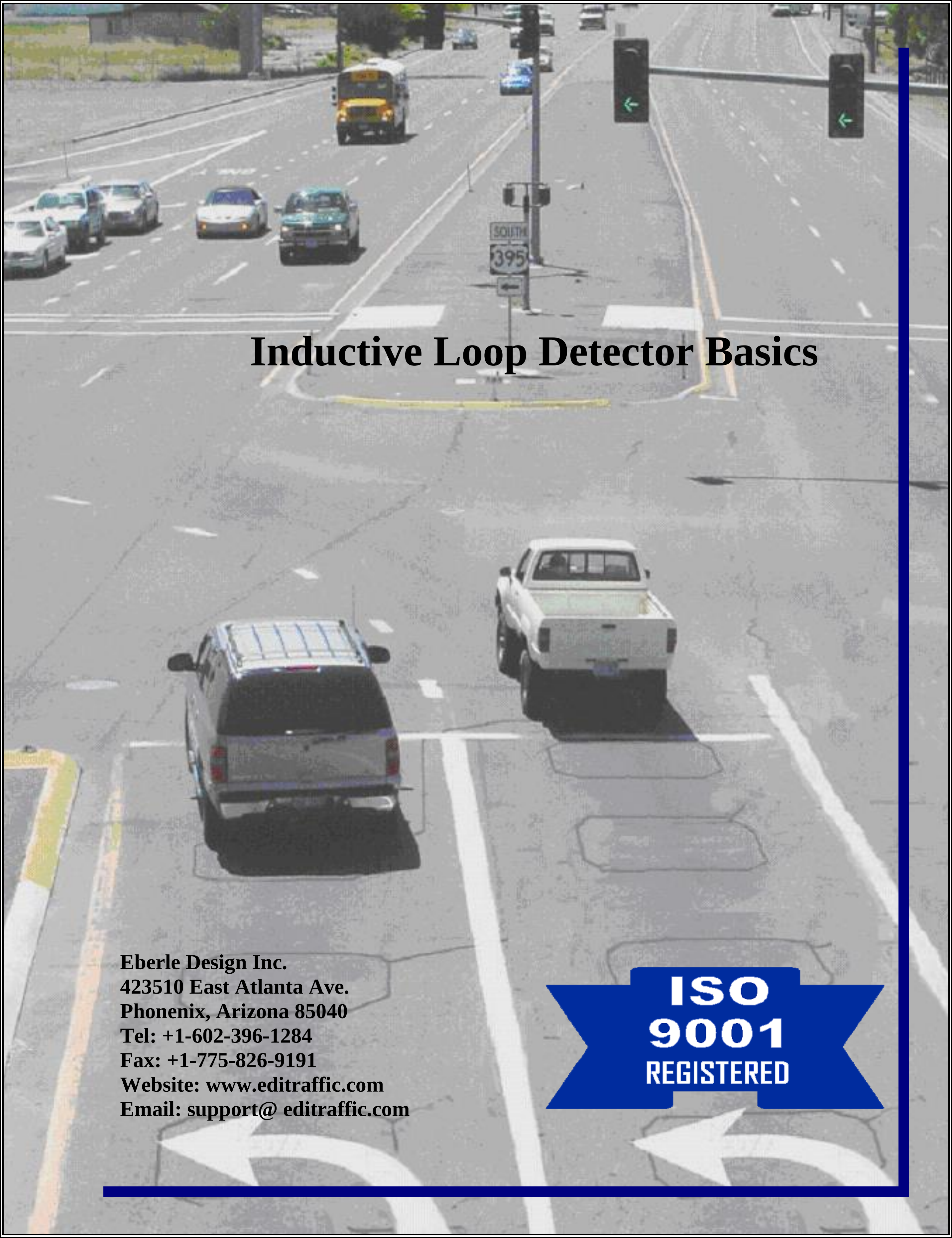

Inductive Loop Detector Basics

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INDUCTIVE LOOP DETECTOR BASICS

TABLE OF CONTENTS

Table of Figures 5
Traffic Detector Systems 6
Inductive Loop Vehicle Detectors 6
Basic Inductive Theory 7
A Few Loop Detector Basics 9
  Canceling the Lead-in Wire's Magnetic Field 9
  Height Considerations 9
Loop Design Considerations 10
Loop Electrical Considerations 11
Multiple Loops 14
Connecting Multiple Loops 14
  Keep the Inductance High 15
  Failure Mode and Full Detection Zone Coverage 15
Smaller-sized Vehicle Considerations 15
Quadrupole™ Loops 16
Loop Behavior 16
  Series Connected Characteristics 17
  Parallel Connected Characteristics 17
Loop Phasing 18
Determining Loop Phasing 18
Loop Installation Techniques 19
Preformed Loops 20
  Saw Slot Installation 21
  Asphalt Overlay 21
  Poured Concrete 22
Detector Module 22
Reno A & E Access Detector Models 23
  Box Type Vehicle Detectors 23
  Card Type Vehicle Detectors 23
Reno A & E Traffic Detector Models 23
  Rack Type Vehicle Detectors 23
  Shelf Type Vehicle Detectors 23
Directional Logic Loop Detectors 24
Automatic Vehicle Identification Systems 25
Frequency Considerations 26
Index 27

TABLE OF FIGURES

FIGURE 1 AN INDUCTIVE LOOP DETECTOR SYSTEM 6
FIGURE 2 A SINGLE ENERGIZED WIRE 7
FIGURE 3 CONCENTRATED MAGNETIC FORCE BY A COIL OF WIRE 7
FIGURE 4 LCR CIRCUIT 8
FIGURE 5 TWO COILS AND A MAGNETIC FIELD 8
FIGURE 6 VEHICLE WITH EDDY CURRENTS 9
FIGURE 7 THE MAGNETIC FIELD AROUND A SQUARE LOOP 9
FIGURE 8 LOOP GEOMETRY 10
FIGURE 9 SERIES LOOP CONFIGURATION 14
FIGURE 10 THE WRONG AND RIGHT QUADRUPOLE™ LOOP INSTALLATION 16
FIGURE 11 MAGNETIC FIELDS AROUND PARALLEL WIRES 16
FIGURE 12 DETECTION CONFIGURATION OF SERIES CONNECTED LOOPS 17
FIGURE 13 DETECTION CONFIGURATION OF PARALLEL CONNECTED LOOPS 17
FIGURE 14 LOOP PHASING 18
FIGURE 15 LOOP PHASING CHART 18
FIGURE 16 LOOP LAYOUT CONFIGURATIONS FOR PAVEMENT 19
FIGURE 17 THE COMPLETED SAW SLOT 20
FIGURE 18 PREFORMED LOOP ASPHALT INSTALLATION 21
FIGURE 19 PREFORMED LOOP CONCRETE INSTALLATION 22
FIGURE 20 DIRECTIONAL LOGIC LOOPS 24
FIGURE 21 MINIMUM RECOMMENDED LOOP SPACING—TRAFFIC 24
FIGURE 22 MAXIMUM RECOMMENDED LOOP SPACING—TRAFFIC/ACCESS 24
FIGURE 23 MINIMUM RECOMMENDED LOOP SPACING—ACCESS/PARKING 25
FIGURE 24 INDUCTIVE LOOP AVI SYSTEM 25
FIGURE 25 PERMANENTLY ATTACHED AVI TRANSMITTER UNIT 26

Traffic Detector Systems

Before the 1920s, traffic control systems were mostly human powered. With whistles and hand signals as their only defense against wayward drivers, traffic police fearlessly stood their ground in the center of busy intersections. As the roadways became more crowded, engineers saw a need to collect traffic data. To these early systems, however, self-preservation ruled while collecting traffic data took a backseat.

Eventually pre-timed traffic control devices replaced humans, all the while, engineers continued to point to the need for collecting traffic data. Some of the early ideas engineers attempted included horn-operated systems, made of boxes mounted on telephone polls; sound detectors, with hollowed out boxes buried in the roadway; pressure sensitive plates and electro-pneumatic systems also buried in the roadway.

The pressure sensitive plates, used for over 30 years, had the longest running success of all these early systems. However, they were expensive to install, plagued with mechanical problems, could only count axles, and were limited to motion detection.

Other systems engineers have tried and continue to work with today include inductive loop, acoustic, video, magnetic, vibration, reflection, and radar detectors.

Inductive Loop Vehicle Detectors

Today's modern traffic control systems must extract the maximum possible use out of our roadways. Roadway systems that, daily, continue to grow more crowded. In order for a controller to respond to the needs of traffic, it needs to detect traffic conditions at all times. This has resulted in a large amount of research and development, and this research and development has resulted in major advances in vehicle detection. Of all the vehicle detection systems studied, and currently in use, the inductive loop method is the most popular. This popularity is the result of performance, reliability, and cost.

Two elements make up the inductive loop detector system: the inductive loop coil with lead-in cable and the electronic module. The loop (buried in the pavement) and its lead-in cable form the sensing portion of the system. The loop's size and shape (geometry) defines the detection zone characteristics. An electronic module, connected to the loop, recognizes the presence of a vehicle in the detection zone. Once the module senses a vehicle, it processes the data according to its programming. The data ca be acted upon immediately (as in the case of traffic lights, gates, etc.), it can accumulate in the detector for later analysis, or the data can become a minor input to a major system.

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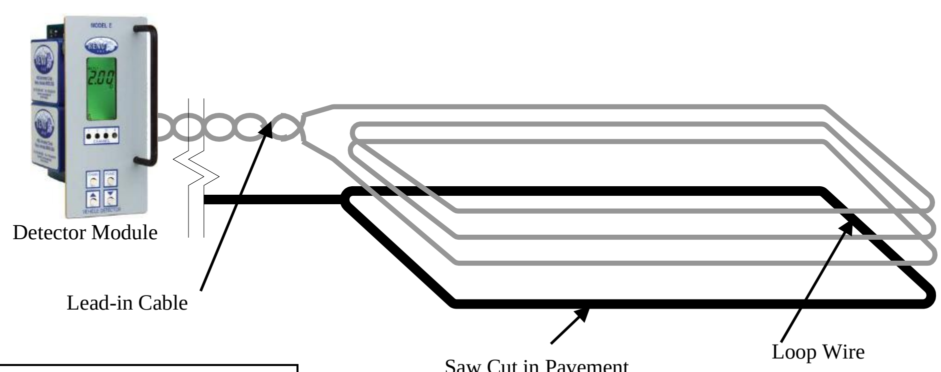


Figure 1 An Inductive Loop Detector System

Basic Inductive Theory

When electric current flows through a conductor a magnetic field forms around the conductor. Remove the current and the magnetic field collapses while trying to maintain the current flow. The property of an electric circuit that opposes this change, that tries to maintain the current flow, is called inductance.

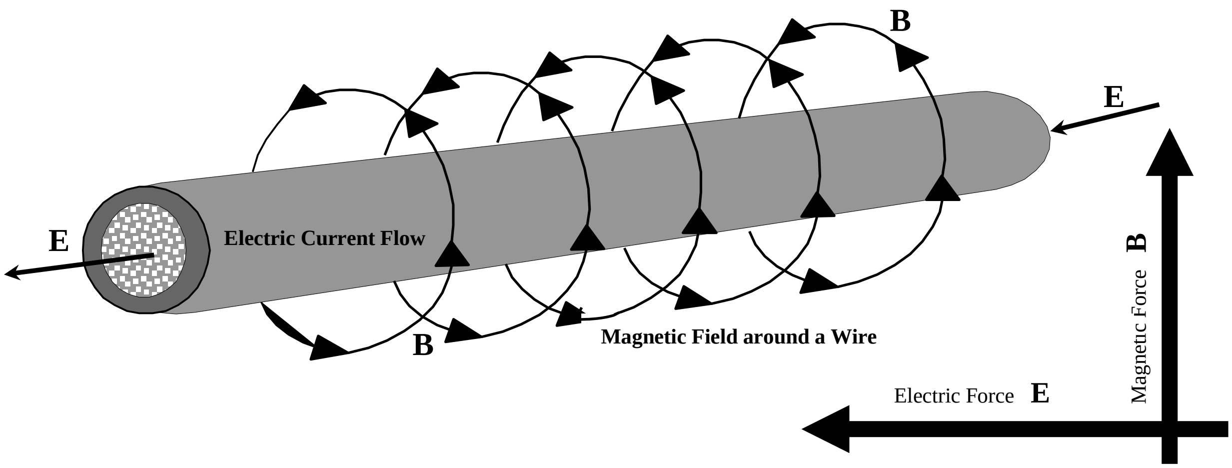


Figure 2 A Single Energized Wire

While the magnetic field associated with a single energized wire is weak, winding that wire into a coil concentrates the magnetic field creating mutual inductance between the turns and intensifying the magnetic fields around the wires. Generators, transformers, solenoids, etc. work because of magnetic fields concentrated by coils of wire that increase the inductance of the circuit.

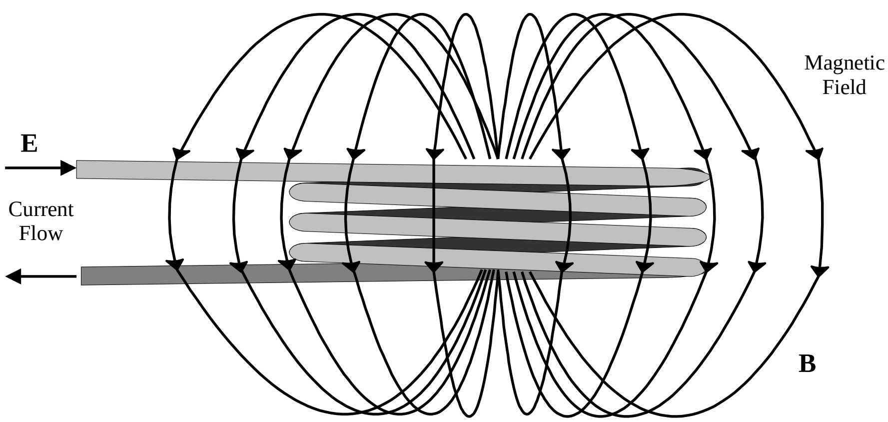


Figure 3 Concentrated Magnetic Force by a Coil of Wire

Add a capacitor in parallel with the inductor (in this case a coil) and we create a parallel LC circuit. We often call this a tank circuit because it can store energy much like water is stored in a tank. When applying energy to the circuit, it is alternately stored in the capacitor and inductor producing a continuous AC wave that oscillates at a resonant frequency. We define the resonant frequency as:

$$\mathbf{f} = \frac{1}{2\pi\sqrt{\mathbf{LC}}}$$

Where: f = frequency (hertz)
L = inductance (henries)
C = capacitance (farads)

The significance of this formula is that when **L** (inductance) or **C** (capacitance) changes, **f** (frequency) will change. If **L** or **C** decreases, then **f** will increase. It is important to understand these variables since digital loop detectors monitor the frequency (or a component) to determine if a change has occurred.

The electrical components of a loop are:

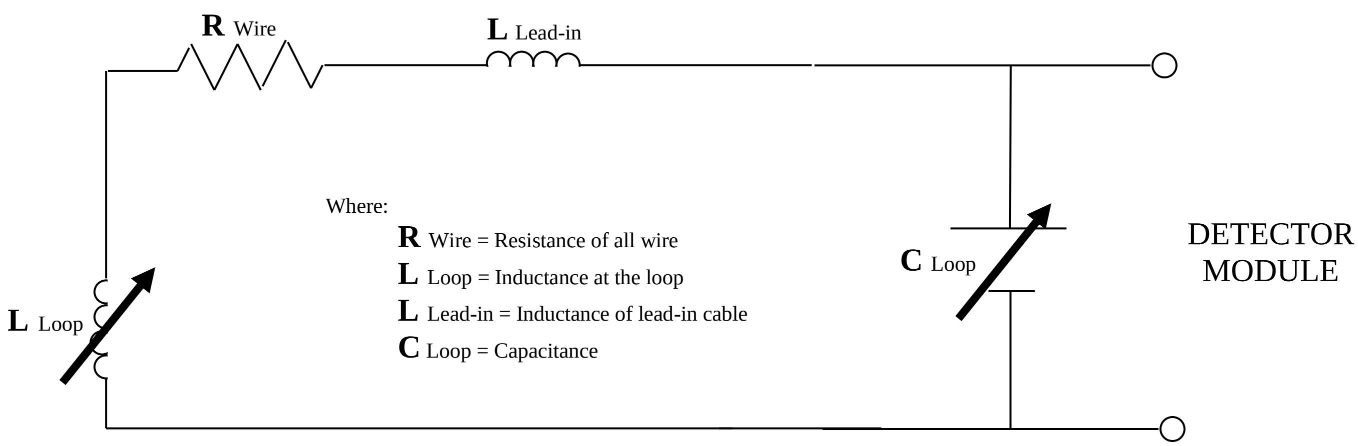


Figure 4 LCR Circuit

The wire's resistance and the lead-in cable's inductance are fixed and should never change. Note: Crimp connections, bad splices, and poor splice seals often cause these values to change.

The inductance of the loop is variable and is where the maximum amount of change should occur when a vehicle enters the detection zone.

Introducing a second coil (secondary winding) into the magnetic fields of the first coil (primary winding) and we create a transformer. The secondary coil couples with the magnetic field from the primary coil and induces a current into the secondary coil. If the secondary coil is open, there is no path for the current flow and the magnetic field does not change. Short the secondary coil and current will flow in the wire. This will result in us seeing some of the magnetic fields of the primary coil induced into the secondary coil, and this will reduce the inductance of the primary coil. Likewise, an increase in the frequency of a stable primary circuit can be an indication that the turns within the loop have shorted.

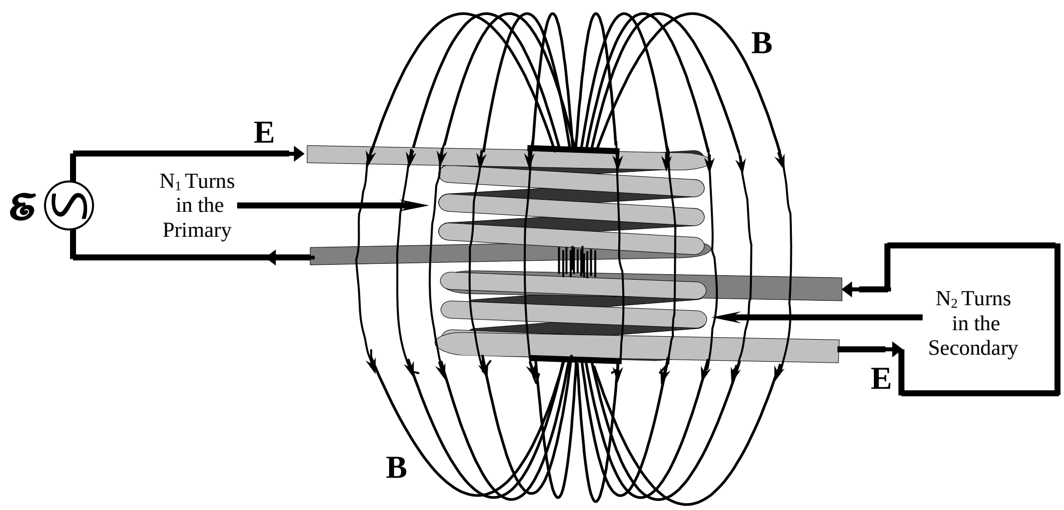


Figure 5 Two Coils and a Magnetic Field

This is how the inductive loop detector system works. The loop in the roadway is part of an isolated secondary circuit. The detector applies an excitation voltage that results in the loop oscillating at a resonant frequency. The current flow in the loop wire creates a magnetic field around the loop wire. Introduce a metallic mass, such as a vehicle, into the loop's magnetic field and the magnetic field will induce eddy currents in the vehicle's surface metal. This reduces the loop's inductance because of the loading effect. The decreased loop inductance causes the resonant frequency to increase. The detector module monitors the resonant frequency (or a component) for any changes, and when changes are detected the detector responds according to its programming.

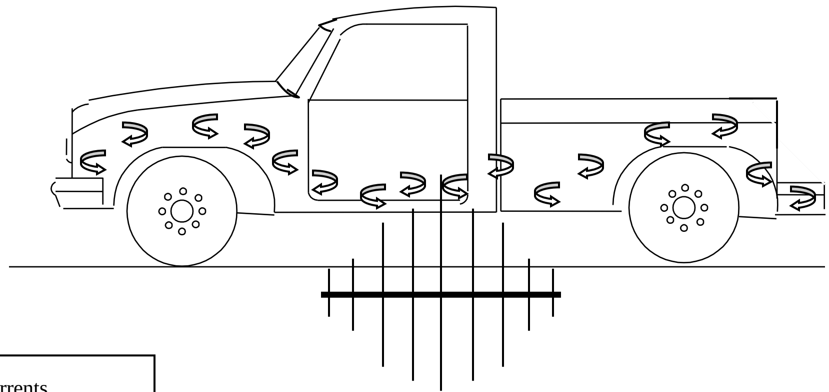


Figure 6 Vehicle with Eddy Currents

A Few Loop Detector Basics

Connecting the loop to the detector module and applying power creates magnetic fields around the loop wires. In a square loop configuration, the magnetic field has more intensity in the middle of a side than at the corners. Other geometries create other effects.

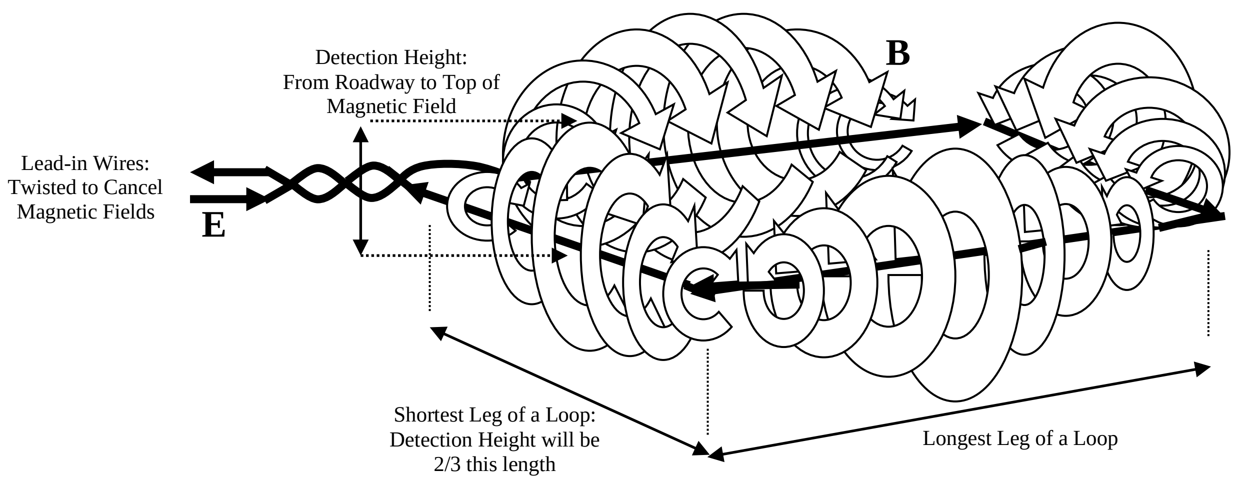


Figure 7 The Magnetic Field Around a Square Loop

Canceling the Lead-in Wire's Magnetic Field

The magnetic fields expand and collapse at an operating frequency of 20 to 100 kHz. At any moment the current flow in the lead-in wires, coming off the loop, are of opposite polarity or 180º out of phase. Therefore, the wire's magnetic fields are also opposite—180º out of phase. The closer we bring these wires together the more the magnetic fields will cancel each other out. Hold the wires together or twist them and the magnetic fields cancel completely. To limit interference from the lead-in wires, the pair of wires directly from the loop should be twisted five or six times per foot. In most cases, a cable with wires already twisted runs from the edge of the pavement to the detector itself, so that the only place we need to be concerned with is from the loop to the lead-in cable.

Height Considerations

The current in the opposite legs (sides) of the loop are also 180º out of phase. The closer the legs are brought together, (the smaller the loop) the more the magnetic fields cancel causing the detection height to be reduced. The standard height rule states that the reliable detection height of a loop is two-thirds that of the shortest leg of the loop. Therefore, the reliable detection height of a 6′ by 6′ loop or a 6′ by 30′ loop is 4 feet (2/3 x 6). Reduce the loop size to a 3′ by 6′ loop or a 3′ by 20′ loop and the reliable detection height becomes 2 feet (2/3 x 3). We use small loops in parking applications because we need to only detect the wheels of the vehicle. These loops are as small as 2′ x 4′ with an effective detection height of 1.33 ft. (2/3 x 2). Conversely, the shortest legs of access control and traffic control loops are 6 ft. giving us a resulting detection height of 4 ft. to ensure the detection of trucks and other high-bodied vehicles.

Loop Design Considerations

Over the years, engineers have tried various loop geometry configurations to find the best for vehicle detection. The crude electronics of early loop detector technology limited these choices. Technological advances have removed many limitations and created a need to reevaluate the loop geometry standards. When selecting a loop's geometry, consider the following parameters:

1. Adjacent lanes: An inductive loop can be designed to detect vehicles in a precise area. Vehicles moving close to the detection zone can adversely effect the operation of the control system.
2. The detection zone area: The data required by the control system determines this parameter. Inductive loop configurations can be selected to provide data for presence in exact or large areas, counts, passage, speed, direction, queue, etc.
3. The types of vehicles to be detected: Motorcycles and high bed trucks can be difficult to detect in many loop configurations. The loop design can be optimized to provide detection of all vehicles licensed to operate on public roads.
4. The distance between the loop and the electronic module: Lead-in cable is a loss to the efficiency of an inductive loop circuit. Give special consideration to lead-in lengths that are greater than four hundred feet whenever designing a detection zone.

Today, we have many loop geometry choices. The following configurations are in widespread use:

1. Single small loops (1.4 ft. by 5 ft. to 6 ft. by 6 ft.)
2. Round loops (6 ft. in diameter)
3. Multiple small loops (typically two or more 6 ft. by 6 ft. loops)
4. Long rectangular loops (6 ft. by 20 ft. to 6 ft. by 100 ft.)
5. Long rectangular loops with a header (6 ft. by 100 ft. with a 6 ft. by 6 ft. header)
6. Quadrupole™ loops
7. Large Loops (25 ft. by 75 ft., for aircraft applications—not shown below)

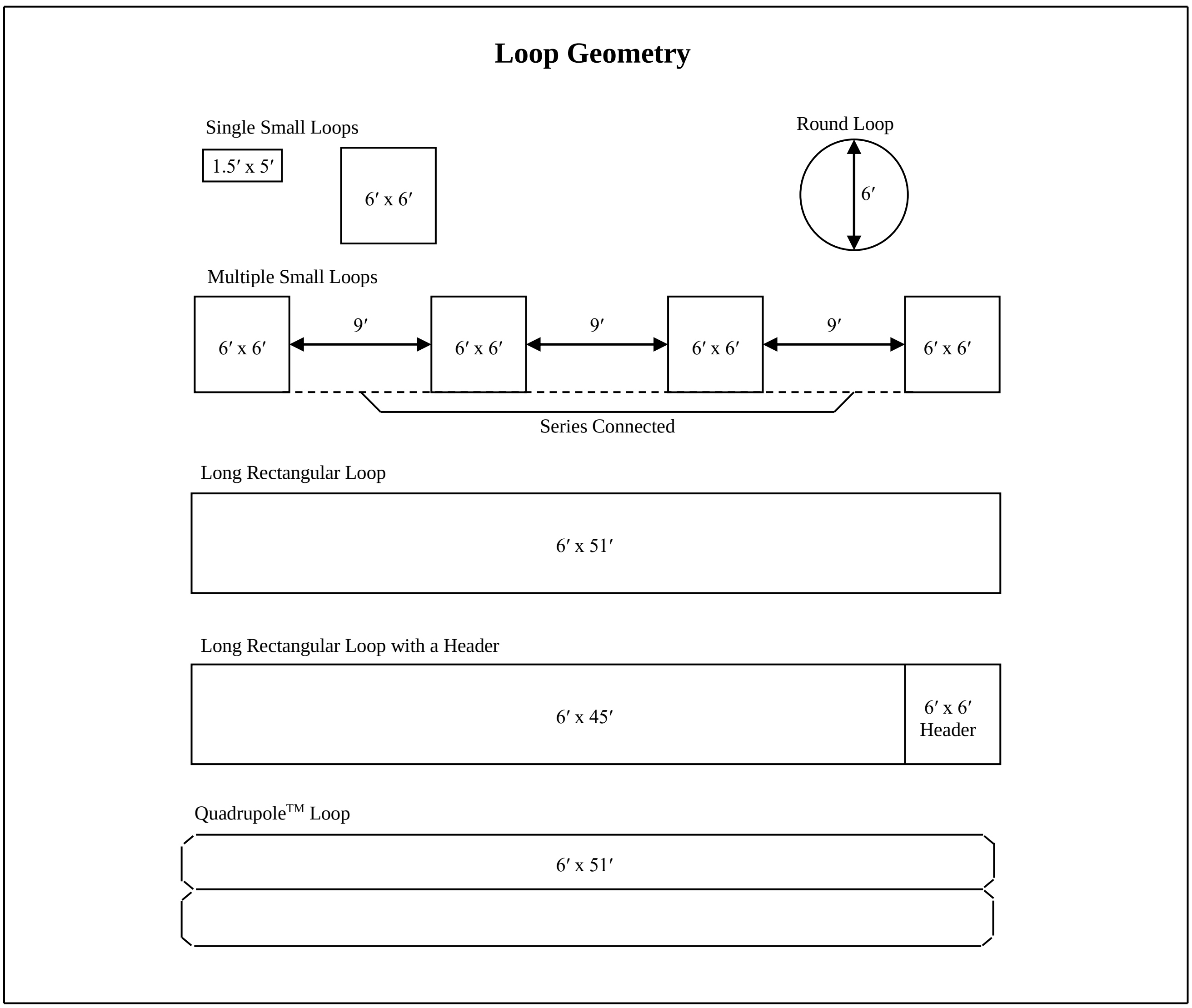


Figure 8 Loop Geometry

Engineers use loops in traffic control to obtain two main types of detection data: presence or passage. The presence of a vehicle in a zone or lane requires loops with large areas. To determine the passage of a vehicle over a specific point, use a single small loop. The 6 ft. by 6 ft. loop is a standard for collecting vehicle count and occupancy data for intersection control and freeway operations. However, each loop's geometry has advantages and disadvantages.

1. Single small loops provide excellent detection for small zones. Use small loops where you need to detect motorcycles, automobiles, and small trucks for access control. Also, use this size loop for counting in parking lot applications. This size loop works well for common vehicles; however, small loops are not good for detecting high bed vehicles since the field height is very low.

2. Round loops are fairly recent and have several advantages over similar sized square loops. Once instillation equipment is acquired, cost and ease of installing are major advantages. The fewer corners and straight cuts into the asphalt, some believe, help to increase the life of the asphalt in the area around the loop. The major drawback to round loops is when they are used in adjacent lanes. Our measurements have shown that the round loop is more susceptible to crosstalk than a similar sized square loop.

3. Multiple small loops can increase the zone area. The advantage is good sensitivity for both small vehicles and high bed vehicles. Four, 6 ft. by 6 ft. loops, spaced 9 ft. apart and wired in series give a zone capability of 51 ft. This configuration is well suited for 12 ft. lane widths. Another advantage is that, when we bring the leads from the four loops individually to the pull box for connection, we obtain maximum flexibility. Consequently, we can install multiple detectors at a future date to meet changes in the system requirements. We can change loop phasing easily, and we can disconnect any one of the four loops if a loop becomes damaged. The one disadvantage to this configuration is that a motorcycle will create multiple outputs. The system will drop the motorcycle call between each of the loops. Also, some additional labor is required to install this configuration.

4. Long loops, such as 5 ft. to 6 ft. wide with lengths greater than 20 ft., provide for a long detection zone. To detect all types of vehicles with this type of loop, the sensitivity at the detector must be set high enough to recognize the small changes associated with small vehicles such as motorcycles. With the sophisticated loop detectors on the market today, the sensitivity can be set high enough to detect a small change like that of a motorcycle in this long loop size. However, the downside to monitoring such a small change is that the loop becomes susceptible to the influence of vehicles in adjacent lanes, crosstalk of adjacent loops, detection of nearby gates and, therefore, unwanted detection can occur. This type of loop was common in the past but we do not recommend long loops for today's applications.

5. Long rectangular loops with headers were often used when both a long detection zone and motorcycle detection were required. This configuration resulted from the low sensitivity of early analog detectors. An important note, this configuration will never be able to detect motorcycles in the long area (tail section) without detecting traffic in adjacent lanes. Reno A & E does not recommend this geometry for replacement or for new design.

6. Quadrupole™ loops can best be thought of as two conventional loops sharing a common saw cut while wired in a series configuration. The detection characteristics of this loop are that of two narrow rectangular loops, an advantage when detecting motorcycles. The wheels of the motorcycle will have a greater probability of being close to one of the wires of the loop. The detection height of this type of loop is about half that of a simple rectangular loop of comparable size. The disadvantages are its poor detection characteristics for high bed vehicles and the additional labor required for installation.

7. Large loops, 25 by 75 feet, are used to detect very large and high objects. With a field height of 2/3 the length of the shortest leg, this size loop has a field height of approximately 16 feet. Airports use these large size loops to detect aircraft.

When designing a loop geometry, consider the percentage of the loop area that a single vehicle will cover. As this percentage decreases (i.e., the loop area increases), the ability to avoid traffic noise in the adjacent lanes also decreases.

Loop Electrical Considerations

After selecting the loop geometry, the next step is to determine the proper number of turns. The geometry defines the detection zone while the number of turns in the loop determines the inductance value of the loop. It is critical to note, the lead-in cable's inductance is also a part of the total input inductance and must be determined. The lead-in cable's inductance should be lesser than or equal to the loop's inductance. By maintaining this minimum ratio, the electronic module will always see at least 50% of the inductance change caused by the vehicle. If the loop inductance is less than the lead-in cable inductance, the detector will see only a small percentage of the signal caused by the vehicle. To compensate for the cable loss, the detector sensitivity will have to be increased, with the system losing some of its ability to reject drift. **Remember that decreasing the loop inductance decreases the system stability.** The difference between a properly designed loop and a marginal loop is the difference between proper operation and false calls.

Let us now examine the methods of estimating the loop's inductance. As we stated previously, the lead-in cable's inductance is a part of the total input inductance and, therefore, must be determined. Record the lead-in cable's length. Lead-in cable normally has an inductance of approximately 0.22 microhenries (μH) per foot. To obtain the total inductance of the cable, use the following formula:

L_T = (Length of lead-in cable) x (Unit inductance) **(EQUATION 1)**

Where: L_T = Total lead-in inductance

Using the example of a 300-foot lead-in cable, we can calculate the total inductance as: (300 ft.) x (0.22 μH/ft.) = 66 μH.

Having estimated the lead-in cable's inductance, we now have a reference point from which to determine the proper number of turns for the loop. We will explore methods of estimating the inductance of the following configurations of loops:

1. Conventional single loops
2. Loops connected in series
3. Loops connected in parallel (described here but *not recommended*)
4. Quadrupole™ loops

Use the following formulas to estimate loop inductance:

1. Conventional single loops:

$$L = \frac{P}{4}(N^2 + N)$$ **(EQUATION 2)**

Where: L = Loop inductance (μH)
P = Perimeter (ft)
N = Number of turns

2. Loops connected in series:

$$L_{Total} = L_1 + L_2 + \ldots + L_N$$ **(EQUATION 3)**

Where: L_N = the Inductance of the highest numbered loop involved.

3. Loops in parallel (*Do not use for new or replacement design*):

$$\frac{1}{L_{Total}} = \frac{1}{L_1} + \frac{1}{L_2} + \cdots + \frac{1}{L_N}$$ **(EQUATION 4)**

or

$$L_{TOTAL} = 1 / [(1 / L_1) + (1 / L_2) + \cdots + (1 / L_N)]$$

Where: L_N = the Inductance of the highest numbered loop involved.

4. Quadrupole™ loops:

L = (O.P.)(K) + (C.L.)(K) **(EQUATION 5)**

Where: L = Loop inductance (μH)
O.P. = Outer perimeter (ft)
C.L. = Center leg (ft)
K = Constant, dependent on number of turns = $(N^2 + N)/4$
N = Number of turns

N	K
1	0.5
2	1.5
3	3.0
4	5.0
5	7.5
6	10.5
7	14.0

Note: The number of turns in the center leg (C.L.) is always twice the number of turns in the outer perimeter (O.P.).

With the calculations acquired to this point, we can now estimate the change that the detector module will see when a vehicle enters the loop field. Use the following formula:

$$\Delta L2 = \Delta L1 \times \left[\frac{\text{Loop Inductance}}{\text{(Loop Inductance) + (Lead-in Cable Inductance)}}\right]$$ **(EQUATION 6)**

When using conventional rectangular or square loops, the following list provides a practical guideline for the number of turns versus loop area. When connecting multiple loops in series, the number of turns per loop may be reduced.

Loop Area (length x width)	Number of Turns
6 – 12 sq. ft.	6
12 – 20 sq. ft.	5
20 – 60 sq. ft.	4
60 – 240 sq. ft.	3
240 – up sq. ft.	2

If using a single loop (e.g., 6 ft. x 6 ft.) with a long lead-in cable (500 ft. or greater), we advise adding one or more additional turns to the loop. The additional turns increase the ratio of the loop inductance to the cable inductance, thereby, improving loop sensitivity and overall system stability.

Using the foregoing formulas, we can now evaluate various loop sizes and configurations and determine the relative efficiency of each. In the following examples, we will assume a lead-in cable with a length of 300 feet. As we saw previously, the lead-in cable's approximate inductance is 66 µH (Eq. 1). In the first three examples, each 6 ft. x 6 ft. loop consists of three turns of wire with a total inductance of approximately 72 µH per loop (Eq. 2).

EXAMPLE 1 – (Four, 3-turn, 6′ x 6′ loops in series)

Loop Inductance = 72 µH + 72 µH + 72 µH + 72 µH = 288 µH (Equation 3)

Total inductance = 288 µH + 66 µH = 354 µH (Loop wire and Lead-in cable)

Efficiency = signal seen by detector = 288/354 x 100 = 81% (Equation 6)

EXAMPLE 2 – (Four, 3-turn, 6′ x 6′ loops in series/parallel)

Loop inductance = (144 µH)/2 = 72 µH (Equation 3 and Equation 4)

Total inductance = 72 µH + 66 µH = 138 µH (Loop wire and Lead-in cable)

Efficiency = signal seen by detector = 72/138 x 100 = 52% (Equation. 6)

EXAMPLE 3 – (Four, 3-turn, 6′ x 6′ loops in parallel)

Loop inductance = (72 µH)/4 = 18 µH (Equation 4)

Total inductance = 18 µH + 66 µH = 84 µH (Loop wire and Lead-in cable)

Efficiency = signal seen by detector = 18/84 x 100 = 21% (Equation 6)

In the following examples, each loop consists of four turns of wire with an inductance of approximately 120 µH. (Eq. 2)

EXAMPLE 4 – (Four, 4-turn, 6′ x 6′ loops in series)

Loop inductance = 120 µH + 120 µH + 120 µH + 120 µH = 480 µH (Equation 3)

Total inductance = 480 µH + 66 µH = 546 µH (Loop wire and Lead-in cable)

Efficiency = signal seen by detector = 480/546 x 100 = 87.9% (Equation 6)

EXAMPLE 5 – (Four, 4-turn, 6′ x 6′ loops in series/parallel)

Loop inductance = (240 µH)/2 = 120 µH (Equation 3 and Equation 4)

Total inductance = 120 µH + 66 µH = 186 µH (Loop wire and Lead-in cable)

Efficiency = signal seen by detector = 120/186 x 100 = 64.5% (Equation 6)

EXAMPLE 6 – (Four, 4-turn, 6′ x 6′ loops in parallel)

Loop inductance = (120 µH)/4 = 30 µH (Equation 4)

Total inductance = 30 µH + 66 µH = 96 µH (Loop wire and Lead-in cable)

Efficiency = signal seen by detector = 30/96 x 100 = 31% (Equation 6)

From these examples, it becomes obvious that, with any given loop/lead-in combination, the lead-in reduces an inductance change in the loop, so that the change seen by the detector is only a percentage of the loop change. To illustrate this, let us consider a vehicle with a mass that causes a 2% change in inductance when it enters the field of a single, 3-turn, 6′ x 6′ loop (72 µH) connected to 300 feet of lead-in cable (66 µH). Using Equation 6 (72 µH/138 µH), we find that the detector sees only 52% of the change on the loop, a change of approximately 1% (0.02 x .52). It is important to note here that in order to detect any given vehicle, the detector module's threshold (or sensitivity) must be equal to or greater than the inductance change at the cabinet.

Connecting four similar loops in series causes the total loop inductance to increase by 400% (288 µH). This increase in loop inductance increases the efficiency to 81% (refer to example 1). The loop area also increases by 400%, thus, reducing the change in loop inductance created by the same vehicle to 25% of that of a single loop. The loop inductance now changes by only 0.5%, but, because of greater efficiency (81%), this change causes a 0.4% (0.005 x 0.81) change at the detector. If connected in parallel (example 3), the loops would cause only a 0.1% (0.005 x .21) change at the cabinet. With the output from the latter case, the detector's threshold (or sensitivity) would need to be increased four times to provide the same detection capability provided in the first case. It should now be obvious that **when multiple loops are used, they should always be connected in series for maximum efficiency** and therefore, greater reliability.

In conclusion, observe three very important factors when designing loops:

1. Correct loop geometry is essential.
2. Loop inductance should be equal to or greater than the lead-in cable inductance.
3. Always connect multiple loops in series.

Multiple Loops

A detector monitors the amount of inductance change. The amount of inductance change is directly proportional to the amount of the loop area that a vehicle affects. Therefore, keeping a loop area small allows a vehicle to make the greatest amount of change in the monitored inductance. So, to cover a large area, use multiple loops on a single loop detector channel. Also, consider using multiple loops to decrease loop area size and for coverage along large gates.

A typical layout in many traffic signal applications is a large detection area for left turn lanes. Consider a desired detection area of 6′ x 51′. If four 6′ x 6′ loops with 9-foot spacing are used (6′ + 9′ + 6′ + 9′ + 6′ + 9′ + 6′ = 51′), the total loop area is less than half that of the single large loop, yet the total detection area is the same ($6^{2\prime} + 6^{2\prime} + 6^{2\prime} + 6^{2\prime}$ = 144 sq. ft. versus 6′ x 51′ = 306 sq. ft.).

In gate applications, we decrease the total loop area with multiple loops. Spacing between these loops is typically much less than the previous example. Vehicles drive perpendicular to the loop (through 2′ of a 2′ x 4′ loop, for example, rather than through 51 feet of a 6′ x 51′ loop) and the loops must be spaced closer together to avoid missing vehicles.

Remember, when connecting more than one loop to a single detector that the loops must be identical and have the same inductance. They must be the same size and shape, and contain the same number of turns to ensure that all the loops have a consistent level of detection sensitivity.

Connecting Multiple Loops

Multiple inductive loops can be connected to one detector channel in series, parallel, or a combination of series and parallel. However, Reno A & E recommends that multiple loops connected to a single detector channel always be wired in series as shown below:

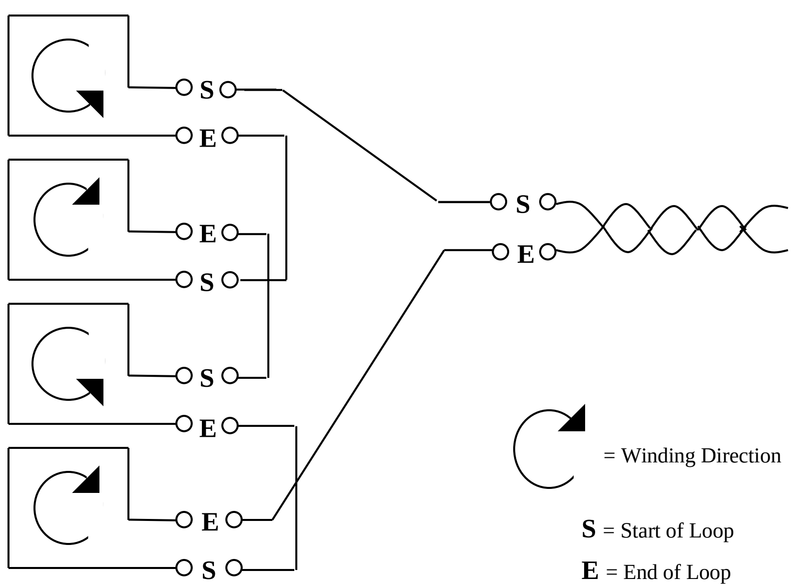


Figure 9 Series Loop Configuration

There are several reasons why Reno A & E recommends series connections:

Keep the Inductance High

The total inductance of multiple loops wired together in series is the sum of the individual loop inductances:

$L_{TOTAL} = L_1 + L_2 + L_3 + L_4 + \ldots + L_N$

The total inductance of multiple loops wired together in parallel is the reciprocal of the sum of the reciprocals of the individual loop inductances:

$L_{TOTAL} = 1 / [(1 / L_1) + (1 / L_2) + (1 / L_3) + (1 / L_4) + \ldots + (1 / L_N)]$

Inductive loop detectors typically tune to inductance values between 20 microhenries (µH) and 1000 µH or between 20 µH and 2500 µH depending on the type of detector. In order to ensure stable detector operation, the loop/lead-in network's total inductance should be greater than 50 µH. Now, let us consider connecting four 72 µH loops together in series; the total inductance will be 288 µH (72 + 72 + 72 + 72). Next, if we connect the four loops in series/parallel, we find the total inductance will be 72 µH (1 / [(1/72) + (1/72)]) + (1 / [(1/72) + (1/72)]). Finally, consider connecting the same four loops in parallel and the total inductance will be only 18 µH (1/[(1/72) + (1/72) + (1/72) + (1/72)]).

As we mentioned earlier, the lead-in cable's inductance will need to be less than or equal to the loop's inductance. Consequently, we can safely use a lead-in cable of over 1200 ft. (1200′ x .22 µH = 264 µH) for the series connected loops. The series/parallel connected loops lead-in cable will need to be limited to 300 ft (300′ x .22 µH = 66 µH). Moreover, the parallel connected loops lead-in inductance will need to be limited to 80 ft. (80′ x .22 µH = 17.6 µH) and even this combination will not be greater than the loop/lead-in network minimum of 50 µH.

Failure Mode and Full Detection Zone Coverage

Reno A & E's detectors have diagnostic capabilities that enable the detector to monitor loop inputs, to check for excessive inductance change in the loop/lead-in network, and to check for open or shorted loops. This monitoring function occurs when using a single loop or when using multiple loops connected together on a loop detector channel.

If multiple loops connected in series experience an open loop failure of one of the loops, then this will result in an open loop diagnostic failure. The detector will operate in the appropriate failure mode. When multiple loops connected in series experience a failure because of an open loop condition, the detector will remain in the failure mode until a technician corrects the loop failure.

If the loop system consists of loops connected in either a parallel or a series/parallel configuration, then an open loop failure of one of the loops will cause the detector to operate in the appropriate failure mode. The system will do this because of an excessive change in the total inductance seen by the detector. Once again, the detector will operate in the appropriate failure mode. However, the initial response when troubleshooting this type of problem is to reset the detector. A reset will cause the detector to ignore the open circuit condition caused by the individual loop failure. The detector will then resume operation by tuning to the other loops within the configuration. The detector will operate normally based on inputs from the remaining intact loops. Yet, the loop with the open will compromise full coverage of the detection zone.

In conclusion, the benefits of connecting loops in series far outweigh any perceived benefits of any other connection configuration. Series connected loops are the only connection configuration a technician needs to be concerned with, allows more flexibility with regard to lead-in cable, and is easier to maintain and troubleshoot.

Smaller-sized Vehicle Considerations

The amount of change caused by a vehicle passing over a small portion of a large loop is considerably less than the change it would cause if it were passing over a smaller sized loop. To design a stable system, make certain that the loop detector sees the greatest amount of change due to a vehicle entering the loop detection area.

To explain this further, the following chart shows the amount of inductance change seen by an inductive loop detector when a motorcycle enters the detection zone of a four, 6 ft. x 6 ft., loop system (connected in series).

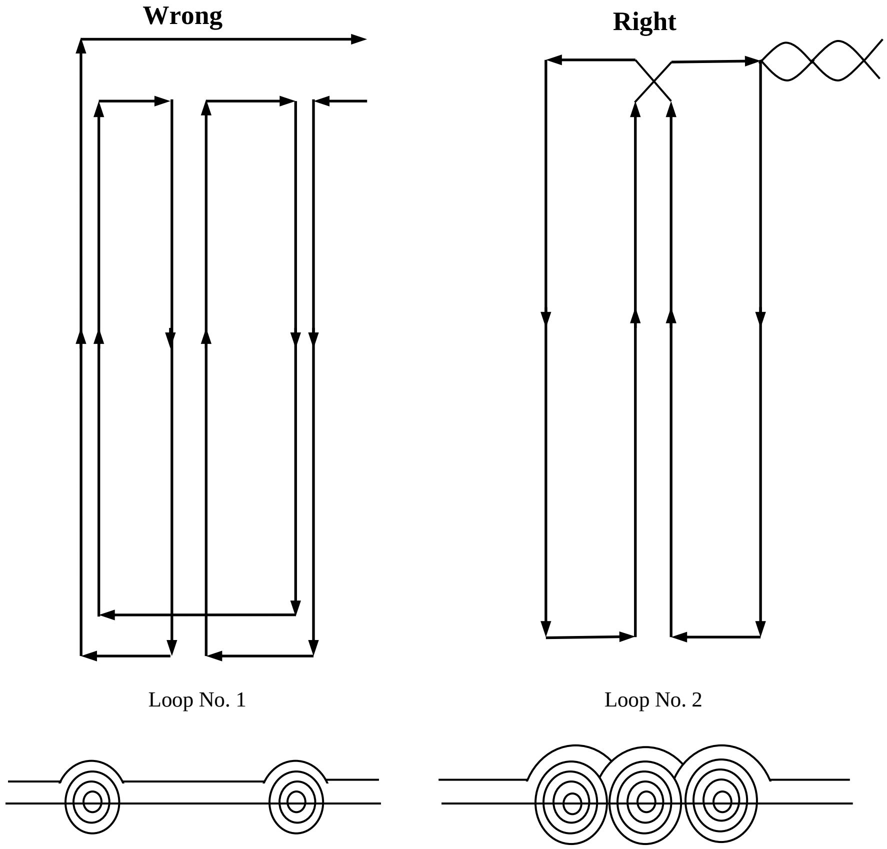
Number of 6 x 6 Foot Loops	Percentage of Inductance Change
1	0.1%
2	0.05%
3	0.033%
4	0.025%

A large 6′ x 51′ loop will detect motorcycles. However, because a motorcycle typically causes a 0.012% inductance change on this size loop, the detector's sensitivity must be set one sensitivity setting higher to detect. Setting a detector's sensitivity level this high creates the potential for detecting adjacent lane traffic.

Quadrupole™ Loops

The Quadrupole™ is a common type of loop. The Quadrupole™ is actually two loops closely coupled by sharing a common slot. This configuration is excellent for detecting motorcycles and bicycles, since, in a Quadrupole™ loop, a wheel has a greater chance of being closer to a wire than in a conventional rectangular loop of the same outer size. This assumes, of course, that the Quadrupole™ is wound with the proper rotation in the center slot to provide attracting fields. **If the Quadrupole™ loop is wound incorrectly (see Figure 10), the center will completely cancel out and, consequently, there will be no detection. This is important!** In addition, a Quadrupole™ loop has a higher inductance than a rectangular loop of the same size because of the mutual inductance of the loop's two sections. However, there is a negative aspect to consider. As we noted earlier, when we bring the opposite sides of a loop closer together, we get a decrease in detection height caused by an increase in field cancellation.

If we compare the detection height of a 6′ by 20′ loop with that of a 3′ by 20′ loop, we will find that the detection height for the 3′ by 20′ loop is half that of the larger loop. A Quadrupole™ is two series connected 3′ by 20′ loops occupying the same area as that of a 6′ by 20′ loop, therefore, capable of only half the detection height.



The wrong way to install a quadrupole type loop, the opposing direction of current in the center conductors causes cancellation of the field. (See Figure 11)

This is the correct way to install a quadrupole type loop. (Wound in the form of a figure eight)

Figure 10 The Wrong and Right Quadrupole™ Loop Installation

Loop Behavior

As we have seen, a current in a wire creates a magnetic field around the wire. The field polarizes with the polarity established by the direction of the current flow in the wire (The Right Hand Thumb Rule—curl your right hand fingers in the direction of the magnetic moment; the wire's current flow will point in the direction of your right hand thumb). If an equal current flows in the opposite direction through a second wire parallel to the first wire, it will create an equal magnetic field of opposite polarity (Figure 11a). These two opposing fields will repel (or cancel) each other. The amount of repulsion depends on the spacing between the wires (the greater the distance, the less the repulsion). If the wires are in very close proximity, the fields will cancel each other out completely. If we reverse the current's direction in either wire (current flowing in the same direction in both wires), the fields will attract (reinforce) each other (Figure 11b). The amount of attraction depends on the spacing between the wires (the greater the distance, the less the attraction).

This is analogous to a pair of magnets. Two magnets with like poles held facing each other (north to north or south to south) would repel each other, the repulsion force increasing as we move the magnets closer together. If we reverse one of the magnets, the magnets will attract each other. In this case, the attracting force increases as we move the magnets closer together.

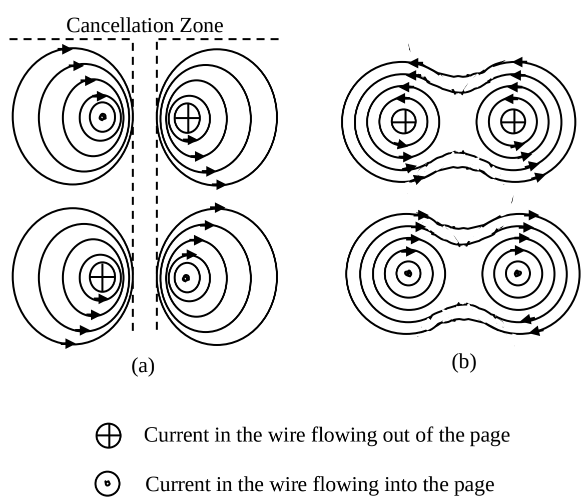
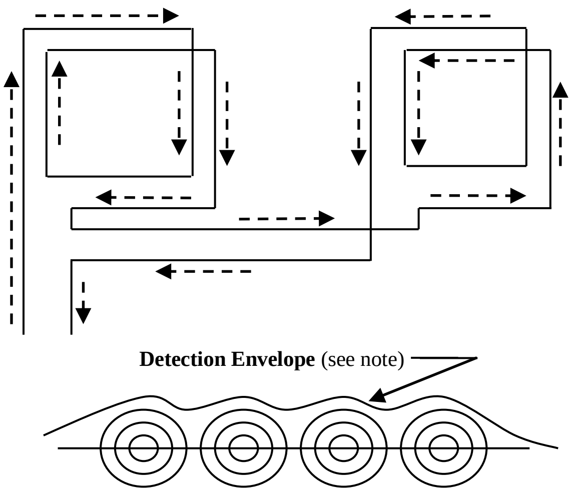


Figure 11 Magnetic Fields Around Parallel Wires

If we examine a square or rectangular loop, we see the situation described in the previous paragraphs. Each pair of parallel sides has the same current flowing in opposing direction—creating equal and repelling fields (see Figure 13). Note that the field is greatest directly over the wire and decreases to a minimum midway between the wires. This means that the point of maximum detection occurs when an object crosses the wire. An object midway between the wires may or may not be detected, depending on its size, shape, and the distance between the wires. In addition, as we decrease the distance between the wires, field repulsion increases, increasing detection height over the adjacent wires. However, this creates a dead zone midway between the wires. This condition is ideal for sliding gates to move between the loops.



Note: The detection envelope shown is a relative profile of the detection height and will vary with the size of the loops, spacing between the loops, and the type of vehicle in the detection zone.

Figure 12 Detection Configuration of Series Connected Loops

Series Connected Characteristics

In series loop installations, this characteristic of attraction or repulsion can work for or against proper operation. Normally, when we connect four loops in series in a single lane, we wind the loops alternately in opposite rotation (clockwise, counterclockwise, clockwise, counterclockwise: see Figure 9 and Figure 12). This allows current to flow in the same direction in adjacent turns of adjacent loops, causing the fields of these adjacent turns to attract each other (see Figure 12).

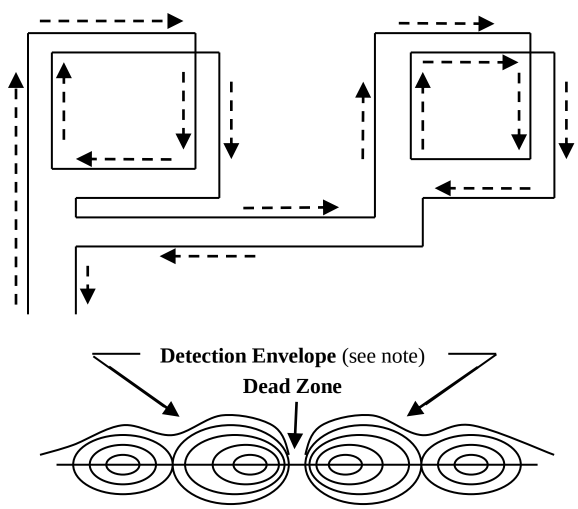
We gain a very important and practical advantage by using series loops wound in opposite rotation. In areas of high transient electrical activity caused by nearby power lines or heavy electrical equipment, this configuration offers the most noise immunity. When the entire loop network is subjected to the influence of electromagnetic interference, the energy, coupled equally into all the loops, creates equal and opposite currents in each pair of loops. This happens only when alternate loops are connected out of phase. This results in a high level of the interference canceling. Please note, even this configuration does not offer any degree of protection against the tremendous electromagnetic fields generated by lightning. We discuss this further in Loop Phasing.

Parallel Connected Characteristics

Winding all the loops in the same direction, a parallel connection, (clockwise, clockwise, etc.) creates dead zones between the loops. These dead zones increase as we reduce the spacing between the loops (Figure 13).

Let us examine two loops used in a presence safety mode for opening and closing a gate. We normally install the loops on opposite sides of the gate and connect them in series. As long as a vehicle remains over either loop, the gate must remain open. If the vehicle leaves the area, the gate should close.

Let us assume that we wind the loops in opposite rotation. Since the fields of the adjacent sides attract each other, they will detect the closing gate as an object present in the gate's path and command the gate to open. When the gate opens again, the process will repeat, …and repeat, … and repeat. By winding the loops in the same rotation, we can take advantage of the dead zone created between the loops. This dead zone provides safe passage for the gate to close without creating a false signal to the loops.



Note: The detection envelope shown is a relative profile of the detection height and will vary with the size of the loops, spacing between the loops, and the type of vehicle in the detection zone. Increase the relative height over the two inside wires by moving the loops closer together and decrease the height by moving the loops apart.

Figure 13 Detection Configuration of Parallel Connected Loops

Loop Phasing

In a single loop application, loop phasing is irrelevant. In instances where we connect multiple loops to the same detector channel or to one channel of a multi-channel detector, loop phasing has advantages.

When dealing with inductive loops, phasing pertains to how we connect the loops with respect to each other. More specifically, phasing is the direction of the current flow within the loops. When loops are in phase and connected to the same detector channel, we amplify noise. When the loops are out of phase, we cancel noise.

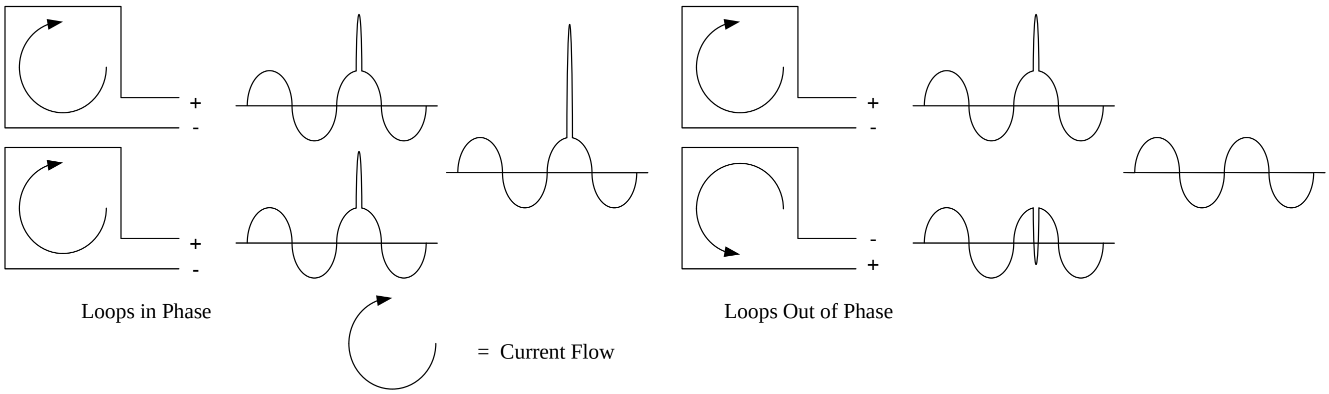


Figure 14 Loop Phasing

Connecting loops out of phase causes adjacent, closely spaced loops to pull their fields together. This results in a uniform field across a loop network. In addition, out of phase loops repulse radiated energy, a condition that can exist when it is necessary to install multiple loops under high-tension electrical transmission lines. Since we connected the loops in opposite directions, the tendency is for the loops to cancel energy received from external sources. That is, the energy induced into loop 1 is equal but opposite to the energy induced into loop 2. The result is that the energy produced by loop 1 cancels the energy produced by loop 2 and the net energy produced is zero. Be aware that this occurs only when the loops under consideration are balanced, i.e. equal in size, number of turns, and, hence, inductance.

Winding loops in phase causes adjacent, closely spaced loops to repel each other and creates a dead zone. As mentioned, sliding gates and roll-up doors benefit from in phase loops in that they can pass without being detected between the loops.

Determining Loop Phasing

Whenever possible, bring all loop ends, the individual loop leads, out to the pull box. This allows us to bypass a defective loop until we can replace it. Just as importantly, in new installations where we have already installed and covered the loops, we can determine the phasing (the direction each loop was wound) and we can connect them in the desired rotation—as we discussed in the preceding sections.

The required tools are simple: a six-volt lantern battery and a pocket compass. Follow these simple steps to determine phasing (see Figure 15):

1. Identify the wire pairs with the loops in the street. Do this by temporarily connecting each wire pair to the detector and by using the Reno A & E, Model LF-300, loop finder to locate the active loop.

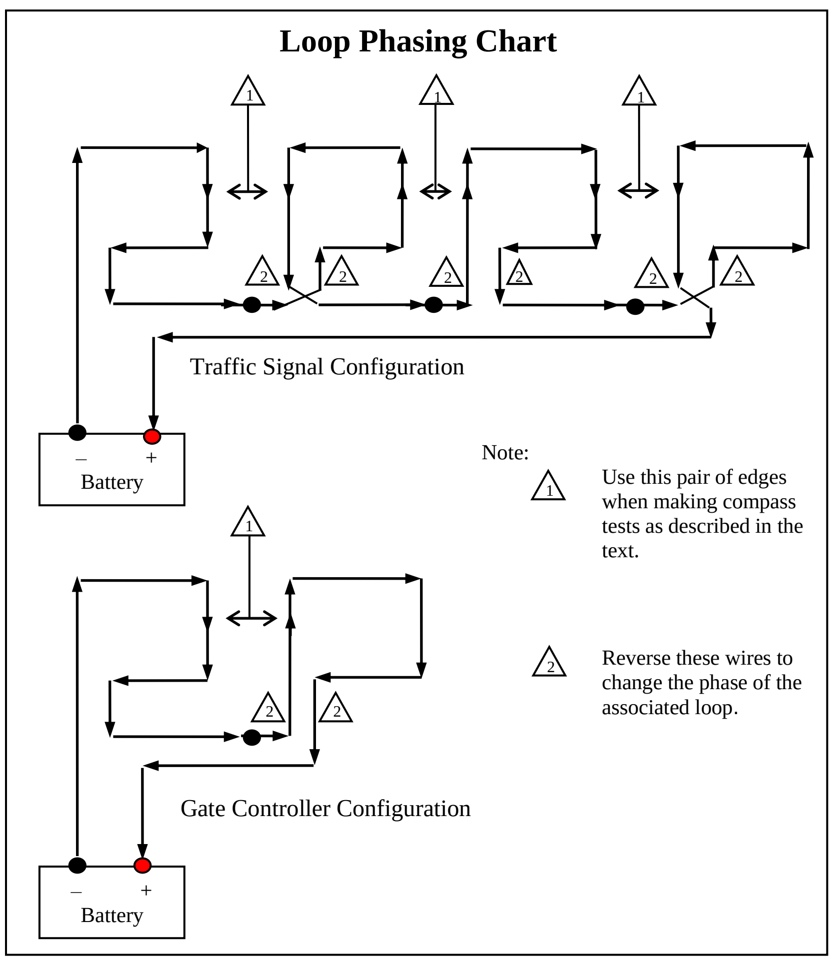


Figure 15 Loop Phasing Chart

2. *Temporarily* connect all loops in series.
3. Connect the free wire from the first loop to one terminal of the battery. Leave it connected until you have checked all of the loops for proper phasing.
4. Place the compass directly over the wire of the first loop on the side nearest the second loop.
5. For a brief moment, connect the free wire from the last loop to the battery and note the direction of the movement of the compass needle (i.e., clockwise or counterclockwise). **Warning: do not hold the connection very long. The low resistance of the loop will act as a short on the battery. This will overheat the loop wire and discharge the battery!**
6. Place the compass directly over the side of the second loop on the side nearest the first loop and repeat step 5.
7. If the movement of the compass needle is in the same direction in steps 4 and 6, the connections are correct for attracting fields (used for traffic configurations). If the needle pointed in the opposite direction in steps 4 and 6, the connections are correct for opposing fields (used for gate controller configurations). To reverse the phasing, reverse the connections for the second loop and repeat steps 4 through 6 to verify the desired phasing.
8. For successive loops, repeat steps 3 through 6, considering the last loop checked as the first loop and the next loop as the second loop.
9. Upon completion, disconnect the wires from the battery and make permanent (solder and waterproof) connections on all wires in the loop circuit, including the lead-in wires that connect to the cabinet.

Loop Installation Techniques

In order to have a detector system operate as a reliable high performance system, it is necessary to pay careful attention to the loop installation. The use of proper installation techniques can reduce frustration, aggravation, and unnecessary service calls, all the while increasing reliability and the number of happy customers. For the best results, observe the following guidelines.

1. Mark the loop outline on the pavement using either a string or a rigid frame and aerosol spray paint. Include the run from the loop to the edge of the pavement that will hold the lead-in wires. When marking the loop outline, note that the corners should be broken and that the saw cuts should extend past the adjoining legs to prevent damage to the wire insulation when the wire is placed into the saw slot as shown below.

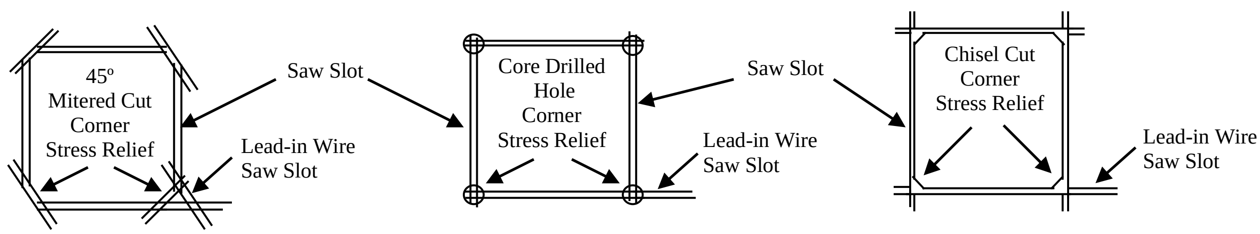


Figure 16 Loop Layout Configurations for Pavement

2. Cut the saw slots to the proper depth—1½ to 3 inches deep. Use a greater depth in softer pavement to protect the loop from roadway wear. The loop saw slot is usually ¼″ or ⅛″ wide, depending on the loop wire's diameter. Clean the saw slot with pressurized water and blow dry with compressed air. Check the saw slot for sharp corners or edges that could damage the insulated wire during installation.
3. For the loop wire, use 20 AWG or 16 AWG stranded wire with insulation rated for direct burial. Since moisture can cause significant changes in the dielectric constant of the insulation, which could result in excessive loop (frequency) drift, choose an insulation that is resistant to moisture. Avoid polyvinyl chloride (PVC) insulation since it tends to absorb moisture. Cross-linked polyethylene (XLPE) insulated wire is very resistant to moisture absorption and provides good abrasion resistance. Reno A & E's LW-120 and LW-116 loop wire meets these requirements. Wind the loop with one continuous length of wire—**do not splice!**
4. Use a plastic foam type material called backer rod to tightly hold the wire in the bottom of the slot. Use this approach for the entire loop perimeter, as well as the saw cut between the corner of the loop and the point where the slot exits the pavement. When backer rod completely covers the wire, it forms a barrier between the wire and the sealant that will allow the wire to move with any pavement shift, thereby, helping to increase the loop's life expectancy. Note: When using backer rod, use either a roller disc or a harmless blunt object to tightly compress the backer rod into the slot. If not properly compressed, water can accumulate in the void between the backer rod and the bottom of the slot. If that happens, a number of freeze/thaw cycles can push the loop up and out of the slot. In addition, securing the loop tightly in the slot will keep the wire from vibrating. A loose vibrating wire can create false calls and cause the detector to operate erratically.

5. Carefully choose a sealant to match the application and the pavement. The sealant selected should have good adhering properties and should match the contracting and expanding characteristics of the pavement material. Do not use hard setting epoxies. Be cautious when using hot sealants: The high temperatures of hot sealants can damage or destroy the wire’s insulation. The sealant should completely cover the loop wire and backer rod so that it serves as a barrier to protect the loop from the environment—be sure to fill all voids.

   Since the type of sealant used varies depending on the job site’s geographical location, it would be impossible to recommend a specific sealant. If questions exist on what is best for a particular location, Reno A & E suggests contacting one of the following manufacturers of sealants:

   3M Corp. (http://www.3m.com/)
   Bondo Corp. (http://www.bondo-online.com/)
   Chemque, Inc. (http://www.chemque.com/)
   W. R. Meadows, Inc. (http://www.wrmeadows.com/)
   RAI Products, Inc. (http://www.raiproducts.com/)
   Sika Chemical Corp. (http://www.sika.com/)

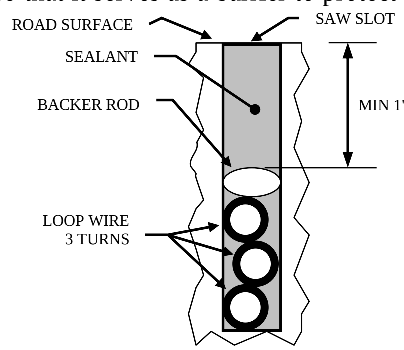


Figure 17 The Completed Saw Slot

6. Where the loop wires leave the saw cut (in the hand hole at the curb or at the pavement’s edge), tightly twist the wires together with a minimum of five turns per foot—this cancels the magnetic fields and helps reduce inductance interference.

7. The lead-in cable should be a two conductor, twisted pair cable made with high-density, cross-linked polyethylene (XLPE) insulation. Reno A & E’s LW-216 loop lead-in wire meets and exceeds all lead-in cable requirements. If you use a shielded cable, float the shield (leave unconnected and insulated) at the loop splice end, and ground the shield at the cabinet end only. Any other grounding arrangement can lead to a grounded loop and cause the system to operate erratically.

8. Solder all splices, even when initially done with crimp type splices. Wire-nut and crimped connections are subject to oxidation, which does not affect solid connections. In most electrical situations, this is not a problem; however, this oxidation often interferes with the inductance signal on which loop technology depends. Protect each splice point with a moisture proof seal. Failing to observe these two precautions, solder and waterproof, are the most common causes of problems in the system. Caution: when soldering use only enough localized heat to adequately flow the solder through the connection without burning the surrounding insulation. Use a copper tip when soldering. **Do not use direct flame!** Use some form of adhesive heat shrink or epoxy resin to seal the soldered joint.

9. Loose connections at the terminal strip in the cabinet are another cause of common problems. Solder crimp-type terminals for additional security, and securely tighten down the screw on the terminal strip. Adding lockwashers to the screws further deters the screws from loosening up over time or vibrating loose.

10. We strongly advise performing loop inductance and leakage tests. Refer to appropriate product manuals for test instructions. Loop inductance measurements should fall between 20 microhenries (µH) and 2500 µH. Leakage resistance should be equal to or greater than 1000 megohms.

Preformed Loops

Preformed loops are prefabricated loop/lead-in assemblies designed for simple and trouble free loop installation. Manufactured and tested in a controlled environment, preformed loops eliminate concerns about wire size, turns, insulation type, and properly made connections. Designed with saw slot installation and hot asphalt or concrete poured applications in mind, preformed loops are ideal for existing, repaved, or new roadways.

Preformed loops consist of three components: the loop, a splice box, and the lead-in cable. Engineered to maximize durability, minimize water penetration, and maintain a flexible form that is easy to install, preformed loops can be configured to fit any geometry: round, rectangular, etc.

Constructed with the optimal thickness of cross-linked polyethylene (XLPE) insulation (an insulation that provides excellent thermal, electrical, physical properties, and is known for its outstanding resistance to moisture and chemicals) preformed loops can withstand temperatures of up to 426 degrees Fahrenheit. The loop and the lead-in cable are filled with a water block gel that prevents water penetration. All splices are soldered and sealed in a two-piece splice enclosure constructed of high impact glass impregnated plastic resin. A mastic gasket is used to provide a seal between the two portions of the splice enclosure, and all voids are filled with a water block gel to provide additional protection against water penetration.

Saw Slot Installation

Preformed Loops can be purchased in the following sizes from Reno A & E

- 16 foot perimeter, 50 foot lead-in cable (PLA-16-50)
- 20 foot perimeter, 50 foot lead-in cable (PLA-20-50)
- 24 foot perimeter, 50 foot lead-in cable (PLA-24-50)
- 28 foot perimeter, 50 foot lead-in cable (PLA-28-50)
- 32 foot perimeter, 50 foot lead-in cable (PLA-32-50)
- 36 foot perimeter, 50 foot lead-in cable (PLA-36-50)
- All other perimeters and lead-in cable sizes are available upon request.

1. Mark the loop layout on the pavement. Remove sharp corners that can damage the loop wire insulation.
2. Set the saw to cut to a depth (typically 2") that insures a minimum of 1" from the top of the wire to the pavement surface. The saw cut width should be larger than the wire diameter to avoid damage to the wire insulation when placed in the saw slot. Cut the loop and feeder slots. Remove all debris from the saw slot with compressed air. Check that the bottom of the slot is smooth.
3. Starting at the splice in the preformed loop, flatten the loop portion of the wire into the slot until finding the center of the loop opposite of the splice. Install the loop starting at the point directly opposite of the feeder saw slot and work your way to the splice saw slot using a wood stick or roller to insert the wire to the bottom of the saw slot (do not use sharp objects). You should have an equal amount of four-conductor loop wire approaching the splice. If not, slide the loop in the saw slot to match the wires in length. Place the splice in the splice saw slot and then place the lead-in wire in the feeder saw slot.
4. The wire must be held firmly in the slot with 1" pieces of backer rod every 1 to 2 feet. This prevents the wire from floating when the loop sealant is applied.
5. Apply the sealant. The sealant selected should have good adhering properties with similar contraction and expansion characteristics to that of the pavement material. Special care should be used where the loop saw slot and splice saw slot meet to insure that this area has no air pockets and that the wire is as deep in the saw slot as possible.

Asphalt Overlay

1. Place the preformed loop in the proper position and orientation on the asphalt base lift.
2. Route the lead-in cable to the desired termination point.
3. Use fiberglass backed mastic tape cut into 2″ x 4″ or 3″ x 4″ strips to hold the loop and lead-in cable in place.
4. Apply the top lift.

Note: When applying the top lift, make certain that the loop cable does not get pulled into the augers on the paving machine.

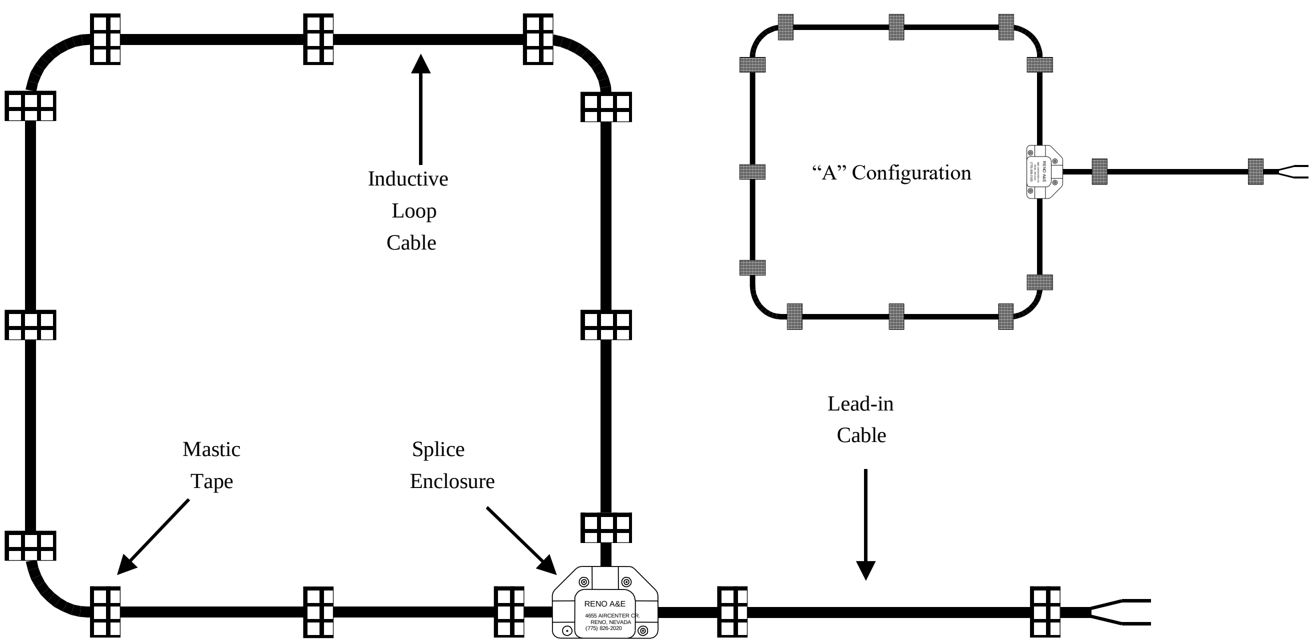


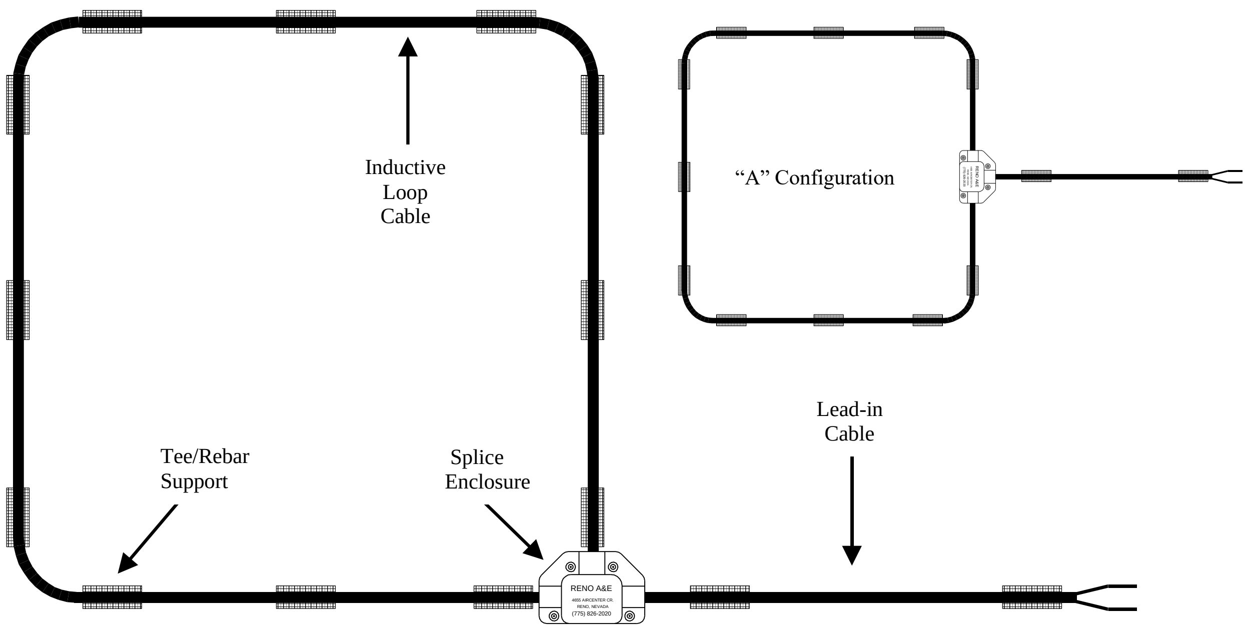
Figure 18 Preformed Loop Asphalt Installation

Poured Concrete

1. Place the preformed loop in the proper position and orientation on top of the concrete reinforcing steel.
2. Route the lead-in cable to the desired termination point.
3. Cut an appropriate number of ½″ poly insert tees as shown in Figure 19A. Cut an equal number of lengths of ⅜″ rebar.
4. Use the tees, rebar and nylon cable ties to hold the loop cable in place. See Figure 19B. Tie the lead-in cable directly to the concrete reinforcing steel.
5. Pour the concrete making certain not to disturb the loop cable.

Notes:

1. Cut the rebar long enough to allow for it to be driven firmly into the ground to hold the tee securely at the correct height above the concrete reinforcing steel.
2. Spacing of the Tee/rebar supports should be such that no more than 2 feet of cable is unsupported.
3. If the thickness of the concrete slab and/or the depth of the reinforcing steel below the top of the slab is such that the minimum dimensions shown in Figure 19B cannot be achieved, contact Technical Support at Reno A & E for guidance.



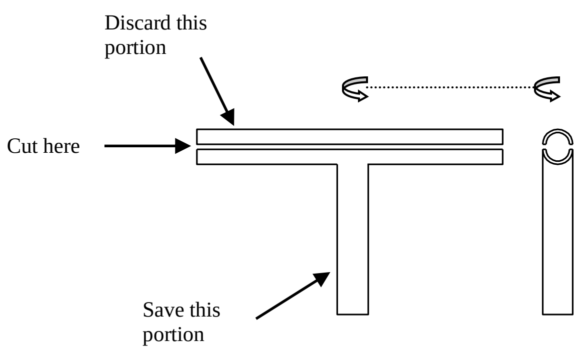


Figure 19A

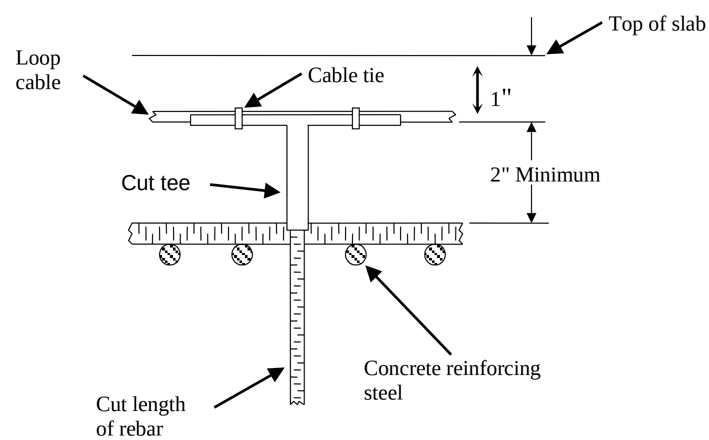


Figure 19B

Figure 19 Preformed Loop Concrete Installation

Detector Module

Now that the loop installation is complete, we can turn our attention to the detector module. Before installing the detector module, carefully check all of the interconnecting wires. Verify that the proper voltage is present. Also, check that the type of voltage is available and that it matches the unit to be installed—AC for an AC unit, DC for a DC unit. Otherwise, severe damage to the unit may occur.

In order to achieve high performance and high reliability, select a high quality detector. Modern digital technology provides the necessary operational characteristics to achieve these requirements. The complete line of Reno A & E's vehicle detectors fulfills these requirements and offers the following advantages:

- Years of proven reliability.
- Solid-state digital technology.
- The LCD advantage (all programming from 3 or 4 buttons on an LCD screen).
- Ability to operate with variations in line voltage.
- Full self-tuning and tracking for a wide inductance range.
- Designed to withstand transients caused by lightning discharges.
- Immediate recovery to full sensitivity and hold time after momentary power outages.
- Fail-safe operation with open or intermittent loop circuits.
- Complete DC loop isolation.
- No crosstalk between adjacent detector units or adjacent channels within the same detector (two and four channel detectors).
- Front panel access so you can shift each loop frequency independently, when it coincides with the frequency of an adjacent loop. (This is needed to eliminate crosstalk between loops.)
- Minimum hold time for any detected vehicle.
- Rapid recovery to full sensitivity and hold time for any gap in traffic.
- Ability to immediately "tune out" vehicles (in less than one second) after two seconds, when operating in the pulse mode.
- Single pulse output per vehicle when operating in the pulse mode.
- Our detectors have a response time of less than 50 milliseconds for any set of operating conditions.

Reno A & E Access Detector Models

Box Type Vehicle Detectors

AX Series	Single Channel – Single Output
AX2 Series	Two Channel – Single Output/Channel
B Series	Single Channel – Two Outputs
BX Series	Single Channel – Two Outputs
BX-LP Series	Single Channel – Two Outputs

Card Type Vehicle Detectors

H1 Series	Single Channel – Three Outputs
J Series	Single Channel – Two Outputs
K Series	Single Channel – Two Outputs

Reno A & E Traffic Detector Models

Rack Type Vehicle Detectors

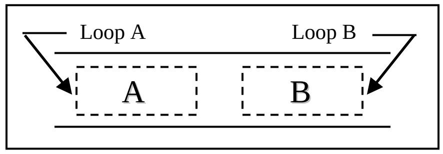
C Series	Two Channel with LCD (liquid crystal display) Control
E Series	Four Channel with LCD Control
222 Series	Two Channel with Dip Switch Control
G Series	Two Channel with Dip Switch Control
222S Series	Two Channel with Dip Switch Control
Y Series	Four Channel with Dip Switch Control
GT-200 Series	Two Channel with Dip Switch Control

Shelf Type Vehicle Detectors

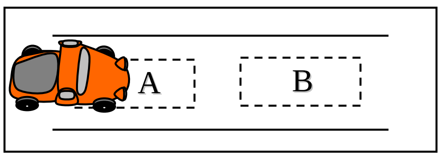
L Series	Single Channel with LCD Control
S Series	Two Channel with LCD Control
T-100 Series	Single Channel with Dip Switch Control
T-110 Series	Two Channel with Dip Switch Control
T-210 Series	Four Channel with Dip Switch Control
T-400 Series	Single Channel with Dip Switch Control
U- Series	Four Channel with LCD Control

Directional Logic Loop Detectors

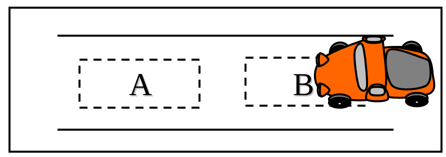
A directional logic loop detector detects the direction that a vehicle is traveling by monitoring two separate loops. The detector recognizes when a vehicle crosses one loop first followed by the crossing of the other loop or, if the vehicle is traveling in the opposite direction, vice versa. Such a detector has use in parking lots where vehicles can enter or exit from the same lane, on freeway ramps for wrong way detection, and in left turn lanes where other movements in the intersection tend to clip the detection zone of the left turn lane. Another common application occurs in situations where the two directional loops are situated such that travel in one direction will generate a signal to open a gate or barrier and travel in the other direction will generate a signal to close the gate or barrier.



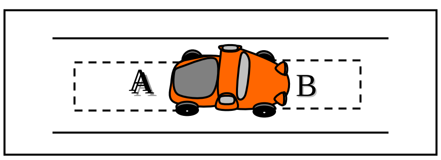
Basic Installation



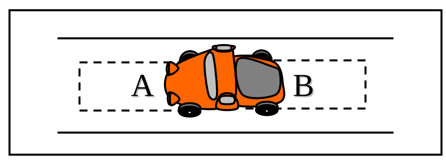
Vehicle Enters Loop A – No Call is Output



Vehicle Enters Loop B – No Call is Output



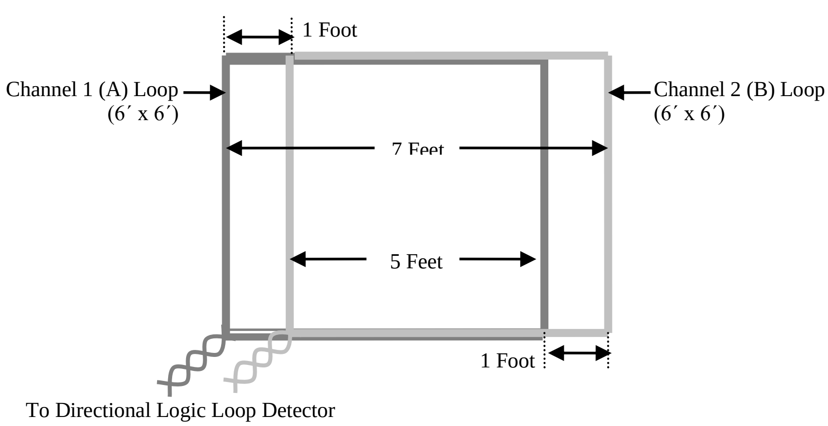
Vehicle Proceeds to Loop B
Call is Ouput on Channel B



Vehicle Proceeds to Loop A
Call is Ouput on Channel A

Figure 20 Directional Logic Loops

Directional logic detectors use a Channel 1 (A) and Channel 2 (B) loop to determine the direction the vehicle is traveling. The loops must be spaced such that a vehicle can span both loops. Installation requires two loops, one after the other in the same lane, spaced anywhere from 6 feet apart to overlapping. The typical directional logic loop installation consists of two 6′ x 6′ or two 2½′ x 6′ loops.



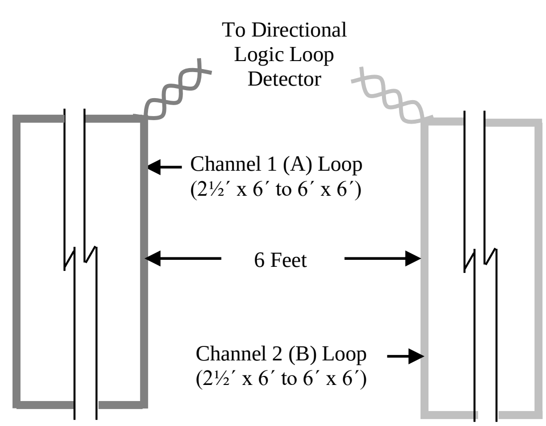


Figure 21 Minimum Recommended Loop Spacing—Traffic

Figure 22 Maximum Recommended Loop Spacing—Traffic/Access

Three important notes:

1.) The overlapping configurations are not recommended for use in situations where detection of fast moving traffic is required.
2.) The 6′ x 6′ loops are typically used in traffic applications. In parking and access applications, smaller loops (2½′ x 6′) are usually required.
3.) In both cases it is important to remember that the accurate detection height of a loop is approximately 2/3 the length of the loop's shortest leg (⅔ x 6 = 4; ⅔ x 2½ = 1⅔).

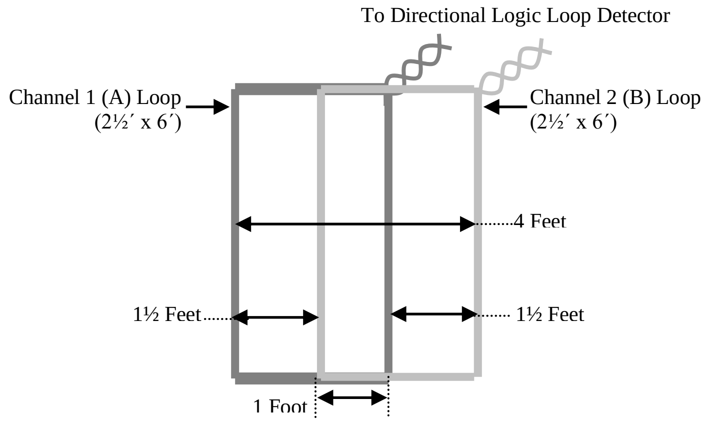


Figure 23 Minimum Recommended Loop Spacing—Access/Parking

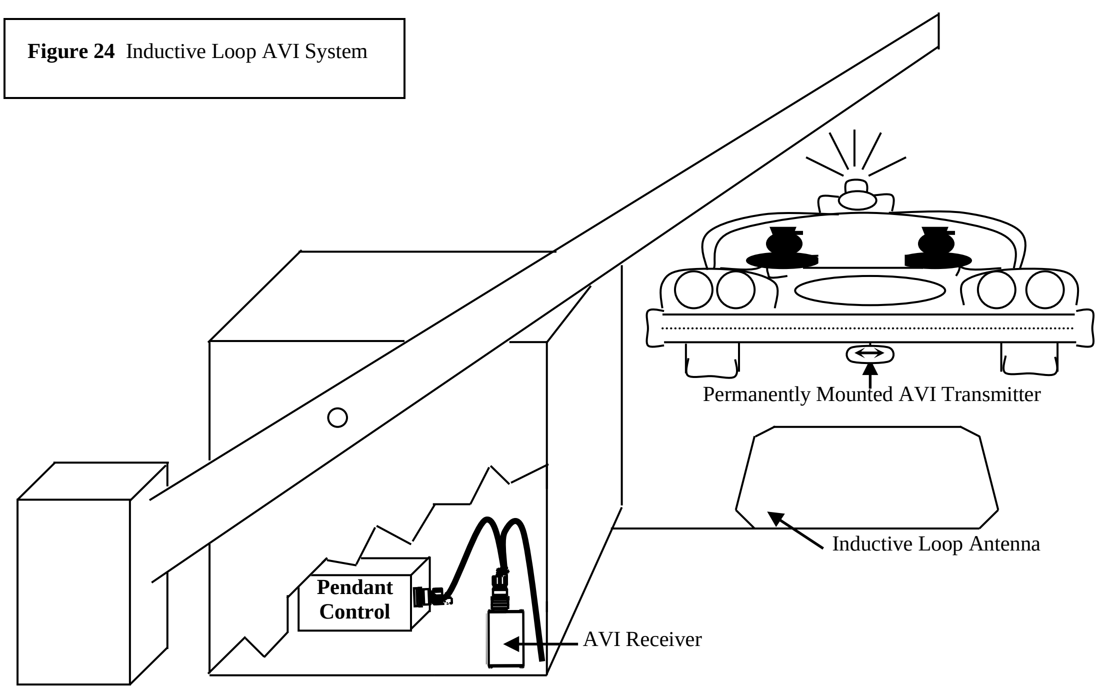
Reno A & E manufactures several multiple channel, inductive loop vehicle detectors with directional logic capability. The Models AX2DL, C-1000, E-1000, S-1200, and U-1200 detectors are scanning detectors that monitor two or more independent inductive loops and provide a separate relay or solid state output for each loop or channel. The loops connected to each channel are sequentially scanned, i.e. each loop is alternately cycled on and off. Since only one channel's loop is active at any given time, this eliminates the potential for crosstalk between adjacent loops connected to the same detector.

Automatic Vehicle Identification Systems

Automatic Vehicle Identification Systems (AVI) come in several technological designs. The AVI systems that operate on inductive loop technology consist of a transmitter attached permanently to a vehicle and a receiver connected to an inductive loop buried in the roadway. The buried AVI loop serves as an antenna for the signal of the transmitter. The inductive loop AVI system allows for accurate detection and identification of specific vehicles.

AVI systems have many uses: Gated communities, industrial complexes, and government agencies use them to allow emergency vehicles unrestricted access to secure areas—saving time, property, and lives. These systems provide a cost efficient way for companies to monitor their facilities, to administer automatic parking, and to limit access to secure areas. Public transportation systems use AVI technology to allow buses to preempt traffic signals so that the buses can stay on schedule. Light rail use these systems on the front and the back of their trains—to turn signals on and, after the train passes, off. In these days of high security concerns, airports use AVI systems to monitor and control ground vehicles.

Figure 24 Inductive Loop AVI System



The inductive loop AVI systems are a simple, cost effective means of providing vehicle identification. The permanently attached transmitter can never be forgotten, misplaced, or lost. Ruggedly built transmitters are encapsulated in an epoxy-based resin that never requires maintenance. The receiver connects to a single loop, of one turn, that is similar in size to a conventional detector loop. If desired, the AVI loop can occupy the same slot as a detector loop. The short communication range between the transmitter and the detection loop practically eliminates false calls. These systems are a proven technology that has been in continuous use in harsh environments for over ten years and has demonstrated a high rate of success.

The inductive loop AVI system is a hands free operation—no buttons to push, no cards to swipe, no codes to remember (or forget)—just drive over the detection coil and the access control gate automatically opens providing immediate access.

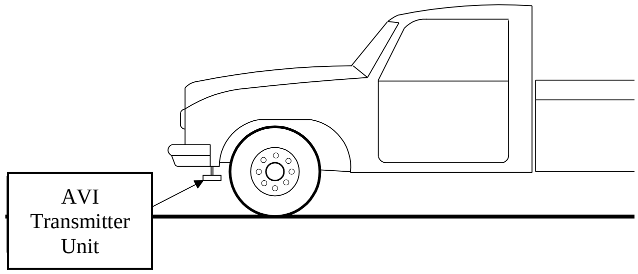


Figure 25 Permanently Attached AVI Transmitter Unit

Frequency Considerations

All of Reno A & E's vehicle detectors offer multiple frequency settings. In most instances, a detector will operate properly with our factory set default values. Under certain circumstances, though, you may find it necessary to change the frequency.

In situations where loop geometry or site layout forces loops to be close to one another, it may be necessary to select different loop frequencies to avoid loop interference—commonly known as crosstalk. The problem of crosstalk occurs when overlapping loop fields are operating at the same frequency. This is analogous to two radio transmitters operating simultaneously on the same frequency. The solution in both cases is to separate the frequencies. In general, the best strategy when setting different loop frequencies is to set the frequencies to be as far apart as possible. **Set the loop with the higher inductance to the lower frequency, and set the loop with the lower inductance to the higher frequency.**

Note: All multiple channel detectors manufactured by Reno A & E are scanning detectors. Multiple loops connected to the same multiple channel detector cannot crosstalk since the loops are excited sequentially. In most instances, it is not necessary to set adjacent loops connected to the same multiple channel detector to different frequencies. If, however, the loops' layout is such that adjacent loops are connected to different multiple channel detectors, changing frequencies may prove beneficial.

If you have any questions about any aspect of inductive loop detectors or inductive loop installation, call us and talk with one of our Tech Support personnel. You can reach us at (775) 826-2020 between 8:00 A.M. and 4:30 P.M. Pacific time, Monday through Friday or send an email to support@renoae.com. We respond to all emails promptly.

Index

3M Corp, 19
adjacent lanes, 9, 10, 14
aircraft, 9, 10
airports, 10
Asphalt Overlay, 20
Automatic Vehicle Identification Systems, 24
AVI, 24
backer rod, 18, 20
bicycles, 15
Bondo Corp, 19
capacitance, 7
capacitor, 6
Chemque, Inc., 19
compass, 17, 18
Concrete, 21
crimp connections, 7
crimped connections, 19
cross-linked polyethylene (XLPE), 18, 19
crosstalk, 10, 25
current flow, 7, 8
dead zone, 16, 17
defective loop, 17
detection zone, 9, 10
directional logic loop detector, 23
eddy currents, 8
efficiency, 12
electric current, 6
electrical transmission lines, 17
electromagnetic fields, 16
electromagnetic interference, 16
factory set default, 25
failure mode, 14
frequency, 7, 25
gate, 10, 13, 16, 18
gated communities, 24
height detection, 8, 10, 15
high bed vehicles, 10
high transient electrical activity, 16
high-bodied vehicles, 8
inductance, 6, 7, 8, 10, 12, 15, 17
inductance change, 10, 13, 14
inductance interference, 19
inductance of the lead-in cable, 10
inductance of the loop, 10
inductive loop, 5, 17
inductor, 6
insert tees, 21
large loops, 9, 10
lead-in cable, 5, 7, 10, 11, 12, 14, 19
lead-in wires, 8, 18
lightning, 16
long loops, 10
long rectangular loops, 9
long rectangular loops with headers, 10
loop, 18
loop area, 12
loop finder, 18
loop geometry, 9, 10, 13
loop geometry, 5
loop inductance, 10, 11, 12
loop phasing, 10, 16
loop wire, 18
loop/lead-in, 12, 14
loops in parallel, 11, 12
loops in series, 11, 12, 13
loops in series/parallel, 12
magnet, 15
magnetic field, 6, 7, 8, 15
motorcycles, 10, 14, 15
multiple loops, 13, 14
multiple small loops, 9, 10
noise, 17
number of turns, 10, 11, 12, 13, 17
parallel, 13, 14
parallel connected loops, 14
parking applications, 8
parking lot applications, 10
polyvinyl chloride (PVC), 18
Preformed loops, 19
pressure sensitive plates, 5
primary winding, 7
pull box, 17
Quadrupole™, 9, 10, 11, 15
RAI Products, Inc., 19
rebar, 21
resonant frequency, 6, 8
Right Hand Thumb Rule, 15
round loops, 9, 10
saw slot, 18, 20
scanning detectors, 25
sealant, 19
secondary winding, 7
sensitivity, 10, 12, 13, 14
series, 10, 11, 13, 14, 15, 16
series/parallel, 14
shielded cable, 19
Sika Chemical Corp., 19
single loop, 11, 12, 14
single small loops, 9, 10
small loops, 8
solder, 19
tank circuit, 6
terminal strip, 19
total inductance, 11, 12, 14
traffic configurations, 18
transformer, 7
transmitter, 24
W. R. Meadows, Inc., 19