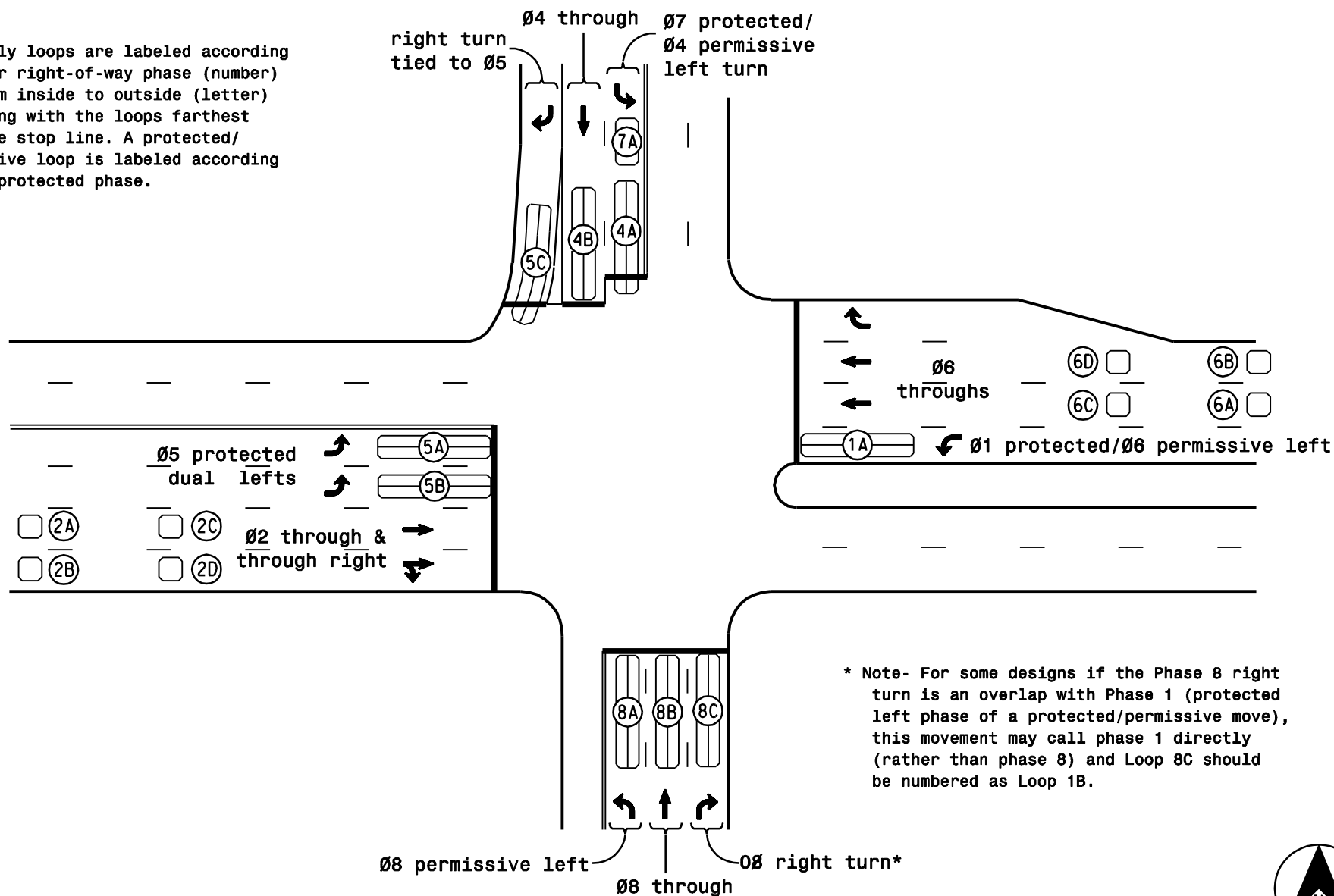


Typically loops are labeled according to their right-of-way phase (number) and from inside to outside (letter) beginning with the loops farthest from the stop line. A protected/permissive loop is labeled according to its protected phase.



* 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 8C should be numbered as Loop 1B.



Typical Numbering of Loops/Detection Zones

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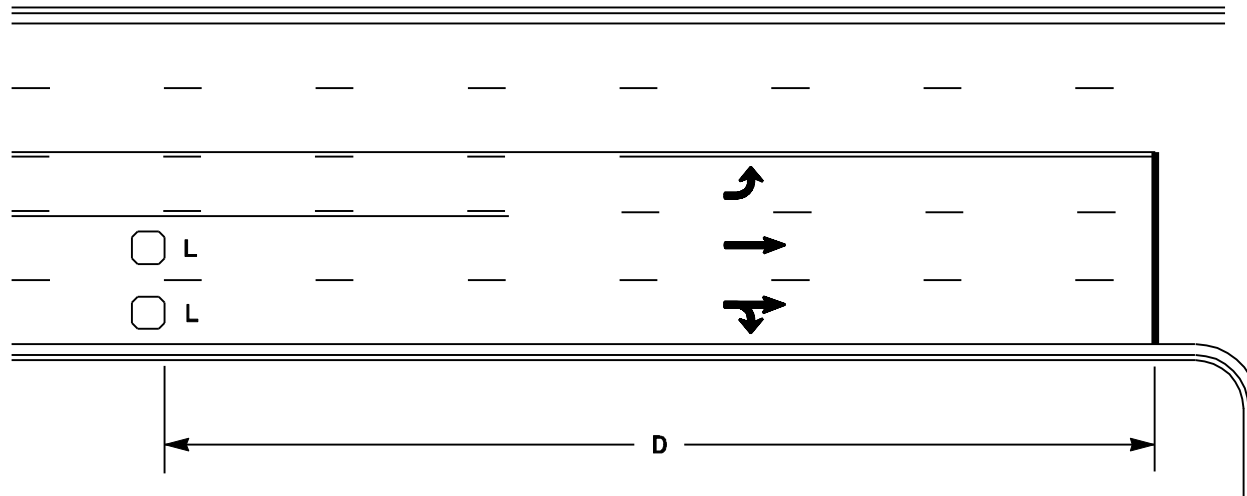
7-09

STD. NO.

4.0

SHEET 1 OF 1

Volume Density Operation



L = 6ft X 6ft (1.8m X 1.8m)

Presence loop

Wired in series for TS1 Controllers

Wired to separate detectors/channels
for 170, TS2, and 2070 Controllers

Design Speed mph (km/hr)	D ft (m)
40 (64)	250 (75)
45 (72)	300 (90)
50 (80)	355 (110)
55 (88)	420 (130)

Design Considerations:

- High speed [≥ 40 mph (64 km/hr)]
- Preferred option for cost and efficiency

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

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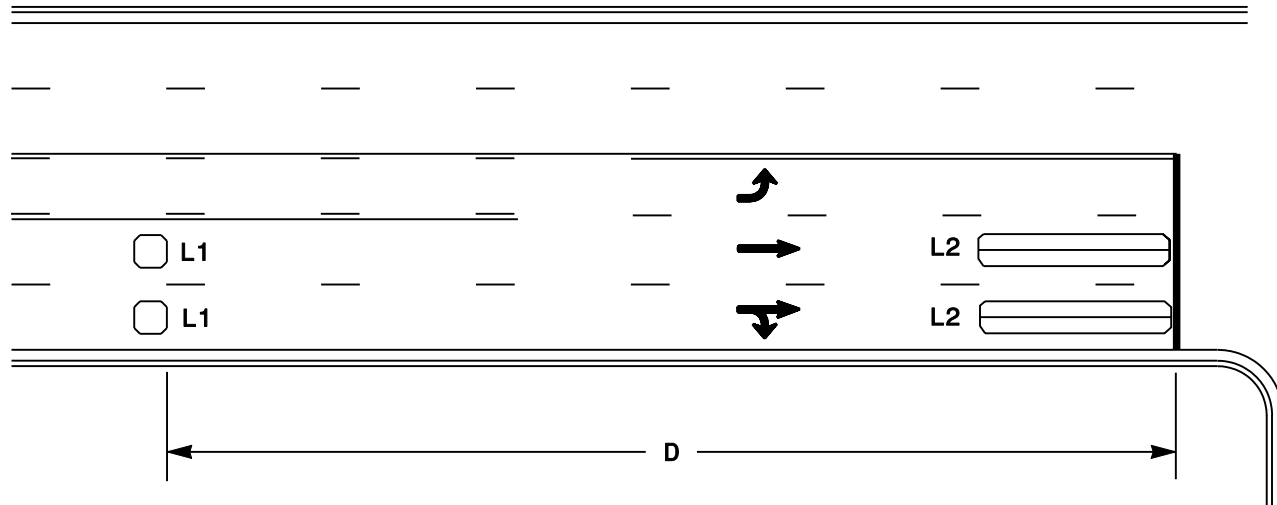
STD. NO.

4.1.1

SHEET 1 OF 4

11-06

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



L1 = 6ft X 6ft (1.8m X 1.8m)

Presence loop

Wired in series for TS1 Controllers

Wired to separate detectors/channels
for 170, TS2, and 2070 Controllers

L2 = 6ft X 40ft

(1.8m X 12.0m)

Quadrupole loop

Wired to separate

detectors/channels

Design Speed mph (km/hr)	D ft (m)	L2	
		Delay sec	Extend sec
40 (64)	250 (75)	5.0	2.0
45 (72)	300 (90)	5.0	2.0
50 (80)	355 (110)	5.0	2.0
55 (88)	420 (130)	5.0	2.0

Design Considerations:

- High speed [≥ 40 mph (64 km/hr)]
- 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 costlier to install and maintain

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" for phases 2 & 6
- Loops L1 can double as system detectors when wired separately

Loop Placement for Main Street Through Movements

SIGNALS & GEOMETRICS SECTION
TRAFFIC ENGINEERING AND SAFETY SYSTEMS BRANCH
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

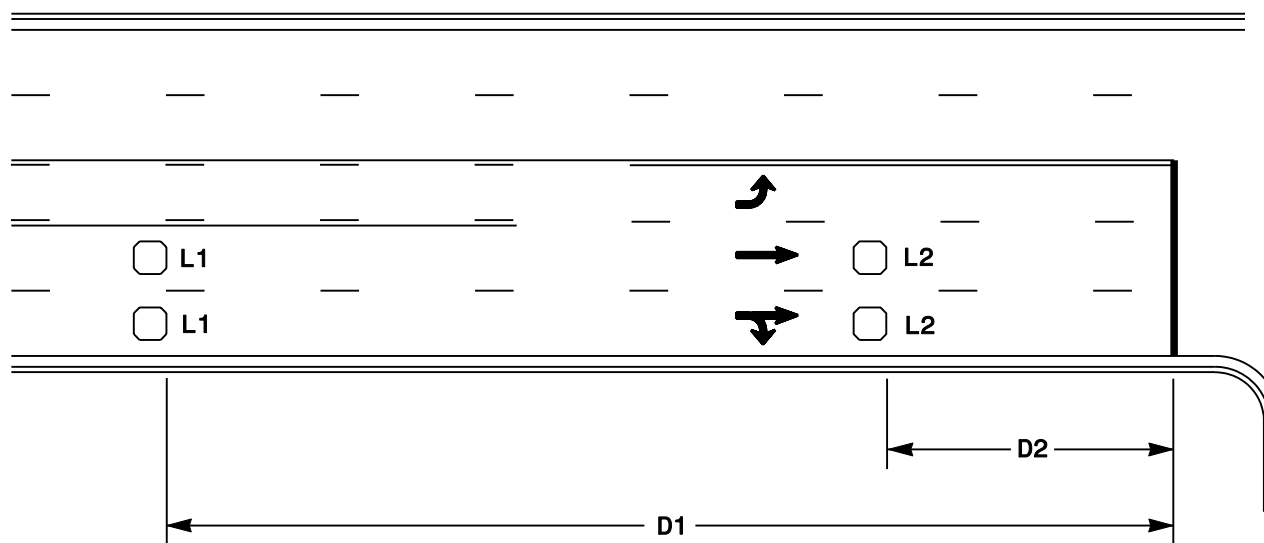
5-05

STD. NO.

4.1.1

SHEET 2 OF 4

Extend (Stretch) Detection



L1 = 6ft X 6ft
(1.8m X 1.8m)
Presence loop
Wired in series

L2 = 6ft X 6ft
(1.8m X 1.8m)
Presence loop
Wired in series

Design Speed mph (km/hr)	D1 ft (m)	D2 ft (m)	Extend sec
40 (64)	250 (75)	80 (25)	1.3
45 (72)	300 (90)	90 (27)	1.6
50 (80)	355 (110)	100 (30)	1.9
55 (88)	420 (130)	110 (35)	2.2

Design Considerations:

- High speed [≥ 40 mph (64 km/hr)]
- 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
- For TS-1 controllers, round Extend time up to nearest 0.25 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.

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

Loop Placement for Main Street Through Movements

SIGNALS & GEOMETRICS SECTION
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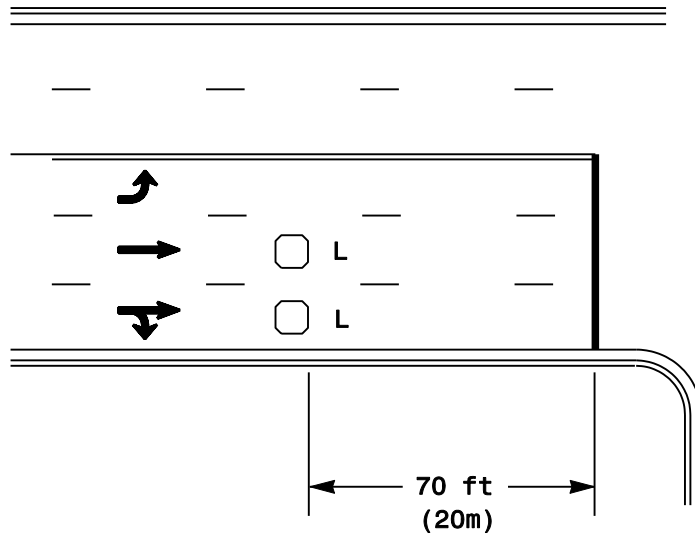
5-05

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4.1.1

SHEET 3 OF 4

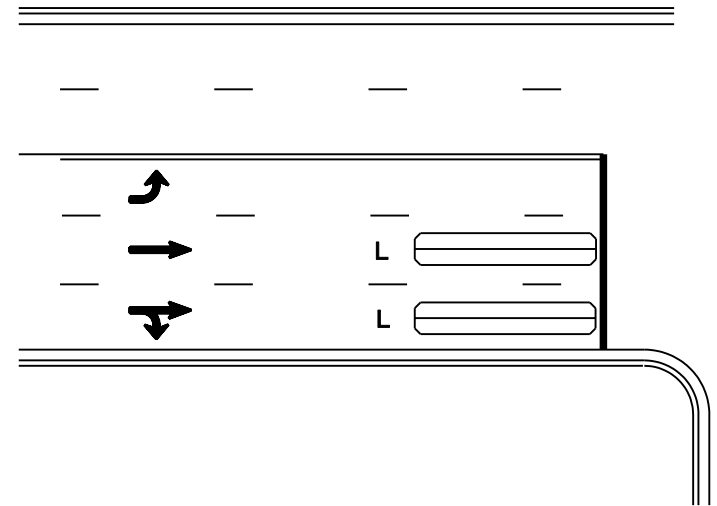
Low Speed Detection



L = 6ft X 6ft (1.8m X 1.8m)
Presence loop, wired in series

Design Considerations:

- Low speed [≤ 35 mph (56 km/hr)]
- Gap time typically 3.0 seconds
- Preferred option



L = 6ft X 40ft (1.8m X 12.0m)
Quadrupole loop, wired to
separate detectors/channels

Design Considerations:

- Low speed [≤ 35 mph (56 km/hr)]
- Gap time typically 0-2 seconds
- Appropriate for use with soft recall

Loop Placement for Main Street Through Movements

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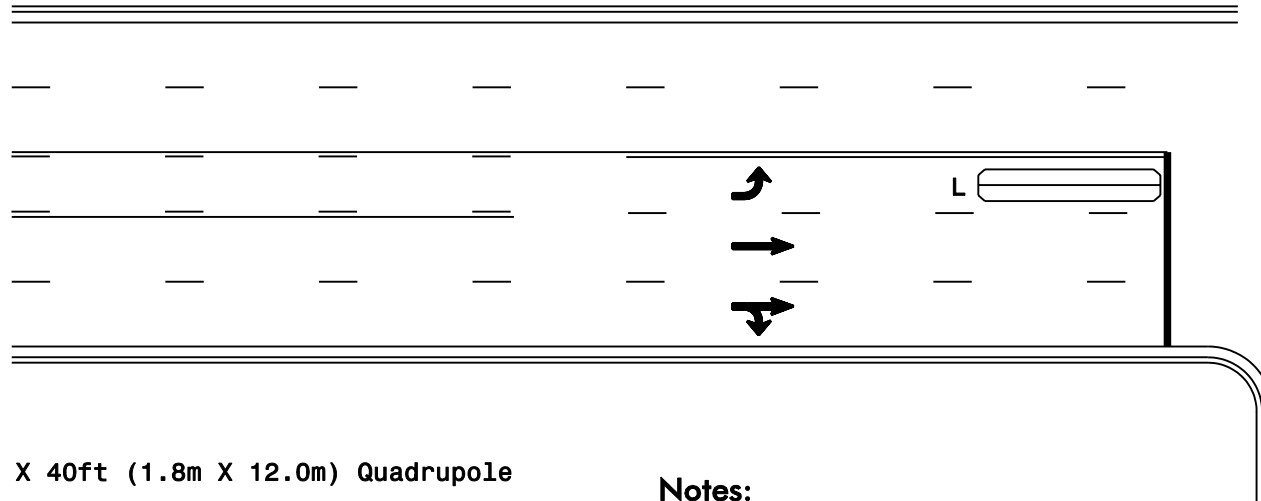
5-05

STD. NO.

4.1.1

SHEET 4 OF 4

Presence Detector



L = 6ft X 40ft (1.8m X 12.0m) Quadrupole
 or, if longer detection area is needed:
 6ft X 50ft (1.8m X 15.0m) Quadrupole
 or
 6ft X 60ft (1.8m X 18.0m) Quadrupole

Notes:

- Loops may not be required for all main street permissive turns
- Option to use 6ft X 6ft (1.8m X 1.8m) 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

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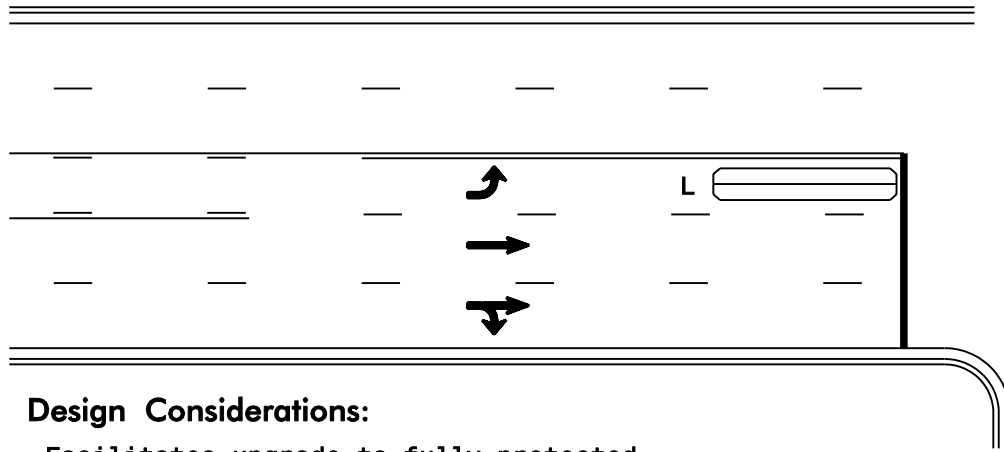
5-05

STD. NO.

4.1.2

SHEET 1 OF 1

Presence Loop with 2 Channel Detector



L = 6ft X 40ft (1.8m X 12.0m) Quadrupole loop
 or, if longer detection area is needed:
 6ft X 50ft (1.8m X 15.0m) Quadrupole loop
 or
 6ft X 60ft (1.8m X 18.0m) 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	No
	2	Permissive Phase	0 sec	N/A
Left Turn Loop on Main Street with Volume Density Detection	1	Protected Phase	10-30 sec	No
	2	Permissive Phase	3-5 sec	Yes
Left Turn Loop on Side Street	1	Protected Phase	10-30 sec	No
	2	Permissive Phase	2-3 sec if "clipping" prevention is desired; 0 sec otherwise	No

Loop Placement for Protected/Permissive Left Turns

SIGNALS & GEOMETRICS SECTION
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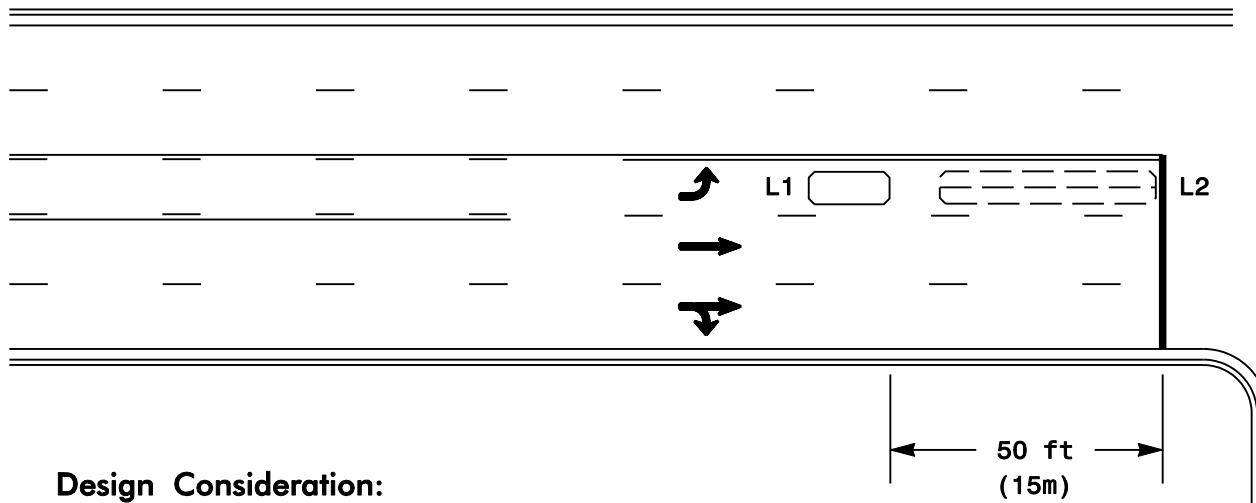
5-05

STD. NO.

4.1.3

SHEET 1 OF 2

Queue Detector Loop



L1 = 6ft X 15ft (1.8m X 4.5m)
Presence loop (Queue detector) with Call delay

L2 = 6ft X 40ft
(1.8m X 12.0m)
Quadrupole loop

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

Design Consideration:

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

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	2-3 sec if "clipping" prevention is desired; 0 sec otherwise	No

Loop Placement for Protected/Permissive Left Turns

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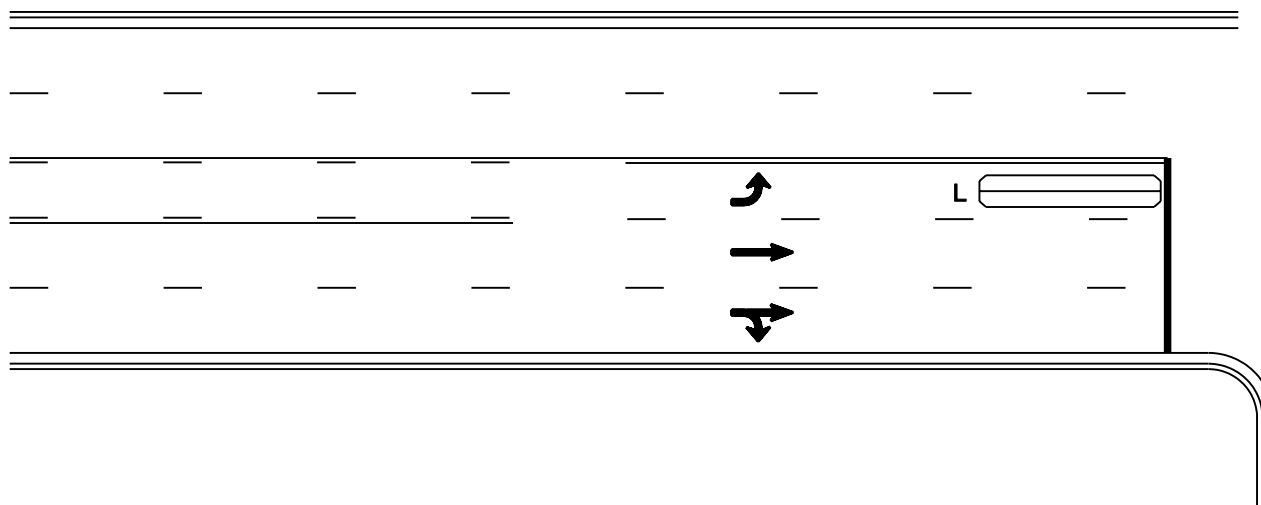
STD. NO.

4.1.3

SHEET 2 OF 2

5-05

Presence Detector



L = 6ft X 40ft (1.8m X 12.0m) Quadrapole

or, if longer detection area is needed:

6ft X 50ft (1.8m X 15.0m) Quadrapole

or

6ft X 60ft (1.8m X 18.0m) Quadrapole

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

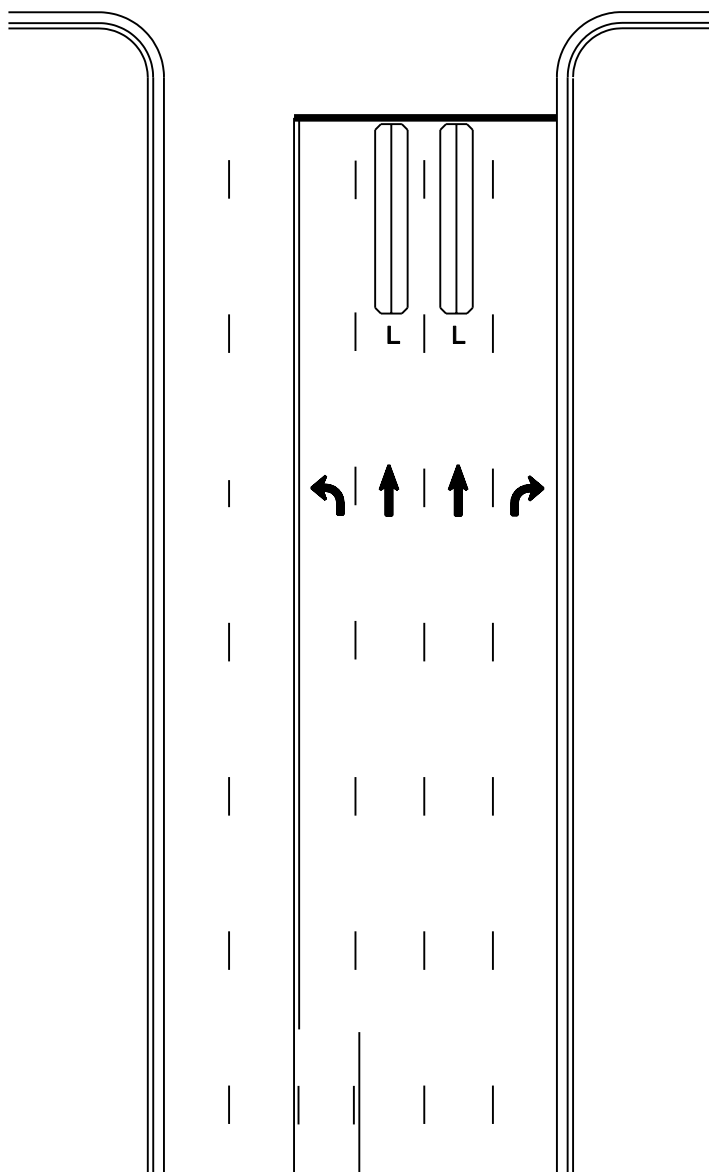
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5-05

STD. NO.

4.1.4

SHEET 1 OF 1



Typical Presence Detection

L = 6ft X 40ft (1.8m X 12.0m)
 Quadrupole loop
 Wired to separate detectors/channels

or, if longer detection area is needed:

6ft X 50ft (1.8m X 15.0m) Quadrupole
 or
 6ft X 60ft (1.8m X 18.0m) 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
- 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

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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 (1.8m X 1.8m) Presence loop
Wired in series for TS1 Controllers
Wired to separate detectors/channels
for 170, TS2, and 2070 Controllers

L2 = 6ft X 40ft (1.8m X 12.0) Quadrupole loop
Wired to separate detectors/channels

Design Speed mph (km/hr)	D ft (m)	L2	
		Delay sec	Extend sec
40 (64)	250 (75)	5.0	2.0
45 (72)	300 (90)	5.0	2.0
50 (80)	355 (110)	5.0	2.0
55 (88)	420 (130)	5.0	2.0

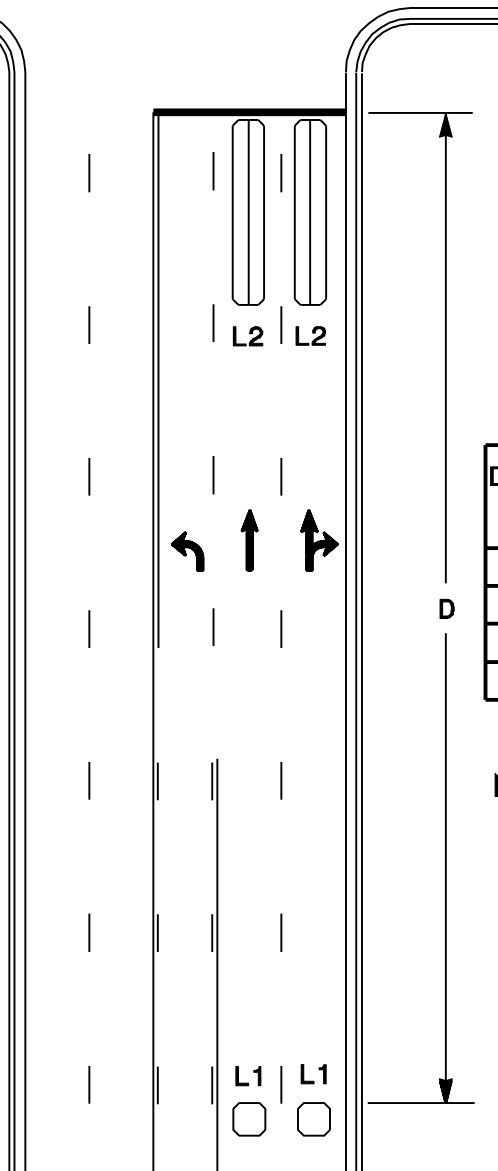
Design Considerations:

- Cross intersection AND
- High speed [≥ 40 mph (64 km/hr)] AND
- Good horizontal and vertical alignment
- In some cases can provide better efficiency than "stretch" detection

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" for phases 4 & 8.
- Loops L1 should be programmed for "EXTENSION" but NOT "CALLING."

- 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.



Loop Placement for Side Street Through Movements

SIGNAL DESIGN SECTION
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NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

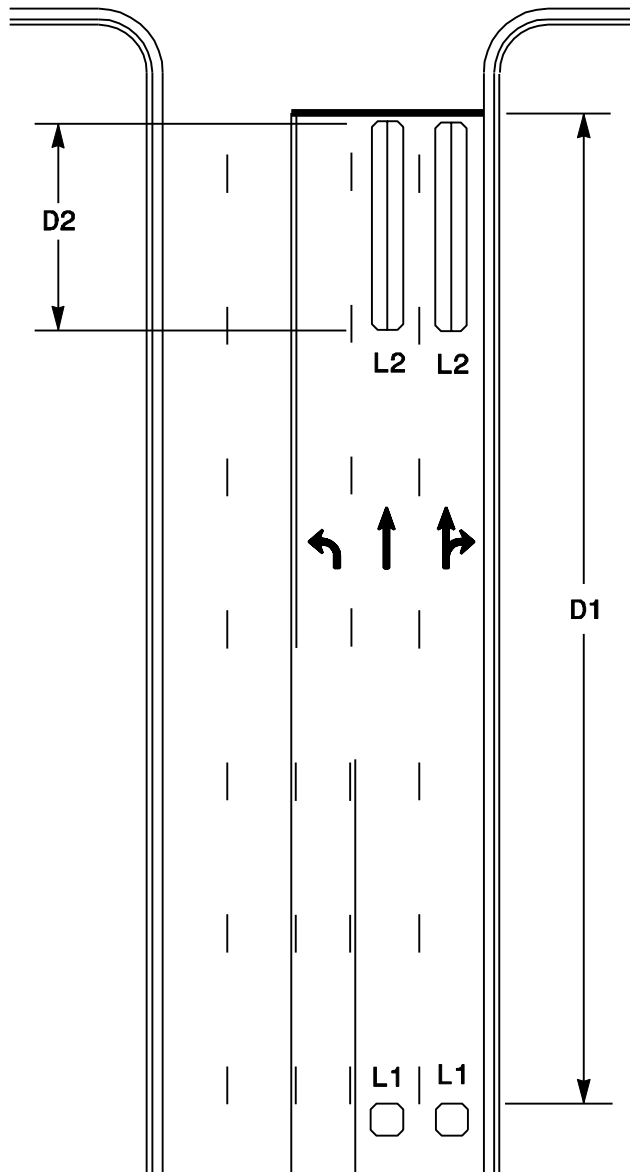
5-05

STD. NO.

4.1.5

SHEET 2 OF 3

Extend (Stretch) Detection



L1 = 6ft X 6ft (1.8m X 1.8m)
Presence loop, Wired in series

L2 = 6ft (1.8m) X D2 Quadrupole loop
Wired to separate detectors/channels

Design Speed mph (km/hr)	D1 ft (m)	D2 ft (m)	Gap Time sec	L1 Extend sec
40 (64)	250 (75)	40 (12)	2.0	3.1
		60 (18)	1.0	2.7
45 (72)	300 (90)	40 (12)	2.0	3.4
		60 (18)	1.0	3.1
50 (80)	355 (110)	40 (12)	2.0	3.8
		60 (18)	1.0	3.5
55 (88)	420 (130)	40 (12)	2.0	4.2
		60 (18)	1.0	3.9

Design Considerations:

- Cross intersection AND
- High speed [≥ 40 mph (64 km/hr)] AND
- Good horizontal and vertical alignment

Notes:

- Loops L1 should be programmed for "EXTENSION" but NOT "CALLING."
- For TS-1 controllers, round Extend time up to nearest 0.25 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 (See Std. 4.1.1:3).
- 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

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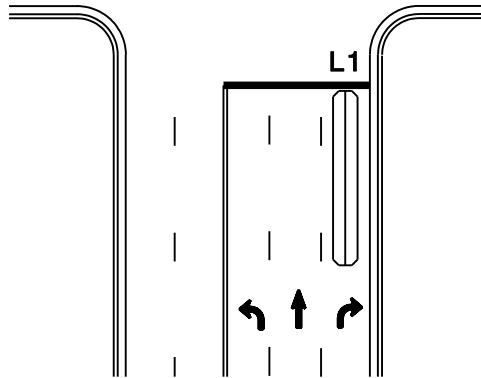
STD. NO.

4.1.5

SHEET 3 OF 3

Typical Detector Layouts

Standard Turn

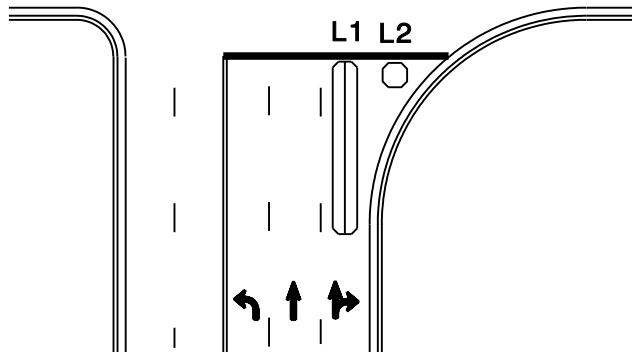


- L1 = 6ft X 40ft (1.8m X 12.0m) Quadrupole loop
- L2 = 6ft X 6ft (1.8m X 1.8m) [Minimum] Presence loop
Wired to separate detector/channel
- L3 = 6ft X 30ft (1.8m X 9.0m) Quadrupole loop

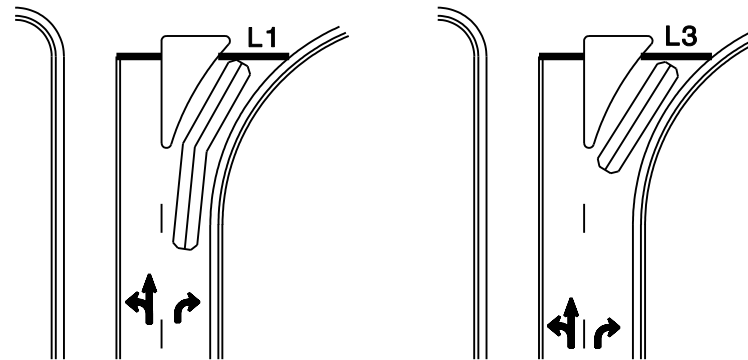
Notes:

- 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



Delete detection for yield condition

Loop Placement for Side Street Right Turns

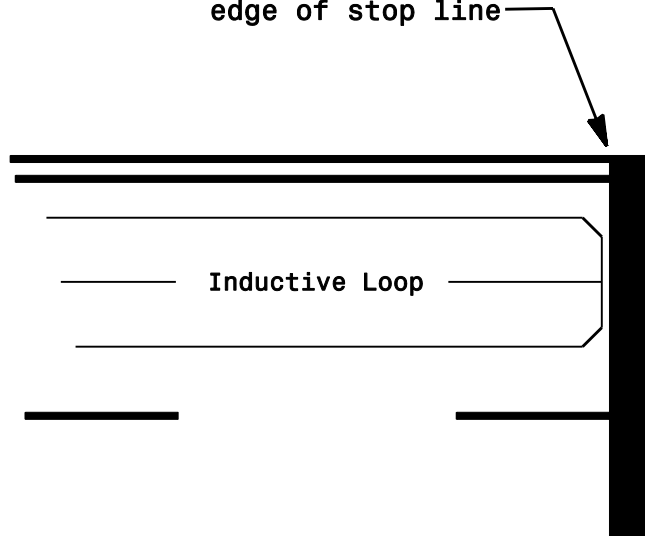
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4.1.6

SHEET 1 OF 1

Locate loop slightly
behind leading
edge of stop line



Note:

Loop may be located in advance of stop line when stop line is greater than 15' (4.5m) from edge of intersecting roadway; or, when loop detects a permissive or protected/permissive left turn.

Placement of Presence Loops

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STD. NO.

4.1.7

SHEET 1 OF 1

Loop Dimension ft (m)	Turns	Inductance μh	Loop Wire ft (m)	Sealant gal * (liter)	Sawcut ft (m)
6 X 6 (1.8 X 1.8)	3	72	72 (22)	0.8 (3)	24 (7)
	4	120	96 (30)		
	5	180	120 (37)		
	6	252	144 (44)		
6 X 15 (1.8 X 4.5)	2	63	84 (26)	1.3 (5)	42 (13)
	3	126	126 (39)		
	4	210	168 (52)		
6 X 25 (1.8 X 7.5)	2-4-2	218	224 (69)	2.7 (10)	87 (27)
6 X 30 (1.8 X 9.0)	2-4-2	258	264 (81)	3.1 (12)	102 (31)
6 X 40 (1.8 X 12.0)	2-4-2	338	344 (105)	4.0 (16)	132 (41)
6 X 50 (1.8 X 15.0)	2-4-2	418	424 (130)	5.0 (19)	162 (50)
6 X 60 (1.8 X 18.0)	2-4-2	498	504 (154)	5.9 (23)	192 (59)

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

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

ENGLISH $L \text{ (ft)} = 6 + (N - 1)12$

METRIC $L \text{ (m)} = 1.8 + (N - 1)3.6$

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:

ENGLISH $S \text{ (gal)} = L \text{ (ft)} / 33$

METRIC $S \text{ (liters)} = L \text{ (m)} / 2.6$

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

Loop Wire and Lead-In Calculations

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TRAFFIC ENGINEERING AND SAFETY SYSTEMS BRANCH
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

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STD. NO.

4.2

SHEET 1 OF 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 μ h/ft (.72 μ h/m)
- The minimum total inductance on a single digital detector (channel) is 50 μ h, the maximum is 1000 μ h.
- The maximum number of turns is 6.
- If the loop (excluding quadrupoles) will have more than 2" (50mm) of cover, add 1 turn to the loop over the normal calculated number of turns.
- Loops connected in series
$$L_{Total} = L_1 + L_2 + \dots + L_N$$

Where: N = Number of loops in series
L = Loop inductance (μ h)
- Recommended number of turns for a single 6' X 6' (1.8m X 1.8m) loop:

Length of Lead-in ft (m)	Number of Turns
< 250 (75)	3
250-375 (75-115)	4
375-525 (115-160)	5
> 525 (160)	6

Loop Wire and Lead-In Calculations

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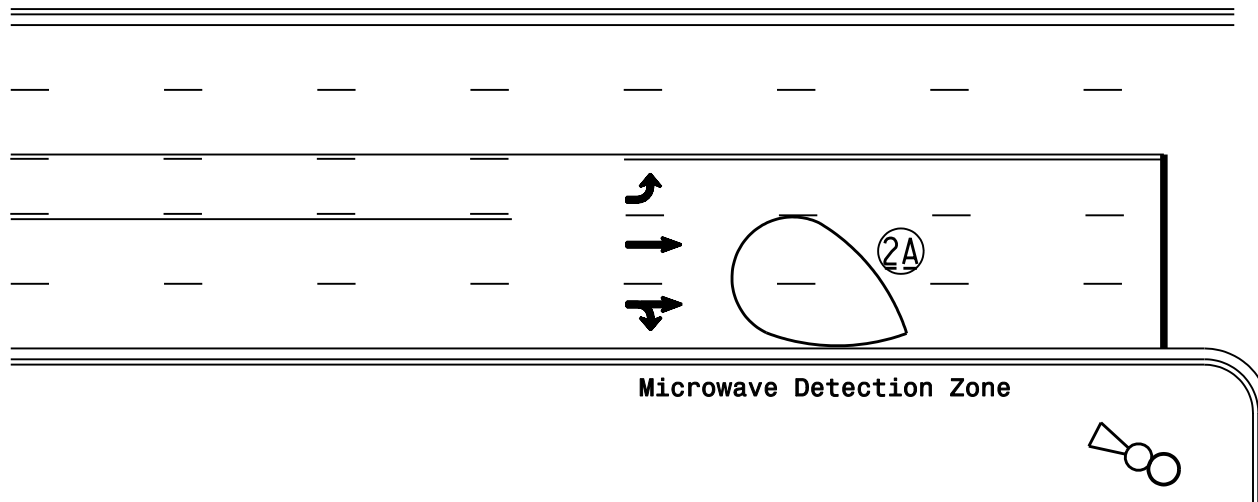
STD. NO.

4.2

SHEET 2 OF 2

5-05

Microwave Vehicle Detector



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.

Notes:

- Requires one microwave detector unit per detection zone.
- Microwave detector needs to face traffic.
- Some microwave detectors have specific detection zone size parameters based on mounting height and distance from zone.
- Cannot be used for system detection or vehicle counting.

2070L LOOP & DETECTOR INSTALLATION												
INDUCTIVE LOOPS					DETECTOR PROGRAMMING							
LOOP	SIZE (FT)	TURNS	DISTANCE FROM STOPBAR (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

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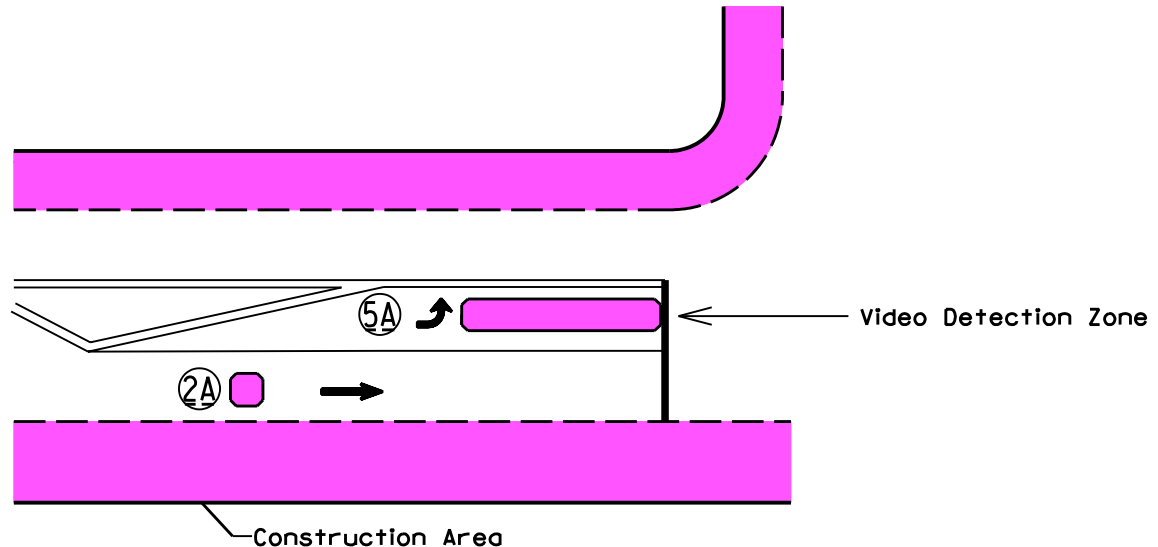
5-05

STD. NO.

4.3

SHEET 1 OF 2

Video Detection Systems (Loop Emulator)



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 constuction phasing
- All other detection options have been exhausted.

Notes:

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

2070L LOOP & DETECTOR INSTALLATION												
INDUCTIVE LOOPS					DETECTOR PROGRAMMING							
LOOP	SIZE (FT)	TURNS	DISTANCE FROM STOPBAR (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	-	-	-	-	*

*Video Detection Zone

Out-of-Street Detection

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STD. NO.

4.3

SHEET 2 OF 2

5-05