RECOGNITION OF VEHICLES
BY THE
INDUCTION LOOP DETECTOR

FEIG ELECTRONIC GmbH ● Lange Straße 4 ● 35781 Weilburg / Germany

Stand: 11.05.2004 chk

Contents

1. Introduction

The principle of metal recognition via inductance has been known for a long time. It means that metals entering an electro-magnetic field will influence and change the fields. Ferromagnetic materials as well as non-ferromagnetic materials effect such changing of the field. Yet the effect is different. Non-ferromagnetic materials weakes the electrical field. Ferromagnetic materials amplify it.

Metal detectors have recently become known, specially as detectors for weapons and explosives at airports. The round loop used with its corresponds to the loop of a vehicle detector installed in the ground, though the demands concerning those instruments are less than the demands concerning a vehicle detector, because the loop is a fixed value and is used in an exactly defined environment.
Further recognition methods for vehicles are e. g. photoelectric barriers, infrared detectors and radar detectors. The principles of recognition at those devices are of a basically different nature. While an induction loop detector only recognises all materials impervious to light. The disadvantages when using the photoelectric barriers are obvious. As it is an optical recognition within a very small geometric area, measurements can be faulty because of contamination and inaccurate adjustment; high-levelled vehicles, vehicles with trailers are not continuously recognised. Further more the installation is awkward and costly. So the photoelectric barrier is only used for recognising vehicles in one-way gate or barrier areas as an additional security check because it can also detect people.
Infrared detectors are based on detecting thermal radiation within their measuring range. There is also no difference between vehicles and persons as both send out heat. Present solar radiation, warm pavement etc. can cause trouble.
At radar detecting systems a high-frequent radar beam is emitted and reflected by metal parts. This system is rather costly and depends on weather influences, e. g. rain or snow, respectively it depends on the coat of lacquer of the vehicles, as the radar beams partly absorbed by them, so it cannot be measured accurately.

2. The system loop – Induction loop detector

In order to ascertain an accurate operation of the system in all fields of application, it is necessary for the operator to learn some of the theoretical basis of the induction loop detector.
As mentioned above this system recognises metals. This system essentially consists of a tuned amplifier circuit contains a loop (inductance) and a capacitor (capacity). The size of the loop and capacitor define the frequency at which the circuit shows resonance. The inductance (L) of the loop is measured in Henry (= 1000 mH = 1 000 000 uH) and the capacity (C) is measured in Farad (= 1000 mF = 1 000 000 uF). The formula concerning the relationship between frequency and capacity, resp. inductance of the tuned amplifier circuit.

$$(1) \quad f = \frac{1}{2\pi\sqrt{L*C}}$$

Only the capacity with the corresponding active components responsible for bringing energy to the tuned amplifier circuit is within the detector device itself. The loop is installed outside in the road. The inductance of the loop is defined by the following factors:

1. number of turns
2. size and range of the loop
3. form of the loop
4. kind and form of the metals, existing within the lines of electric flux of the loop.

Feeding energy via the detector AC is generated in the loop corresponding to the frequency determined by the value of “L and C”. This current creates an electromagnetic field. As demonstrated in figure 1, the field is most intensive near the metallic conductor and much less in distance to the conductor.
If an iron is brought into a field the lines of electric flux are concentrated and the field is

amplified, this means the rise of inductance (principle of electromagnets). If a wire of approximately the same size as the loop is brought near the loop, a counter-voltage is induced in this wire (mutual inductance), which attenuates the electromagnetic field of the loop. This helps when recognising a vehicle. The bottom plate of a vehicle forms relatively total metal part. This reacts like a closed ring circuit with a circulating current. These currents, like the short-circuited wire mentioned above, cause the attenuation of the field of the loop installed in the ground.

covers, armouring, insulating foils made of aluminium or copper, also influence the inductance but in a negative way. The sensitivity of the total system can be greatly reduced up to inability to function. Only metals are recognised, no wood or plastic materials. A coat of metallic paint or a metallic foil are sufficient to make vehicles with plastic or wooden bottoms (caravan) recognisable.

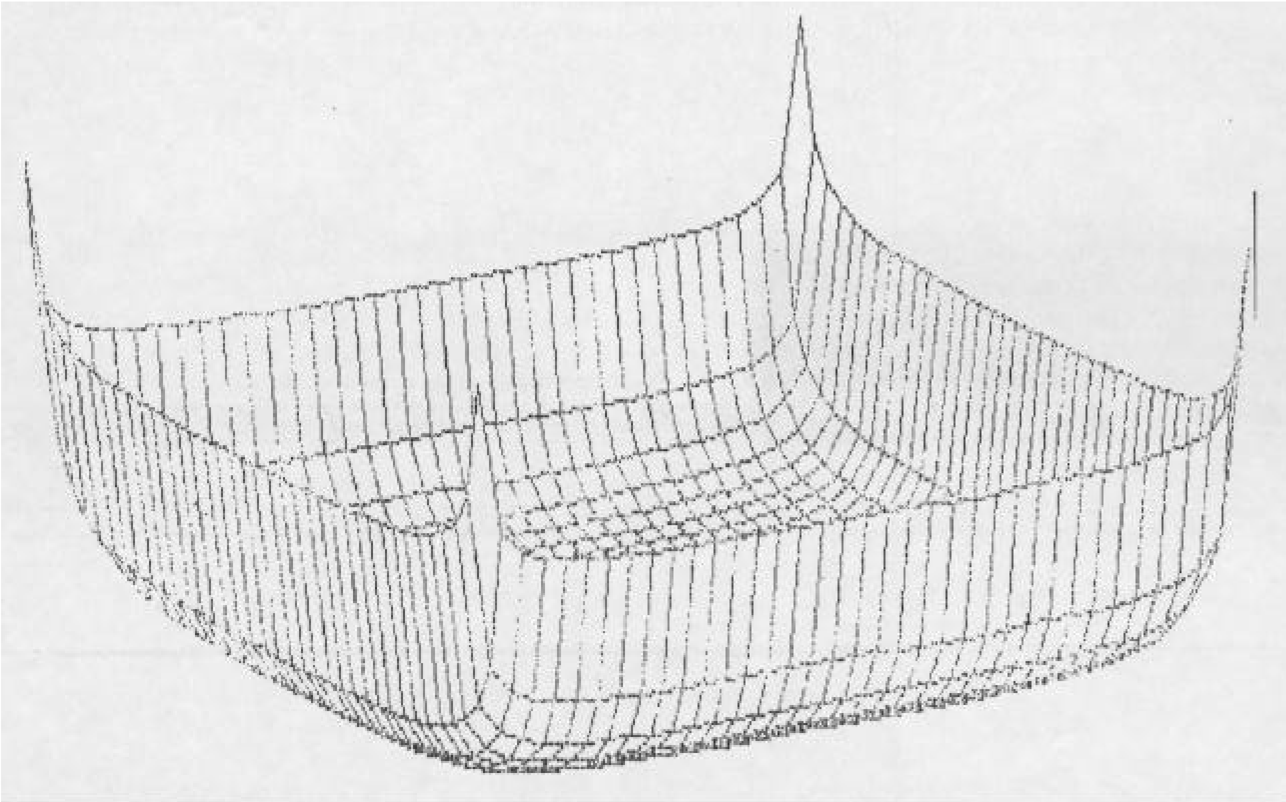


Figure 1: Qualitative field course within the loop

The better conductivity of the bottom plate of the vehicle the more intensive is the attenuation of the field. And this attenuation changes the inductance and hence the frequency:
The frequency rises as the inductance becomes less. This effect is used for vehicle recognition. As just said a good conductivity of the bottom of the vehicle means good recognition. Yet the ferromagnetic iron reacts just the other way, that means big quantities of iron (low-levelled axis) counter-react the attenuation of the magnetic field and therefore are not recognised that easily. If in general metals influence the inductance of the loop installed in the road, on which the measuring principle is based, the unwanted influences on a loop have to be considered as well. Thus metal parts in the ground, such as manhole

So far it was only mentioned that a tuned amplifier circuit changes its frequency if the inductance of the tuned amplifier circuit changes if metals come nearby. So metals increase or decrease the frequency of the tuned amplifier circuit. The wanted effect is the increase of the frequency of the tuned amplifier circuit. Now just the change in frequency of the tuned amplifier circuit has to be measured and a mechanism has to be initiated if a certain frequency is exceeded. The problem measuring the frequency of the tuned amplifier circuit lies in the fact that the frequency of the tuned amplifier circuit of an undamped loop installed in the ground is not constant because of environmental influences such as temperature and humidity. The frequency varies around a certain value up or down. As detunings down to about 20 Hz with an basic frequency of approx. 100 kHz (100 000 Hz) must be recognised, though the change in frequency usually is much higher, it has to be compensated. This detuning generally happens much slower than the vehicle passing the loop. Intelligent systems, such as they are used nowadays with microprocessors, can differ between a vehicle crossing the loop and a detuning of frequency by e. g. changing temperature. In order to evaluate the detuning a large-scaled software is used. This is called a digital temperature-frequency control (DTCF). Thus an infinite stopping time is reached if the loop is engaged. The actual evaluation is very easy, if a limit frequency is reached a relay is triggered and so gives the message that a vehicle has driven on the loop.

3. What should be known about loops – Planning of loops

3.1 Basic Rules

The most important basic rule is that the installation of loops has to be considered already when planning the construction, e.g. parking places or crossroads. Here the basis is presented for all successful loop installation, respectively vehicle recognition. This is where the decisive mistakes are made which lead to big problems and high costs. First you have to consider which purpose induction loops have, in what distance to the barrier or door the vehicles have to be recognised, which reactions have to be executed, what time interval is possible or permissible between the vehicle recognition and reaction of the installation. Priorities have to be set; a decision has to be made whether a manhole cover is more important than a loop, armourings should be installed outside the loop range or the loop should be installed higher above the armourings or the metallic vapour barriers. It should be known that resistance mats as they are installed on ramps often lead to problems if loops are installed nearby or above, so this space should be spared out. The loop size should be tuned to the expected vehicle size, loops must not be installed in shunting areas or in the swivelling range of metal gates.

It is advisable to install the loop and its lead-in very carefully. The installation should be performed or supervised by a specialised firm, that ought to guarantee the functioning of the installation later on. This applies especially if pre-made loops are poured in concrete as the exact position of the loop is then hardly noticeable and the distance between armouring and pre-made loop may alter when pouring in concrete, respectively it may not be considered.

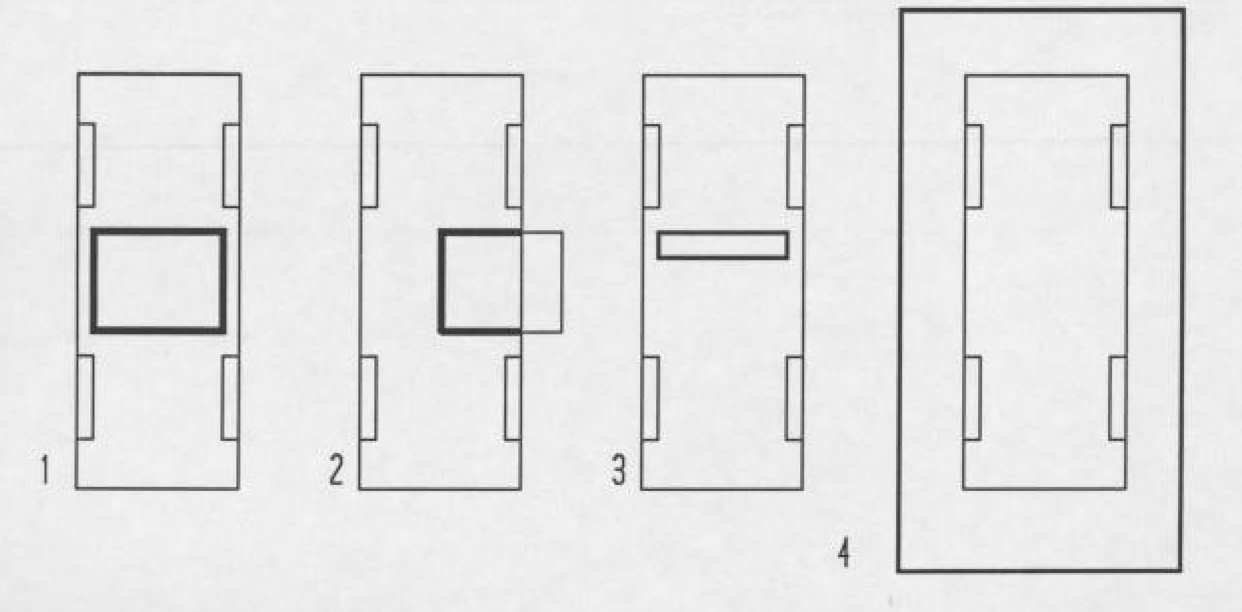
3.2 Loop size and number of turns

There is a connection between the number of turns and the loop size as can be seen in table 1 below. As the systems operate in a frequency range between 30 and 130 kHz (130 kHz is the highest frequency licensed by the post office) a certain number of turns must be installed concerning the loop size. The loop size is defined by the size of vehicles to be recognised. The ideal loop size is a bit smaller than the floor-space of the vehicle. This loop size cannot always be followed because of the geometric conditions when building. The loops often are very shortened so that often loops of 0.6 – 0.9 m width and 1.2 – 1.5 m length have to be used at one-wayed lanes in multi-story car-parks. Concerning lorries or trucks the loops should be bigger and should approach the ideal loop size mentioned above. The vehicles should be led directly above the loops. Loops that are too big, especially if they are much bigger than the vehicle to be recognised, can have the result that a vehicle “disappears” in the middle of the loop and it is recognised twice: first when entering the loop and secondly when leaving the loop, or it is not recognised at all. It is also clear that if loops are crossed only partially the frequency changes less. This might cause that the vehicle is not recognised at all. At loops that are small, especially if they are long and narrow, the parallel sides damp each other thus the sensitivity of the systems is reduced (smaller than 30 x 50 cm).

Loop size	**Number of turns**
smaller than 3 m	6
3 – 4 m	5
4 – 6 m	4
6 – 12 m	3
bigger than 12 m	2

table 1: Recommended number of turns at rectangular loops

There are several examples in the following figure 2 which shows the relation between the size of the loop and the dimension of the vehicle. It has to be considered that the part of the loop covered by the vehicle – not the area of the loop in general – is responsible for the magnitude of detuning.



1. Schleifenrgöße im richtigen Verhältnis zum Fahrzeug
2. Nur ein Teil des Schleifenumfanges ist aktiv, da Fahrzeug an der Schleife vorbeifahren kann.
3. Schleife zu klein, die Wirkung der Feldlinien hebt sich weitgehend gegenseitig auf- Schleife unempfindlich.
4. Schleife zu groß, nur ein kleiner Teil der Schleife kann aktiv werden.

1. Loop size is in correct relation to the vehicle
2. Just a part is acting, because the vehicle can partly miss the loop
3. Loop is too small, the effect of the lines of electric flux compensates loop is insensitive
4. Loop is too big, only a small part of the loop can be active

Figure 2

The field intensity as well as the sensitivity of a loop outside its size does not drop to zero at once but its decline is rather steep as can be seen in figure 1.

3.3 Loop forms

The mostly used form is the rectangular one. It is of uncomplicated geometrical form. Often the edges are bevelled in order to lessen the mechanical strain of the loop wire. The data mentioned above concerning the number of turns and the loop size fit to that form (Fig. 3a).

In order to recognise bicycles which cause a very low change of inductance, loops are installed in form of a parallelogram (Fig. 3b). As the field intensity along the loop wires is the highest, a bicycle following such a line is recognised best. A bike cannot be expected to follow exactly one of the two-side-lines of a loop. By crossing the loop circumference diagonally, more lines of electric flux are intersected and thus the detuning is bigger.
If loops are to be installed between tracks, e.g. of a street car or a train it is recommended to install the loop in shape of an eight. The distance to the tracks should be 20 cm at least. This special shape extensively prevents interferences of the electric currents in the tracks. (Fig. 4a)
In order to save the amount of detectors one piece of wire sometimes is used for two loops leading to one detector. Be cautions of this variant, because the loop necessarily is extended. The circumference of the single loops is covered in sequence, so the total covering value is at maximum 50%, conditional on the construction, that means the total system is correspondingly less sensitive and there might be problems with the vehicle recognition. Furthermore it must be considered that the ground outside the gate is mostly armoured. Hence there are different dampings and so different sensitivities. In this example the inner loop is less sensitive than the outside. An optimum matching to the armouring conditions is not to be reached with one detector. In these cases it is recommended to use a detector to which two loops can be separately connected. The expenses for such an installation are 50% more than a single detector and the price for the installation is the same in both cases.

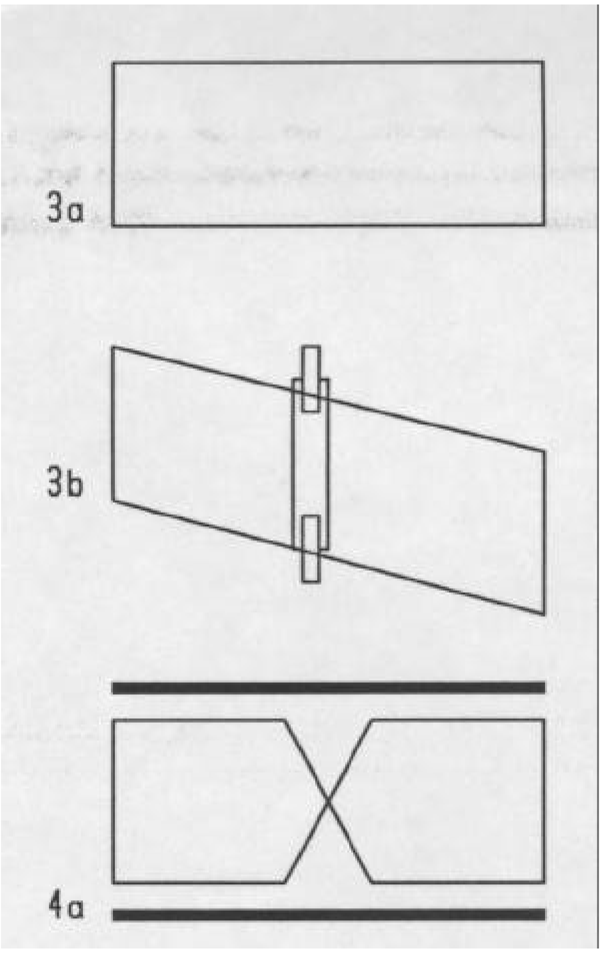


Figure 3 and 4

3.4 Loop fields

If loops are installed one after the other or side by side this is called loop fields. It is meant for covering big areas, e.g. in front of wide gates. Be cautions when planning such fields. The loops must be installed in a distance to each other of 50 cm at least in order to avoid their influencing each other. The longer the parallel exposure is the longer the distance must be (rule-of-thumb: distance = ½ length of the parallel exposure). The better solution is to ban indiscriminately passing over a big area by markings on the lane (e.g. Kerbstones or coloured markings) and then to use only a few loops within these marked areas. In some cases other geometrical shapes are used to fulfil special purposes. Each loop shape is basically to be realised; the course of the lines of electric flux, which can be derived from that of the rectangular loop, should be clear. If there is any problem of that kind it is recommended to install a test loop and check the functioning empirically.

3.5 Loop lead-in

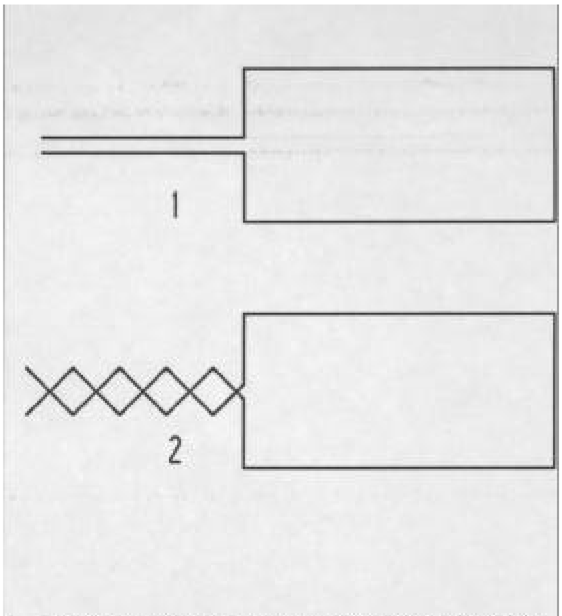
The loop lead-in is theoretically nothing but a loop itself. An untwisted loop lead-in can be regarded as a very long narrow loop. So the loop lead-in also contains a certain inductance. This inductance is as influenced by metals as the loop itself. The aim must be that the inductance of the lead-in is very small compared to the actual loop in order to reach a high efficiency. By twisting the loop lead-in a low inductance can be reached. There are three advantages.

1. This very low inductance can no longer be influenced by metals

2. The geometry does not change any more when moving the lead-in wire

3. The “dead” part of the inductance is very low.

It is very important for the loop lead-in to be twisted well. Using relatively short loops up to approximately 10 m, the twisting can be performed with a drilling machine; using longer lead-ins a pre-twisted cable is recommended, to be connected to the loop at a proper spot. When using pre-twisted cables the inductance has to be considered; the manufacturer usually informs about inductance per metre. The maximum permissible lead-in length can be learned from the pamphlets of the manufacturers. Yet it must be realised that the sensitivity of the system decreases with the length of the lead-in. The efficiency average has to be considered, too, specially with long lead-ins. The total system should not have a bigger internal resistance than about 20 Ohm, otherwise the system might not stimulate the oscillation any more:



1. Zuleitung unverdrillt, wirkt wie eine schmale Schleife
2. Verdrillte Zuleitung, Induktivität dieser Schleifenzuleitung geht gegen 0

Figure 5

1. Lead-in untwisted, is like a narrow loop
2. Twisted lead-in, inductance of this loop is row

The total internal resistance of the loop and the lead-in can be calculated in the following way:

(2) R = 0.017*(U*W/Q1+2*L/Q2) + Rü

R	=	loop-lead-in resistance in Ohm
0.017	=	specific resistance of copper
U	=	circumference of the loop
W	=	number of turns
Q1	=	cross-section of the loop wire in qmm
Q2	=	cross-section of the lead in qmm
L	=	single length of lead-in
Rü	=	transition resistance of all contact points

Example: Loop 0.9 x 0.6m, cross section 1.5 qmm, 6 turns
lead-in 200m, cross section 0.14mm,
transition
resistance 2 Ohm

R = 0.017*(3*6/1,5 + 2*100/0.14) + 2 = 26,5 Ohm

This shows that the total resistance can become critical if the lead-ins are long, the cross-sections are small and the transition resistances are high. If pre-twisted cables are used at long lead-ins it must be taken into account that the cross section is not to small. Twisted pairs of wires must not be laid parallel for rising the cross-section, otherwise the effect of twisting is lost.

Coaxial cables can also be used in critical cases, because it has a low inductance per metre. The loop lead-ins should be installed in a possibly great distance to the lead-ins of power supply (at least 20 cm). Loop lead-ins and supply mains must not be installed in one conduit or pipe in any case. Loop lead-ins should also be permanently installed, so that they cannot be moved. This also has to be regarded when installing within the switch cabinet – it stands to reason that the lead-ins must be twisted as well.

3.6 Installation of loops

The most usual way of installing loops is to mill grooves of ca. 4 to 10 mm and ca. 30 – 60 mm depth into the concrete or into the asphalt by means of a special cutting disk; a commercially available copper wire, 1.5 qmm plastic armoured, e.g. H05V-K1.0 or H07V-K1.5 (NSYA-F) is installed in the grooves in several turns.

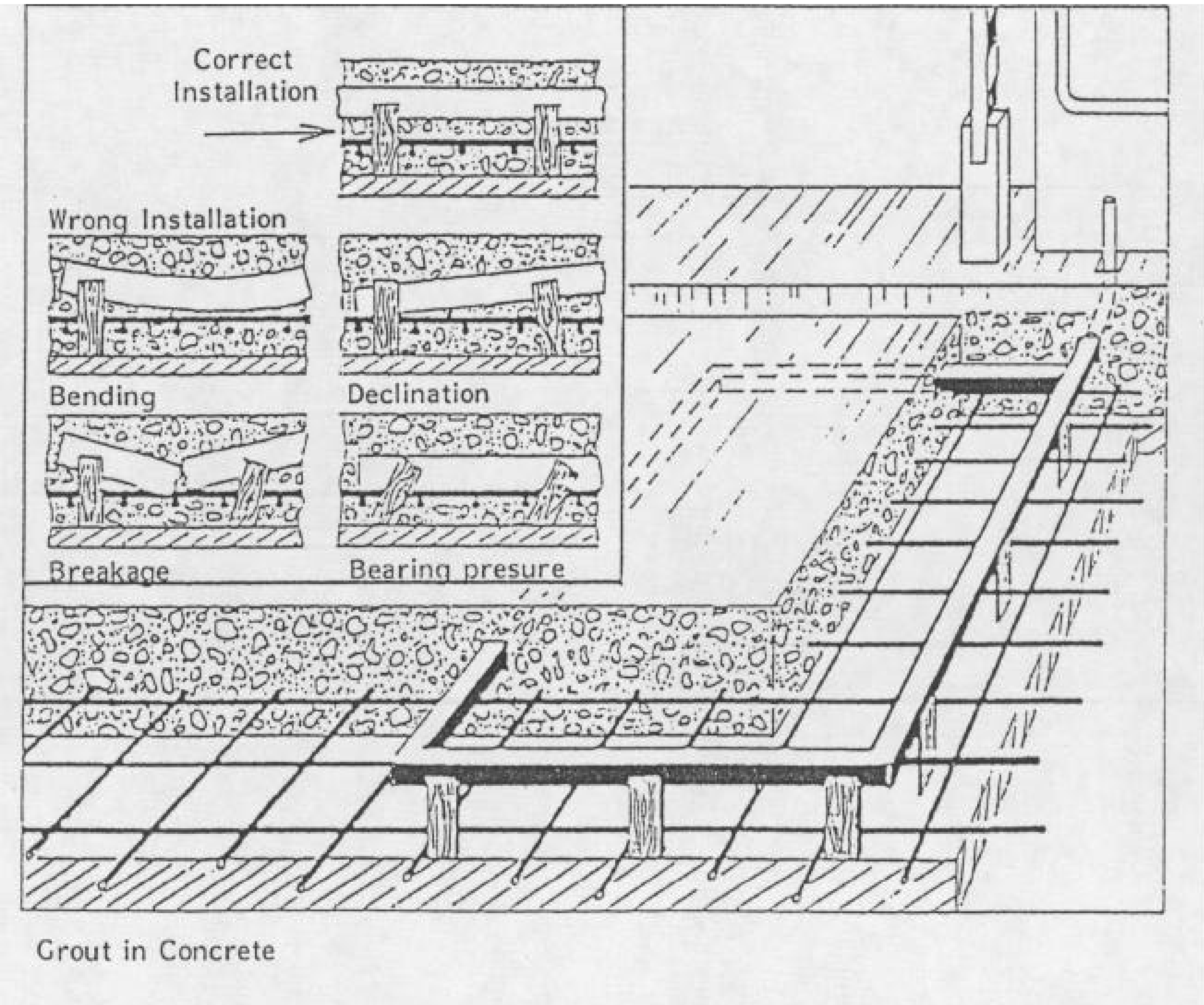


Figure 6

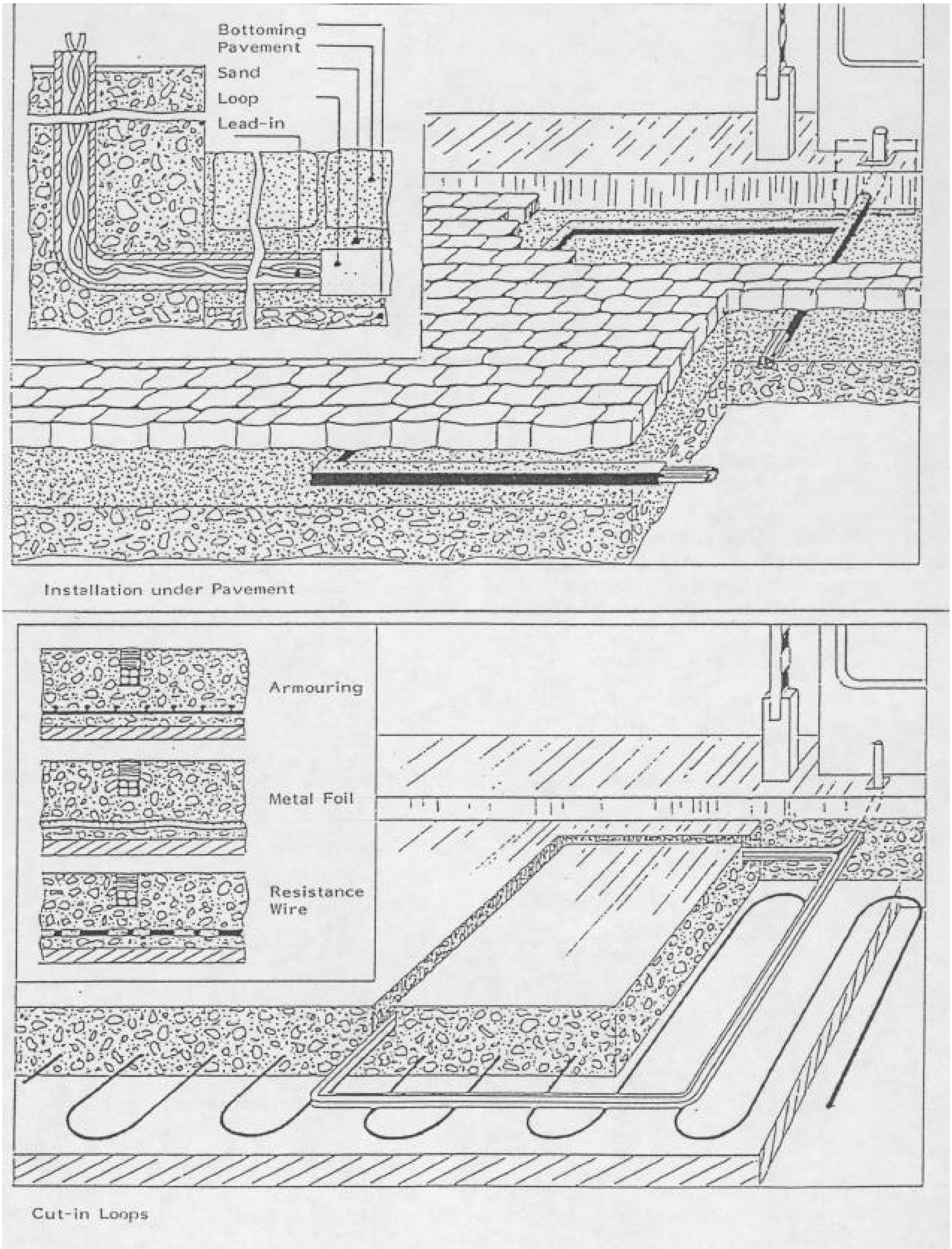


Figure 6 continued

The connecting groove between loop and detector is cut a bit wider so that the twisted cable fits into it. The loop is spilled with a special casting compound. There are hot and cold casting compounds. If a hot casting compound is used it must be considered that the commercially available copper wires only can stand temperatures up to max. 70 degrees, that means if a hot casting compound is used, a silicone – treated wire should be taken. Then the temperature of the casting compound can go up to max. 200 degrees. The following materials can be used for pouring: Racofix or Upadfix for concrete, Vedagum for asphalt.

The corners are to be cut oblique at rectangular loops to avoid a too high strain of the loop wire at the corners, which can lead to cable breakage or insulation breakage. If inexperienced with cutting loops or installing loops, one of the numerous specified firms should be called in to avoid problems. Manhole covers, sewers, hydrants etc. which are within the range of the loop, must have a minimum distance to the loop of ca. 0,5 m, otherwise there is a partial damping. If there is any steel armouring in the ground, the loop should be above this armouring at least 5 cm (Fig. 6) Expansion joints are often necessary in concrete. If the loop wire passes an expansion joint, a small loop is to be installed or the loop will be shorn off if the concrete slabs move. Loops and loop lead-ins must not be installed in the expansion joints. An alternative technique for installation, which is not recommended, is to install the loops before concrete or asphalt. If necessary in any case it should be worked with pre-made loops which are installed in the pre-made geometric shape and it is concrete or asphalt. There is the danger of breaking or moving or the loop might sag to the armouring. Later it will be hardly possible to know how the loop lies underground or even where the loop is.

Another critical technique is installing loops under pavement. The loop leads must not be laid in the sand only fixed by logs. Basically only pre-made loops should be used, but the loops must lay on a firm underground not to break. Furthermore it has to be considered that rain can easily enter the layer of sand through the pavement, so the inductance of the loop may change. The humid earth and the layer of sand reacts specially in combination with de-icing salt like a (relatively bad transmitting) metal, that means the loop reacts like being damped. Furthermore the pre-made loops must not be installed too deep in the layer of sand, otherwise the distance top edge-loop is too big and this causes a bad sensitivity.

3.7 Measurement at loops

After installing a loop it should be determined if the loop meets the demands the traffic detector claims and if there is no damage.

1. The insulation resistance towards the earth must be measured. The earth in the switch cabinet serves as reference earth or even better an iron rod is driven into the ground near the loop – if possible – and the measurement is taken opposite this rod. The insulation resistance should not be below 5 MOhm. Any value greatly below 5 MOhm shows the leakage of the loop, that means probably there is an insulation mistake.

2. To make sure that the loop hat not been damaged during installation the volume resistance is measured with an ohmmeter, the resistance must not exceed 30 Ohm. The measurements at the loop should be taken directly at the binder of the detector to ascertain, that the total connecting way is taken into account when measuring. A short circuit of the loop is very difficult to recognise because the theoretical loop resistance must be compared with the measured one. Depending on where the short circuit is the differences are rather little and can be in the range of the measuring accuracy. An insulation mistake often is Measured at a short circuit. A short circuit shows for example if the system loop detector does not stimulate the oscillation, that means if no frequency is measured or if the frequency is a lot higher than the frequency of a comparable loop.

3. Measuring the inductance of a loop is not necessary as this measurement can be substituted by measuring the frequency at the detector

4. After connecting the detector to the loop the basic frequency is to be measured with which the loop oscillates. The basic frequency should be between 30 and 130 kHz, it must not be above130 kHz in any because this is forbidden following the postal rules. Feig-detectors are constructed in a way that a fault message is given at frequencies beyond this range. Almost all Feig-detectors have connecting jacks for a frequency meter. By the frequency meter the detuning caused by a

vehicle can also be measured. If a loop is installed properly and there are no armouring or metal foils below and which is covered completely by a car, a detuning of 1000 to 2000 Hz can be assumed. Lorries or trucks cause a detuning 4 – 5 times less.

Sometimes, specially concerning older loops that are about to be connected to a new installation, and of which the exact position is not known, the detector is connected to the loop as well as to the frequency meter. Now you use a piece of sheet metal or a wire bent to an oblong loop and approach the suspected location of the loop, searched for, close to the ground. If the sheet metal is about parallel to one of the loop wires the frequency meter will show a higher detuning. This is done at all four sides (considering the loop is a rectangular one) to detect the exact position of the loop. It is advisable to mark the position of the loop for further investigations . If a loop causes a detuning of much less than 1000 – 2000 Hz at a standard car, it means that there are metal foils or iron armouring in the ground. The less the detuning is the closer the loop is to the foil or armouring. In unlucky cases this might lead to a non-proper recognition of the detuning caused by a vehicle. Another reason may be that the loop is too deep in the ground (20 cm and deeper). As said above it is very important that the loop cannot move within the ground and does not perform movements of its own if there is any shaking. Every movement of the loop means a change of inductance and as the detector cannot recognise the cause of this change this may lead to an incorrect balancing or to a fault message.

If it is not quite clear whether a loop to be installed at a certain position will work properly it is recommended firstly to install a test loop (specially if there are problems with the armouring). Nowadays there are loops that can be glued to the road surface and can be used for several days or weeks – yet this is not advisable as a permanent solution but only for tests.

4. Environmental influences

The loop is one part of a tuned amplifier circuit (inductance). the other part is placed in the detector (capacity). A tuned amplifier circuit only oscillates very regularly if both parts defining the frequency, that is inductance and capacity, will not alter. The capacity is constant because of some special arrangements. Further more the components of the detector are only expelled very limited to environmental influences, as they are safely inside the detector cabinet. This is completely different to the loop. The loop is installed in a medium that is not clearly defined. There environmental influences can extremely act upon it, e.g. temperature and/or humidity. these influences effect that the inductance of the loop is not constant even in quiescent condition (loop not occupied). The inductance alters permanently more or less in an uncontrolled way in both directions; hence the frequency of the total tuned amplifier circuit alters as well. Only using rather costly software in a microprocessor system, succeeds in compensating the constant alternation of the tuned amplifier circuit. Then the detector is able to differ between the detuning of the frequency caused by a vehicle or environmental influences. Changing of ground temperature means a detuning of the frequency. Humidity penetrating into the ground changes its conductivity. This has a similar effect to damping the loop with metal. Problem occurs when installing the loop under pavement without a solid bed are not only caused by movements of the loop wire but also by the possibility of humidity penetrating into the ground. If you have a compound filled loop and the casting compound loosens it has a double effect: the loop moves when a car is driving over it and water can get into joints (this can also cause immense street damage).

As well as by penetrating into the ground rain can lead to trouble by forming a water film on the road. This can become extremely critical if the water film gets thicker above the loop e.g. by blocked drains or a cloud burst. Snow and ice can lead to the same problems. This might happen especially if a snowplough pushes all the snow to one side. Eventually the detectors are constructed to be able to handle these problems on their own. But together with other unfavourable circumstances such conditions may be the cause for problems with the loop-detector system.

5. Range of application

Multi-storey car parks, parking lots

The demands on a vehicle detector vary a lot because of its broad range of application. The manufacturers try to cover many applications with the same system. There is the big field of multi-storey car parks and parking lots, where mainly passenger cars are to be handled. Loops are installed at the entrances and outward runs to distribute tickets, open or close barriers and for counts. The loops are comparatively small so that they are covered completely proposed there a right traffic regulations. Problems especially occur in multi-storey car parks with armouring and metallic vapour barriers. Planning car park system the exact locations of armouring, vapour barriers and resistance mats are not often known. Many times the traffic regulations are not properly and the vehicles do not drive exactly above or even besides the loops. Problems may arise if parking spots are directly besides a loop and causes a permanent damping of the loop. The detector will retune this after a while and the sensitivity diminishes. Especially concerning counts the logical course has to be considered carefully. There must not be any shunting within the area of any counting loops.

Street traffic, long-distance traffic, tunnel monitoring

Concerning street traffic vehicle detectors are used for recognising vehicles in front of traffic lights in order to regulate crossroads. The variety of vehicles in street traffic is much bigger than in car parks. There are cars, trucks, motorcycles, mopeds and bicycles that have to be detected. Cars are comparatively easy to recognise as they cause a high detuning. At trucks the bottom plate is relatively high above the ground thus the recognising is more difficult. Very hard is the recognition of double-wheels as the metal area parallel to the ground is almost zero. Here the wheels are used for recognition. But when they drive over the loop it has to be parallel or at least diagonally to the loop wires in order to affect a detuning: a right-angled crossing of the loop wires does not cause any detuning of the loop. For this reason the loops that are to recognise double-wheels are installed in the shape of a parallelogram. This means the loop wires are oblique to the street direction. The sort of loop to recognise electrical rail vehicles is mentioned above.
Loops are used increasingly in long-distance traffic for traffic regulations such as recognition of traffic jams and measuring the velocity and length of vehicles. Latter one is mainly to differ between cars and trucks or lorries.

Doors

Vehicle detectors are also used to open gates that are moving horizontally or vertically in an automatic way. It is important to use detectors with unlimited holding time so that the door or barrier does not close while the vehicle is still in its range. As doors often consist of metal or have a metal frame the loop must not be installed to close to the door (distance 1 – 1,5 m). Otherwise the detector might recognise the door as a vehicle. In this application relatively big loops are often installed to reach a bigger range. In reference to chapter 3.3 big loops might lead to the problem of hardly or not recognising vehicles. To cover a big range it is therefore better to install several small loops. The expenditure of installing is hardly higher and a double detector is not double as costly as a single detector. Furthermore the loop for a door of 5 m width does not need the size of 5 m as well, 3 m is sufficient if the loop is installed in the middle of the gate.

Safety of machines

Detectors are used to avoid that pallets are deposited near a machine or that vehicles are in the danger area of the machine. Here again the loops should not be too big and the detector should have an unlimited holding time.

6. Vehicle recognition (kind and type of vehicle)

The loop geometry must necessarily fit to the plans of vehicles crossing the loop. It should be decided if all kinds of vehicles shall be considered even those of odd or very seldom existence. This is a question of expenses. But it is quite obvious that troubles might arise in extreme cases if restrictions are decided for because of the expenses.
Vehicles are basically recognised because of two characteristics: 1st characteristic is the bottom plate, 2nd characteristic are the wheels (material, size and structure). The wheels are important because their metal parts are closest to the loop wires. The geometrical position of the wheels towards the loop wires is also great significance: wheels standing or moving parallel to the loop wires are recognised very easily, wheels standing at right angle to the wires are not recognised at all. Passenger cars are very uncomplicated to be recognised provided the loop is properly planned and installed. All-terrain vehicles recently built and spread are more complicated to be recognised. The lower bottom plate of these vehicles is much higher than that of passenger cars. Cars with trailers can cause problems. The cars are easily recognised but the trailer is not; if the bottom plate is made of wood or plastic, only the wheels or only the axis is recognised. That means the detuning drops between car and trailer and is thus recognised as two separate vehicles. This might

happen before the trailer has crossed the loop completely , because the detector regards the end of the wheel or the end of the axis as the end of the trailer. This means practically that for example gates or barriers close between car and trailer or close too early at the end of the trailer. This problem can be avoid by planning the loops correspondingly (e.g. several loops one after the other).
Trucks have generally a higher gravity centre and thus a bigger distance to the loop. Their bottom plate is not modelled uniform, so separate circuits develop with separate counter inductance, which can simulate some vehicles instead of one in extreme cases, especially if the sensitivity of the detector is not set high enough. What is said about passenger cars with trailers is also valid for trucks with trailers.

Vehicles for transportation used inside and fork stackers

The forks of an empty fork stacker are recognised relatively badly while the bottom plate is recognised well. There must also be differed between the empty and the loaded fork stacker. So called high-speed doors are often installed, that means the fork stacker is driven fast to the door and the door must open quickly. Depending on the load of the fork stacker the vehicle is already recognised when the loaded forks cross the loop or only when the stacker itself crosses the loop. This must be taken into account when planning the loop, especially when planning the distance to the door so that the fork stacker can be driven towards the door at a constant speed and the door opens in time.

7. Basic data of loop detectors

When using loop detectors it should be clear in advance what purpose the device is meant for. Feig Electronic delivers devices in plastic housings with type of protection IP as 19” slide-in units and devices in metal cases. If used at doors cabinets being mounted directly on the wall and protected against humidity and dust are more suitable. If several detectors are used in an installation the 19” partial slide-in unit can be used. These devices are delivered with direct voltage connection 24V. Devices in metal cases are very suitable for the use in barriers.
Concerning the functioning there is a difference between single detectors connected to only one loop and double detectors connected separately to two loops and disposing of two separate evaluations systems. If the direction of vehicles is to be recognised two loops are installed and they are connected to a detector suitable recognising directions. Detectors for measuring velocity or recognising the length of vehicles are used in general traffic.
In order to avoid interference it is necessary for loops close to each other to have different frequencies, the difference in frequency should be at least 15 kHz. To get this difference in frequency in spite of the same loop size, which means the same inductance, the detectors have a frequency switch to set different frequencies at the single devices. The frequencies of adjoining systems should be verified as they are not certain to have different frequencies if the frequency switches of the single detectors are in different positions. Small distinctions of the geometry of the loop or different influences of armouring can cause equal frequencies in spite of the frequency switches being in different positions. If the number of turns of the loop are installed according to the manufacturers instructions the tuned amplifier circuit of the detector will oscillate within the prescribed range of 30 to 130 kHz. Outside this range the detectors simulate faulty operation and either indicate loop breakage or loop short-circuit. As each microprocessor has a distinct cycle time the maximum velocity of driving over the loop and the speed of reaction of each detector are limited. This has to be considered when choosing a device. The sensitivity of the device compared to other measuring instruments is extraordinary high. In the most sensitive position the minimum triggering level is 0,02% of the basic frequency. At the FEIG - detectors 8 different sensitivity positions can be chosen from. But for safety measure the sensitivity should not be higher than necessary for certain recognition. The balancing and rebalancing of the device is automatically carried out but it should be ascertained that there is no vehicle on the loop when balancing the first time, this means when the device is switched on or the reset key is pressed. In some cases when driving over a loop the detuning does not rise continuously and after reaching a maximum does not drop continuously but depending on the size of the loop there is a breaking-in of the detuning when the vehicle is in the middle of the loop. To avoid that the detectors are equipped with a so-called hysteresis – hence the relay of the detector does not drop temporarily while the loop is driven over by a vehicle. The signal output is frequently equipped with relais. So if bigger powers with AC are to be switched the connected contacts must be screened with RC-sections. If power outages are to be expected it is to be recommended to use detectors backed up by a battery to assure that the tuned amplifier circuit is still operational. So the condition of the moment of power outage is

recognised after the system is switched on again. If it is not sufficient to store the old condition, as it is done by some products, because when the power is connected again the stored condition, which might not be available any more, is output.

LOOPS AND TURNS

ADJUSTABLE FOR LOOP - DETECTOR

? f	/ sensitivity - steps
> 2kHz	1
1,5 – 2 kHz	2
800 – 1,5 kHz	3,4
400 – 800 Hz	5
200 – 400 Hz	6
100 – 200 Hz	7
< 100 Hz	8