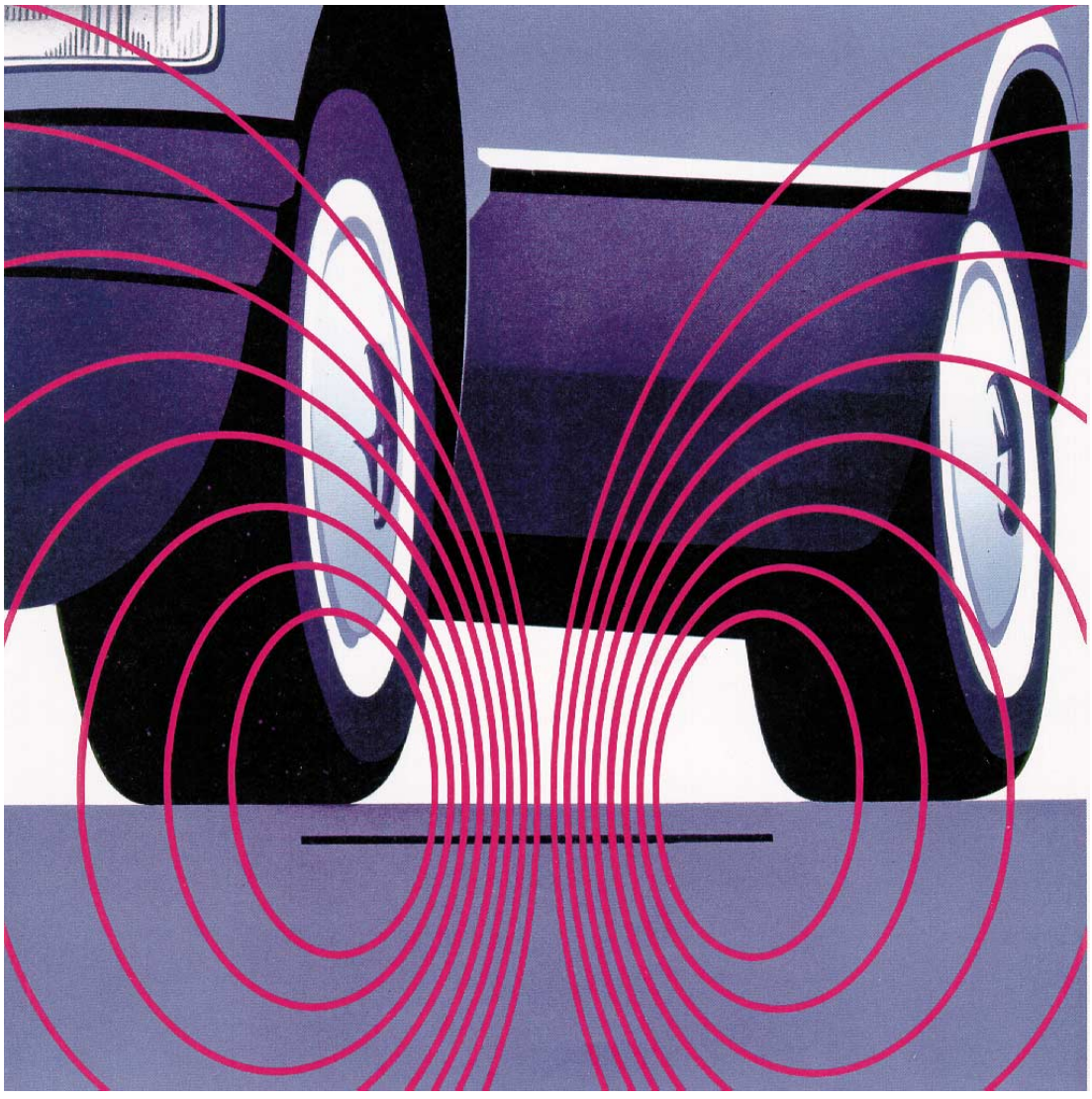
SIEMENS

Loop Detector LD4



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Loop Detector LD4

Nowadays, it is largely inductive loop detectors that are used to measure road traffic. These inductive loop detectors primarily feature a precisely defined range in which they detect metal objects. This range is determined by the wire loop measuring sensor buried in the road surface. When a vehicle is present, detectors supply a signal with which vehicles can be signalled or counted. Counted values are used, for instance, to determine the traffic volume (vehicles per hour) and thus form the basis for traffic statistics and traffic planning. Measurable variables that are important primarily for traffic control can be derived from the duration of the signals resp. their sequence. These measurable variables include, for instance, the occupancy (which is a measure of the traffic density) and the time gap. Using two loops ("double loop") arranged close together and one behind the other in travel direction, it is also possible to obtain information on speed, vehicle type and travel direction, used, for instance, for traffic management and for traffic statistics.

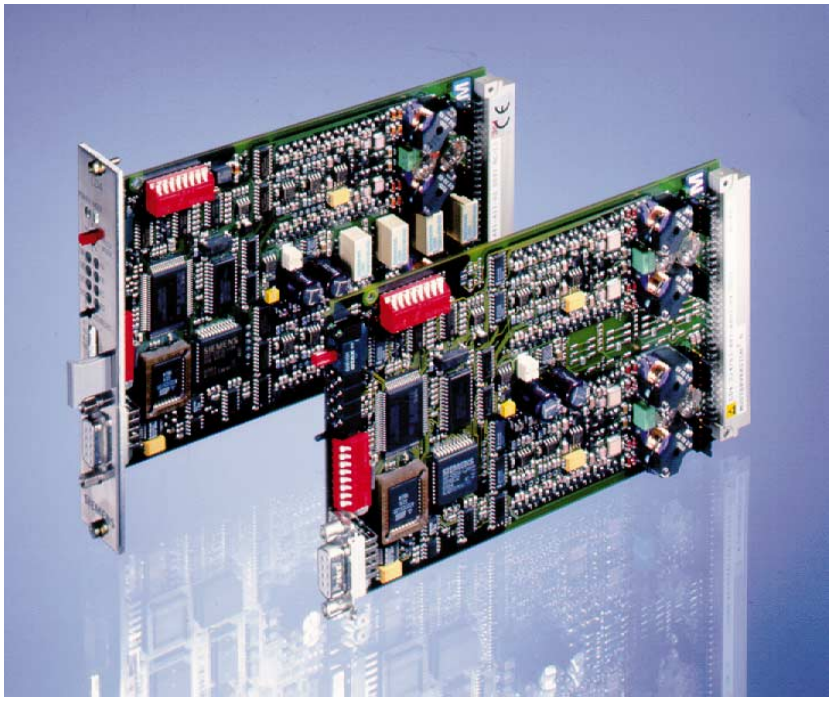

Figure 1: LD4 Detector module

Function

The function of the loop detector is based on the principle of a change in inductance of a coil through whose field a metallic object moves. The coil is formed by a cable loop, the inductive loop, laid in the roadway.

It is laid in a narrow slot that is cut into the roadway and is then surfaced over. The inductance of the loop depends on its size and the number of wire windings. The position and dimensions of an inductive loop are determined by the relevant application.

An alternating current (approx. 40 to 100 kHz) generated by an oscillator (loop generator) is passed through the loop. This oscillator causes a magnetic alternating field in the area of the loop that, in turn, generates eddy currents in the metal parts of a vehicle passing over it. These, in turn, influence the alternating field of the loop, thus causing its inductance to drop and the generator frequency to rise.

A detector module contains the sensor circuit for four inductive loops. Each loop is powered by its own loop generator. In order to avoid mutual interference, different frequencies are used, and these frequencies can be set in six frequency channels or freely selectively per loop. The frequency is adjusted automatically.

One frequency meter per loop measures the relevant loop frequency in consecutive measuring cycles in conjunction with the processor. Pulses of a crystal oscillator-controlled reference generator are counted in one measuring cycle during a "time window" formed by the loop frequency. The pulse count reached during the time window is inversely proportional to the loop frequency. The difference between the pulse counts of consecutive measuring cycles is a measure of the variation of

the loop frequency ("detuning"). It is used for indication of the vehicles. On the basis of these measurement results, the processor generates the electronic detector output signals and the fault signals available at the outputs of the module.

The response threshold is selected depending on the vehicle types to be detected. In the normal setting for motor vehicles without motorcycles, the detector "learns" the optimum response threshold from the traffic activity (e.g. important owing to less detuning in the case of reinforced roadway).

A watchdog circuit monitors the program run in the microprocessor and the operating voltage. If a fault or error occurs, the detector is reset and a fault signal is issued.

The detector functions and the connected processing system can be checked with the aid of test operating modes.

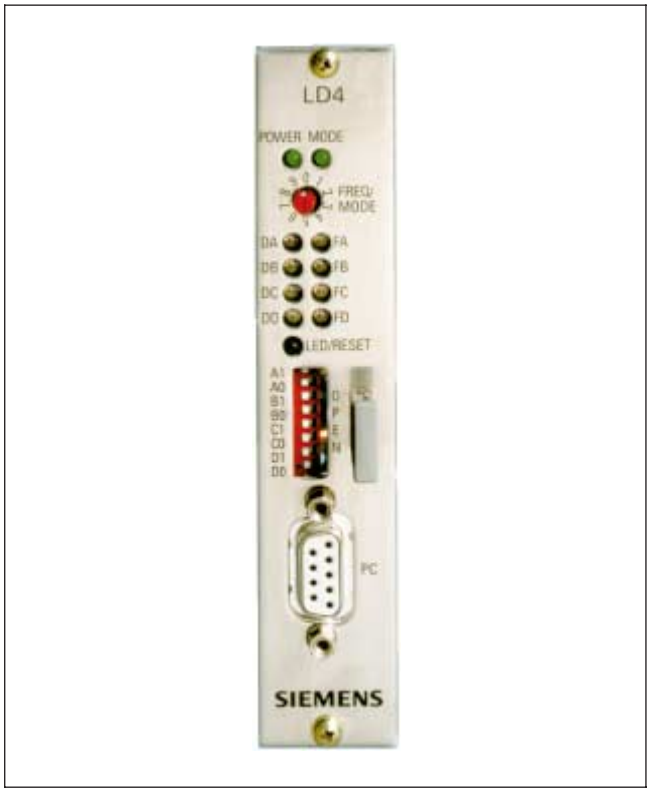

Figure 2: Front panel of the loop detector LD4

Performance characteristics

Detector LD4 is a further-development of the time-proven SDA/SDB detector but can handle 4 loops instead of 2 loops per module. It features high sensitivity, short measuring times and high functionality. Automatic sensitivity and loop frequency settings allow easy commissioning and operability. A convenient PC configuration program is available for optimum matching to an extremely wide variety of applications, for programming the extensive special functions and for diagnosis and servicing purposes. The LD4 allows precise measurements of speed and vehicle type (into up to 9 classes) as demanded in accordance with TLS for motorway applications.

The most important features are as follows:

- Module (European-format) with 4 sensor circuits (detectors A, B, C and D) for each inductive loop
- Rear panel plug assignment to TR0100
- Operating modes "Independent loops" (single loops) or "Double loops" can be selected optionally, separately for A/B and C/D.
- Functions of the "Independent loops" operating mode:
  - Vehicle occupancy/gap
  - Bicycle request

  Additional functions of the "Double loops" operating mode **):
  - Speed and travel time
  - Vehicle type (car/truck or in up to 9 classes)
  - Vehicle length
  - Travel direction
- Classification of the vehicle types to TLS of the BAST. Output via the serial port **).
- Measured values per vehicle if using the serial port **):
  - Occupancy time in ms
  - Preceding time gap in ms
  - Travel direction in the case of double loop
  - Travel time between two loops of one double loop in ms

  - Speed in the case of double loop in km/h
  - Vehicle length in the case of double loop in m
  - Vehicle type in the case of double loop in 9 classes

  Up to 25 vehicles are buffered without data loss or data falsification
- Fault indications/alarms
  - Loop break (loop short-circuit restrictedly)
  - Watchdog (program monitoring)
  - Voltage monitoring
  - Channel monitoring (frequency setting)
- Outputs: 2 per loop, of these 1 as relay contact, for occupancy and error, or special functions
- Master fault output (optocoupler), isolated
- Indicators: 2 LEDs per loop, same significance as outputs
- Automatic setting and matching of the response threshold (sensitivity) if only motor vehicles (not including motorcycles, bicycles) are to be detected ("normal" sensitivity setting).
- Additional 4 fixed response thresholds for motor vehicles and bicycles (medium/high and double sensitivity settings)
- Any individually adjustable response thresholds up to 0.04 ‰ $\Delta L/L$ *)
- Multiple polling of the detuning values (oversampling) for particularly interference-immune detection of the response and release thresholds
- Dynamically controlled measuring thresholds for response, speed measurement, vehicle type discrimination and, thus, optimally matched to loop and traffic, low adjacent-lane interference
- Six different frequency channels are available for the loop frequencies (40 ... 90 kHz); common setting for all four loops of a module, switchable in groups, or individually selectable with PC
- Frequency individually adjustable optionally with PC (30 ... 120 kHz)
- Automatic adjustment of the loop frequency with monitoring simplifies commissioning and guarantees safe operation without interfering with neighbouring loops
- Automatic matching to ambient changes: the impedance of the loop and supply cable may change in the long term as the result of external influences (e.g. temperature influence, mechanical change); the change in loop frequency and sensitivity caused by this is corrected automatically, thus dispensing with the need for readjustments
- Serial RS232 interface for PC on the front panel of the module for measurement of traffic-engineering and physical variables, for checking the detector functions, for assistance in problematic applications and for programming diverse special functions (extended performance features)
- Serial RS485 interface for communication with roadside stations and signal controllers for up to 32 modules on one bus **)
- Vehicle values for up to 25 vehicles remain buffered in the detector until fetched via the serial port, thus dispensing with the need for simultaneous polling
- Indication of PC-modified settings (stored special functions or modified parameters) by LED on the front panel of the module
- Optional front panel available (included on -A11, -A12)

Extended performance features

The LD4 loop detector can be set in diverse ways to meet the needs of special applications by activating or modifying special performance features either alternatively or as additional features. These features are selected via a convenient configuration program with a PC. The settings are internally and permanently stored on the module (no battery required) and can be saved to diskette or reloaded from diskette and printed out.

Traffic-engineering functions

- **Presence time** *)
  This can be set in 16 steps from 1 s to several hours. Regardless of the actual loop occupancy, the occupancy signal is reset at the latest after this set time. This means that the detector is "unoccupied" again and thus, for instance, responds to further vehicles that enter the loop even though there is another vehicle on it, e.g. in the case of wide loops.
- **Presence time in the case of bicycle detection** *)
  The presence time is normally limited to 2 s resp. 20 s for very slight detuning, as produced by bicycles. This is in order to guarantee safe operation. This restriction can be cancelled for specific applications.
- **Pulse mode**
  A fixed-length pulse (approx. 150 ms) can also be issued with each vehicle instead of an occupancy signal. This corresponds to a detector with a very short presence time, thus preventing blocking of a wide loop as the result of parked vehicles.
- **Delay feature** **)
  Adjustable delay of the start of the occupancy signal (possible settings: 1 ... 60 s). The output is set only after the set time is exceeded (e.g. queue detection, delayed demand). The output is reset undelayed when the loop is left.
- **Extension feature** **)
  Adjustable extension of the end of the occupancy signal (possible settings: 0.5 ... 49.5 s). The output remains set through to the set time even after the loop is left. The start of occupancy remains undelayed.
- **Direction detection** **)
  The travel direction is determined in double loop mode by comparing the occupancy sequence of both loops. Either the "Direction with B" method (standard, only for motor vehicles), "Direction with A" method (also for bicycles) and "Opposite direction with A" method (only for motor vehicles), even combined, may be selected. In the case of "Direction with B", only vehicles which first enter loop A and then loop B simultaneously (occupancy overlap) are detected whilst, in the case of "Direction with A" all vehicles which do not enter B beforehand and then enter A simultaneously are signalled. "Opposite direction with A" requires an overlap of the occupancies, first B then A simultaneously.
- **Speed selection** **)
  If an adjustable speed is overshot or undershot by any motor vehicle, the corresponding output is set. The speed limit can be entered between 15 km/h and 140 km/h in 1 km/h steps. This requires double loop operating mode.
- **Speed selection for trucks** **)
  If an adjustable speed is overshot or undershot by a truck, the corresponding output is set. The speed limit can be entered between 15 km/h and 120 km/h in 5 km/h steps. This requires double loop operating mode.
- **Vehicle type selection** *) **)
  A signal is issued in the case of a selectable vehicle type. This allows buses (including articulates buses) for instance, to be selected, thus allowing passive detection of public-transport service buses. This requires double loop operating mode.
- **Vehicle length selection** **)
  If the actual vehicle length is greater than or

less than a specific vehicle length, the corresponding output is set. The setting range is 2 to 25 m. This requires double loop operating mode.

- **Permanent occupancy in the case of loop fault**
  Normally, in the event of a loop fault, the occupancy output is also set in order to generate a request, in addition to the fault output. In the case of applications with queue loops however, this is undesirable. Consequently, this behaviour can also be deactivated.
- **Fault latch**
  This function allows a loop fault to be latched if it is pending for longer than 1 minute (self-latching). The fault is then reset only after reset or switching off the power.
- **Loop dimensions** *) **)
  Loop dimensions differing from the TLS-standard can be compensated for conditionally. As standard, the sensor circuitry assumes a headway of 4 m (resp. 2.5 m) and a loop length of 2.5 m (resp. 1 m) (TLS type 1 resp. 2). The setting range is approx. 2.0 ... 5.1 m for the headway and 0.5...4.0 m for the loop length.

Controller or detector-specific functions:

- **Loop frequency** *)
  The loop frequency can also be set directly manually. This means that there are even more than 6 channels possible in specific applications, setting range 30 ... 120 kHz.
- **Response threshold** *)
  The response threshold can also be set individually the values between 0.04 and 99 ‰, besides the fixed levels resp. automatic setting. This also allows critical applications, e.g. for airfield surface movement detection.
- **Power management** **)
  The LEDs for fault detection are normally on. For applications requiring energy economy, an automatic function can switch off all LEDs after a stipulated time (Power Save active). They are switched back on again when a switch is operated or when a PC is connected.

  If the relay outputs are not required in an application, the relays can also be switched off permanently, thus reducing the power consumption in idle state by approx. 50 mA at 24 V.
- **Measuring intervals, scan time**
  The measuring intervals within which the detector measures the frequency variation as the result of detuning of each loop are determined by the sensitivity level. The resulting scan time for each loop (i.e. the repetition interval) is determining for the time accuracy of the detector. Short intervals (scan time around 4 ms) are possible in the case of low sensitivity, thus allowing a high time accuracy; correspondingly longer intervals (around 32 ms) are required in the case of high sensitivity (e.g. for bicycle detection). The setting is normally made automatically. Longer intervals which lead to a smoothing of the detuning values can be selected for all sensitivities for filtering interference (in the case of instabilities, electrical interference pick-up).
- **Drift compensation (Tracking)**
  The detector automatically readjusts its response thresholds for matching to various ambient

influences (in particular temperature and relative humidity). However, this also results in a limitation of the presence time (settling time behaviour). In order to allow longer presence times in certain applications or, vice versa, in order to compensate to a greater extent for higher external influences, the drift compensation rate can be varied. Adjustment range 0.003...4.000 ‰/minute. *)

- **Function of the outputs/LEDs** **)
  The significance of the existing inputs and LEDs can be configured such that the required functions are output at any output (with related LED). The output levels can be inverted.
- **Internal functions**
  Other internal functions can be selected, including, for instance, variation of internal measurement thresholds (for response behaviour, speed measurement, vehicle discrimination, vehicle length measurement), delay of the fault alarm.

*) Requires detailed clarification if these functions are used.

**) not in the case of LD4 -A12

Operating modes

The detector features four sensor circuits for a total of four loops (A, B, C and D). Two loops (A/B and/or C/D) in each case can be configured to form double loops. Two different loop operating modes are scheduled for this purpose

- "Independent loops", i.e. each set of two loops with sensor circuits generates mutually independent signals: "Occupancy/request" and "Loop fault"
- "Double loops", i.e. each set of two loops arranged a certain distance apart (e.g. 4 m) in travel direction (A and B resp. C and D) generate signals derived from both loops: "Travel time between two loops", "Vehicle type" and "Travel direction", besides the "Loop occupancy" and "Loop fault".

The functions of the "double loop" cannot be used with the LD4 -A12.

Further to operating mode "Double loops":

- **Speed measurement**

The travel time of a motor vehicle from loop A to loop B or vice versa is measured for this purpose. The measured speed is output either as a travel time pulse after exiting from loop B (only in the case of travel from A to B), whereby its length corresponds to the travel time from the start of loop A to the start of loop B or it can be polled via the serial port (for both travel directions). The measuring range is approx. 2 to 250 km/h. This also applies accordingly to loops C and D.

- **Vehicle type discrimination**
  The LD4 loop detector can distinguish between up to 9 different vehicle types:
  - Motorcycle
  - Car
  - Car with trailer
  - Delivery van up to 3.5 tonnes
  - Truck
  - Truck with (short) trailer
  - Truck and trailer

- Semitrailer truck
- Bus or coach (for motorways or public-transport)
- Others (vehicle cannot be assessed)

The measurement is conducted for both travel directions. Depending on use, these classes can be combined into two groups (cars/trucks), 5 + 1 (TLS) or 8 + 1 (TLS). In the default setting, the vehicle type is output in two classes at one output (only for travel from A to B resp. C to D); with extended settings, it is possible to selectively choose individual classes or groups optionally (bus or coach). All classes are available via the serial port for both travel directions.

- **Method for vehicle type discrimination**
  The detector measures the speed of the vehicle and its occupancy period on the loop in order to distinguish between the vehicle types. The vehicle length which represents the criterion for distinction is calculated from the occupancy period. In addition, the relative magnitude of the loop detuning and other characteristics are used for evaluation (analysis of the vehicle signature) in the critical zone between short trucks and long trucks or for differentiating between vehicles with trailers and buses/coaches. At speeds over 120 km/h, the vehicle is always classified as a car (requirement of TLS).
- **Travel direction discrimination**
  If a motor vehicle travels over the two loops in direction A to B (resp. C to D), a request signal is issued. By contrast, if the vehicle travels over the two loops in the opposite direction, this does not trigger a signal (default setting) or triggers a signal at another output (extended settings). The response thresholds of both loops of a double loop are normally set automatically to the same value. However, they may also be set mutually independently as an option. This allows individual adaptation, e.g. if a high sensitivity is required for additional bicycle detection, and reduces malfunctions caused by vehicles turning off.

Diagnosis and servicing

Special test operating modes can be used to check the interaction with a connected controller or a roadside station.

- Setting/resetting all outputs manually (for simulating occupancy, fault, special function).
- Cyclically generated vehicle sequences simulate traffic in the main direction or opposite direction.

The characteristics of the detector and its measured values can be read out with the aid of the PC and the configuration program.

- Detector identifiers (software version, serial number, addressing)
- Detuning of the vehicle (instantaneous and maximum)
- Current response thresholds
- Speed of the vehicle in km/h
- Vehicle type in 2 or 8 classes
- Vehicle length
- Loop frequency
- Loop inductance and noise voltage
- Settings of all characteristics (read-out, modify, save, load, duplicate, print)

All special settings are made with a configuration program. They can be saved to diskette, loaded from diskette and printed out in clear form.

Technical data

Designation	Loop detector LD4 LD4-B S24763-A81-A21 (twin electronic outputs) LD4-OEM1 S24763-A81-A11 (relay + electronic outputs, with front panel) LD4-OEM2 S24763-A81-A12 (relay + electronic outputs, with front panel, basic functions only) Front panel for mounting frame single, with accessories, for -A21, 25 mm wide S24763-G82-A1 Configuration program for Win95/98/NT LD4-KONFIG P24734-M90-A937
Detector type	Quasi-static inductive loop detector with 4 sensor circuits (for 4 loops, A-D)
Measurement method	CW frequency measurement [1] with crystal oscillator reference, frequency diversity
Loop inductance range	50...2000 µH in 3 ranges (including feader cable)
Recommended loop inductance	50 to 350 µH
Recommended loop wire	N4GAF 1.5 mm^2
Feader cable	Up to 50 m: loop wire direct Up to 200 m: telephone cable 0.8 mm ∅
Loop frequencies	- 6 different frequency channels, frequency band 40 ... 90 kHz, selectable via rotary switch (jointly in 6 groups as combinations for all loops) or - individual channel can be assigned per loop with PC or - flexible frequency setting in the band 30...120 kHz with PC - automatic adjustment and monitoring during operation
Sensitivity (response threshold)	via switch in 3 (5) levels or freely settable via PC - Level "normal" (motor vehicles without motorcycles): Automatic setting, determined automatically from the actual detuning of the vehicles (0.5 ... 100 ‰) - "medium" level (all motor vehicles): 0.5 ‰ or 0.25 ‰ - "high" level (with bicycles): 0.15 ‰ or 0.07 ‰ - Freely selectable with PC: 0.04 ... 100 ‰ [2] Thresholds specified as ΔL/L
Loop operating modes	Selectable with switch - Independent loops (occupancy/request), A/B resp. C/D - Double loop (occupancy/request, direction-dependent request, speed measurement, vehicle type discrimination, car/truck or into up to 9 classes), A/B or C/D (not in the case of -A12) - Detector OFF (per loop A-D)
Test operating modes	- Outputs On/Off manual - Cyclic vehicle sequences - PC diagnosis via front-panel connector
Presence time	via switch (for A/B resp. C/D) - 4 min, 35 min (in the case of motor vehicles) - 2 s , 20 s (in the case of bicycles) via PC (per loop) - 1, 3, 4, 10, 20, 30 s - 1, 2, 4, 10, 20, 35 min

- 1, 4, 10 h [2)]
- unlimited [2)]

Measured values

Can be fetched via the serial port, per vehicle (not in the case of -A12)
- Occupancy time in ms
- Preceding time gap in ms
- Travel direction in the case of double loop
- Travel time between two loops of a double loop in ms
- Speed in the case of double loop in km/h
- Vehicle length in the case of double loop in m
- Vehicle type in the case of double loop in 9 classes:
  - Motorcycle
  - Car
  - Car with trailer
  - Delivery van up to 3.5 tonnes
  - Truck
  - Truck (short) trailer
  - Truck and trailer
  - Semitrailer truck
  - Coach/bus (for motorways or public-transport)
  - Others (vehicles cannot be assessed)

Switching outputs

Switch type:
- Relay changeover contact (max. 150 V AC/DC/0.1 A), isolated, only -A11, -A12
- Transistor Open Collector (max. 35 V/50 mA DC, voltage drop 2.5 V @ 50 mA, typically 0.7 V @ 1 mA), active On
- Opto Transistor (max. 50 V/50 mA DC, voltage drop 2.5 V @ 50 mA, typically 0.7 V @ 1 mA), floating, active Off, only -A11, -A12

Function and type in the case of loop operating mode independent loops (A/B resp. C/D):
- Occupancy per loop: 1 x transistor, 1 x relay
- Fault per loop: 1 x transistor
- Master fault output for all loops A-D: 1 x opto

Function and type in the case of loop operating mode double loop (A/B resp. C/D):
- Occupancy loop A: 1 x transistor, 1 x relay
- Direction with occupancy loop B: 1 x transistor, 1 x relay
- Car/truck A/B: 1 x transistor
- Fault loop A/B: 1 x transistor
- Occupancy loop C: 1 x transistor, 1 x relay
- Direction with occupancy loop D: 1 x transistor, 1 x relay
- Car/truck C/D: 1 x transistor
- Fault loop C/D: 1 x transistor
- Master fault output for all loops A-D: 1 x opto

On -A21: The relay is replaced by a transistor
Other significances may be assigned to the outputs via PC (not -A12)

Indicators
- 4 x 2 LEDs for occupancy/fault or other functions, extra-bright
- 1 x LED supply/operate/watchdog
- 1 x LED mode (marking for PC-modified characteristics, Power Save active)

Switches
- 1 rotary switch for Test/Operation (frequency channel) from front
- 2 x DIP per loop for sensitivity (3 levels)/OFF, from front
- 8 x DIP for additional functions (loop operating mode, presence time, sensitivity factor), at side
- Loop connection area I/II/III per loop, jumpers on the rear panel plug
- Reset button, from front

Serial ports	- RS232 for PC on front of module (programming, diagnosis and servicing) - RS485 with SITOS protocol for vehicle values, with buffering for 25 vehicles (not -A12) - SCB (5 V level) as an alternative to RS485, full-duplex, for expansions, bus-capable (not -A12)	
Addressing	32 addresses on the basis of wiring at rear panel plug or internally programmed for bus wiring (RS485/SCB)	
Lightning protection	by overvoltage arrester on module	
Fault monitoring	Detection of - loop fault - program fault (watchdog) - power failure - frequency adjustment problem	
Mechanical construction	4 detector sensor circuits on PC board 100 x 162/176 mm (extended-length Eurocard), rear panel plug DIN 41612, Type B (64-pin, 2-row), assignment to TR0100	
Ambient temperature range	25 to +80 °C	
Operating voltage	Rated voltage 24 V DC	
Operating range	without relay (-A21): with relay (-A11, -A12):	+10 ... 35 V DC +19 ... 30 V DC
Current consumption, typical (without/with occupancy)	without relay (-A21): with relay (-A11, -A12):	35/45 mA @ 24 V 30/30 mA @ 24 V with Power Save active 60/75 mA @ 12 V 50/50 mA @ 12 V with Power Save active 85/45 mA @ 24 V

Complying with the following standards:

CE: Generic emission standard to EN 50 081-1 (residential area), prEN 50 293 (1997)
Generic immunity standard to EN 50 082-2 (industrial area), prEN 50 293 (1997)
TLS (of the BASt for Federal German motorways)
TR0100 (Appendix A-G) for UK on request

1 CW = Continuous Wave, i.e. unmodulated, constant sinusoidal oscillation by contrast with the scan principle in which the loops are permanently switched over cyclically, i.e. the loop voltage is "chopped".

2 Requires detailed clarification if these functions are used.

Further informations:
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Order no. A24705-X-A328-*-7604
Edition 06/99
PA 08992.0
Printed in Germany
on chlorine-free, environment-friendly paper