LMD301, LMD302, LMD304
Shelf Mount Series

DEFLECTOMETER™

Inductive Loop Monitor™

Operations Manual

THIS MANUAL CONTAINS TECHNICAL INFORMATION FOR THE **LMD301, LMD301S, LMD301T, LMD301TS, LMD302, LMD302T, LMD302TS, LMD304, and LMD304S** SERIES INDUCTIVE LOOP MONITOR. INCLUDED ARE GENERAL DESCRIPTION, OPERATIONAL DESCRIPTION, INSTALLATION, AND SPECIFICATIONS.

THE LMD301, LMD302, and LMD304 SERIES IS DESIGNED AND MANUFACTURED IN THE USA BY EBERLE DESIGN INC., PHOENIX, ARIZONA.

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Section 1
GENERAL

1.1 DESCRIPTION

The LMD301 Loop Monitor™ DEFLECTOMETER™ Series is a single channel inductive loop vehicle detector. The LMD302 Loop Monitor™ DEFLECTOMETER™ Series is a two channel inductive loop vehicle detector. The LMD304 Loop Monitor™ DEFLECTOMETER™ Series is a four channel inductive loop vehicle detector. The units meet or exceed all requirements for detectors as defined in ***Nema Standard TS1-1989 (R2005)***. Each channel has individual controls for setting up sensitivity, operational mode and frequency on the front panel, along with detection and fault status indicators.

Model	Channels	Features
LMD301	One Channel	
LMD301S	One Channel	Solid State Outputs
LMD301T	One Channel	Delay and Extension Timing
LMD302	Two Channel	
LMD302S	Two Channel	Solid State Outputs
LMD302T	Two Channel	Delay and Extension Timing
LMD304	Four Channel	
LMD304S	Four Channel	Solid State Outputs

1.2 OVERVIEW

A dynamic Overview of the LMD operation which includes an LMD Simulator is available on the EDI Web Site; www.EDItraffic.com.

1.3 DEFLECTOMETER FEATURE

The LMD Series Loop Monitor™ introduces a concept to the inductive loop detector field that revolutionizes the process of installing and programming a loop detector. The new user interface of the LMD Series provides the feedback necessary to the signal technician to quickly and accurately program the parameters of the detector exactly to the loop plus lead-in system characteristics.

Why guess when you can know!

- ☑ The DEFLECTOMETER™ display shows the relative strength of the call while a vehicle is in the detection zone. This provides feedback that the unit is optimally tuned to detect vehicles of all sizes.
- ☑ Setting the sensitivity level of the detector can be easily done in one step with a “typical” vehicle parked in the detection zone. The DEFLECTOMETER™ display updates dynamically as the sensitivity level is changed. See section 2.1.1.
- ☑ The simple push-button interface is intuitive and eliminates many of the reliability problems found with tiny DIP switches of conventional detectors.
- ☑ Operational mode, Frequency, and Sensitivity are all programmed and displayed using the push-button interface. Settings are stored in non-volatile memory.

Loop diagnostic capabilities incorporated within the LMD Series Loop Monitor™ enable the detection of short or open circuit loops and sudden changes of inductance exceeding 25 percent of the nominal inductance. Each type of fault is signified by the fault indicator emitting a different flash sequence. This information can greatly assist the user in the diagnosis of loop related problems.

Section 2
Installation and Adjustments

2.1 SET THE SENSITIVITY LEVEL

The DEFLECTOMETER™ (front panel 7-segment LED display) aids in setting the detector to the most optimum sensitivity level to ensure the detection of all vehicles, including motorcycles and high bed vehicles.

- While the LMD Series unit is in the Call state (DEFLECTOMETER = 1-9), the DEFLECTOMETER displays the Call Strength (1 – 9). The Call Strength will increase or decrease one step as the Sensitivity Level is increased or decreased one step.
- The Call Strength value will depend on the size and type of vehicle in the detection zone as well as the Sensitivity Level setting of the channel. The optimum value for a mid-sized vehicle is 5.
- The procedure in section 2.1.1 provides a quick and simple way to program the Sensitivity Level to the optimum setting to ensure all classes of vehicles are reliably detected with one simple step.
- The resulting Sensitivity Level can be then be displayed using the procedure in section 2.1.2. While the LMD Series is in the No-Call state (DEFLECTOMETER = 0), the DEFLECTOMETER will display the Sensitivity Level (1 – 9) when either SENS button is pressed once.

For typical vehicles (mid-size vehicle / small pick up) utilizing properly installed roadway loops, when the Call Strength value 4, **5**, or 6 **(5 being optimum)** is displayed on the DEFLECTOMETER during the DETECT output period then the sensitivity level is set correctly. For high profile vehicles (commercial trucks, 4x4's, etc…), a DEFLECTOMETER Call Strength value of 4 will be best. For low profile vehicles (sports cars, etc…), a DEFLECTOMETER Call Strength value of 6 will be best.

2.1.1 Adjusting Sensitivity Using the DEFLECTOMETER (Recommended)

The DEFLECTOMETER should read zero (0) with no vehicle over the roadway loop. With a typical mid-sized vehicle in the detection zone (DET indicator On), the DEFLECTOMETER will display the Call Strength value (1 - 9).

If a mid-size vehicle, located over the roadway loop causes the Call Strength value "7" to be displayed on the DEFLECTOMETER, the sensitivity should be lowered two levels (7 – 2 = DEFLECTOMETER reading "5"). This is done by pressing the front panel SENS▼ (down) button twice.

If a mid-size vehicle, located over the roadway loop causes the value "2" to be displayed on the DEFLECTOMETER, the sensitivity should be increased three levels (2 + 3 = DEFLECTOMETER reading "5". This is done by pressing the front panel SENS▲ (up) button three times.

NOTE: The DEFLECTOMETER dynamically updates after each Sensitivity Level change, allowing changes to the Sensitivity setting while a vehicle remains in the loop detection zone. Note that the Call Strength value may be different than the actual Sensitivity Level setting.

2.1.2 Adjusting Sensitivity Directly

The LMD Series offers nine levels of sensitivity (1 to 9). The Sensitivity Level can be manually set to any desired level by pressing the SENS▲ or SENS▼ front panel buttons when a vehicle is NOT over the roadway loop. The Sensitivity Level will be now displayed on the DEFLECTOMETER. Pressing the SENS▲ or SENS▼ button once will display the Sensitivity Level without changing the setting. After pressing the SENS▲ or SENS▼ buttons to display the Sensitivity Level, the setting can then be modified

by pressing the SENS▲ or SENS▼ buttons again. The display will automatically return to the normal display after three seconds. The factory default Sensitivity Level is 6.

Sensitivity	ΔL / L	Sensitivity	ΔL / L
9	0.01%	4	0.32%
8	0.02%	3	0.64%
7	0.04%	2	1.28%
6	**0.08%**	1	2.56%
5	0.16%	-	-

Note that each change of the Sensitivity Level while in this "direct adjust" mode causes the LMD Series to retune.

2.1.3 Dynamic DEFLECTOMETER Display Operation

While the LMD Series is in the Call state (DEFLECTOMETER = 1-9), the DEFLECTOMETER displays the Call Strength (1 – 9). When the Call terminates (DET indicator Off) the Call Strength will be displayed for an additional three seconds. Pressing the SENS▲ or SENS▼ button during this interval will modify the Sensitivity Level as described in section 2.1.1, with the DEFLECTOMETER display remaining in the Call Strength mode.

Pressing the SENS▲ or SENS▼ button when the LMD Series is not in the Call state (DEFLECTOMETER = 0) will display and modify the Sensitivity Level directly as described in section 2.1.2. In this case the DEFLECTOMETER displays the actual Sensitivity Level.

2.2 SET THE OPERATIONAL MODE

Operational mode can be set to Short Presence, Long Presence, Pulse, Call or Off mode. Pressing the MODE button once will display the Operational Mode without changing the setting. After pressing the MODE button to display the current Operational Mode, the setting can then be changed by pressing the MODE button again. The display will automatically return to the normal display after several seconds.

Setting a new Operational Mode will cause the channel to retune.

2.2.1 Output Call Test

When the MODE button is pressed and held for one second, the unit will generate a pulsed (125 ms) Call state (true) output every 1500 ms. This operation can be used to quickly verify that a Call output is being received by the Controller Unit.

2.2.2 Short Presence Mode (S)

The Short Presence mode will tune out a continuous Call after 30 minutes. Use Short Presence unless the detection zone is expected to be continuously occupied for periods of time in excess of 30 minutes.

2.2.3 Long Presence Mode (L)

The Long Presence mode will tune out a continuous Call after 120 minutes.

2.2.4 Pulse Mode (P)

The Pulse mode will provide a 125 ms ± 25ms width output pulse for each vehicle entering the loop..

2.2.5 Call Mode (C)

The Call mode will set the channel output to the Call state (True). This mode can be used to provide a continuous Call state to the Controller Unit regardless of the state of the detection zone. Loop fault conditions are ignored in this mode.

2.2.6 Off Mode (-)

The Off mode will set the channel output to the No Call state (False). This mode can be used if the channel is not used or not connected to a loop. Loop fault conditions are ignored in this mode.

2.2.7 Output Minimum Pulse Option

When the diode jumper labeled OPT2 on the PCB is installed, the unit will limit the minimum output Call state (True) to 125 milliseconds.

2.3 SET THE FREQUENCY

Frequency	
Level 4	High
Level 3	Medium High
Level 2	Medium Low
Level 1	Low

Pressing the FREQ button once will display the Frequency Level (1 – 4) without changing the setting. After pressing the FREQ button to display the current Frequency Level, the setting can then be changed by pressing the FREQ button again. The display will automatically return to the normal display after several seconds.

The Frequency level needs to be changed only if interference occurs between adjacent loops connected to different sensor units. Interference or crosstalk may manifest itself as chattering of the call output or a detect call occurring at the same time as an adjacent unit when there is no vehicle present. If crosstalk is suspected, try to separate the frequencies of the channels causing the problem. A minimum of 5 KHz separation is recommended. Four frequency levels are available on each channel to assist in alleviating interference affecting more than two units.

Changing the Frequency Level will cause the channel to retune.

2.3.1 Displaying the Loop Frequency

The current loop frequency is displayed by after pressing the FREQ button to display the current Frequency Level. The frequency is shown in KHz with a "-" symbol displayed both before and after the numeric digits shown on the DEFLECTOMETER.

For example, after pressing the FREQ button once the display sequence might show:

"3" ⇨ "-" ⇨ "2" ⇨ "7" ⇨ "-"

This sequence would indicate Frequency Level "3" and a loop reference frequency of 27 KHz.

2.4 SET THE DELAY AND EXTEND TIMING (LMD301T AND LMD302T ONLY)

2.4.1 Delay Timing

For each channel, a delay time of 1 to 63 seconds can be set via the DELAY DIP switches. The numeric sum of the switches in the On position is equal to the Delay time. Call Delay time starts counting down when a vehicle enters the loop detection area. During the Delay time the DET indicator will flash two times per second and the DEFLECTOMETER will display the letter "d". Delay time can be overridden by a True signal at the Timer Control input.

2.4.2 Extend Timing

For each channel, an extend time of 0.25 to 15.75 seconds can be set via the EXTEND DIP switches. The numeric sum of the switches in the On position is equal to the Extend time.

Call Extend time starts counting down when the last vehicle clears the loop detection zone. During the Extend time the DET indicator will flash four times per second and the DEFLECTOMETER will display the letter "E". Any vehicle entering the loop detection zone during the Extend time period causes the Extend timer to be reset and the output maintained. The Timer Control input has no effect on this mode.

2.4.3 Timer Control Input

A Timer Control input is provided for to modify the operation of the Delay Timing functions. The application of an AC voltage will inhibit the Delay timing function as described in section 2.4.1. When the Timer Control Input is active (True) the decimal point of the channel DEFLECTOMETER display will illuminate.

The Timer Control input is primarily provided for downward compatibility.

2.5 MISCELLANEOUS

2.5.1 Channel Off

If a channel is not to be used, it may be switched off (disabled) by setting the Operational Mode to OFF. See section 2.2.6.

2.5.2 Retune or Reset a Channel

Press the MODE and FREQ buttons simultaneously to reset the channel. This will clear any previous loop fault indication and cause the channel to retune.

2.5.3 Factory Default Settings

Press the MODE and FREQ buttons simultaneously while first applying power to the unit to reset all channels to the factory default settings.

Factory Defaults	
Sensitivity Level	6
Operational Mode	Short Presence
Frequency Level	High

2.6 LOOP FAULT MONITORING

The LMD Series Loop Monitor™ continuously checks the integrity of the loop. The system is able to detect open circuit loops, shorted loops, or sudden changes in inductance exceeding 25% of the nominal inductance.

2.6.1 Current Fault

If a fault is detected, both the DET (Red) and FLT (Yellow) LEDs continuously emit a sequence of flashes and the DEFLECTOMETER will display the letter “F”. Each type of fault is identified by a different flash sequence followed by a one second pause:

Flash Sequence	Fault
1 flash	Open Circuit Loop (or Inductance too high)
2 flashes	Shorted Circuit Loop (or inductance too low)
3 flashes	>25% Change in Inductance

2.6.2 Previous Fault

If the fault condition is removed, the DET indicator and the channel output will return to normal operation. The FLT indicator will continue to flash indicating that a fault had previously occurred. This Previous Fault indication may be reset by momentarily pressing the MODE and FREQ buttons simultaneously. See section 2.5.2.

Section 3
Loop Installation

The typical sensing height is 2/3 of the shortest leg of a loop (in feet). Therefore a 4' x 8' loop typically has a detection height of 2.6'.

The inductance of a conventional four-sided loop can be estimated using the formula:

$L = P \times (T^2 + T) / 4$ Where L = Loop Inductance in microHenries
P = Loop Perimeter in feet
T = Number of wires in saw slot

Therefore a 4' x 8' loop with 3 turns would be:

$L = (4 + 8 + 4 + 8) \times (3^2 + 3) / 4$
$L = 24 \times (9 + 3) / 4$
$L = 24 \times 12 / 4$
$L = 72$ microHenries

Note: Loop feeder cable typically adds 0.22 microHenries of inductance per foot of cable.

The following are suggested guidelines for loop installation:

To begin, make sure that the pavement surface in the area that loops are to be installed is dry and free of debris. The outline of the loop(s) should be marked on the pavement in such a way that the lines can be followed easily by the saw operator and not be erased by the water feed from the saw itself.

All 90-degree corners should be chamfered so that the course of the loop wire does not change direction sharply but rather at shallower angles of 45 degrees or less. Core drilling of the corners achieves the same effect but can still lead to failure due to sharp edges remaining in the corner area. When the outline of the loop and lead-in has been marked, the pavement can be cut. Diamond blade cutting saws are recommended. The saw cut should be approximately 2.0 inches deep and 0.25 inches wide. The saw slot should then be cleaned out and allowed to dry. Compressed air is useful both for ejecting debris and speeding up the drying process. All debris in the vicinity of the saw slot should also be removed so that it is not accidentally pushed back in.

As a general rule loops with circumference lengths less than 12 feet require 5 turns of wire, 12 to 60 feet require 3 to 4 turns of wire, loops with greater circumference lengths should have 2 to 3 turns.

Recommended loop wire is typically 14, 16, 18, or 20 AWG with cross-linked polyethylene insulation. Since moisture can cause significant changes in the dielectric constant of the insulation, which results in excessive loop (frequency) drift, choose insulation, which is most impervious to moisture. PVC, TFFN, THHN, and THHN-THWN should be avoided since they tend to absorb moisture and crack easily. XLPE (Cross Linked Polyethylene) is very resistant to moisture absorption and provides good abrasion resistance.

If long lead-ins are required, it is suggested that the loop cable be spliced onto shielded, pre-twisted, lead-in wire (IMSA specification 50-2 is suggested) at a convenient pull box location close to the loop. The shield may be connected to earth at the cabinet end but should then be insulated and isolated from earth ground at the loop end. The inductance of the loop itself should be at least 50% of the sum of loop inductance plus lead-in inductance.

Start laying the loop wire from the termination of the lead-in out towards the loop, continue around the loop for the number of turns required and finally return to the lead-in termination. Leave the lead-in wire out of the slot so that it may be twisted together before being laid in the slot. Lead-ins should be twisted with a minimum of 4 to 6 twists per foot to prevent any separation of the lead-in wires.

Make sure that the loop wire is pushed fully to the bottom of the saw slot. Small pieces of foam rubber (backer rod) or similar material may be used at various points around the circumference to prevent the loop wire from rising up while the sealant is poured and curing.

Many different types of loop sealant are now available. Single part types are the easiest to apply since no mixing is required, but they also tend to be more expensive in terms of linear feet of saw slot filled. When

applying the sealant, make sure that it is able to sink to the bottom of the slot and completely encase the loop wire. The wire should not be able to move when the sealant has set. Ensure that there is enough sealant to completely fill the slot; if possible the sealant should protrude slightly above the surface of the pavement so that small rocks or other debris cannot collect in the slot.

The sealant manufacturer instructions concerning setting time should be noted especially when determining the length of time to wait before allowing vehicles to cross the loop area.

Consult the Eberle Design web site at www.EDItraffic.com for further application information regarding loop design.

Section 4
Specifications

4.1 MECHANICAL

4.1.1 LMD301

Height ..... 5.5 inches
Width ..... 2.0 inches
Depth (chassis only) ..... 5.4 inches

4.1.2 LMD302 and LMD304

Height ..... 6.4 inches
Width ..... 3.0 inches
Depth (chassis only) ..... 7.3 inches

4.2 ENVIRONMENTAL

Storage Temperature Range ..... -45 to +85 ^{o}C
Operating Temperature Range ..... -34 to +74 ^{o}C
Humidity Range (non-condensing) ..... 0 to 95% Relative

4.3 ELECTRICAL

AC Supply Voltage Minimum ..... 89 Vac
AC Supply Voltage Maximum ..... 270 Vac
AC Supply Frequency ..... 50/60 Hz
AC Supply Power Maximum ..... 3 watts
AC Timer Control Inputs
- True (active) ..... greater than 70 Vac
- False (not active) ..... less than 15 Vac

Optically Isolated Outputs
- True (low, 50 mA) ..... less than 1.5 Vdc
- False (high) ..... greater than 16 Vdc
- Maximum Leakage Current (high) ..... less than 1 uA
- Maximum Current ..... 100 mA

Relay Outputs
- AC Contact Rating ..... 5A @ 240 Vac
- DC Contact Rating ..... 5A @ 30 Vdc

4.4 TUNING

4.4.1 Loop Inductance (Tuning) Range

The detector will automatically tune to a loop and lead-in combination within the tuning range of 20 to 2500 microHenry with a Q factor greater than 5.

4.4.2 Environmental Tracking

The detector automatically and continuously compensates for component drift and environmental effects throughout the tuning range and across the entire temperature range.

4.4.3 Grounded Loop Operation

A detector channel will operate when connected to poor quality loops including those that have a short to ground at a single point.

4.4.4 Lead-in Length

The unit will operate with lead-in (feeder) lengths up to 5,000 feet (1,524 m.) with appropriate loops and proper lead-in cable.

4.5 LOOP INPUT (LIGHTNING PROTECTION)

The loop input incorporates lightning and transient protection devices and the loop oscillator circuitry is transformer-isolated for each channel. The lightning protection will withstand the discharge of a 10uF capacitor charged to 2,000V across the loop inputs or between a loop input and Earth Ground. The transformer isolation allows operation with a loop which is grounded at a single point.

4.6 RESPONSE TIMING

4.6.1 LMD301 and LMD301T

Sensitivity Level	Response	Sensitivity Level	Response
9	32-49 ms	**4**	17-26 ms
8	20-30 ms	**3**	17-26 ms
7	17-26 ms	**2**	17-26 ms
6	17-26 ms	**1**	17-26 ms
5	17-26 ms	**--**	--

4.6.2 LMD301S (Solid-State Outputs)

Sensitivity Level	Response	Sensitivity Level	Response
9	25-38 ms	**4**	11-16 ms
8	13-19 ms	**3**	11-16 ms
7	11-16 ms	**2**	11-16 ms
6	11-16 ms	**1**	11-16 ms
5	11-16 ms	**--**	--

4.7 LMD301(T) CONNECTOR PIN ASSIGNMENTS

Pin	Function
A	Neutral (AC-)
B	Ch 1 Output Relay Common (Emitter)
C	Power (AC+)
D	Channel 1 Loop Input
E	Channel 1 Loop Input
F	Ch 1 Output Relay N.O. (Collector)
G	Ch 1 Output Relay N.C.
H	Earth Ground
I	No Connect
J	Ch 1 Timer Control (LMD301T)

N.O. is Normally Open, N.C. is Normally Closed.
Relay Contacts are shown with power applied, loops connected and no vehicle present.

4.8 LMD302(T) CONNECTOR PIN ASSIGNMENTS

Pin	Channel 1 Function	Pin	Channel 2 Function
A	Neutral (AC-)	**A**	No Connect
B	Ch 1 Output Relay Common (Emitter)	**B**	Ch 2 Output Relay Common (Emitter)
C	Power (AC+)	**C**	No Connect
D	Channel 1 Loop Input	**D**	Channel 2 Loop Input
E	Channel 1 Loop Input	**E**	Channel 2 Loop Input
F	Ch 1 Output Relay N.O. (Collector)	**F**	Ch 2 Output Relay N.O. (Collector)
G	Ch 1 Output Relay N.C.	**G**	Ch 2 Output Relay N.C.
H	Earth Ground	**H**	Earth Ground

Pin	Channel 1 Function	Pin	Channel 2 Function
I	No Connect	**I**	No Connect
J	Ch 1 Timer Control (LMD302T)	**J**	Ch 2 Timer Control (LMD302T)

N.O. is Normally Open, N.C. is Normally Closed.
Relay Contacts are shown with power applied, loops connected and no vehicle present.

4.9 LMD304 CONNECTOR PIN ASSIGNMENTS

Pin	Function
A	Neutral (AC-)
B	Ch 4 Output Relay Common (Emitter)
C	Power (AC+)
D	Channel 1 Loop Input
E	Channel 1 Loop Input
F	Channel 2 Loop Input
G	Channel 2 Loop Input
H	Earth Ground
J	Channel 3 Loop Input
K	Channel 3 Loop Input
L	Channel 4 Loop Input
M	Channel 4 Loop Input
N	Ch 1 Output Relay N.O. (Collector)
P	Ch 1 Output Relay Common (Emitter)
R	Ch 2 Output Relay Common (Emitter)
S	Ch 2 Output Relay N.O. (Collector)
T	Ch 3 Output Relay Common (Emitter)
U	Ch 3 Output Relay N.O. (Collector)
V	Ch 4 Output Relay N.O. (Collector)

N.O. is Normally Open, N.C. is Normally Closed.
Relay Contacts are shown with power applied, loops connected and no vehicle present.