VEHICLE DETECTION LOOP: INFORMATION GUIDE

Foreword

This document has been assembled as a summation of information available to the writer, Jeff Moylan, to act as a discussion document, and to advance the understanding, of the basic parameters requisite of vehicle detection loops, as typically used in the parking control and gate automation industry.

The included information has been developed over a 2 year period, prompted by several requests, from OEM users, and end users, of traffic control barriers and ticket issuing machines, making use of typical modern vehicle detection loops, connected to typical modern vehicle loop detectors.

The writer was first involved in the installation of vehicle detection loops in the early 1970’s, in large parking garages equipped for the Johannesburg City Council with cashiered exit pay – parking systems using ticket-spitters, barriers, and a multiplicity of vehicle loops for equipment control, floor counting, enabling of cash registers, etc.

The writer is still involved in the loop detector industry to this day. Accordingly this document also draws on Jeff’s now 37 years of experience in the parking control industry. Experience that includes that learnt from mistakes as well as certain triumphs in this period. Inevitably some industry “norms” may be repeated, no information has been intentionally drawn from printed matter that could be subject to copyright, and certainly the writer allows free duplication of this document in a manner described in following pages.

The requests made were primarily for a document explaining:

1. What is involved in installing a typical “standard” vehicle detection loop?
2. How reliable are such loops?
3. How should loops be tested for evaluation purposes?

Whilst all loop detector manufacturers supply varying degrees of detail, or lack of detail, about their products, it is apparent that all loop detector manufacturers bias their information towards their product, and not the loop it is connected to. There seems to be some reluctance to put much effort into explaining the basic essential requirements for the installation of a “Good” vehicle detection loop, and practical guidance in the target parameters to be aimed for when installing a (vehicle detection) loop, that can be expected to work with virtually any typical modern loop detector.

It can be readily accepted that any instructions provided by the detector manufacturer, should be read carefully, and if necessary, information provided in this document modified, to suit that information. Having said that, it is believed that this document will act as a useful guide to cover most expected requirements for the installation, and proper testing, of vehicle detection loops as described in the following pages.

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GENERAL COMMENT ON THE AIMS OF THIS DOCUMENT
This document has been assembled to give some guidance in the installation, testing, and basic technical requirements for a vehicle detection loop typical of that required for parking control applications. It is not intended to cover specialised applications for high-speed detection and classification of vehicles on highways, and similar uses. It is intended for traffic barrier, ticket-issuing machine, gate automation, vehicle space counting, and related applications typical of parking and entry control installations. It has been written by a Director of “WLD”, who himself has had experience in all aspects of parking and entry control installations, at all levels, from 1971 to the present day. This document provides information based on actual experiences, information provided by the manufacturer of the detector product range he now represents and distributes, and some use of information guides from a range of other sources, and other individuals having appropriate experience.

The “Mystique” Related to Vehicle Detection Loops
There is a certain air of “mystique”, and a definite prior absence of a document such as this that attempts to provide some sensible, general guidance, and facts, about this subject. There are logical reasons why this situation has persisted until now. Just a few are: the wide range of factors which effect the performance of a vehicle detection loop, the absence of any requirement or scheme to train installers in basic requirements, the (sometimes unwarranted) trust users and facilities managers place in organisations and individuals involved in support of traffic control equipment, and more.

This document is intended for the enlightenment, education, and guidance, of all personnel involved in the use of vehicle loop detectors, be they users, installers, support staff, etc.

GENERAL DESCRIPTION: VEHICLE DETECTION LOOPS
Vehicle detection loops comprise, as their name implies, a loop of electrical cable, laid in, or on, a roadway surface, for the purpose of detecting the presence of vehicles. Loops typically comprise 2 to 6 turns of suitable cable brought to a lead off point, from where the twisted feeder will lead off to an electronic loop detector, which monitors the condition of the loop, and gives appropriate outputs and indications.

These indications are dependant on loop condition, and whether or not it has sensed the presence of a metallic object (a vehicle of some sort, or metallic object of sufficient mass/size to be detected), or it may have sensed a fault condition in the loop being monitored. This document deals with the loops themselves, as the loop detector used to monitor the ground loop, will invariably be supplied with its own documentation, describing set-up and operation.

FUNCTIONING OF A LOOP DETECTOR, RELATED TO LOOP CONNECTED
General
Optimum functioning of a vehicle loop detector unit is largely dependant on factors associated with the sensing loop connected it. These factors include choice of materials, loop configuration, and correct installation practice. A successful inductive loop vehicle detection system can be achieved bearing the following constraints in mind, and strictly following appropriate installation instructions. The detector should as a general rule, be mounted as close to the loop as is practically possible.
Cross-talk

When two loop configurations are in close proximity, the fields of one can overlap and disturb the field of the other. This phenomena, known as cross-talk, can cause false detects and detector lock-up. Cross-talk can be eliminated by;

1. Careful choice of operating frequency. The closer together the loops, the further apart the operating frequencies must be. Operating frequency is generally related to loop inductance, which for similar sized loops are related to number of turns in the loop, hence the common instruction (in loop detector information) to ensure adjacent loops have a different number of turns (typically 1 turn different, and sometimes 2). The closer together the loops, the further apart the operating frequencies should be. The modern loop detector will often offer a choice of up to 4, or even more, operating frequency ranges.
2. Physical Separation between adjacent loops. The closer together the loops, with their associated single loop detectors, the greater the likelihood of mutual interference becomes. Equally, the further apart the sensing loops are installed, the lesser the chance of interference in operation becomes.
3. Careful screening of feeder cables, if they are routed together with other electric services. The screen must be earthed at the detector end only.

Cross-talk Can Be Eliminated by the use of 2 channel detector (or higher numbers of multi-channels are incorporated in a single detector controller unit) where the monitoring of the individual loops being supervised are multiplexed in a manner that completely does away with the problem of interference between the loops driven by the multi-loop detector unit. Not all manufacturers adopt such multiplexing techniques.

Reinforcing

The existence of reinforced steel below road surface has the effect of reducing the effective inductance, and therefore sensitivity, of the loop detection system. Hence, where reinforcing exists, an additional 2 turns should be added to standard guidelines that apply to tarmac, or un-reinforced concrete roadways, or to loops laid below block paving, etc.

The ideal minimum spacing between the loop cable and the steel reinforcing is 150mm, though this is commonly not always practically possible. To maximise this spacing the slot depth should be kept as shallow as possible, with due consideration for mechanical protection of loop cable and loop feeder.

LOOP CONSTRUCTION

The loop and feeder will normally be made of a continuous length of insulated wire/cable, with a copper, or tinned copper, multi-strand core, provided with a protective insulated sheath appropriate to the requirement. The cable used should be a minimum of 1.0mm cross sectional area, 1.5mm c.s.a. Preferred, and for some improvement in performance 2.5mm may be used (particularly on larger loops). The loop will typically be square or rectangular in shape (though diamond shaped loops are often used in some traffic sensing applications) with the feeder pair, from loop to detector, being twisted with at least 20 turns per metre.

The feeder is recommended to be kept as short as possible, so that the loop detector being used, is itself as close as possible to the loop being monitored. Whilst loop feeders of up to 50M may be used when required, this requires a high level of experience and often pre-installation mock-up testing. As a basic rule limit loop feed to 20M. As a basic practical maximum, though always remember THE SHORTER THE LOOP FEEDER THE BETTER THE PERFORMANCE of the loop and detector connected to it. As the loop feeder becomes longer the sensitivity of the loop and detector reduces. Feeders, which may pick up electrical noise, should use screened cable, carefully chosen with a “good” twist of the internal conductors, with the screen well earthed at the detector unit end.

LOOP CABLE

“Loop Cable” is a common expression used by trade suppliers, to describe cable suitable for the construction of vehicle detection loops, which are laid in a roadway surface in a slot prepared with a surface saw. Traditionally the slot is sealed using hot pitch, and accordingly the cable sheath requires a specification that can tolerate the temperature likely to be experienced using this sealing technique.
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Loop cable may be expected therefore, to use a high temperature rubber, or high temperature silicon sheath. Both types of cable can tolerate 160 to 180°C. With the rubber sheathed cable being substantially larger in OD than the silicon sheathed item.

CABLE SUITABLE FOR USE FOR VEHICLE DETECTION LOOPS

“Cable suitable for vehicle detection loops” is an entirely different description covering a much wider range of cable types, types of sheath material, & types of core construction. Dependant on the method of construction of the vehicle detection loop, the type of sealant used for the loop slot, or the type of containment used for pre-formed loops, a wide range of cable types may be electrically adequate to provide appropriate performance. Such cable may vary from standard “house wire” to traditional and modern “Loop Cable” and many variations of core material and sheath insulating material.

LOOP INSTALLATION GUIDELINES

Loop Cable Length and Number of Turns

The majority of vehicle detection loops in parking control applications are square or rectangular. The most common typical size is a loop of approximately 2 by 1M, giving a loop perimeter of 6M.

A simple guide to the number of turns required for a reasonably specified loop, suitable for use with most typical modern loop detector units, is for the length of cable used in the loop construction to be not less than 20M and not more than 30M. For guide purposes a length of 24M can be used as a convenient figure for guide calculation of the number of turns required for a given loop size (perimeter) Hence a 2 x 1M loop (with a perimeter of 6M): 24 ÷ 6 = 4, which indicates that 4 turns will be preferred number for this size loop (as a minimum; more may be required to compensate for steel reinforcement). See the guide schedule provided later in this document. If in doubt consult your detector supplier, or lay a test loop out on flat ground and test with intended detector.

Note that when a pair of conductors, to be used as feeder, are twisted by 20 turns per metre, the overall length of the twisted pair is substantially less than the initial length of the untwisted pair.

The effect of Loop Turns on Loop Inductance and Sensitivity

Simplistically put, the more turns used on a loop, the greater with be the inductance of the loop, and this has a bearing on the sensitivity and performance of the loop detector connected to it.

To put this into perspective, a recent event describes the effect of loop turns (in this instance lack of loop turns) on sensitivity to traffic crossing the loop.

A contractor not familiar with detection loop installations installed a loop. Due to a misunderstanding in instructions, a single turn loop 2.5M x 1M was laid, where a 3-turn loop was intended to be installed. By chance the loop inductance was adequate, with the detector/logic unit being used, able to “tune to the loop” as installed.

It was noted that the loop/detector combination seemed particularly sensitive, regardless of sensitivity setting used. Only during later discussion with the main contractor, when this event was examined in some detail, did the reason for the “high sensitivity” become apparent. Sensitivity of a detector, related to each sensitivity range offered, is directly related to the actual inductance of the loop being monitored. Sensitivity settings are described as being a function of change required to be detected when compared to idle state, and it may be appreciated that a 1% change related to an inductance of 20µH is 50 times less than 1% change related to an inductance of 1000µH, effectively making the former loop, with the lower inductance, react 50 times more sensitively than the latter.

This leads on further to the consideration that the higher the loop inductance, the bigger differentiation between the detector sensitivity settings available, and hence the better control over what mass is necessary to obtain the detection performance required, and exclude lower mass objects.

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**Installation of a Typical Vehicle Detection Loop**

By far the majority of vehicle detection loops are installed in the surface of the roadway, at the point at which the desired vehicle detection facility is required. Cutting a slot in the roadway surface, into which the loop, and its feeder cable is laid, makes this possible. The loop slot is sized to give the required coverage area, and actual width and depth of the slot are sized to suit the overall diameter of the “loop cable” being used, and the number of turns deemed necessary, respectively.

The slot is normally cut using a surface saw, to a width typically 0.5 to 1mm greater than the overall diameter of the cable being used. The depth is generally set as being cable diameter time’s number of turns, plus 25mm to allow for slot sealing after the loop cable is laid carefully in the slot. It is also universally accepted procedure to cut across the corner of a loop slot, at 45°, so that the minimum bend radius of the cable is kept within acceptable limits. This further assists in the laying of the loop by making it easier to turn the corners whilst reducing the chances of incurring physical damage to the cable being used.

The loop feeder, comprising a tightly twisted pair of the loop cable, obviously requires a width of a little over two cable diameters, and a slot depth of typically two diameters plus 25mm as a minimum to allow for sealing and mechanical protection.

When loop cable and feeder have been laid, with care, and properly bedded in the bottom of their slots, it is necessary to seal the slots to prevent ingress of foreign material and water.

This is done with a suitable sealant, dependant on roadway surface, and cable type used. It may be hot pitch, cold sealants applied with a hand operated gun of some sort, or a two-pack resin, which cures giving a suitable resilient seal to the wire below.

A well laid and sealed loop and feeder has an almost indefinite life, subject only to a lack of ground movement, which can cause open or short circuit faults in the loop cable laid in it.

**A Schematic Illustration of Loop Slots and Twisted Loop Feeder/Tail is shown below:**

![Loop installation in hard surface](image-url)
## DETECTION LOOP GUIDE TO REQUIRED "TURNS"

<table>
<thead>
<tr>
<th>LOOP SIZE</th>
<th>PERIMETER</th>
<th>NUMBER OF TURNS, Basic</th>
<th>NUMBER OF TURNS, Plus 2</th>
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**TURNS, Plus 2** is basic guide to compensate for local reinforcing steel

## THE EVALUATION OF VEHICLE DETECTION LOOPS

**Evaluation by related Vehicle Loop Detector**

Virtually all modern electronic loop detectors monitor the connected detection loop for open circuit, short circuit, low resistance, high resistance, as well as measuring inductance by indicating a fault condition if the detector is unable to tune to the connected loop. Note; Often resistance to earth is not measured or monitored. If a failure in system operation has been observed FIRST check the detector to see if a fault condition is indicated. If a fault indicator is ON check detector manual for details of fault, and follow remedial instructions given.

BEFORE relaying a suspected faulty loop perform a full evaluation using a suitable “LCR” meter to check and record all technical parameters. IF loop parameters, as recorded, are within acceptable limits, REPLACE the loop detector with a unit KNOWN to be operational, and retest system. If operation is normal then discard detector that has caused system problems (or, if support is available from a specialist supplier of such products, consideration may be given to sending faulty detector for basic function testing. Low costs of some detectors may not justify this expense).

**Evaluation by Technical Support Staff**

It is a fact that the variables that affect loop and detector performance and operation are often complex, and equally fact that few installation staff may have ever received even basic training in these variables. Without adequate knowledge of the basic requirements of loop parameters, and some understanding of the effect of these on the working of the related loop detector, it is difficult to evaluate whether a loop, or detector, requires replacing, or not.

1. It is reasonable to assume that at end of 2008, a high proportion of parking control equipment technicians make invalid judgements on the operational condition of vehicle loops, due to not having had adequate information, education, or training, in the desired physical parameters required of a suitable loop.

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2. Commonly judgements on the operational status of a vehicle detection loop are made on the basis of (assumed) parallels with mains electrical practice.

3. The most common reason given for the need to replace a vehicle-sensing loop is that its resistance to earth is (typically) less than 5MΩ (sometimes 3MΩ). In reality this is one of the lesser important measures of loop performance; more of that later.

4. Almost universally, nearly all, modern loop detectors modules tend to have a similar loop “SIZE” ability, that is the ability to tune to, and operate with, any wired loop coil with an INDUCTANCE of 20µH to 1500µH. (Some cope with a 15 to 2500µH range).

5. Loop detectors typically draw a maximum power of 2VA with a minority share of that power being fed at a controlled and monitored frequency into the sensor loop. At the low power involved (low voltage and current) resistance to earth can often be as low as 250kΩ and still allow satisfactory operation with a correctly functioning loop detector. Certainly it should not be necessary to condemn a loop, as requiring replacement, when it has a resistance to earth over 1MΩ.

6. In order of importance loop condition should be measured by: -
   6.1 Inductance
   6.2 Loop Resistance
   6.3 Resistance to earth.

7. **Inductance Limits**
   Inductance is normally measured with an LCR meter (where L = inductance, C = Capacitance, and R = resistance). LCR meters tend to use a signal test frequency of some 250Hz, but regardless of meter test frequency, due to the methodology used, “stray” inductance of up to some 10µH can be picked up, in addition to the true inductance of the loop coil being measured, particularly when using the ranges looking for the lower part of those ranges covered.
   With this in mind it is apparent that a meter reading of 30µH from the LCR meter can in fact indicate a true inductance of 20µH. Conversely it follows that to be confident that a loop coil has an inductance in excess of 20µH, a LCR meter reading of 30µH should be considered the minimum acceptable reading, with a meter reading of 40µH or higher a safer minimum figure to aim for. A typical 2 x 1M loop, by rote often laid as a 3-turn loop, will often have an inductance very close to the typical 20µH minimum required by many detector units. Great care is often required to assure good loop & detector matching.

8. **Loop Resistance Limits**
   A typical 2 x 1M loop, laid using 1.5 or 2.5mm wire with 3 turns, will have a loop resistance of typically 0.2 to 0.3Ω. Anything below 0.2Ω may indicate a short between one coil, and its neighbour, during installation, or caused by ground movement. Also, normally, anything above 1Ω would also indicate a potential problem.

9. **Resistance to earth Limits**
   This has, in part, been dealt with earlier. Resistance to earth becomes of interest only when loop inductance and loop resistance are within acceptable limits, and operating problems are being experienced. If resistance to earth is above 1MΩ check loop by another detector unit before condemning the loop installation.

10. **Preferred Loop Characteristics**
    9.1. Preferred Inductance Range: It is good practice to ensure that loop specification is reasonably within the range covered by the loop detector in use (particularly as some may only tune in the range 50 to 1500µH). A target range of 50µ to 1200µH is reasonable
    9.2. Expected Loop Resistance Range: As loop size increases so does loop resistance.
    Typical loops will have a loop resistance of 0.3Ω to not much over 1Ω, so any loop resistance below 0.2Ω or above 2Ω will tend to indicate a faulty loop installation.

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9. **Preferred Loop Characteristics (continued)**

9.3. Resistance to Earth: It has been stated earlier that as a general rule a resistance to earth above 1MΩ will nearly always be ok. Between 250KΩ and 1MΩ test with a loop detector known to be fully functional. Below 250KΩ loop replacement will probably be necessary.

BEFORE relaying a suspected faulty loop, perform a full evaluation using a suitable “LCR” meter to check and record all technical parameters. IF loop parameters, as recorded, are within acceptable limits, REPLACE the loop detector with a unit KNOWN to be operational, and retest system. If operation is normal then discard detector that has caused system problems (or, if support is available from a specialist supplier of such products, consideration may be given to sending faulty detector for basic function testing. Low costs of some detectors may not justify this expense).

**A CLOSING COMMENT:** the old adage “If it isn’t broke, don’t fix it” can easily apply to vehicle loops and the detector they are connected to. If no obvious recurring problem is apparent, there may well not be any problem at all, particularly if the detector does NOT indicate a fault condition. Think, test thoroughly and properly, and let results guide remedial work

**FINAL CLOSING COMMENT:** We remind the reader that there are many variables that affect performance of the loop and detector combination. We have described the main ones in this document; wire used, wire size, insulation, physical characteristics, stability of the ground the loop is laid in, distance between individual loops, number of turns of the loop, tightness of the turns in the feeder to the detector, electrical (mains or other AC signals) interference, length of the feeder, stability of the loop and feeder (normally the loop is fixed in a slot so cannot move, but not so the feeder which also requires to be securely fixed), proximity of metal fabrications (piping, reinforcing mesh, etc), stability of power supply, quality of detector (varies with manufacturer), quality of overall installation, experience of installer, heavy rain showers, and More!

**YOU MAY NEED AN LCR METER SOONER RATHER THAN LATER. THEY ARE AN INEXPENSIVE ITEM. FOR REGULAR INSTALLERS THEY ARE A MUST HAVE ITEM!**

**AN AMUSING EXAMPLE FROM THE PAST.** A large underground parking garage experienced random opening of a free exit barrier that was installed to prevent invalid entry to the area. It would open randomly when no vehicle was exiting, and stay open for 20 seconds until timer close operated (no vehicle crossed close loop to cause immediate closing). After months of investigation and trials it was a matter of the study of waste water piping drawings and luck and a “team test” that showed that the open loop triggered when a large number of toilets in a tower block were flushed close together. Just below the loop were 2 plastic wastewater drain pipes which when carrying a large “slug” of water triggered the detector, opening the barrier!
Remedy required moving barrier and loop (with turns doubled) by some 1.5M.

The moral of this story; loops & detectors are not as simple as is often believed to be the case.