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1. Introduction

The 3M™ Canoga™ Vehicle Detection System Model 701 Microloop is a unique, reliable device for sensing vehicles passing over it. This passive device is contained in a small, cylindrical probe, which transforms changes in magnetic field intensity into changes in inductance. Vehicles change the intensity of the earth’s magnetic field. When the Microloop is attached to a device that senses changes in inductance, such as an inductive loop detector, vehicle passage over the Microloop is detected.

![Figure 1-1. Model 701 Microloop – Dual Probe Set](image)

The Microloop is intended to be buried beneath the roadway surface and connected, via lead-in cable, to a loop detector. Installation costs may be significantly less than those for conventional loops, because only single, straight ¼-in. sawcuts need to be made and a 1-in. diameter hole drilled about 20 inches deep. Also resulting is the opportunity for greatly increased service life due to the reduced exposure to hazards such as road traffic, pavement movement, pavement deterioration, and roadwork.

Figure 1-1. Model 701 Microloop – Dual Probe Set

The Microloop is not installed in the pavement and that the lead-in is very durable allows the Microloop to be used in situations such as cobblestone pavements, poor pavements, dirt/gravel roads, and bridge decks. Minimal intrusion into good pavements is another benefit.

The area of detection provided by a probe is smaller than that provided by a 6-ft. x 6-ft. loop and may be considered a point detector. This characteristic allows separation of closely spaced vehicles, very good resistance to detecting vehicles in adjacent lanes, and near immunity to “crosstalk” problems.

The Model 701 Microloop is ideally suited for detecting the passage of moving vehicles (vehicles moving at a 10 mph or faster) when connected to a Canoga™ Digital Loop Detector. The Model 701 Microloop is not recommended for detecting slowly moving or stationary vehicles. For details, see Section 3, Operational Characteristics/Usage Considerations.

1.1 Basic Application Guide

The recommended applications for the Model 701 Microloop include advance detection, speed measurement, counting, and ramp metering passage detection. These passage type applications are normally served well by inductive loop detectors operating in the PULSE mode. It is recommended that all inductive loop detectors connected to Microloops be operated in the PULSE mode.

Microloops may be used in several different configurations to customize vehicle detection results. They may be placed in series to ensure detection of small vehicles, such as bicycles, in a lane, or for multilane detection. They may also be placed in series with standard loops for specialized detection configurations. (See Section 3 for detailed recommendations).

Microloop operation with Canoga™ Digital Loop Detectors has been fully characterized. The Canoga Digital Loop Detector should be set to use PULSE mode, NORMAL recovery mode, and NORMAL or LOW frequency. The total inductance connected to a channel should be 400 microhenries or less to ensure proper signal amplitude to the Microloop.

Usage of the Model 701 Microloop with other brands of inductive loop detectors may provide satisfactory performance. However, the user must determine if performance is acceptable.

To determine if another brand of detector will perform satisfactorily several factors must be considered. The Model 701 Microloop inductance is about 25 microhenries per probe, Q is less than 5, the peak-to-peak voltage (per probe) must be within .25 to 1 volt p-p, sensitivity decreases as the loop frequency increases, and the inductive loop detector must adequately handle inductance increases. Many models of inductive loop detectors do not provide the set of operating conditions required by the
Microloop. For guidance in using other loop detectors with the Model 701 Microloop, see Section 3.6, Matching the Microloop to Digital Loop Detectors.

Adequate handling of inductance increases is the troublesome parameter for most digital inductive loop detectors. Often this problem will be missed during a casual performance observation.

Model 701 Microloops decrease in inductance as the magnetic field intensity through them increases above the earth’s ambient magnetic field. Similarly, their inductance increases as the magnetic field intensity through them decreases below the earth’s ambient magnetic field. Typically, as a vehicle passes over the Microloop, the magnetic field intensity through the Microloop may be instantaneously either less than or greater than the earth’s ambient magnetic field intensity. This results in both inductance increases and decreases being seen by the inductive loop detector.

Many inductive loop detectors almost instantly adapt (use as the new reference frequency) to a frequency decrease caused by an inductance increase. If vehicles are moving very slowly, or stop at the proper position, the inductive loop detector may quickly adjust to use the decreased frequency as its new reference frequency. When the vehicle then leaves, the vehicle detector will function as though a vehicle is actually there. PULSE mode will eliminate such a false “call” in about 2 seconds. NEMA TS 1-1983 Section 15.2.17.2 requires that a loop detector in PULSE mode become responsive to additional vehicles entering a loop within 3 seconds after a vehicle has stopped over a portion of the loop. In PRESENCE mode a call could remain for several minutes.

Canoga Digital Loop Detectors, in NORMAL recovery mode, adapt to frequency decreases (inductance increases) relatively slowly. If traffic speeds always exceed 10 mph, PRESENCE mode detection can be used. If stop-and-go traffic regularly occurs, only PULSE mode should be used. This will ensure that adaptation to an inductance increase creates only a momentary operational change.

1.2 Description

The Model 701 Microloop is comprised of an injection molded urethane cylinder (7/8-in. diameter) with cable emerging from one end as shown in Figure 1–1. The cable is jacketed with durable urethane and will fit into a ¼-in. sawcut.

Microloop probes are available in standard sets as singles and doubles. They are also available in customized configurations by special order. Customized configurations may have any probe separation, any lead-in cable length, and a maximum of four probes per set.

1.3 Basic Installation Guide

Installation is straightforward. A 1-in. diameter hole (18-in. to 24-in. deep) is drilled for the probe(s). A shallow, ¼-in. sawcut from the hole(s) to the edge of the road provides a path for the lead-in wire. The probe(s), with lead-in, is inserted into the hole(s), and the hole(s) filled with dry sand. 3M Brand Detector Loop Sealant material is then used to fill the slot and top portion of the hole(s).

It is important that the probe be installed in a vertical position and that the vertical position of the probe be maintained. Under some soil conditions, installation can be further simplified by installing the Microloop inside a length of PVC pipe (not steel pipe) with an interior diameter of about 1 inch. In this case, the hole must be slightly larger than the outside diameter of the PVC pipe, typically 1-5/8-in. or less. After insertion of the PVC pipe and Microloop, all cavities are back-filled with fine, dry sand and the installation completed in the normal manner.

See Section 5 for detailed installation guidelines.
2. Theory of Operation

2.1 Basic Theory

The heart of the Microloop probe is a network of passive inductive components. One of these components contains a special magnetic material that causes the inductance of the Microloop probe to change as the magnetic field intensity through the probe changes. The response of a typical single probe is shown in Figure 2-1.

The Microloop is designed to be installed in a vertical position, and it uses the vertical portion of the earth’s field (geomagnetic field) as its ambient bias magnetic field intensity. Most cars will cause the magnetic field intensity through the probe to increase 20%. A typical location in the United States could have a 500 milloersted ambient field. Thus, the field intensity in the probe would move to 600 milloersted. This would cause the inductance of the probe in Figure 2-1 to change from about 36.7 microhenries to 36 microhenries (a change of –700 nanohenries or a 1.9% decrease). Sensitivity is defined as a change in inductance for a change in magnetic field intensity. A typical Microloop sensitivity is 7 nanohenries/milloersted or .000007 henries/oersted.

The change in the magnetic field intensity caused by the ferromagnetic materials in the vehicle is primarily a function of vehicle height. Therefore, the Microloop’s ability to detect small vehicles, such as bicycles, is significantly better than that of a standard loop. On the other hand, if the vehicle is made completely of non-ferromagnetic materials, such as aluminum, the Microloop will not sense it because such a vehicle does not disturb the earth’s magnetic field.

Note that the probe inductance increases as well as decreases. Vehicles approaching a probe cause the magnetic field intensity through the probe to decrease, and the inductance of the probe to increase. Any inductive loop detector used with the Microloop must be capable of ignoring this inductive increase or adjusting to it slowly.

Two other significant points are shown in Figure 2-1. First, the ambient magnetic field intensity must be 200 milloersted or greater in magnitude. Second, the probe is not sensitive to the polarity of the ambient magnetic field. It is sensitive only to the magnitude of the magnetic field intensity. The Model 701 Microloop is equally effective north or south of the equator, and the Model 701 responds to changes in the magnetic field both above and below it.

2.2 Magnetic Principles

To fully understand Microloop performance and considerations in its use, it is helpful to understand the basic magnetic principles upon which it relies. Geomagnetism, the natural magnetism of the earth, supplies the bias magnetic field upon which the Microloop relies. This is the same magnetic field that causes a compass to point north. The bias magnetic field must be disturbed (increased), by a vehicle before an inductive loop detector attached to the Microloop can detect the passage of a vehicle. Materials that have what is called high magnetic permeability will cause a “focusing” of the earth’s magnetic field intensity. The most common such materials are iron and most of its alloys. Vehicles in use today contain significant quantities of steel and iron.
Figure 2-1. Typical Microloop Probe Response (Single Probe)
2.2.1 Geomagnetism

The earth’s magnetic field is represented in Figure 2-2. Its total intensity is about .6 oersted. The force lines of this field intersect the earth’s surface at an angle, which is a function of the earth’s latitude. The angle varies from 90 degrees at the magnetic poles to 0 degrees at the magnetic equator. A map of the world showing the angle from horizontal of the earth’s magnetic field is detailed in Figure 2-3. As one example, the intersection angle is approximately 58 degrees at Los Angeles, California, U.S.A. Thus, the vertical component of the magnetic field has an intensity of:

$$H_{vert} = 0.6 \times \sin(58 \text{ deg.}) = 0.51 \text{ oersted.}$$

Note that the vertical component of the earth’s magnetic field intensity exceeds 200 milloersted (.2 oersted) for most of the world. See Figure 2-3. Also, recall that the Microloop functions the same regardless of the direction of the magnetic field through it. Thus, the Microloop functions equally well in either the northern or southern hemisphere.

2.2.2 Effects of Ferromagnetic Material on Earth’s Magnetic Field

Ferromagnetic material will cause the magnetic field intensity in the Microloop to change. It does this by “focusing” the earth’s field and by adding magnetic field from magnetized material in the vehicle to the earth’s field. In a typical vehicle, both factors are important. A third source of magnetic field, current flowing in wires, may be significant on vehicles with electric brakes, or other electrical systems or accessories.

Ferromagnetic materials, such as the iron and steel used to construct vehicles, have a high magnetic permeability. What this means is that it is easier for the magnetic lines of force to go through the ferromagnetic material than through the air or other less permeable materials.

This results in a focusing (concentrating) of the magnetic lines of force beneath a vehicle. This is shown in Figure 2-4. It is important to also observe that this causes a reduction in the magnetic field intensity in front of the vehicle, to the rear of the vehicle, and to the sides of the vehicle. The taller the vehicle is, the stronger the effect is of focusing (and reducing) the earth’s magnetic field intensity.

The focusing effect caused by a vehicle (vertical piece of ferromagnetic or high permeability material) is most closely characterized as a percent change in the vertical component of the earth’s magnetic field. This means that the Microloop has greater apparent sensitivity in areas of the world that have a higher relative strength of the vertical component of the earth’s magnetic field.

Figure 2-2. Model of the Earth and its Magnetic Field
For instance, let’s assume a vehicle causes a 10% field change. Ten percent of 500 milloersteds is 50 milloersteds and 10% of 200 milloersteds is 20 milloersteds. For the probe shown in Figure 2-1, its inductance would decrease 350 nanohenries in the first case and 140 nanohenries in the second. Obviously the inductive loop detector sensitivity must be set more sensitive to detect the vehicle in the second case.

Portions of the iron and steel in a vehicle are somewhat magnetized. This is either intentional (a normal magnet) or the natural effect of the processes used to shape steel pieces such as the body panels. The magnetic field intensity from a magnetic drops rapidly as one moves away from the magnet. However, the sum of the magnetic field caused by focusing the earth’s field and the fields from these magnetized pieces of metal can create great changes in the total magnetic field intensity near the roadway surface. This is also shown in Figure 2-4. For this reason, the Microloop is installed well below the roadway surface (about 20 inches in most applications). This causes the Microloop to detect primarily the focusing of the earth’s magnetic field, rather than the widely varying magnetic field that exists closer to the roadway surface. As long as the Microloop is installed at a depth below the roadway surface, which separates it from the vehicle to be detected by less than ½ the height of that vehicle, it will experience the earth’s magnetic field focusing effects caused by that vehicle.

In general cars are about twice as high as bicycles. Since the Microloop installation depth is the same, one would expect a motorcycle or bicycle to cause only about ¼ of the focusing effect of a car, since the Microloop is effectively twice as far away (relative to vehicle height). Measurements confirm this is approximately the case. Thus, increasing inductive loop detector sensitivity by a factor of 4 from that required to sense a car will permit sensing all vehicle types.

Figure 2-3. Map of the Angle of the Earth’s Magnetic Field Showing Regions (Areas Not Crosshatched) Which Are Suitable for Microloop Operation
Figure 2-4. Effects of a Vehicle on the Magnetic Field Through the Microloop
3. Operational Characteristics and Usage Considerations

The Microloop has unique characteristics. Knowing and understanding these characteristics will help ensure that the device is properly used and the desired results are achieved. This section provides information that must be considered in planning applications of the Microloop.

3.1 Vehicle Detection Characteristics

The function of the Microloop, when attached to an inductive loop detector, is to detect vehicles. All factors that pertain to applications using wire loops must be considered such as: vehicle shape; vehicle speed; vehicle type; vehicle separation; lane widths; detector capabilities; distance of “loop” from the detector; pavement conditions; and end application of the vehicle detection. The Microloop lessens the degree of many problems. It does add some unique considerations such as; ambient magnetic field limits; magnetic field noise limits; and inductance increases (as well a normally expected inductance decreases). To assist in clarifying explanations, the Microloop’s characteristics will be compared to the characteristics of 6-ft. x 6-ft. loops where similarity exists.

3.1.1 Sensitivity to Vehicle Presence – Vehicle Size and Type

Vertical pieces of ferromagnetic material, principally iron and steel, in a vehicle cause the magnetic field intensity in a Microloop to change. This causes the inductance of the Microloop to change. A field increase causes an inductance decrease and, conversely, a field decrease causes an inductance increase.

The taller the vertical steel is, the more it changes the magnetic field. Similarly, the longer the piece of vertical steel is, the more it changes the magnetic field. In addition to its size, the location (distance above the road surface) of the vertical steel is important. The higher it is above the road, the less it will change the magnetic field in the Microloop probe.

Table 3-1 gives numerical illustration of the effects of vehicle size where the vehicles pass directly over the probe(s). For the data shown, the Microloop was buried 20 inches deep. An automobile is about twice as tall and twice as long as a bicycle. One would expect a signal about four times larger, and this is what was measured. The tractor for a tractor-trailer unit is about twice as tall as a car and about the same length. It caused a signal about twice that of a car. Again, this was the expected result.

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>H vert. (Oersted)</th>
<th>% H change</th>
<th>Change in H vert (Milloersteds)</th>
<th>Change in L (nanohenries)</th>
<th>L [loop + 200 ft. lead-in] (microhenries)</th>
<th>% L Change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Truck</td>
<td>.560</td>
<td>32.0</td>
<td>180</td>
<td>900</td>
<td>1800</td>
<td>4000</td>
</tr>
<tr>
<td>Car</td>
<td>.560</td>
<td>16.0</td>
<td>90</td>
<td>450</td>
<td>900</td>
<td>3000</td>
</tr>
<tr>
<td>Motorcycle</td>
<td>.560</td>
<td>3.6</td>
<td>20</td>
<td>100</td>
<td>130</td>
<td>100</td>
</tr>
<tr>
<td>Bicycle</td>
<td>.560</td>
<td>4.5</td>
<td>25</td>
<td>150</td>
<td>200</td>
<td>15</td>
</tr>
<tr>
<td>Vehicle Signal Ratio (largest to smallest):</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Test Conditions: Single and Dual Across-the-Lane Microloop Probes, sensitivity of 5 nanohenries/milloersted
Because of the magnetic field intensity reduction around a vehicle and the small size of the Microloop, for most purposes one may assume the inductance will decrease only when the vehicle is over the Microloop. This applies regardless of vehicle size, direction of travel, or speed. Further details are given in Section 3.2, Microloop Probe Placement Configurations.

Table 3-1 illustrates another significant characteristic. Notice that the Microloop is much more sensitive to small vehicles, such as bicycles, than is a 6-ft. x 6-ft. three-turn loop. The ratio of the percent change in \( L \) caused by the largest vehicle to that caused by the smallest vehicle is only about 10 for Microloops. That same ratio is about 340 for 6-ft. x 6-ft. loops. This greatly simplifies design of vehicle detection installations designed to detect broad types of vehicles.

Table 3-1 does not mention the trailer portion of tractor-trailer units. One should expect that a tractor-trailer will be detected as two vehicles by across the lane Microloop installations. Today a significant portion of most trailers is aluminum or stainless steel (many grades of stainless steel are not ferromagnetic). The normal steel portions are the bed I-beams, the parking stand, and the rear axle/suspension system. The bed I-beams are of insufficient height for their distance from the Microloop to be detected. The rear axle/suspension has been detected for all trailers tested to date. If the trailer contains a cargo with large pieces of vertical steel, the tractor-trailer unit may be detected as one vehicle.

A similar situation applies to cars pulling trailers. The lack of vertical steel between the hitch and the trailer will cause the car and trailer to be detected as two separate vehicles by across-the-lane Microloop installations.

Another situation where a single vehicle may be detected as two vehicles is aluminum body vans without cargo containing vertical steel. This situation is somewhat similar to the typical tractor-trailer unit. Depending on the construction of the specific van, there may be only horizontal steel between the cab and the rear axle/suspension. Such a vehicle will frequently be detected as two vehicles by across-the-lane Microloop installations.

Standard 6-ft. x 6-ft. loops also tend to detect these types of vehicles as two vehicles. Special diamond shaped loops with extra turns have been successfully used to detect these vehicles as a single vehicle where such classification was a direct requirement of the traffic control software, for instance where one of the main variables is vehicle length.

These examples vividly illustrate the ability of the Microloop to separate closely spaced vehicles. Horizontal sections of steel will not likely be detected unless significant portions are magnetized.
3.1.2 Loop Detector Sensitivity Setting

Different inductive loop detectors used different relationships between change in inductance and total inductance as thresholds for vehicle detection. Canoga Digital Loop Detectors use the formula:

\[
\text{Detect if:} \quad \frac{\text{change in } L}{\sqrt{L + 150 \text{ microhenries}}} \quad \text{is greater than threshold (sensitivity)}
\]

Note that for loops with \( L \) less than 150 microhenries, the sensitivity and change in \( L \) are nearly directly related. Table 3-2 gives a rough approximation of the change in magnetic field intensity in a Microloop that will cause a Canoga Digital Loop Detector to register vehicle detection.

Values shown in this table assume each probe detects the same increase in magnetic field intensity. If only one probe detects the field increase, use the column for a one Probe Set regardless of whether the actual case is a one, two, or three Probe Set. This table assumes nominal sensitivity Microloops, not minimum sensitivity Microloops. Multiplying table numbers (those in milloersteds) by 1.5 will approximate the relationship for all probes at minimal sensitivity. This table is only a rough guide. The nominal magnitude of the earth’s magnetic field intensity, length of home-run cable, and other factors that affect the total inductance will cause variations.

As is customary practice with standard loops, the sensitivity on the inductive loop detector should be set so that at least 2X margin-for-error is allowed. For instance, the numbers in Table 3-1 show that for a single probe a Canoga Detector would detect the car at SENSITIVITY 1. SENSITIVITY 2 (twice as sensitive) should be used. Similarly, while SENSITIVITY 3 will detect motorcycles, SENSITIVITY 4 should be used to achieve consistent detection.

The sensitivity range for Model 701 Microloop probes is about 3.5 to 8 nanohenries/milloersted. The practice of setting the loop detector to a sensitivity twice as high as possibly required allows for probe sensitivity variations and variations in magnetic field intensity increases caused by similar vehicles.

3.1.3 Inductance Increases

Inductance increases are a normal part of Microloop operation. While the inductance of a 6-ft. x 6-ft. loop may also increase slightly, particularly when a vehicle is about to enter a loop, the increase is normally small relative to the inductance decrease when the vehicle is over the loop.

To more specifically define this inductance increase characteristic, the following example is provided. With a depth of 20 inches from the road surface to the bottom of the probe, one should anticipate that a vehicle could cause an inductance increase of about \( \frac{1}{2} \) the inductance decrease caused by that vehicle. For example, if a vehicle causes an inductance increase

<table>
<thead>
<tr>
<th>Sensitivity (Canoga Digital Loop Detector)</th>
<th>1 Probe Set (milloersteds)</th>
<th>2 Probe Set (milloersteds)</th>
<th>3 Probe Set (milloersteds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>60</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>30</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
<td>7.5</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>7</td>
<td>3.5</td>
<td>2.3</td>
</tr>
<tr>
<td>*5</td>
<td>3.5</td>
<td>1.8</td>
<td>1.2</td>
</tr>
</tbody>
</table>

*5, 6, 7, 8 are too sensitive for use with Microloops
The change in magnetic field strength is assumed to occur at each probe in a multiple probe set, not at just one probe in the set.
decrease of 450 nanohenries, there is likely a location, relative to the probe, where the same vehicle will cause the probe inductance to increase by 225 nanohenries. Typically, this will be when the vehicle is approaching the probe but will pass to the left or right of the probe rather than over it. The reason for the inductance increase is that a vehicle reduces the magnetic field intensity through the Microloop, when the Microloop is located in the reduced field area some distance to the rear, front or sides of the vehicle. See Figure 2-4, Effects of a Vehicle on the Magnetic Field through a Microloop, and Figure 2-1, Typical Microloop Probe Response.

For moving vehicles, the duration of an inductance increase is very short relative to the duration of an inductance decrease, and the increase will be ignored by the loop detector. However, when stop and go traffic is involved, this may not always be the case. If the loop detector adjusts to the frequency decrease (inductance increase) caused by a vehicle stopped at a location near (not over) the Microloop, the loop detector may respond as though a vehicle is over the Microloop, when the vehicle leaves the area. This is because the inductance returned to the “no vehicle” state after the vehicle left, and this is an inductance decrease from the “vehicle nearby” state.

Most models of inductance loop detectors are designed to almost instantly “adapt” to inductance increases. “Adapt” here is defined as the inductive loop detector calling any frequency decrease (assumed to be caused by an inductance increase) the new reference frequency for detecting vehicles. This feature is useful during periods of constant occupancy of a loop during peak traffic periods. If the loop is vacated, even momentarily, the ability of the inductive loop detector to continue sensing constant loop occupancy is refreshed. This prevents loss of vehicle detection, due to environmental adapt features in inductive loop detectors, on loops that are constantly occupied during traffic peaks.

If the traffic is not constantly moving at an estimated 45 mph or faster, this fast adapt feature of inductive loop detectors can cause erratic operation when such inductive loop detectors are connected to a Microloop. Canoga Digital Loop Detectors have a front panel switch that controls the rate at which the detector adjusts to frequency decreases (inductance increases). The NORMAL position is recommended. The adjust rate in this position is ½ detection threshold per second. This means that up to a 2-second inductance increase will not cause a “call” to be locked in. This allows vehicle speeds at least as slow as 10 mph. If the “FAST RECOVERY” position on a Canoga Digital Loop Detector were used, an inductance increase as short as 2 milliseconds could cause a “call” to be locked in. Most new inductive loop detectors adapt to inductance increases in less than .1 seconds.

To prevent any possibility of erroneous locked in “calls” due to stop-and-go traffic, we recommend using PULSE mode and NORMAL mode on Canoga Digital Loop Detectors. PULSE mode will cause any “locked in call” to be canceled in under 2 seconds, should it ever occur. If PULSE mode cancels a “locked in call”, vehicles may not be detected for 2 to 10 seconds. However, this is usually preferable to the situation of having a continuous detect condition for 15 to 60 minutes.

3.1.4 PRESENCE Versus PASSAGE Detection

PRESENCE applications require the detector to detect the vehicle for the entire time it is over the loop. Typical applications include occupancy detection such as stop bar detection and turn lane detection, gap measurement, long vehicle detection, queue detection, etc.

PASSAGE applications require the detector to sense the movement of a vehicle past a point. Typical applications include counting, speed measurement, advance detection, etc. In most passage applications, the inductive loop detector may be operated in the PULSE mode or PRESENCE mode interchangeably.

Considered only as a self-contained sensing device, the Model 701 Microloop is capable of PRESENCE detection or PASSAGE detection. However, when the characteristics of inductive loop detectors are also considered, its use for PRESENCE detection is best limited to locations where stop-and-go traffic will not normally occur. The reasons for this are explained in Section 3.1.3, Inductance Increases.
Use of inductive loop detectors configured in other than PULSE mode should be done only after considering the possible side effects of inductance increases:

a. Possible long duration call (with no vehicle present) after inductive loop detector adaptation to an inductance increase. The more sensitive the inductive loop detector is set, the more likely it is this will happen.

b. Depending on the amount of adaptation by the inductive loop detector to an inductance increase and its sensitivity setting, it is possible to have double counting of each vehicle: one count as it approaches the Microloop probe and one as it moves away from the probe. This is due to inductance increases caused by the magnetic field reduction to the front and rear of the vehicle. These inductance increases may cause the inductive loop detector to change from a “detect” status to a “non-detect” status. This phenomenon will normally occur only in slow moving traffic. Note that this possibility will partially cancel, or at least postpone the observation of the long duration call discussed in paragraph a. above.

3.2 Microloop Probe Placement Configurations

The configuration of Microloop probes to be installed under the road is determined by the results desired. Two primary considerations are assumed: 1) detect all vehicles in the lane, and 2) do not detect vehicles in adjacent lanes.

When inductive loop detector sensitivity is set as recommended in Section 3.1.2, Loop Detector Sensitivity Setting, vehicles will usually be detected at a distance of up to ½ the vehicle height to the left or right of a single probe installation. In multiple probe, across the lane installations, this detection distance is reduced for vehicles passing to the left or right of the installation, because the next probe in line sees a reduced magnetic field intensity and has an inductance increase that partially offsets the inductance decrease of the nearer probe. This phenomenon contributes to the Microloop’s excellent ability to avoid detection of vehicles in adjacent lanes.

3.2.1 Vehicles Centered in a Traffic Lane

A single Microloop probe centered in the traffic lane will allow detection of all vehicles centered on that lane, including bicycles.

Vehicles that could be missed are those centered on the lane separation line, because they are switching lanes, and vehicles that tend not to travel in the center of the lane such as motorcycles.

3.2.2 Vehicles Changing Lanes and Motorcycles/Bicycles

Two Microloop probes placed across the lane and spaced 4 ft. apart will allow detection of cars and trucks changing lanes and most motorcycles and bicycles.

If it is necessary to allow detection of nearly all motorcycles and bicycles, three Microloop probes spaced 3 ft. apart and going across the lane will provide the needed sensitivity.

Use of four probes across the lane in an attempt to detect motorcycles traveling down the lane division stripe is not advisable, because adjacent lane rejection would be noticeably reduced.

3.2.3 Ensuring a Single Detection per Vehicle

There are applications where it is desirable to have one detection output per vehicle regardless of vehicle length or type. An obvious extension of the use of multiple across-the-lane probes to ensure detection is to add multiple down-the-lane probes to guarantee car-trailer, tractor-trailer, and aluminum body vans are classified as one vehicle. A configuration using three Microloops (arranged in a pyramid pattern with Microloops placed at the three points, with two as the base spaced 4 ft. apart across and centered in the lane and one as the peak 14 ft. upstream) would likely guarantee the desired result.

When Microloops are connected in series for multiple probe applications, the inductance change in each probe is additive as shown in Table 3-1. In the three probe Microloop configuration just proposed, the sensitivity of the inductive loop detector would have to be set at that necessary to detect motorcycles to guarantee detecting all vehicles and to ensure one detection output from the loop detector for all vehicle types.
This system would require the ambient magnetic field noise at this location to be less than 4.0 milloersted. While it is not unusual to have ambient magnetic field noise intensities this low, it is possible that magnetic fields generated by current in nearby power lines may approach this level.

When sets of Microloop probes are used on a single loop detector channel, it is conceivable that a situation could occur where a vehicle was stopped close to the Microloops, but not over any of them. If this reduced the magnetic field through several of the probes, a relatively large inductance increase would occur. The inductive loop detector would adapt to the resulting large frequency decrease. When the vehicle left, a large frequency increase would occur, leaving a large signal “detect” condition. This would disappear in less than 2 seconds for an inductive loop detector in PULSE mode, but the “detect” condition might last for hours in PRESENCE mode.

There is an alternative to special probe configurations that can give a single detection per vehicle. It does, however, also increase the possibility of not detecting vehicles “tail gating” the preceding vehicle. This alternative is the use of an inductive loop detector with timing to extend the detection pulse through the section of the vehicle that is not detectable to the next portion of the vehicle that is detectable by the Microloops. See Table 3-3.

Using extension timing of .25 seconds gives a total detection pulse of .25 + .118 = .368 seconds, where .118 sec. is the normal pulse duration in PULSE mode. A truck with an undetectable section 20-ft. long would now be classified as a single vehicle at speeds of 37 mph and faster. This operational condition may give acceptable results on many limited access roadways. It is effective over a reasonable range of speeds, and vehicle spacing requirements are reasonable.

### 3.3 Detection Area

With most vehicles, detection will start at approximately the front bumper and end at approximately the rear bumper. Oddly shaped vehicles such as bicycles and trailers may appear shorter to the Microloop than their actual length. For example, some bicycles detect only for a short period of time near the center of the bicycle. Aluminum or fiberglass trailers will likely detect only for a short period of time around the axle and suspension.

These characteristics are very similar to those of a 6-ft. x 6-ft. loop. The primary difference is that the Microloop in itself is only a point (or a line for multiple probe across-the-lane installations) rather than a 36 square foot area. This allows detection of closely spaced vehicles. It also places a new limit on maximum vehicle speed to obtain vehicle detection.

### 3.4 Vehicle Speed, Vehicle Spacing Considerations

The Microloop has no built-in signal delays. Therefore, vehicle speed considerations are similar to those for a 6-ft. x 6-ft. loop. Again, the primary difference is that the vehicle is detected for a shorter period of time due to the fact that the Microloop is a point or line detection device.

Assume, for example, a vehicle 18 ft. long. A 6-ft. x 6-ft. loop has a detection length of about 12 ft. Thus for the 6-ft. x 6-ft. loop, the detection output will classify the vehicle as 30 ft. long. The Microloop will classify this vehicle as 20 ft. long. At 65 mph (95.3 ft./sec.), a 6-ft. x 6-ft. loop will then detect this vehicle for about .32 seconds. The Microloop would detect that same vehicle for about .21 seconds.

<table>
<thead>
<tr>
<th>Pulse Width (seconds)</th>
<th>Slowest Speed Without Double Detection (mph)</th>
<th>Minimum Vehicle Spacing at 65 mph (ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>.118</td>
<td>116</td>
<td>11 (default condition)</td>
</tr>
<tr>
<td>.368</td>
<td>37</td>
<td>35 (.250 sec. extension)</td>
</tr>
<tr>
<td>.618</td>
<td>22</td>
<td>59 (500 sec. extension)</td>
</tr>
</tbody>
</table>

Slowest speed calculations assume the vehicle section length that is not detectable is 20 ft. long.
The maximum speed at which a vehicle will be detected is a function of the inductive loop detector scan rate and the effective vehicle length. The equation below may be used to calculate the effective vehicle length:

\[ \text{Maximum Vehicle Speed} = \frac{\text{Effective Vehicle Length}}{\text{Scan Time}} \]

Let’s examine a practical worst case condition using a Canoga Digital Loop Detector. Consider a motorcycle with an effective length of 4 ft. Triple probe sets will be assumed on each of the four channels with a loop detector SENSITIVITY 4 for each channel. Scan time is then about 40 milliseconds. Therefore, the motorcycle must be over the Microloop for 40 milliseconds to ensure it is being detected. This means the motorcycle must be traveling no faster than 4 ft./40 milliseconds = 100.0 ft./sec. = 68.2 mph. This may be acceptable for freeway detection requirements of motorcycles.

If all four detector channels were operated at SENSITIVITY 3, the maximum speed for detecting motorcycles would double to 136 mph. Use of a two channel Canoga Loop Detector would allow a maximum motorcycle speed of about 136 mph at SENSITIVITY 4 and 227 mph at SENSITIVITY 3. There is no effective speed constraint when a two channel Canoga Digital Loop Detector is used.

A similar approach is taken to determine the minimum vehicle spacing that will cause the individual vehicles to be detected. In PRESENCE mode, the equation is as follows:

\[ \text{Minimum Spacing} = (\text{speed}) \times (\text{scan time}) \]

If the digital loop detector has a scan time of 40 milliseconds, vehicles as close together as 3.8 ft. can be detected at 65 mph. Vehicles spaced as closely as 1.8 ft. can be individually detected at 30 mph.

In PULSE mode the duration of the detect output is also important. A second vehicle cannot be detected during the detect indication. The default setting of pulse width in PULSE mode for Canoga Digital Loop Detectors is 118 milliseconds. Other available options are 15, 59, and 236 milliseconds. If the pulse width is longer than the scan time (the actual case most of the time), the equation for calculating minimum vehicle spacing while operating in the PULSE mode becomes:

\[ \text{Minimum Spacing} = (\text{speed}) \times (\text{output pulse width}) \]

At 65 mph, this is 11.3 ft. At 30 mph, this is 5.2 ft. Minimum vehicle spacing can be increased or decreased by use of the optional pulse widths. Table 3-3 shows some effects of increasing pulse width using EXTENSION timing.

**NOTE:** In PULSE mode the minimum vehicle spacing length that allows detection of individual vehicles is also the maximum length of a vehicle section, such as a tractor-trailer, that will not cause a second detect condition. PULSE mode noticeably reduces the number of tractor-trailers, car-trailers, and aluminum box vans that are counted as two vehicles. This occurs without any real reduction in the ability to individually detect closely spaced vehicles.

### 3.5 Microloop Operating Environment Requirements

#### 3.5.1 Magnetic Field Intensity

To obtain optimum performance of the Model 701 Microloop, it is essential that magnetic field measurements be done before making the actual installation. Unlike 6-ft. x 6-ft. loops the Microloop will function correctly in areas containing large amounts of iron, such as reinforcement rod, etc. (See Section 3.5.3, High Iron Environments). The Model 701 Microloop must, to have adequate sensitivity, be located in a position that has at least .2 oersted of vertical magnetic field intensity.

Most regions of the earth have a vertical component of magnetic field intensity that is between .2 oersted and .6 oersted (See Figure 2-3). The excluded portion is a band across central Africa, central South America, Malaysia, southern India, and a small portion of southern China.

The 3M Model MM-9 Magnetic Field Analyzer was designed specifically for analyzing magnetic fields for magnetometer and Microloop applications. It is simple to use and accurate. Other commercially available instruments may be used, but the user must be familiar with that instrument to ensure the correct measurements are made.

Measurement of Vertical Component of Magnetic Field Intensity:

**Limits:** .2 oersted minimum; .6 oersted maximum
Set the MM-9 to H. Place the probe vertically at the location where the Microloop is planned to be installed. The probe standing on the road surface is usually a sufficient measure, even though the Microloop probe will generally be installed with its bottom 20 inches below the road surface.

Nearby iron may cause the earth’s apparent magnetic field intensity to be higher or lower than normal ambient. Move the MM-9 probe somewhat to the left, right, forward, or back until a location is found that is near the area’s normal magnetic field intensity. There is usually a location within one foot of the originally intended location that will have near normal values of the vertical component of the earth’s magnetic field.

### 3.5.2 Magnetic Field Noise

Set the MM-9 to Hac. Read the magnetic field noise. If the noise is greater than that shown in Table 3-4 Approximate Magnetic Field Noise Limits, false calls will likely result. This situation is rare. However, if it does occur, use a vehicle-sensing device other than the Microloop.

All significant magnetic noise is man-made. Its primary source is currents flowing in nearby conductors. Very few sources carry currents large enough to disturb the Microloop, if those conductors are 30 ft. or more away.

Sites where noise may be expected are near trolley/bus lines, subways, elevators, main power distribution lines, and sometimes on overpasses (closer to a power line). Since main power lines may be buried underground, it is always best to check for magnetic noise, even though the site appears suitable.

Another type of man-made magnetic noise can come from vehicles traveling above or below the Microloop, but not on the road surface being monitored. Some examples are subway trains in a tunnel below the road, vehicles traveling below an overpass (Microloop intended to detect vehicles traveling on the overpass), and vehicles on other levels of a multi-level bridge. The MM-9 scale for delta H is used to check for this type of magnetic field noise. The same limits apply as for Hac. To check, set the MM-9 to the delta H scale, place the MM-9 probe where a Microloop probe will be located, and observe the readings. The potentially offending vehicular traffic must be occurring while measurements are being taken.

<table>
<thead>
<tr>
<th>Canoga Digital Loop Detector Sensitivity</th>
<th>Approximate Magnetic Noise Limits (Oersted p-p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.050/# of probes</td>
</tr>
<tr>
<td>2</td>
<td>.025/# of probes</td>
</tr>
<tr>
<td>3</td>
<td>.012/# of probes</td>
</tr>
<tr>
<td>4</td>
<td>.006/# of probes</td>
</tr>
<tr>
<td>5,6,7,8</td>
<td>Not recommended for use</td>
</tr>
</tbody>
</table>
3.5.3 High Iron Environments

Microloops, unlike 6-ft. x 6-ft. loops, perform in a normal manner in most high iron environments. Figure 3-1 shows the use of a Microloop on a bridge deck. Use the MM-9 to ensure that the Microloop is located in a position having normal magnetic field intensity (200 to 600 milloersteds) and low magnetic field noise (see Section 3.5.2, Magnetic Field Noise).

If the nearby iron fully shields the Microloop from the earth’s magnetic field, the Microloop cannot be used. One possible problem location is inside a steel lined tunnel. Always use the MM-9 to measure the field before assuming the Microloop will not work. Most steel structures will not fully shield the Microloop from the earth’s field.

3.6 Matching the Microloop to Digital Loop Detectors

The Model 701 Microloop performs well with Canoga Digital Loop Detectors, and its performance has been fully characterized when used with them. It is possible that other brands and models of digital detectors may be used. However, the details of operation of digital loop detectors are changing so rapidly that generalizations cannot be made. We have found that two inductive loop detectors from the same manufacturer that appear identical may operate differently due to component value changes and different software revision levels. For consistent results, use of Canoga Digital Loop Detectors with the Microloop is strongly recommended.

Figure 3-1. Microloop Usage on a Bridge Deck
For those who wish to test for compatibility with precisely defined versions of other digital loop detectors, several guidelines are offered. These factors have been found significant:

- Ability to operate with low inductance loops
- Ability to operate with low Q loops
- Amplitude of signal driving the Microloop
- Frequency of signal driving the Microloop
- Method used by the inductive loop detector for handling inductance increases (frequency decreases).

Unless your applications will never use single probe Microloop installations, most tests should be run using a single Microloop probe. All checks can be made with one Microloop and a sample digital loop detector. A fast storage oscilloscope with flexible external triggering, an MM-9 Magnetic Field Analyzer, a probe holder (for the Microloop and the MM-9 probe spaced 3 inches apart and held vertically), inductors (33 microhenries to 1000 microhenries with Q greater than 10), and a piece of sheet metal (about 2 ft. x 3 ft.) vertically mounted (2 ft. dimension horizontal) on a non-ferromagnetic material cart with the height of the sheet metal adjustable above the floor. It is useful to have a Canoga Digital Loop Detector available to use as a reference for performance checks.

Operational familiarity with test instrument usage is assumed and will not be described here.

Connect the Microloop to the digital loop detector, place the Microloop in its holder (vertical position) and turn the detector ON. If it completes initialization, carry the sheet steel over the Microloop and see if it is detected. If everything appears normal to this point, tests are more straightforward. Otherwise, “troubleshooting” must take place.

If initialization does not occur, the detector probably requires more inductance. To check if the primary requirement is higher Q, place a 50 microhenry inductor parallel with the Microloop. This will increase loop Q even though an inductance decrease occurs. If the detector will now initialize, its primary requirement is higher Q. Then find the largest inductor that can be placed in parallel with the Microloop and still have the detector operate. In actual application, it is desirable to use as large a value of inductance in parallel as practical so that the least amount of sensitivity reduction occurs.

If the Q requirement check is unsuccessful, place the 50-microhenry inductor in series with the Microloop rather than parallel. At this point initialization should occur. If it doesn’t, the detector may be functioning improperly.

After getting a functional system, check for operation by bringing the sheet steel (held in a vertical position) over the Microloop (about 16 inches from the probe bottom to the bottom of the steel). This will produce a large increase in the magnetic field intensity through the Microloop probe. The MM-9, set to the H scale, can be used to confirm this. A 50 milloersted to 100 milloersted change is a large signal. The steel should be detected. If detection doesn’t occur, recheck the detector sensitivity setting. Reinitialize the detector (steel sheet at least 2 ft. from probe). Recheck.

Movement of magnets, steel carts, etc., in the area during the testing can confuse results. Control your magnetic environment. The magnetic field change through the Microloop (and resulting inductance decrease) can be increased by adjusting the height of the sheet steel (reducing the vertical distance between the sheet steel and the Microloop probe).

Next, check the amplitude of the signal being applied to the Microloop. It must be at least .25 Volts peak-to-peak (.25 Vp-p) for full probe response. If it is less than .1 Vp-p, the probe will probably have no response. The signal should be less than 1 Vp-p. If it is greater than 2 Vp-p, the probe will probably give no response.

Assuming full functionality at this point, check for proper signal amplitude delivery to the Microloop over the range of probable total inductances. The signal amplitudes are required across each probe. For example, with four probes in series, the minimum amplitude level is 1.0 volt total across the Microloop probe set. Assume, for purposes of this check, that each Microloop probe is 33 microhenries. Add series inductors, 33 microhenries at a time, until the signal amplitude across the test Microloop reaches .25 Vp-p. This will give a reasonable estimate of the maximum total inductance that can be attached to this detector, when the system contains at least one Microloop probe.
Measure the frequency of the signal applied to the Microloop by the detector. The sensitivity of the Microloop (amount of inductance decrease for a magnetic field intensity increase) decreases as the frequency of the applied signal increases. If the signal is over 100 kHz, the Microloop’s sensitivity will probably be insufficient for many applications. This can, however, be measured in detail with the test items you are using.

Assuming everything is fine to this point, verify digital detector’s handling of inductance increases. Ignoring the Microloop and the detector for the moment, use the MM-9 (set to the H scale) and the cart-mounted sheet steel to determine how to locate the sheet steel relative to the MM-9 probe (and consequently Microloop probe) to decrease the field through the probe about 50 milloersteds. This position will be with the sheet steel some distance to the side of the probes. Make certain the plane of the Microloop and MM-9 probes is parallel to the sheet steel so that both probes see the same magnetic field intensities.

Arrange your test configuration so that you can quickly push the cart through this position (one that provides a significant inductance increase) relative to the Microloop. Detector response (detector in PRESENCE mode) is to be observed as this is done. The detector should not detect the sheet steel or have a detection indication “locked in” after the sheet steel leaves the vicinity of the Microloop (at least 2 ft. away). Cart velocity initially should be the equivalent of 10 mph. If the initial test is successful, continue repeating the test using a slower cart velocity each time. At some rate of movement, detection indication “lock-up” will occur. The Microloop will give consistent performance with this detector when used in PASSAGE detection applications where vehicle speeds are higher than the cart speed that created a problem.

The final step is to determine how to set sensitivities for this detector to ensure vehicles are properly detected. This can be done by connecting the detector to an actual Microloop installation and driving vehicles of each type to be detected over the Microloop. An alternative is to calibrate your test configuration. Table 3-1 gives typical amounts of magnetic field intensity increases caused by different vehicles. First, use the MM-9 to verify that the vertical component of the earth’s magnetic field intensity at the calibration location if typical of that in your local area. Steel used in constructing buildings can create significant variations from the field seen at a roadway installation. The MM-9, set to the H scale, can be used to find those heights of the sheet steel above the bottom of the Microloop probe(s) that will cause the same increases in magnetic field intensity as vehicles would. The cart can then be moved over the Microloop probe(s) at higher than minimum velocity (determined by detector handling of inductance increases) to simulate actual vehicles.

Since many digital detectors claim to detect the ratio of inductance change divided by total inductance, the Microloop configuration being tested for calibration of detector sensitivity must approximate that which would occur at an installation. Actual home-run cable length must be used or simulated by using an inductor. The correct number of probes must be used. If the Microloop probe(s) is in series or parallel with a loop, the loop must be attached or simulated using an inductor. When checking for large vehicle response (cars, trucks, etc.), align the probes parallel (separated by at least 3 inches) with the sheet steel on the cart so that all Microloop probes see the same field. When checking for response to motorcycles and bicycles, separate the Microloop probes as they would be in the street, and consider the sheet steel to be the bicycle.

The detector sensitivity calibration procedure just described gives an excellent approximation of actual installation requirements, assuming that the magnetic environment in the calibration test area was controlled during testing.
4. Guide to Specific Applications

Use of the Microloop for PASSAGE applications is verify similar to using 6-ft. x 6-ft. loops. The primary differences revolve around the fact that the Microloop is a point detector rather than an area detector, and the fact that the microloop has greater inductance increases than does a 6-ft. x 6-ft. loop. Microloop inductance decreases are similar in character to the inductance decreases of a 6-ft. x 6-ft. loop.

Several specific PASSAGE applications are covered in some detail to illustrate these differences and similarities.

4.1 Speed Measurement

To measure speed, two Microloop probe sets are used in the same manner as two loops would be used. A typical placement is shown in Figure 4-1.

Figure 4-1 shows use of a single Microloop probe in the lane center for one lane of the speed measurement configuration. This will allow detection of all size vehicles where some portion of the vehicle travels over the Microloop or within 1 ft. to 3 ft. (depending on vehicle height and length) to the left or right of it. If the only purpose of these “loops” is speed measurement, use of a single probe per configuration portion should be adequate. In this case it is unimportant that a motorcycle is not detected at one or both of the Microloops because of where it is traveling in the lane. Similarly, missing an occasional detection because of vehicle is changing lanes should not matter. If one or more of the Microloops is also doing a counting function, the techniques shown in Section 4.2, Counting Vehicles, should be used to achieve good count accuracies.

For measuring vehicle speed, it is recommended that the Microloop be connected to a two-channel Canoga Digital Loop Detector for reliable and predictable performance. The detector should be operated in NORMAL recovery mode, MEDIUM (NORMAL) or LOW frequency, and PULSE mode. The lowest practical sensitivity should be used. This is SENSITIVITY 3 or 4 if detection of motorcycles is required, and SENSITIVITY 1 (two or three probes per “loop”), or 2 (one probe per “loop”) for detecting cars, trucks, and buses.

Speed is measured by having a computerized device perform the following calculation:

\[
\text{Speed} = \frac{D}{(T_2 - T_1)}
\]

\(D\) = distance between Microloops

\(T_1\) = time vehicle detection started at Microloop 1

\(T_2\) = time vehicle detection started at Microloop 2

(T1 and T2 are times-of-day, i.e., 09:30:50)
Measurement accuracy is a function of the certainty in times T1 and T2. That certainty is dependent on consistent detection of a vehicle at a specific point on the vehicle, the scan time of the digital detector, the accuracy of the computerized calculating device in determining the time of the starting edge of the detection indication, and the vehicle speed determines the percent the uncertainty is of the difference between T1 and T2.

\[ T2 - T1 = \frac{D}{\text{Speed}} = 0.168 \text{ seconds} \] (assuming perfect accuracy) at 65 mph and 0.242 seconds at 45 mph. Now let’s take a look at timing uncertainties.

With the Microloop, detection begins within about 1 ft. of the actual front of a vehicle. Inaccuracy in position detection by loops is frequently assumed to not create measurement error. Those making this assumption say that since the position error should be the same at each loop for a specific vehicle, no net error from detection position errors results. In fact, however, it is a certainty some error occurs. If a positional error of 1 ft. occurred, a 6.3% error in speed measurement would result. A positional error of 3 inches causes a 1.6% error. It is almost certain errors in the 2% range actually occur. If attempts are made to measure it, error in position detection by the Microloop will be less than that of a regular loop. The Microloop response is usually not affected by vehicle alignment with lane center, vehicle bounce, and other factors affecting loop response.

With a Canoga Digital Loop Detector, a vehicle must be over the Microloop for the duration of one scan cycle to guarantee detection. This time is shorter than for most scanning detectors. Here are some actual measurements:

<table>
<thead>
<tr>
<th>Sensitivity Setting</th>
<th>Scan Time (milliseconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.5</td>
</tr>
<tr>
<td>2</td>
<td>7.4</td>
</tr>
<tr>
<td>3</td>
<td>10.6</td>
</tr>
<tr>
<td>4</td>
<td>17.1</td>
</tr>
</tbody>
</table>

Notice that the scan time is very short. At 65 mph (a worse case than 45 mph) the scan time creates an uncertainty range of from 3.3% at SENSITIVITY 1 to 10.2% at SENSITIVITY 4. The shortest scan time on other digital loop detectors is 20 milliseconds and is typically closer to 40 milliseconds.

Next, let’s examine error introduced by the ability of the speed-calculating device to ascertain exactly when each detection started. This is entirely dependent on the design of the computerized calculating device. It can range from nearly zero error (a dedicated hardware counter used to measure T1-T2 for each speed trap), to interrupt driven software (probably .1 millisecond resolution), to scanned sampling of multiple traps (probably 10 millisecond resolution). Therefore, this portion of the system provides from 0% to 6% error potential.

**Summary of error sources (referenced to 65 mph):**

- Positional detection due to “loop”: 1% to 6%
- Canoga Digital Loop Detector scan time delays: 3% to 10%
- (Scan time delay error from other digital detectors: 12% to 25%)
- Computerized speed calculation: 0% to 6%

**Total for recommended configuration:**

4% to 22%

**Total for other brands of digital detectors:**

13% to 37%

This is a range of +/-2% to +/-11%. It is likely speed measurement traps operate at an actual accuracy of no better than +/-5%. The Microloop, as compared with a 6-ft. x 6-ft. loop, will help enhance accuracy.
Using digital loop detectors in PULSE mode for speed measurement places the detector in the position of defining the minimum vehicle separation. This is determined by the PULSE width. Vehicles must be separated, in time, by at least the PULSE width plus one scan cycle. For Canoga Digital Loop Detectors this time is .120 seconds. Therefore, at 100 mph (146.7 ft/sec), vehicles must be separated by 17.6 ft. At 65 mph (95.3 ft/sec), the required separation is 11.4 ft. This should not interfere with speed measurement performance.

4.2 Counting Vehicles

There are many reasons for counting vehicles. All revolve around getting data necessary to make a decision by the local intersection controller, by a traffic control system, or by a traffic engineer. Ideally, this information would include all considerations that relate to the final decision. For instance, a tractor-trailer is different from a car, a fully loaded tractor-trailer is different from an empty tractor-trailer, a motorcycle is different from a car.

Vehicle counting installations cover a wide range of techniques for attempting to deliver complete information. The most sophisticated installations probably combine axle weighing, axle counting, vehicle counting, vehicle length measurement, vehicle speed measurement, and date/time of day. This data is taken as a set for each vehicle. The simplest installation probably only counts axles.

Where it is not economical to have a full information set to process for each vehicle, many different approaches have been taken to making “good” decisions on limited data. If a decision is being made solely on the number of vehicles, perhaps it is desirable to count tractor-trailers and car-trailers as two vehicles. For instance, with axle counting installations, a common approach is to say two axles represent one vehicle. This will call a tractor-trailer 2.5 vehicles, a car-trailer 1.5 or 2.0 vehicles, etc.

Straightforward use of the Microloop in vehicle counting applications will cause continuous vehicles with sheet steel exteriors or constructed of vertical steel members, such as cars, motorcycles, and bicycles to be counted as one vehicle. Non-continuous vehicles, such as car-trailers, and vehicles having a large section without vertical steel, such as the trailer of many tractor-trailers and trucks (vans) with aluminum boxes, will be counted as two vehicles (depending on the length of the section not containing vertical steel and vehicle speed).

Typical Microloop installations for counting are shown in Figure 4-2. A two-probe set is used in each lane to catch vehicles changing lanes and most motorcycles. If it is necessary to detect all motorcycles except those traveling down the lane, a three-probe set should be used in each lane.
For counting vehicles, it is recommended that the Microloop probe set be connected to a Canoga Digital Loop Detector for reliable and predictable performance. The detector should be operated in the NORMAL recovery mode, MEDIUM (or NORMAL) or LOW frequency, and PULSE mode. The lowest practical sensitivity should be used. This is SENSITIVITY 3 or 4 when motorcycle detection is required, and SENSITIVITY 1 (two or three probes per “loop”) or SENSITIVITY 2 (one probe per “loop”) for detecting cars, trucks, and buses.

The down-the-lane probe configurations have been shown to be quite reliable in providing a single detection per vehicle or measurement of vehicle length. These topics are discussed in Section 3.1.4, PRESENCE Versus PASSAGE Detection; Section 3.2.3, Ensuring a Single Detection per Vehicle, and Section 3.3, Detection Area.

4.3 Advance Detection

Loops installed for the PASSAGE application of advance detection at signalized intersections typically have at least two uses. They allow reactivation of the extension timer for “dilemma zone” safety and allow counting of vehicles arriving during the RED signal indicator to provide for added or variable initialization.

The first use simply requires detection of vehicles moving past the location of the Microloop. The requirements of the counting portion of advance detection are covered in Section 4.2, Counting Vehicles.

A typical installation is shown in Figure 4-3. In this application, a three Probe Set (with probes spaced 3 ft. apart) would be used in each lane. Motorcycles are as important as cars in advance detection.

For advance detection, it is recommended that the Microloop probe sets be connected to Canoga Digital Loop Detectors for reliable and predictable performance. The detector should be operated in the NORMAL recovery mode, MEDIUM (NORMAL) or LOW frequency, and PULSE mode. The lowest practical sensitivity should be used. This is SENSITIVITY 3 or SENSITIVITY 4 for motorcycle detection.

Figure 4-3. Typical Advance Detection PASSAGE Application
4.4 Ramp Metering

Control of the entrance ramps uses multiple PASSAGE type vehicle detectors as well as some PRESENCE type vehicle detectors. The Microloop is well suited for the PASSAGE applications.

Relative to loops, Microloops can be installed quickly. This is of major significance for high volume, limited access roadways. Frequently there is no suitable alternative route for vehicles using that roadway. The shorter the length of time required to install or repair necessary detection sensors, the less time traffic is disrupted.

Entrance ramp metering typically controls the number and spacing of vehicles allowed to enter the roadway. The goal is to optimize the roadway’s vehicle handling capacity. Multiple measurements and control methods are used to achieve traffic responsive performance.

One possible ramp metering application is shown in Figure 4-4. Microloops V1 through V6 are typically used to measure speed, count vehicles, measure occupancy, and project gaps in the traffic.

Typically, PRESENCE detectors are used to measure occupancy. Occupancy is defined as the percent of time that a vehicle is over a loop during a total period of time. The equation is:

\[
\text{Occupancy} = \left(\frac{\text{sum of detection durations}}{\text{time period over which detection durations are summed}}\right) \times 100
\]

If sufficient accuracy is achieved by assuming an average vehicle length, PASSAGE detectors in PULSE mode can also measure occupancy. The equation becomes:

\[
\text{Occupancy} = \left(\frac{\text{(Vehicle count)} \times \text{(Average vehicle length/Average vehicle speed)}}{\text{(time period over which measurement is made)}}\right) \times 100
\]

Across-the-lane Microloop configurations will count many long vehicles as two vehicles (due to a section of the vehicle that has very little vertical steel). The down-the-lane probe configuration can provide a single detection per vehicle.

Figure 4-4. Typical Ramp Control Application
It is likely traffic will be moving faster than 10 mph on the limited access roadway. It is also likely that detection of motorcycles will not be of significance. In this instance, a Dual Probe across-the-lane, or a Dual Probe down-the-lane, connected to a Canoga Digital Loop Detector set to PRESENCE mode, SENSITIVITY 2, NORMAL recovery mode, and NORMAL or LOW frequency will give good PRESENCE detection results. Across-the-lane configurations will not give precise estimates of average vehicle length, if a significant percentage of the traffic is tractor-trailers and aluminum body vans. However, it will give a good estimate of occupancy, speed, and gaps. The down-the-lane configuration can provide good data for all measurements, provided that the vehicles are separated by 14 ft. or more.

Therefore, Microloops may be used for either PRESENCE or PASSAGE (detector in PULSE mode) applications for vehicle detection in the lanes on a limited access roadway. The design engineer must make the choice based on design requirements.

Some other definitions are:

**Gap Time** = time between successive detections at a single Microloop

**Volume** = (number of vehicles counted) / (time period over which vehicles are counted)

Vehicle counting is covered in Section 4.2, Counting Vehicles. Vehicle speed measurement is covered in Section 4.1, Speed Measurement. Refer to those sections for more detail on those Microloop applications.

Precisely where the Microloop should be located upstream from the ramp is a function of the specific ramp control strategy being used and will not be covered here.

The Microloop installation at location V8 in Figure 4-4 is the “check-out” detector (a PASSAGE application). It can be used to verify that a vehicle left the ramp signal after a green indication. Frequently it would be located 6 ft. to 8 ft. downstream of the ramp signal.

The “check-in” detection loop at location V7 and the “merge lane” detection loop at location V9 are area PRESENCE detection applications. Such applications are well served by standard loops.

For ramp metering control applications, it is recommended that the Microloop probe sets be connected to Canoga Digital Loop Detectors for reliable and predictable performance. For PASSAGE detectors in this application, the detector should be operated in the NORMAL recovery mode, MEDIUM (or NORMAL) or LOW frequency, and PULSE mode. The lowest practical sensitivity should be used. This is SENSITIVITY 1 (two Probe or three Probe installation) or SENSITIVITY 2 (one Probe installation) for detecting cars, trucks, and buses. SENSITIVITY 3 or SENSITIVITY 4 is used for motorcycle detection.

Settings for limited usage of Microloops in PRESENCE mode were covered earlier in this section.
5. Microloop Installation

5.1 General

The 3M™ Canoga™ Vehicle Detection System Model 701 Microloop is a small, passive, cylindrical device that transforms magnetic field intensity changes into changes in inductance. It is intended for use with inductive loop detector units operating in PULSE mode for detecting vehicle passage. Microloops provide point detection as compared to area detection. When used with Canoga Digital Loop Detectors, Microloop operation is fully characterized.

A single Microloop probe may be used on an inductive loop detector channel, or up to ten probes may be connected in series on an inductive loop detector channel for unusual detection patterns. Probes may also be connected in series with themselves and normal wire loops on an inductive loop detector channel for other detection configurations.

5.2 Microloop Descriptive Data

5.2.1 Physical

Probe: Cylindrical – 0.88-in. diameter, 3.63-in. long. Installs vertically in a 1-in. diameter hole, nominally 20-in. deep, bored through the pavement.

Cable: AWG #22, four conductor, polyurethane jacketed, 0.20-in. outside diameter. Color coded RED, GREEN, BLACK and WHITE (BLACK & WHITE are not used. Cable fits in a ¼-in. sawcut from Microloop probe location(s) to roadside pull box. Probes can be ordered with up to 200 ft. of lead-in cable.

5.2.2 Environmental

Temperature Range: -35°F to +165°F (-37°C to +74°C)
Humidity: 0% to 100% relative humidity. Withstands immersion in solutions typical of roadway runoff.
Magnetic Field Intensity: .20 oersted to .60 oersted, vertical component of ambient magnetic field intensity.
Magnetic Field Noise: Must be less than .05 oersted. This upper limit is reduced as multiple probes are placed in series and as inductive loop detector sensitivity is increased.

5.2.3 Electrical

Sensitivity: Approximately 3.5 to 8 microhenries/oersted at 40 kHz and .2 to .6 oersted ambient magnetic field. Sensitivity at 100 kHz is about 60% of the sensitivity at 40 kHz.
Inductance: 25 microhenries nominal plus 21 microhenries nominal per 100 ft. of cable.
Q: Approximately 3 at .4 Oe, 40 kHz, approximately 5 at .4 Oe, 100 kHz.
Resistance: 0.5 ohms nominal per probe plus 3.2 ohms nominal per 100 ft. of cable.
Operating Voltage: .25 volts peak-to-peak to 1.0 volts peak-to-peak. This requirement is met on Canoga Digital Loop Detectors, if the total inductance on a channel does not exceed 400 microhenries.
Operating Frequency: 10 kHz to 100 kHz Sensitivity decreases with increasing frequency.
5.3 Installation Steps

Installation follows these basic steps:

1. Installation planning
2. Magnetic field measurements at installation site
3. Hole boring and saw cutting
4. Microloop probe and cable placement
5. Resistance checks
6. Backfilling and sawcut sealing
7. Splice to lead-in (home-run) cable
8. Connection to inductive loop detector and final checks

5.3.1 Installation Planning

Details are covered elsewhere in this Manual. Most considerations are summarized here.

1. List requirements of the PASSAGE application to be implemented using the Microloop, vehicle types expected, minimum and maximum speed, lane widths, specific results desired and type of inductive loop detection to be used.

   **CAUTION**

   If inductive loop detectors other than Canoga Digital Loop Detectors are to be used, carefully verify that they will provide the intended results by testing in a representative installation under simulated or real traffic conditions.

2. Plan the physical requirements of the installation based on the application needs. Some general guidelines are:

   **Point Detection:** Vehicles are detected while over the Microloop and the Microloop is a point (or a line, in across-the-lane and down-the-lane configurations).

   - Auto, Trucks, Buses – one probe per lane
     - OR two probes per lane at 4-ft. intervals (to detect vehicles changing lanes)
   - Motorcycles, Bicycles – two probes per lane at 4-ft. intervals (will detect most such vehicles)
     - OR three probes per lane at 3-ft. intervals (will detect all steel-framed bikes)
     - OR two probes per lane at 14-ft. separation down-the-lane, on lane center (to obtain one detection per vehicle)
     - OR Three probes per lane, two probes across-the-lane, 14 ft. apart, and one probe 14 ft. back (to obtain one detection per vehicle and detect most motorcycles and bicycles)
   - Probe Depth – 20-in. from road surface to bottom of probe (16-in. minimum to 24-in. maximum)

   Installing the Microloop closer to the road surface increases sensitivity, but will tend to multiple count some vehicles. Installing it further from the road surface may cause motorcycles and bicycles to go undetected.

   **Special Configurations:** Special configurations can achieve area detection and/or a single detection for all vehicle types, but should be tested to determine if desired results are achieved.

   Other configurations depend on the specific application being implemented. Always keep in mind that “normal” Microloop installation configurations achieve point detection, i.e., vehicles are detected for a shorter period of time than when loops are used.

   **Order Microloop Probe Sets to Match Installation Needs:** Installation is most convenient when the amount of cable between probes, in multiple probe sets, exactly matches the depth and probe spacing requirements. If the interconnecting cable is too short for the desired depth and spacing, we recommend compromising on the spacing. If the cable is too long, some method of handling the excess cable must be devised. While some excess cable can be coiled and placed at the top of the hole, it is somewhat difficult to hold in place for final sealing. Custom ordered sets are available with virtually the same lead time as standard units. If the standard sizes don’t match your needs, custom ordered sets would be your best choice.

   A representative physical installation is shown in Figure 5-1. A second representative installation on a bridge deck is shown in Figure 5-2.
Figure 5-1. Typical Microloop Intersection Installation

Figure 5-2. Microloop Usage on a Bridge Deck
5.3.2 Magnetic Field Measurements at Installation Site

Microloops should never be installed without conducting a magnetic field analysis prior to commencing boring and cutting of pavement. The 3M Model MM-9 Magnetic Field Analyzer is recommended for this purpose.

Measurement of Vertical Component of Magnetic Field Intensity:

Limits: .2 oersted minimum; .6 oersted maximum.

Set the MM-9 to H. Place the MM-9 probe vertically at the location where the Microloop is to be installed. The MM-9 probe standing on the road surface is usually a sufficient measure, even though the Microloop probe will generally be installed with its bottom 20 inches below the road surface.

Nearby iron may cause the earth’s apparent magnetic field intensity to be higher or lower than normal. Move the MM-9 probe somewhat to the left, right, forward, or back until a location is found that is near your area’s normal magnetic field intensity. There is usually a location within 1 ft. of the originally intended location that will have near normal values of the vertical component of earth’s magnetic field.

NOTE: On bridge checks it is important to observe the polarity of the ambient magnetic field as it is being measured with the MM-9. Magnetization of the structural I-beams can cause ambient magnetic field reading polarity to be opposite that of the earth’s magnetic field. If this is observed, the Microloop may not be used at this location. Because of the “reversed” polarity, vehicles would cause decreases in the magnetic field around the probe and increases in the inductance. Loop detectors sense decreases in inductance and therefore detection would not occur. With the MM-9, measure alternate locations to determine if the polarity is the same as the earth’s at other sites.

Set the MM-9 to Hac. Measure the magnetic field noise at the locations just selected for installing a Microloop probe, following the approach for measuring H. Note that the recommended maximum peak-to-peak noise varies with sensitivity and the number of probes connected in series to an inductive loop detector channel. The numbers in Table 5-1 are appropriate for Canoga Digital Loop Detectors.

For example, at SENSITIVITY 4 and with three probes in series to a channel, the maximum Hac is .002 oersted peak-to-peak. The MM-9 reads .100 oersted peak-to-peak full scale. There are 50 divisions from 0 to full scale, so each division is .002 oersted peak-to-peak. Therefore, the magnetic field noise must be less than one division. Carefully mechanically zero the meter in the physical position in which you will operate it, before turning the MM-9 ON.

Also, check to be certain that unanticipated vehicular traffic in tunnels below the roadway, on roadways below the deck, or on decks above this roadway does not create the potential for a problem. Set the MM-9 to delta H (reads +/- 10 milloersteds full-scale). Place the MM-9 probe at the locations where Microloops will be installed. Observe readings during the times potentially offending traffic is present. The maximum permissible readings for + delta H are the same as for Hac.

<table>
<thead>
<tr>
<th>Table 5-1. Measurement of Magnetic Field Noise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canoga Digital Loop Detector Sensitivity</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5,6,7,8 Not recommended for use</td>
</tr>
</tbody>
</table>
5.3.3 Hole Boring and Saw Cutting

Typically a 1-in. diameter hole is bored to a depth several inches deeper than final placement to allow for debris in the bottom of the hole. If the soil is such that the hole walls may collapse, it is suggested that a length of PVC pipe (plumbing or electrical) be used to line the hole. This will ensure the Microloop probe is mounted in a vertical position. It is imperative that the probe be mounted in a vertical position and that its position is stable. When a liner is used, the bored hole must then be somewhat larger than the pipe outside diameter. Measure the pipe. Plumbing pipe is different than electrical pipe. Plumbing PVC pipe will probably be 1-1/16-in. diameter and electrical PVC pipe will probably be 1-5/32-in. diameter.

After boring the hole (and inserting PVC tube, if used) measure the hole depth to ensure sufficient depth for the probe to be installed.

A ¼-in. wide sawcut is then made from the road edge to each hole in the normal manner as for loops. The cut can be shallower than for loop leads, because the cable is only .19-in. diameter. If more convenient, sawcuts may be made before drilling holes for the Microloop probes.

5.3.4 Microloop Probe and Cable Placement

Before inserting the Microloop probes into their holes, it is suggested that a ring of colored electrical tape be placed on the cable, so that the top of the tape will line up with the bottom of the sawcut when the bottom of the probe is at the correct depth. Insert all probes and lead-in cable. Note that when probe sets are used, the probe with only a single lead going into it is normally the probe of that set this is inserted furthest from the road edge.

A “typical” probe installation is shown in Figure 5-3.

![Figure 5-3. Typical Microloop Buried Installation](image)
5.3.5 Resistance Checks

As a last check before beginning permanent installation, resistance checks should be made. All probe sets are fully checked at the factory. However, it is possible a set could have been inadvertently damaged during installation. Such damage will usually be uncovered by a resistance check using an ohmmeter. Anticipated readings are shown in Table 5-2.

5.3.6 Backfilling and Sawcut Sealing

Fine, dry sand, such as sandblasting sand, works well for filling the holes in which the Microloop probes are installed. If PVC pipe sleeves were used, fill any excess area around the sleeve also. It will probably work best to fill the tube first. Pour some sand over the probe. Then slowly lift the probe until the depth marking tape aligns with the bottom of the sawcut. Release the probe. If it goes back down, add more sand and repeat. After stabilizing the probe depth, fully fill the hole to the bottom of the sawcut, also filling around the PVC tube sleeve if used.

Complete the installation by filling the sawcut and hole tops with 3M Brand Detector Loop Sealant.

5.3.7 Splice to Lead-in (Home-run) Cable

Connections of the Microloop probes, series connections and connections to the home-run cable, are made as shown in Figure 5-4. Items of particular importance are:

- Correct series connection of probe sets (if needed)
- Use of twisted conductor cable for the home-run cable
- Making of electrically sound, waterproof connections

Use of 3M Type 30003 twisted, shielded cable is strongly recommended for the home-run cable. It was designed for this application and will provide excellent reliability and system performance.

Type 30003 cable is a four-conductor #18 AWG shielded cable with a tough, high-density polyethylene jacket. It is resistant to abrasion damage during pulling through conduit. The cable is filled with an amorphous material, which prevents the penetration of water into the cable. This protects the cable and system from environmental factors that might otherwise degrade the cable and impede system performance.

This cable uses twisted wires (not twisted pairs) to reject magnetic field induced noise. To achieve this noise rejection, opposite pairs (RED, GREEN) or (BLACK, WHITE) must be used in the same manner as a twisted pair would be used. The cable is also shielded. Canoga Loop Detectors perform best when the shield is not terminated (left open) at both ends of the cable and is insulated to prevent it from contacting other conductors.

All further connection descriptions refer to this cable.

If desired, the Microloop probe sets may be connected in series to a single channel of an inductive loop detector. The connections would likely be made at a roadside pull box. See Figure 5-4 for an example. Note that the RED from the first probe set goes to RED of the home-run cable, GREEN from the first probe set goes to RED of the second probe set, etc., and GREEN from the probe set goes to GREEN of the home-run cable.

### Table 5-2. Resistance Checks – Expected Readings

<table>
<thead>
<tr>
<th>Measuring Points (Probe Cable Wire Colors)</th>
<th>Correct Resistance <em>(Calculate prior to measuring)</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>RED – to – GREEN</td>
<td>.5 ohms nominal per probe in series chain PLUS 3.2 ohms nominal per 100 ft. of interconnecting and lead-in cable</td>
</tr>
<tr>
<td>RED to Earth Ground or GREEN to Earth Ground</td>
<td>Greater than 1 megohm</td>
</tr>
</tbody>
</table>

*Total Resistance = [(# of probes in series) * (ohms per probe)] + [# feet of cable] * (ohms per 100 feet)/(100)*
Also note that the BLACK and WHITE wires in the Microloop cable are not used. These wires are cut off at the factory and covered with a seal. They will not be seen unless the lead-in cable has been shortened in the field.

The BLACK, WHITE wire pair in the Type 30003 home-run cable may be used to connect a second channel of the inductive loop detector to another Microloop probe set or loop. Both channels using the four wires within the Type 30003 cable must go to a single inductive loop detector that sequentially scans its channels.

It is strongly recommended that all connections be soldered, insulated, and then sealed in a waterproof manner. This will ensure a long, reliable life. The Canoga 30672 Splice Kit simultaneously accomplishes splice insulation and waterproofing. For more complex splicing applications, such as connecting probe sets in series at the pull box, 3M 3800 “SUPER CAN” Buried Service Wire (BSW) Splice Encapsulation Kits may also be used. Follow directions included with those kits.

5.3.8 Connection to Inductive Loop Detector and Final Checks

Before connecting the home-run cable to an inductive loop detector, use an ohmmeter to repeat the resistance checks described in Section 5.3.5 and Table 5-2. This should detect any wiring errors.

Connect the RED and GREEN wires to the inductive loop detector’s loop input. Set the inductive loop detector controls to the proper settings. For Canoga Digital Loop Detectors the usual settings are:

- NORMAL recovery mode
- PULSE mode on channels connected to Microloops
- LOW or NORMAL frequency
- SENSITIVITY: Typically 2 for autos, trucks, buses; typically 3 or 4 for motorcycles and bicycles
**Important:** FAST recovery mode (typical on most digital detectors) will give erratic results unless traffic is relatively fast and continuous.

PRESENCE mode will result in long duration “locked calls” in stop-and-go traffic conditions for most useful combinations of probe configurations and sensitivities. On Canoga Digital Loop Detectors, PRESENCE mode operation is predictable if these sensitivity/probe configurations are used:

- One Probe per Channel – SENSITIVITY 3 (useful)
- Two Probes per Channel – SENSITIVITY 2 (useful)
- Three Probes per Channel – SENSITIVITY 1 (may not be useful)

The Model 701 Microloop is intended for PASSAGE applications that can be implemented using PULSE mode. Other applications should receive careful evaluation prior to implementation.

Turn on the inductive loop detector and check for proper operation. Check each probe for proper operation. This can be done best by standing a 3-ft. by 4-ft. piece of sheet steel on end over each probe, one at a time. Another alternative is to carry a bar magnet over each probe. However, the bar magnet method is somewhat uncertain, as care must be exercised not to inadvertently activate the adjacent microloop in multi-probe sets. Stronger bar magnets can place calls 15 ft. from a Microloop probe. Use of sheet steel on end is a better approach.
6. Proposed Specification for Canoga Microloop

6.1 General

This device shall transform magnetic field intensity changes into inductance changes. A magnetic field intensity increase shall cause an inductance decrease. The device shall be a small, cylindrical unit designed to be buried beneath the road surface. When the device is connected to an inductive loop detector with compatible operating specifications, all vehicles containing significant vertical sections of ferromagnetic material shall be detectable.

A full description of operating characteristics shall be furnished for use with at least one type of inductive loop detector, such as Canoga Digital Loop Detectors. This device is intended for use in PASSAGE applications of vehicle detection with the inductive loop detector in PULSE mode. This does not preclude furnishing of a device that will also operate in PRESENCE mode of vehicle detection.

6.2 Physical

Assembly shall be sealed against moisture entry.

**Probe:** Cylinder: Gray color, 0.88-in. outside diameter and 3.63-in. long.

**Probe Interconnecting and Lead-in Cable:** 0.20-in. outside diameter, polyurethane jacketed, 4 conductor, #22 AWG, RED, GREEN, BLACK, WHITE conductor color coding, bundle twisted at 4 to 6 twists per ft.

6.3 Environmental

**Temperature Range:** -35°F to +165°F (-37°C to +74°C)

**Humidity:** 0% to 100% relative humidity, including submersion in solutions of chemicals typical of roadway runoff.

**Magnetic Field Noise:** AC magnetic field intensity noise must be less than 10 milloersteds peak-to-peak divided by the number of probes connected in series for most common installation configurations.

**Ambient Magnetic Field Intensity:** 200 to 600 milloersteds operating magnetic field intensity (the polarity must be the same as that of the earth’s magnetic field in the installation area).

6.4 Electrical

**Inductance:** 25 microhenries nominal per probe plus 21 microhenries nominal per 100 ft. of interconnecting and lead-in cable.

**Resistance:** 0.5 ohms nominal per probe plus 3.2 ohms nominal per 100 ft. of interconnecting and lead-in cable.

**Q:** Nominally 3 at 40 kHz, 400 milloersteds ambient magnetic field intensity, nominally 5 at 100 kHz, 400 milloersteds magnetic field intensity.

**Sensitivity:** 3.5 to 8.0 nanohenries per milloersted at 40 kHz, 400 milloersteds ambient magnetic field intensity. Sensitivity at 100 kHz, 400 milloersteds ambient magnetic field intensity is about 60% of the sensitivity at 40 kHz.
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