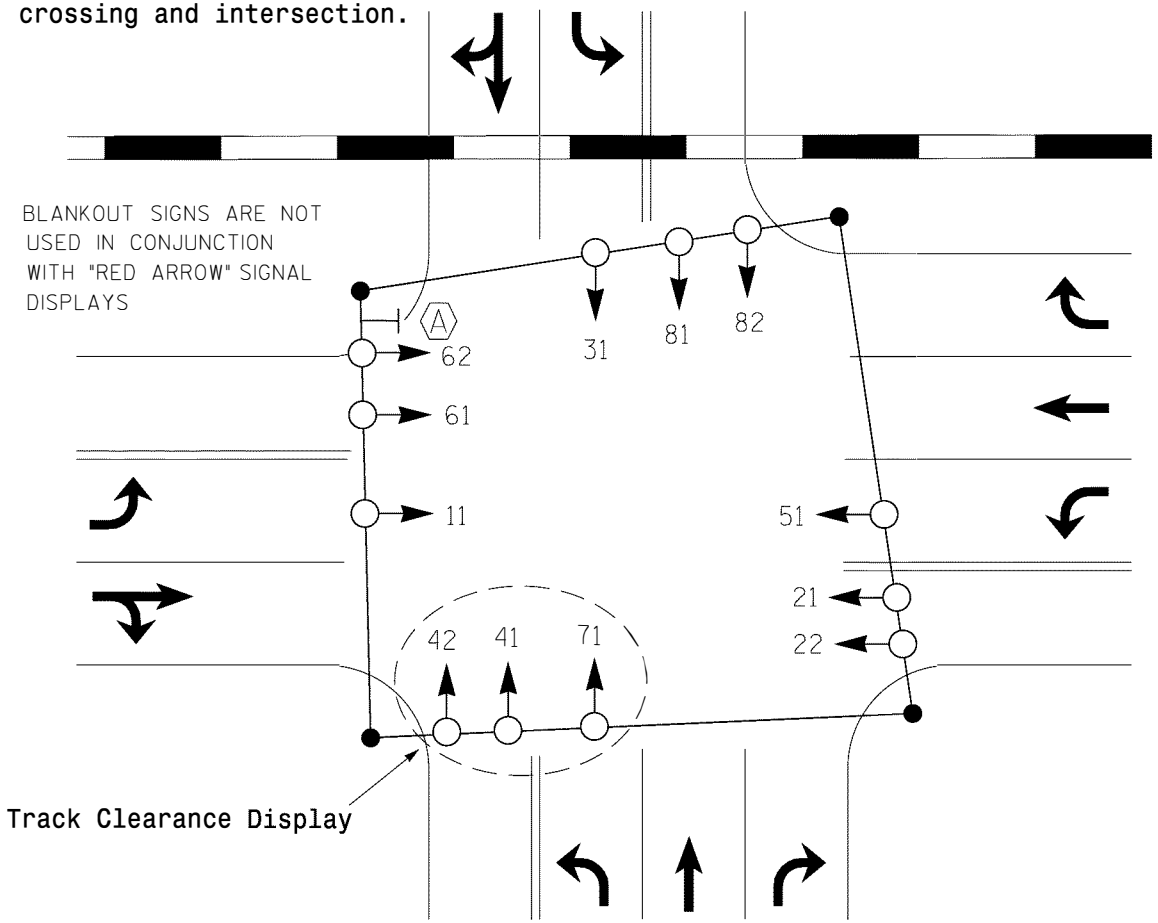
✳ SEE NOTE X

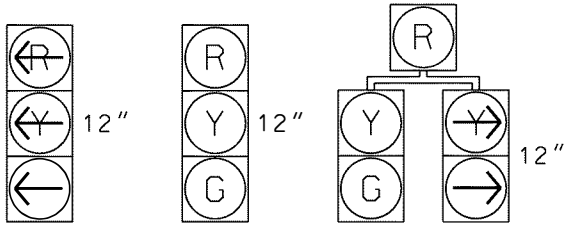
Railroad Preemption: Use of Signal Heads and Blankout Signs

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

Protected Only Displays

NOTE: Pre-signal may be used to control vehicles prior to railroad crossing to address queuing between crossing and intersection.





11
31
51
71

21, 22
41, 42
61
81

62
82

(A) "NO RIGHT TURN" L.E.D. Blankout Sign

TABLE OF OPERATION

SIGNAL FACE	PHASE				
	RR CLR	RR DWL 1	RR DWL 2	RR DWL 3	FLASH
11	~~R~~	~~←~~	~~R~~	~~R~~	~~R~~
21, 22	R	R	G	R	R
31	~~R~~	~~R~~	~~R~~	~~←~~	~~R~~
41, 42	G	R	R	R	Y
51	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~
61	R	G	G	R	R
62	R	G	G	R	R
71	~~←~~	~~R~~	~~R~~	~~R~~	~~R~~
81	R	R	R	R	Y
82	R	R→	R	R→	Y
SIGN A	ON	ON	ON	ON	*

* SEE NOTE X

Railroad Preemption: Use of Signal Heads and Blankout Signs

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO. 13.1.3

Pre–Signals

A pre-signal may be used to help stop vehicular traffic prior to a railroad crossing in an effort to reduce the potential for vehicles queuing from a downstream intersection onto the rallroad crossing. The pre-signal can also work in conjunction with active railroad warning devices, such as flashers and gates, to keep a crossing clear in advance of an approaching train movement. A pre-signal is considered a primary signal; a minimum of two signal signal heads are required. The operation of a pre-signal is often coordinated with the downstream signal at the intersection. When a pre-signal is used, the green displays of the downstream signal should be visibility limited.

A pre-signal should be used if there are railroad warning flashers but no gates present at the crossing, but is also recommended for other situations. It should be considered when the clear storage distance (throat between crossing and downstream intersection) is less than the length of the design vehicle. If a pre-signal is used, a protected only or lagging protected/permissive left turn should be used at the downstream intersection for the approach that crosses the tracks to reduce potential for vehicles to be queued on the tracks during a red signal.

The pre-signal may be in advance of (upstream) or after (downstream) the crossing, but the stop line should be a minimum of 40 feet from the pre-signal. When a pre-signal is located prior to the railroad crossing, the stop line for the pre-signal may also serve as the stop line for the railroad crossing, meaning a separate stop line at the railroad flashers is not required. When a pre-signal is mounted on the far side of the railroad tracks, the stop line for the railroad warning flashers may serve as a stop line for the pre-signal. Pre-signal heads should not block or obstruct railroad warning flashers mounted on a cantilever (if used), nor should they be obstructed by the warning flashers. Pre-signals may be mounted on the railroad cantilever with railroad approval.

When an approaching train is detected, a pre-signal shall transition from a green to a red display prior to or immediately upon activation of the railroad warning flashers. The steady red indication of the pre-signal shall be displayed during the Track Clearance interval to prohibit additional vehicles from crossing the railroad tracks, and shall remain red at least until the passage of the train.

A pre-signal should be designed to operate in conjunction with the downstream intersection signal as part of normal operation. The signal heads shall consist of 12-inch CIRCULAR RED, CIRCULAR YELLOW, and straight-through GREEN ARROW sections. The use of a GREEN ARROW may deter a confused or disoriented driver from inadvertently turning onto the railroad tracks. The pre-signal should operate in a way to help keep vehicles from queuing in the area between the intersection and the tracks (throat). This may include the use of a short overlap between the clearance of the pre-signal and the clearance of the intersection signal. The use of lagging protected/permissive or protected only left turn phasing should also be considered to help minimize the potential for queuing.

Reference: "Preemption of Traffic Signals Near Railroad Crossings - An ITE Recommended Practice," 2020

Pre–Signal
(With Minimal or No Storage Between Railroad Crossing and Downstream Intersection)

Design Considerations for Use:

Simultaneous Preemption

When there is minimal to no distance to queue a single (design) vehicle between the railroad tracks or exit gates (if present) and the intersection.

Traffic shall stop for intersection signal and railroad crossing at stop line prior to railroad track. A "NO TURN ON RED" (R10-11) sign shall be used.

A minimal Track Clearance Green (10 seconds) is generally used.

Signal clearance times for intersection should be calculated to clear a vehicle from the stop line before the railroad track.

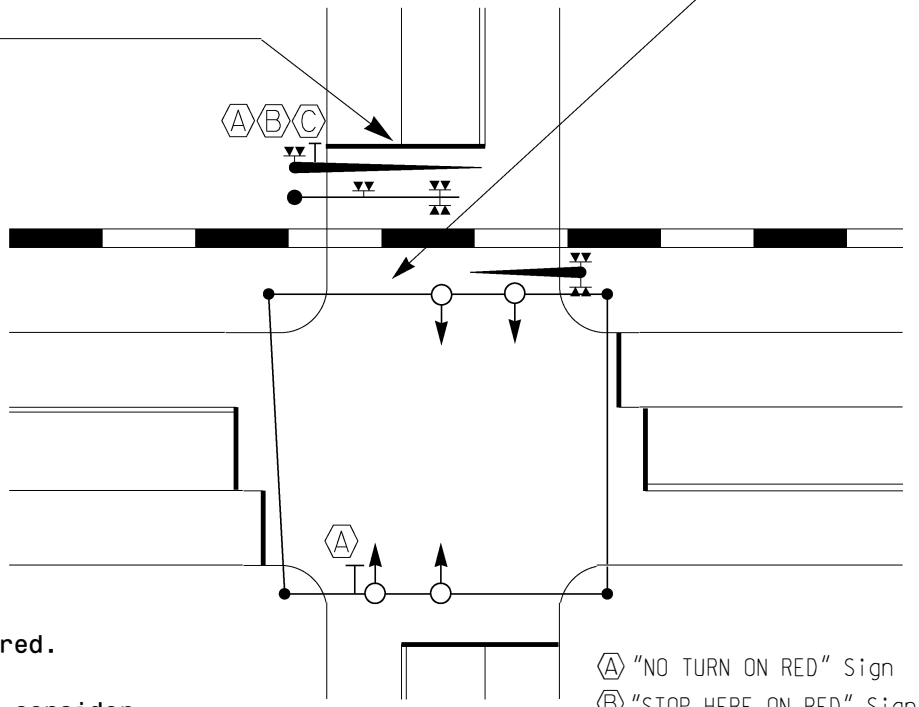
Pre-signal should be used if no railroad gates are present at the crossing.

If a pre-signal is used, it should be designed to operate with the normal operation of the intersection signal. The displays should be identical to the downstream signal heads, except when entering preempt and during the Track Clearance Phase. A timed overlap between the pre-signal and downstream signal may not be required.

For the left turns crossing the railroad tracks, consider either a protected only left turn or a lagging protected left (if P/P) to prevent turning traffic queuing on the tracks.

Engineering Judgement and Diagnostic Team of Individual Crossing should determine if Pre-Signal is needed.

If signal heads are on far span, a supplemental (near) side head may be required for distance.



Ⓐ "NO TURN ON RED" Sign (R10-11)
Ⓑ "STOP HERE ON RED" Sign (R10-6)
Ⓒ "DO NOT STOP ON TRACKS" Sign (R8-8)

Railroad Preemption: Use of Signal Heads and Blankout Signs

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

Pre–Signal
(With Limited Storage Between Railroad Crossing and Downstream Intersection)

Design Considerations for Use:

Advance Preemption

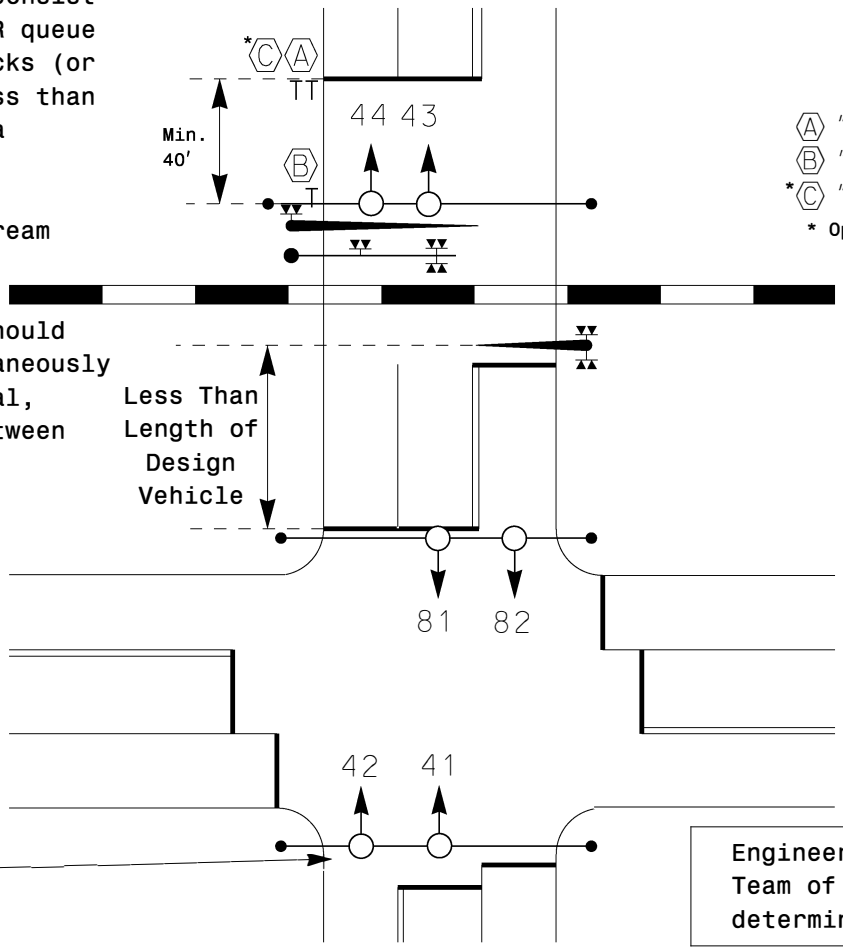
When active crossing warning devices consist only of flashers (no gates present) OR queue distance for vehicles between the tracks (or exit gate) and the intersection is less than the length required for the queue of a design vehicle.

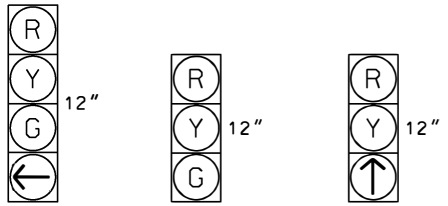
Pre-signal heads may be placed downstream of (across) the railroad tracks.

During normal operation, pre-signal should be designed so it begins green simultaneously with the downstream intersection signal, but a short overlap should be used between the (red and yellow) clearance of the pre-signal and the downstream signal to minimize queue of vehicles in storage throat.

For the left turns off the approach crossing the tracks, consider either a protected only left turn or a lagging protected left (if P/P).

When pre-signal is used, consider visibly limiting the Flashing YELLOW ARROW (if used) and green (proceed) signal indications for the approach from the railroad at the intersection.





Ⓐ "STOP HERE ON RED" Sign (R10-6)
Ⓑ "DO NOT STOP ON TRACKS" Sign (R8-8)
*Ⓒ "STOP HERE WHEN FLASHING" Sign (R8-10)
* Optional

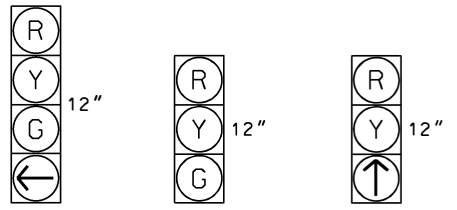
TABLE OF OPERATION

SIGNAL FACE	PHASE Ø4+8	TOL	RR CLR	RR DWL	FLASH
41	G	G	G ←	R	Y
42	G	G	G	R	Y
43, 44	↑	R	R	R	R
81, 82	G	G	R	R	Y

Engineering Judgement and Diagnostic Team of Individual Crossing should determine if Pre-Signal is needed.

Railroad Preemption: Use of Signal Heads and Blankout Signs

Pre–Signal
(With Storage Between Railroad Crossing and Downstream Intersection)



Ⓐ "STOP HERE ON RED" Sign (R10-6)
Ⓑ "DO NOT STOP ON TRACKS" Sign (R8-8)
*Ⓒ "STOP HERE WHEN FLASHING" Sign (R8-10)
* Optional

Design Considerations for Use:

Advance Preemption where there may be a longer offset between the beginning of traffic signal preemption and activation of railroad warning devices.

When active crossing warning devices consist only of flashers (no gates present) OR queue distance for vehicles between the tracks (or exit gate) and the intersection is the more than the length required for the queue of a design vehicle.

Pre-signal should display red and green indications simultaneously with the downstream intersection signal during normal operation.

Pre-signal heads may be placed downstream of (across) the railroad tracks.

When pre-signal is used, consider visibly limiting the Flashing YELLOW ARROW (if used) and green (proceed) signal indications for the approach from the railroad at the intersection.

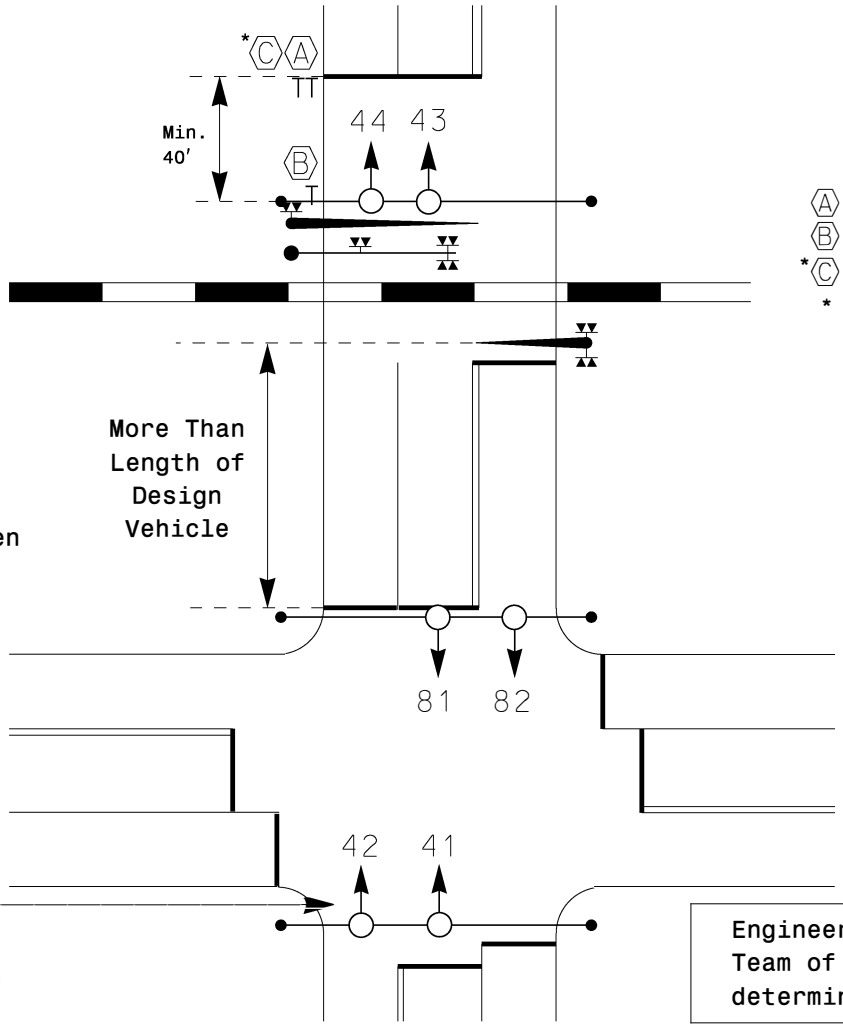


TABLE OF OPERATION				
SIGNAL FACE	PHASE			
	Ø4+8	RR CLR	RR DWL	FLASH
41	G	G ←	R	Y
42	G	G	R	Y
43, 44	↑	R	R	R
81, 82	G	R	R	Y

Engineering Judgement and Diagnostic Team of Individual Crossing should determine if Pre-Signal is needed.

Railroad Preemption: Use of Signal Heads and Blankout Signs

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

Queue Cutter

A queue cutter is a form of a pre-signal which only controls vehicular traffic approaching railroad crossing in one direction and operates independently of other adjacent traffic signals. It should be considered where there is potential for traffic from a downstream signal (or other traffic situation) to regularly queue to the railroad crossing, but the downstream signal is too far from the railroad crossing to effectively rely on track clearance via railroad preemption due to a long clearance distance and warning time required. It is always interconnected to the railroad crossing to provide preemption for an approaching train and may also be connected to a downstream signal. It may be located in advance of or downstream of the adjacent grade crossing to provide the most effective display. A queue cutter should follow the guidelines for pre-signals relative to the placement of signal heads and stop lines.

Since the queue cutter is near a railroad crossing where no turns are desired, the display shall consist of a (12-nch) CIRCULAR RED, CIRCULAR YELLOW, and straight-through GREEN ARROW section to deter accidental turns onto the railroad tracks by a disoriented motorist.

The queue cutter uses vehicle detection loops (6′X15′) to determine that the storage area (throat) between the railroad crossing and the downstream intersection is full. When the loops detect a steady queue of traffic, they direct the queue cutter signal heads to change to red to stop additional vehicles from crossing the tracks and adding to the back of queue. The queue loops should be placed so that the queue can be detected and the queue cutter signal changed to a red display before the downstream queue extends to or across the railroad tracks. The queue cutter will also change to red as soon as notice of an approaching train detected by the track circuitry, even if the railroad warning devices have not begun to activate (advance preemption). This prevents additional traffic from crossing the tracks and adding to the queue of vehicles that need to be cleared.

The queue cutter signal will remain red until the train passes and the preemption call is released or when the vehicle detectors no longer detect a steady queue. In some cases, the queue cutter signal may be interconnected to the downstream signal. This has several advantages. When the downstream signal turns green, the queue cutter may also release to green, allowing traffic to enter the throat knowing that the downstream signal is green and not likely to immediately queue. By changing to green simultaneously with the downstream signal and not as soon as the queue detector loops are clear, it prevents a situation where the loops may initially clear and think the queue has released, but the addition of one vehicle to the queue would reactivate the queue cutter signal to turn red, potentially leading to quick cycles that can be confusing and frustrating to motorists.

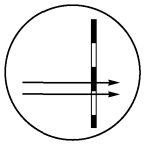
Reference: "Preemption of Traffic Signals Near Railroad Crossings - An ITE Recommended Practice," 2020

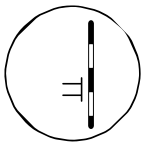
Queue Cutter

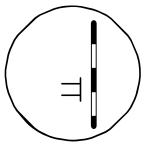
RAIL PREEMPT PHASES (High Priority) QUEUE PREEMPT PHASES (Medium Priority)

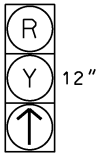
TABLE OF OPERATION				
SIGNAL FACE	PHASE Ø2	PRE 1 RR	QUEUE 2E	FLASH
21, 22	↑	R	R	R

Ⓐ "STOP HERE ON RED" Sign (R10-6)
Ⓑ "DO NOT STOP ON TRACKS" Sign (R8-8)
*Ⓒ "STOP HERE WHEN FLASHING" Sign (R8-10)
* Optional


Ø2


PRE 1


PRE 2



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Railroad Preemption: Use of Signal Heads and Blankout Signs

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

7-21

STD. NO. 13.1.3

Use of Railroad Preemption

A traffic signal should be interconnected to allow for railroad preemption when a highway-railroad grade crossing with active warning devices (at least flashing lights) exists within 200 feet on at least one of the approaches to a signalized intersection. Preemption or other mitigation should also be considered if there is potential for regular queuing from the intersection to extend close to or beyond the adjacent railroad grade crossing(s).

Blankout Signs

A blankout sign is used to reinforce a temporary turn restriction that is in place to the presence of a train. It is normally used for permissive turning movements or when a CIRCULAR indication is displayed during preemption. It is not used in conjunction with a (right or left) RED ARROW display. While a CIRCULAR GREEN indication may be displayed for a movement parallel to the railroad tracks, a "NO RIGHT TURN- TRAIN" blankout sign may be mounted next to the right most signal head to indicate that a right turn should not be made despite the green indication. If there is separate right turn signal head controlling a right turn across the tracks, a blankout sign should also be used with the CIRCULAR RED indication, unless a full time "NO TURN ON RED" sign is posted at the intersection.

A blankout sign shall illuminate at the beginning of the yellow clearance when transition begins into railroad preemption. The sign shall remain on until the signal exits preemption and returns to normal operation and displays a green indiction for exit phase after preemption. Blankout signs should also be programmed to operate if a preempt call is received while the signal is in a (programmed or failure) flashing mode operation.

Overlap P

An active railroad grade crossing system includes flashing horizontal red lights and may also include warning gates. While there is variability in normal signal phasing operation, it is imperative that there be some consistency in the traffic signal operation of the Railroad Preemption and Track Clearance sequence relative to the operation of the active railroad grade crossing warning system. In order to ensure consistency in the operation of the traffic signal preemption sequence relative to the operation of the railroad active warning system, Overlap P should be used in the traffic signal controller. Overlap P is a background timer that operates during all normal phases but must be cleared before the preemption sequence can begin. It serves to ensure that the entire time designed for the preemption sequence is used, even if the signal may otherwise enter the preemption sequence sooner than normally intended. It is intended to make sure that the Track Clearance Green Phase does not begin timing early or terminate until after entrance gates for the railroad crossing are horizontal. Overlap P should be used for most railroad preemption timings, whether Simultaneous or Advanced Preemption is used.

Simultaneous Preemption

Simultaneous Preemption is when the Traffic Signal begins the transition to the Preemption sequence at the same time the railroad active warning devices begin to activate in advance of an approaching train. It is typically used when the railroad provides only motion detection or presence detection of a train within the approach or island circuit.

For Simultaneous Preemption, the Track Clearance Green time is the same time provided by Greenshield's Formula, with a typical minimum of 12 seconds used. Simultaneous Preemption is recommended for locations where there is little to no storage room to queue vehicles between the intersection and the tracks and the vehicles approaching the intersection stop prior to the railroad crossing for the intersection traffic signal.

Advance Preemption

Advance Preemption is when the Traffic Signal begins the transition to the Preemption sequence before the railroad active warning devices begin to activate in advance of an approaching train. The time difference between beginning of the traffic signal preemption sequence and the activation of the railroad active warning devices (flashing lights) is know as the Advance Preemption Time. This time is usually determined by the railroad, but a time of 6-8 seconds is desired. Advance Preemption is typically used for crossings with long storage throats between the tracks and the intersection, or where a pre-signal may be used to help control traffic at the railroad grade crossing. A railroad must use a predictor (constant warning time) at a grade crossing to provide Advance Preemption.

Railroads are required to provide a minimum of 20 seconds (Minimum Warning Time or MWT) of warning time in advance of a train. While some railroads may provide warning longer times, most do not want to operate their devices for more than 35-40 seconds prior to the train arrival at a grade crossing. This offset between the time required for a traffic signal (Maximum Preemption Warning Time or MPWT) and the MWT creates the advance preemption time. A goal of advance preemption is to begin a Track Clearance Green display at the same time railroad warning devices begin to activate.

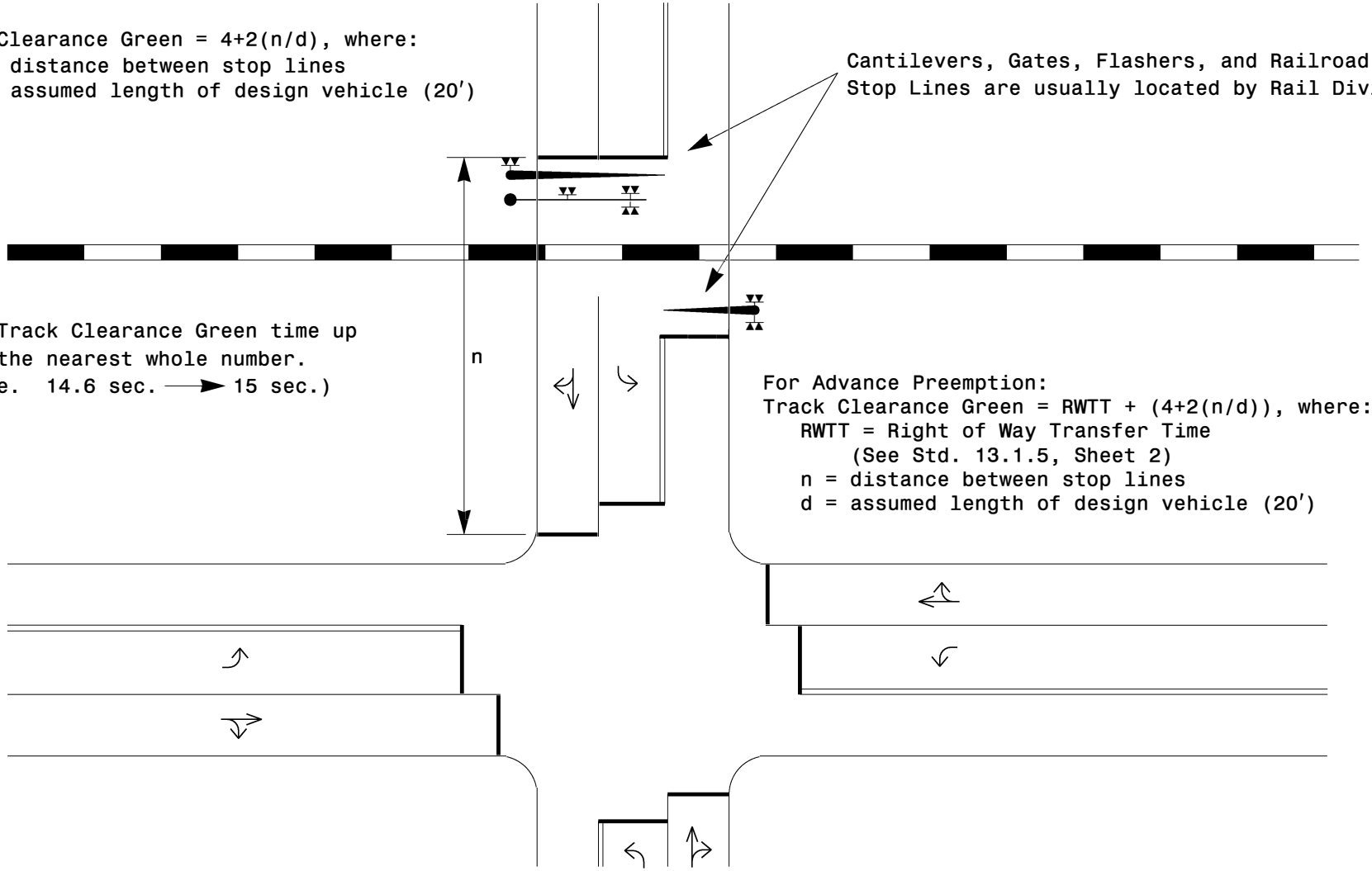
Due to the initial offset between the beginnng of the Track Clearance phase and the activation of the warning devices, it may be necessary to add additional time to the Track Clearance Green (TCG) time to ensure that the railroad warning gates are fully horizontal and blocking the crossing prior to the termination of the Track Clearance Green. This additional time normally involves adding the Right of Way Transfer Time (RWTT) into the Track Clear Green, which accounts for initial offset between the beginning of traffic signal preemption and the activation of the railroad warning devices. Additional time adjustments may be needed based on the individual characteristics of the crossing and/or the use of a pre-signal.

Track Clearance Phase Times

Greenshield's Formula:

Track Clearance Green = 4+2(n/d), where:
- n = distance between stop lines
- d = assumed length of design vehicle (20′)

Round Track Clearance Green time up to the nearest whole number.
(i.e. 14.6 sec. ⟶ 15 sec.)



Cantilevers, Gates, Flashers, and Railroad Stop Lines are usually located by Rail Division

For Advance Preemption:
Track Clearance Green = RWTT + (4+2(n/d)), where:
- RWTT = Right of Way Transfer Time (See Std. 13.1.5, Sheet 2)
- n = distance between stop lines
- d = assumed length of design vehicle (20′)

Railroad Preemption Timing

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.
13.1.5
SHEET 1 OF 2

Elements for Calculating Maximum Preemption Warning Time (MPWT)

Right of Way Transfer Time (RWTT)
- Delay Before Preempt
- Ped Clear Before Preempt *
- Min Green Before Preempt
- # Yellow Clear Before Preempt *
- # Red Clear Before Preempt

Track Clear Green

May Overlap w/ Train Arrival if Long Storage Throat
- Track Clear Yellow **
- Track Clear Red **

OR Time for Exit Gates **

Safety Equipment Reaction Time (Usually 5 Seconds)

Add the above to find the Maximum Preemption Warning Time (MPWT) needed to clear signal for preemption and request this time from Rail Division.

* These values may clear simultaneously with some types of traffic signal software.

\# Values associated with Overlap P

** If 4 quadrant (exit) gates are used, do not include Track Clear Yellow and Track Clear Red times in this equation. Instead add:
- 12 Seconds for exit gates to descend to horizontal position.
- 5 seconds (exit gates should be horizontal 5 seconds prior to train arrival).

Elements on a Signal Plan with Railroad Preemption

-AAR DOT Crossing Number and Name of operating Railroad(s).
-Show all gates, flashers, and cantilevers on signal plan.
-Railroad Preemption Timing Chart for software used with appropriate times entered, including for Overlap P.
-Show if traffic signal is designed for Simultaneous or Advanced Preemption.
-Show Railroad Preemption Phasing Diagram(s), including Track Clearance Phase and all Dwell phases. If Alternate Phasing is used during normal operation, multiple preemption diagrams may be needed.
-Railroad Preemption should have priority over Emergency Vehicle Preemption and most other types of preemptions.
-Show "NO RIGHT (LEFT) TURN" L.E.D. Blankout signs as needed in Table of Operation. Illuminate blankout signs during track clearance and all preempt Dwell (hold) phases.
-Include note for blankout sign operation during flash mode.
-When entering the preemption sequence, yellow traps are permitted if necessary to provide immediate track clearance. Use a flashing YELLOW ARROW or an "ONCOMING TRAFFIC MAY HAVE EXTENDED GREEN" (W25-2) sign on the approach(es) if necessary to mitigate a potential yellow trap.
-Use a "DO NOT STOP ON TRACKS" sign (R8-8) on approach crossing tracks leading to signal (add any other time there is potential for traffic to queue across tracks).
-Use a "STOP HERE ON RED" sign (R10-6) if traffic is to stop prior to tracks for a signal or pre-signal. A "NO TURN ON RED" (R10-11) sign may also be required.
-When possible, the street crossing the tracks should flash Yellow during flashing operation, even if it is not the main phase (2+6). An All Red flashing indication may also be used at some locations.
-An exit phase should be designated upon leaving Railroad Preemption. Typically, exit to the primary phase that was unable to move due to the presence of a train.

Railroad Preemption Timing