



**ETG – In-Pavement Loop Tester  
Model Number:**



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- 1 Equipment description
- 2 Loop Detector functional specification
- 3 Equipment electrical and Physical specification

### Legislative and Regulatory Compliance

RoHS - EU Directive 2002/95/EC per Category 9 / Annex IA – Exempt until 2010  
Electrical Power surge 1kV - rise time 1.2sec/hold 50 secs  
CE / Ctick compliant IEC1000-4-5/ EN61000-4-5

Note: This is not a laboratory test instrument. This is a purpose designed field test instrument that facilitates evaluation of in-pavement loop characteristics including; inductance, DC Resistance, tuned frequency, 'Q' and insulation integrity.

**!!!!!! WARNING \*\*\*\*\* CAUTION !!!!!**

EXTREME CARE REQUIRED WHEN using the insulation breakdown test function. This is a controlled voltage 'Megger' test where typically 500V is applied to the output pins for a preset period (100milliseconds) while the microcomputer monitors the resistance to earth.

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## The LT-1000M in-pavement loop tester

Enhanced features from the LT100M

- Loop Location – moving vehicle, audible ‘ping’ when loop detected
- Loop ‘winding’ location – hand held operation walking on road surface
- Loop wire Insulation Integrity

This is a field service device suitable for in-pavement loop analysis. The device has an LCD display which displays all relevant in-pavement loop parameters including; DC Resistance, Inductance, Loop ‘Q’, Loop tuned frequency, insulation integrity and Loop location. Additionally an analogue bargraph display indicates a vehicle actuation and relevant energy change associated with the actual vehicle detection.

This purpose designed, rugged, portable hand held device connects to loop feeder cables via flexible leads with ‘alligator’ style clips. The loop location function requires an external ‘tuned’ probe. The device has an LCD panel for displaying relevant loop parameters. The device has a single power-ON / OFF momentary switch and for night-time use the touch sensitive keypad for backlight operation will activate the back light when selected to save energy. The analyser is powered by a single 9V D cell.

The device will automatically switch OFF after a preset period to enable longer battery life – WHEN disconnected from a loop. Activating the ON button ‘wakes up’ the internal microprocessor which then controls battery power for a preset period. Inactivity will cause the microprocessor to return to ‘sleep’ mode. The OFF function is selected via the ON /OFF switch which is a momentary operation in both directions

There are no external adjustments. The device will automatically detect the loop parameters and report the parameters on the LCD screen. The device indicates battery voltage and when the battery becomes low should be replaced in order for the internal measurement circuit to produce an error free analysis of the loop parameters.

The field technician can identify the following in-pavement loop verification

- The DC Resistance of the loop and feeder
- The Inductance of the combined loop and feeder
- The Tuned frequency of the loop and feeder
- The ‘Q’ of the combined loop and feeder
- Quickly identify ‘short-circuits’
- Quickly identify ‘open-circuits’
- Loop position within the pavement identified from a moving vehicle (max speed 110khr)
- Loop wire (winding) location  $\pm$  1 cm (hand-held operation)
- Loop wire insulation integrity  $>100$ Megohms
- Loop operation incorporating an analogue bargraph display of the actuation

## Instructions for Field Use – Measuring Loop Characteristics

### Step 1

Connect the two loop feeder leads using the alligator clips. There is no polarity however the clips should be attached in a manner which does not short circuit the connectors that would cause malfunction and or false readings.

### Step 2

Switch on the unit via the ON/OFF switch – the unit will automatically switch off after a preset period of no activity. The unit will hold on and display data while connected to a loop.

### Step 3

If using the LTM 100 at night press the momentary button to enable the backlight. Excessive use of the backlight will decrease the battery life.

### Step 4

The screen display is self explanatory

Frequency: Is the resonant frequency of the loop (Typically 15-140Khz).  
Inductance: Is the inductance value of the loop (Typically 70-700 Microhenries)  
Resistance: Is the DC resistance of the loop and (Typically 1-3ohms)  
'Q': Is the performance value of the loop (Typically >6)\*  
For vehicle classification > 12 is appropriate

OPEN CIRCUIT - This is displayed if the loop is open circuit  
SHORT CIRCUIT - This is displayed if the instrument identifies a short circuit

Loops and loop feeder cables are all part of the in-pavement loop circuit and an extension of the vehicle detector circuitry. A suggested analysis procedure is to commence at the detector and progress backwards to the actual in-pavement loop in compartmentalized steps. It is important for the 'Q' calculation to evaluate the complete in-pavement circuit including the loop PLUS the feeder cable (refer to notes herein concerning calculation of 'Q').

## Instructions for Field Use – Insulation Breakdown

**!!!!!! WARNING \*\*\*\*\* CAUTION !!!!!**

EXTREME CARE REQUIRED WHEN using the insulation breakdown test function. This is a controlled voltage 'Megger' test where typically 500V is applied to the output pins for a preset period (100milliseconds) while the microcomputer monitors the resistance to earth. The test is an automated sequence and report generation to the LCD display.

DISCONNECT THE LOOP AND FEEDER FROM ALL OTHER EQUIPMENT IN THE CABINET. THE HIGH VOLTAGE ASSOCIATED WITH THIS TEST WILL DAMAGE THE SENSITIVE ELECTRONIC CIRCUITRY ASSOCIATED WITH VEHICLE DETECTION.

Make sure the TESTER is switched OFF – verify no LCD display (BLANK)

Connect the RED lead to a single loop wire. Connect the Black wire to an appropriate EARTH connection point. Switch on the device and select the insulation integrity test. The device will generate the 500V pulse required by the test for a sustained period to enable a resistance measurement to be determined. The insulation resistance will be displayed on the LCD display. The qualification for what is a PASS or FAIL is done by the operator to eliminate test variables associated with the same loop. Laboratory testing indicated that the same loop measured after a days rain, 4 hours since the last rain fell and on a dry day will indicate three different resistance readings.

### Insulation Integrity Test Range

Resistance < 10Megohm (Indicates a resistance less than 10Megohm)  
Resistance > 10Megohms (Indicates a resistance greater than 10 Megohm but less than 200Megohms)  
Resistance > 200Megohms(Indicates a resistance greater than 200Megohms)

## Instructions for Locating Loops from a moving vehicle

**\*\* THERE IS NO VISUAL DISPLAY TO DISTRACT THE DRIVER \*\*\***

An audible 'PING' sound is emitted when an active in-pavement loop electromagnetic field is detected.

The external probe must be located and secured approximately 50cms from the road surface in a manner such that there is direct line of sight between the probe and the road surface. A location with no metal between the vehicle and the road surface will provide the best results. The probe may be hung from the door and the door closed carefully onto the cable to avoid damage to the cable. The vehicle must be driven in a manner that enables the probe to pass within the boundary of the in-pavement loop to provide the best results.

The vehicle should be driven in a safe manner with the drivers attention to the driving function being of primary importance and therefore it is recommended that the task requires a driver and an 'observer'. The vehicle may be driven at speeds between 20kmhr and 100kmhr in accordance with the speed limits and nominal speed of surrounding vehicles.

The location where the audible ping is emitted should be noted by the observer.

## Instructions for Locating a Loop winding – walking on the road surface

**!!!!!! WARNING \*\*\*\*\* CAUTION !!!!!**


**This function requires the operator to walk on the road where the in-pavement loop is located. This function requires the operator to view the display in order to find the position of the loop wire within 2 cms positional accuracy. Therefore the operator must have taken appropriate steps to make the section of road safe where the test is being performed as it is not possible to observe the instrument AND observe approaching vehicles simultaneously. This specific nature of this requirement may vary according to different jurisdictions and local OH&S legislation. The loop location test should only be undertaken when the operator is in no danger from moving vehicles on the road surface.**

The external probe should be swept over the area where the loop is located. The probe is located approximately 5-10cms above the road surface. An audible 'ping' will indicate that the probe is within a loop field and the display will rise as in (a) below and the boxes located at the bottom of the LCD display will darken / filling in black (c).

The probe is moved back and forth to confirm the presence of an electromagnetic field. When attempting to locate a loop winding wire best results are achieved when the probe is drawn from within the in-pavement loop to outside of the in-pavement loop. The display indicates a HIGH level when a field is detected. The field is present inside the loop and for a short distance outside the loop. When the probe is directly on top of the loop winding wire the field is ZERO – this is the position of the loop winding. This is indicated by the dip (or sustained dip if held in the same position) in (b) below and the box display (c) progresses quickly from darken boxes to empty boxes and naturally back to darken when the probe is moved off the position directly above the loop wire winding.

(a)  **Signal goes high when a field is detected**

(b)  **The signal dips when the probe is directly over the wire winding**

(c)  - Empty rectangular boxes are displayed bottom right of LCD

 **When a signal level is detected these boxes will darken**

### Note on the validity of cross-talk compensation by simple adjustment of capacitance

Resonant frequency change is the basis of inductive vehicle detection

$\omega$  is the frequency in radians/sec

For a resonant circuit:

$$\omega = 1 / \text{SQRT}(LC)$$

therefore  $\omega$  is proportional to  $1/\text{SQRT}(L)$  or  $L^{-0.5}$

Therefore any variation in L of X% translates to a much smaller variation of  $\omega$ . However, this variation is not affected by C. C only affects the absolute value of  $\omega$ .

What does all this mean? Changing the resonant frequency point for a fixed inductor (a loop) requires changing the capacitance C. Since C is not related to the change in  $\omega$  when L changes we can say that doing so is a pointless exercise.

### Note on 'Q' calculation (effective performance of the loop)

\*'Q' for normal vehicle detection may be as low as 6 however for vehicle classification applications and accurate speed detection 'Q' should be greater than 15.

Q or the performance of the loop is effectively the relationship between inductance of the loop and resistance / impedance in the feeder cable hence longer feeders (higher impedance/resistance) need more inductance in the loop for compensation.

The following formula and reference gives it a scientific presence:

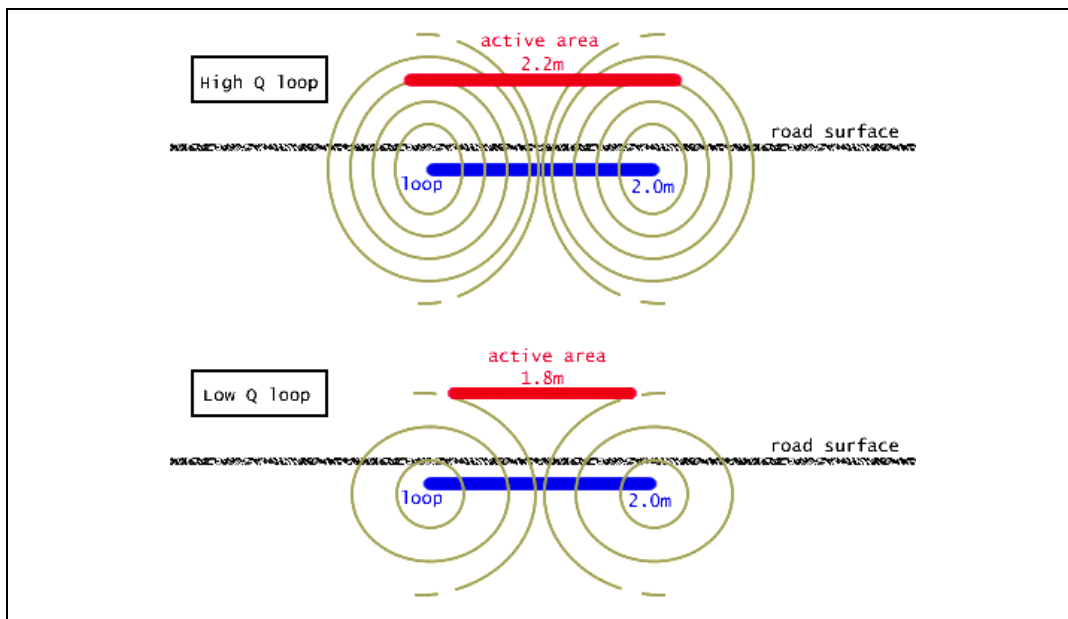
$$Q \text{ (at resonance)} = \frac{\text{Frequency (radians)} \times \text{inductance (henries)}}{\text{DC Resistance (ohms)}} \text{ [divided]}$$

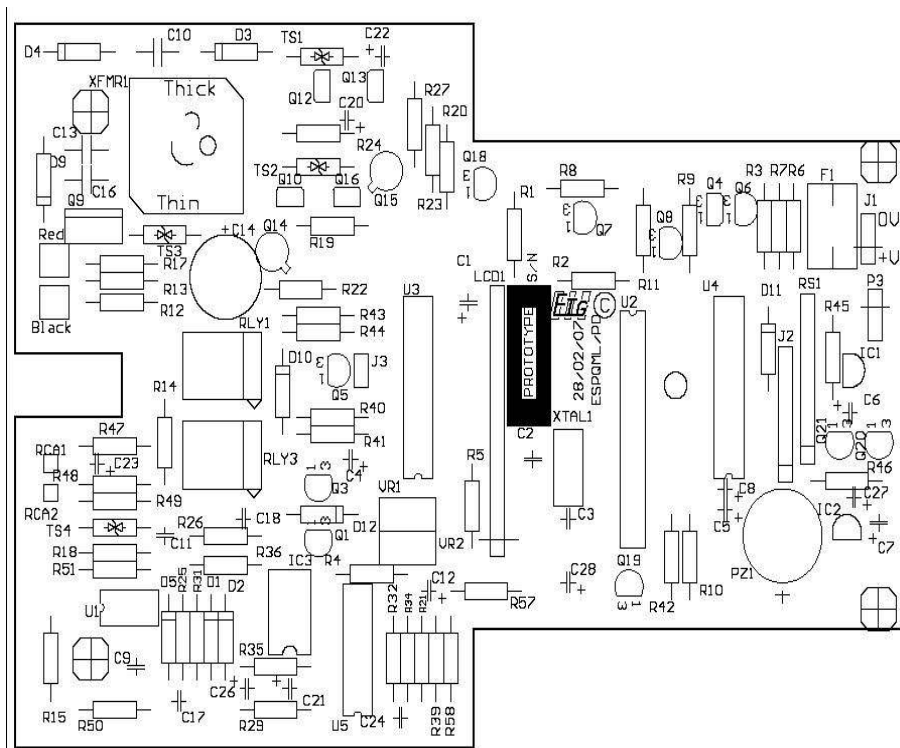
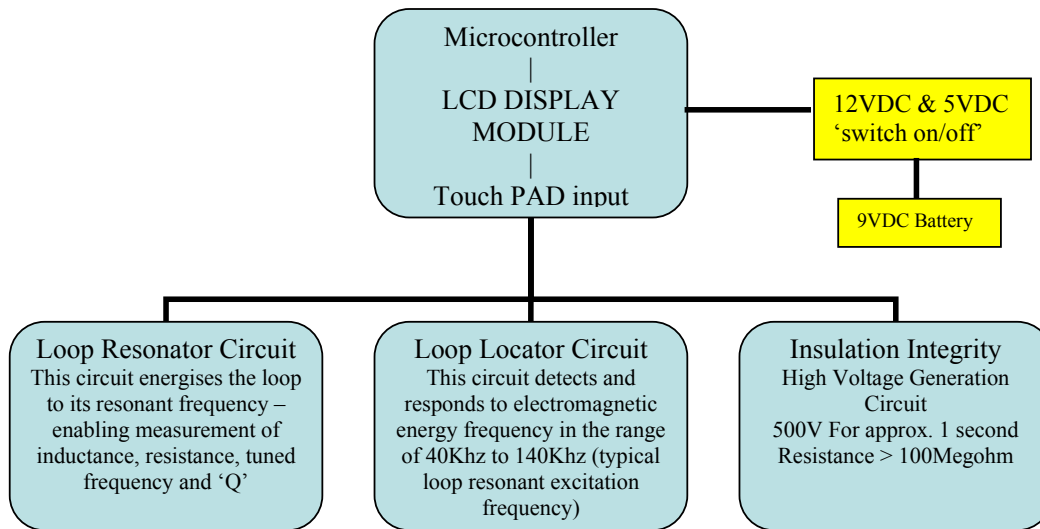
DC Resistance (ohms)

\*\* Where Radians = 2 (multiplied) pi (multiplied) hz

**Reference:** *Electronics A Top-down approach to computer-aided circuit design* by Hamley 1994 P904-908

Loop length is the length of the active area of the loop in the direction of travel. The active area is size of the loop electromagnetic field in which a vehicle will change the inductance of the loop above the detection threshold. The size of the active area is determined by, the sensitivity of the loop (Q), the depth of the loop, and the sensitivity of the detector.





LTM-1000 Main Circuit Board Layout

These drawings provide a functional block representation of the in-pavement loop tester. The device has a single 9 Volt battery source. The power management circuitry converts the 9volts to 12volts and 5 volts. The 5VDC source is utilized by the microcontroller and logic circuitry. The 12VDC source is utilized by the loop drive and sense circuitry. An LCD display provides status and measurement data to the user and functions are selected via touch pad circuitry mounted on the front of the device.

This circuitry, which is driven by the microcontroller excites the in-pavement loop to operate at its ‘tuned’ or resonant frequency. This excitation is a function of the loops resistance, inductance, capacitance, susceptance and other minor electrical characteristics. The microcontroller searches for resonance and then computes the related values of resistance, inductance and ‘Q’ within the resonance equation.

The tester has a high voltage generation circuit which produces 500Vs for approximately 1 second in order to verify that the insulation integrity (resistance) is greater than 100meg ohms to earth.

The tester incorporates a tuned input circuit connected via a coil located within the external probe. This enables the operator to search for an electromagnetic field with a frequency within a typical loop frequency range of 40-140Khz.

## Detector Test Equipment Specification

### General Performance Specification

- Vehicle detector function self tuning in the range of 50 to 800 microHenries
- Typical Loop frequency range between 40kHz and 150kHz.
- Typical Loop inductance range 40 to 800 Microhenries
- Optimised measurement accuracy 'mid inductance range' between 100 and 400 microhenries
- Measurement accuracy typically 3% >120microhenries

### General Operational Specification

Manual ON - momentary switch actuation ON (Circuit operation sustained by internal microcontroller)

Manual OFF – momentary switch actuation OFF.

Shutdown timer approximately 15 seconds – after removal from loop connection

Loop location from moving vehicle 'sweep' – maximum speed 110khr

Loop winding location from walking 'sweep' +/- 1 CM

Loop insulation integrity >100Megohms

### General Electrical Specification

#### Serial Ports (Where applicable)

Ethernet, RS232C and RS422 IEEE electrical signal level compatible. Configuration port baud 300baud -115kbit.

#### Digital I/O (Where applicable)

OUTPUT Devices: PVAZ172 MOSFET Photovoltaic Relay 60volt 500 milliamp S/capability

INPUT Devices: PC844 Opto-isolator 5000V rms Isolation, Input 20milliamps @ 1.2volts

LOOP Interface: Transorb and Line isolation transformers 1:1 Typical 100 millihenries

#### Connector Specification (Where applicable)

DB Series Current rating 1 Amp, Contact Resistance 20Mohmsmax@DC100mA.

DIN41612 Current rating 2Amp, Contact Resistance 30Mohmmax @ DC100mA.

Mate-enlock Current rating 3amp per pin, Contact Resistance 30Mohmmax @DC100mA

PCB Modular Terminal 'Phoenix style' 10Amp Rated Voltage 300VAC

IDC Style Connectors Withstanding Voltage 500v RMS for 1 minute, .5amp Current rating

TEST LEADS – 4mm'bannana' style plug-socket, Cable Length 700mms Withstanding 500V < 1 minute

#### Environmental, Power Supply and Physical Specification

Circuitry implemented on all cards is rated from -25<sup>0</sup>C to 65<sup>0</sup>C operation with a relative non-condensing humidity of 90%. Circuit cards are conformal coated and will operate within ISO and Australian Standard Guidelines for Traffic Control Devices. PCB CONFORMAL coating Electrolube SCC3 CC dielectric strength of 90KV/mm and an operational temperature range of -70<sup>0</sup> C to +200<sup>0</sup> C and is self extinguishing when exposed to a flame.

Specification LT100 Enclosure 185mm x 100mm x H30 mms, Weight 0.45kgs, 9Volt DC battery

Specification LTM1000 Enclosure 260mm x 120mm x 60mms, Weight 0.75kgs 9Volt DC battery

\* Some degree of variation in current consumption will occur due to operational states and usage – anticipated 2 hours continuous usage with regular Alkaline Battery.

LTM-100 Tester – Portable device requiring a 9VDC battery

#### Legislative and Regulatory Compliance

RoHS - EU Directive 2002/95/EC per Category 9 / Annex IA – Exempt until 2010

Electrical Power surge 1kV - rise time 1.2sec/hold 50 secs

CE / C<sup>√</sup>tick compliant IEC1000-4-5/ EN61000-4-5

#### MTBF for loop detectors

Statistical MTBF individual component extrapolation (MIL-STD-217-E)

\* Using chi-squared test, we can state with 90% confidence: > 100,000hrs

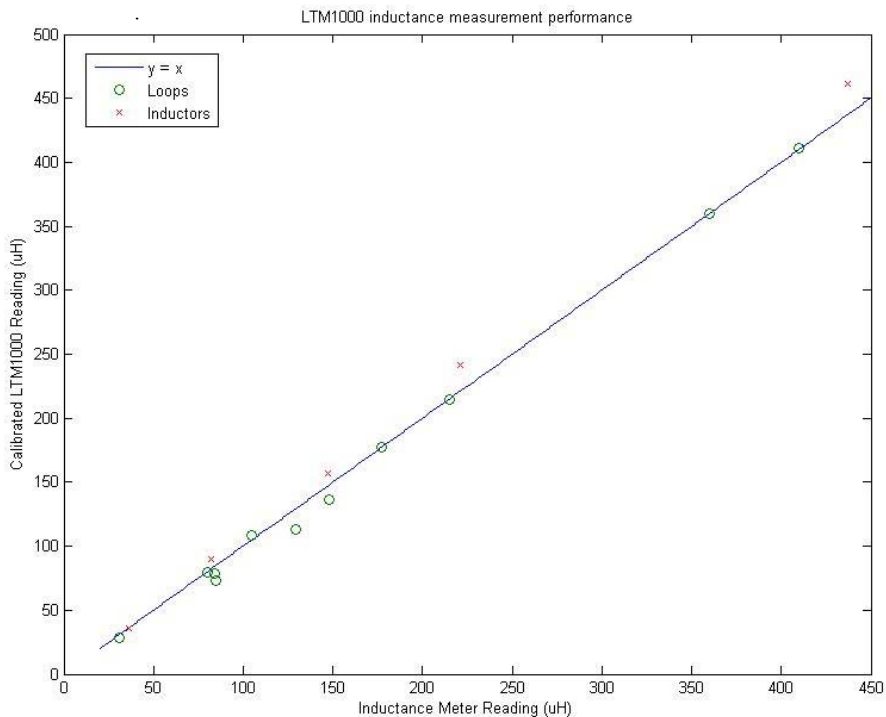
Field History – based on reasonable care





## Specification LT\_IND50-420 In-pavement Vehicle Detector Loop Tester

Equipment Type:	LTM-1000 In-pavement Loop Tester Serial Number ET-0708-029
Equipment Description	The in-pavement loop is a primary source of vehicle detection on the public road network. The device under test (DUT) excites an in-pavement loop coil (typically 100micorhenries) to a resonant state (typically 50khz). Upon detecting resonance and measuring resistance the device reverse calculates the coil inductance based on frequency and a preset capacitance reference. . The LTM1000 generates a <500V DC pulse for typically 50 milliseconds to determine insulation quality. The LTM1000 incorporates a highly sensitive receiver circuit which detects in-pavement loop frequencies in the range of 40Khz to 140Khz
Power Supply	9VDC battery Source
Microcontroller	PIC16F874 / 11.0592 Mhz Oscillator
Road Loops	Typically 4 Turns of wire 2 Metres x 2 Metres Square roadbased Surge Protection (Lightning Discharge) each roadbased loop 1500 V 1/2 W 100kohms 90V Inductance A - 128 Microhenries/Res 2.6 ohms Inductance B - 174 Microhenries/Res 2.1 ohms Inductance C - 345 Microhenries/Res 1.9 ohms Inductance D - 420 Microhenries/Res 1.6 ohms





**Specification Conformity Declaration  
 In-pavement Vehicle Detector Loop Tester**

Report No: ETG-0512-29/ST

Date Issued 5<sup>th</sup> December 2007

Equipment Type: LTM-1000 In-pavement Loop Tester  
 Serial Number ET-0708-029

Equipment Description The in-pavement loop is a primary source of vehicle detection on the public road network. The device under test (DUT) excites an in-pavement loop coil (typically 100micorhenries) to a resonant state (typically 50khz). Upon detecting resonance and measuring resistance the device reverse calculates the coil inductance based on frequency and a preset capacitance reference.

Test Schedule and Compliance Statement

The LTM1000 'In-pavement Loop Tester' Serial Number ET-0708-029 was tested in relation to preset calibrated test loops and in accordance with the manufacturers product specification LT\_IND50-420 is certified as compliant with this specification.

Power Supply 9VDC battery Source  
 Microcontroller PIC16F874 / 11.0592 Mhz Oscillator  
 Road Loops Typically 4 Turns of wire 2 Metres x 2 Metres Square roadbased  
 Surge Protection (Lightning Discharge) each roadbased loop  
 1500 V 1/2 W 100kohms 90V  
 Inductance A - 128 Microhenries/Res 2.6 ohms  
 Inductance B - 174 Microhenries/Res 2.1 ohms  
 Inductance C - 345 Microhenries/Res 1.9 ohms  
 Inductance D - 420 Microhenries/Res 1.6 ohms

Communication No Provision - not used

Signature

Date 05\_ / 12\_ / 07

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**CE Conformity Declaration  
 In-pavement Vehicle Detector Loop Tester**

Report No: ETG-010807CE

Date Issued 1<sup>st</sup> August 2007

Equipment Type: LT1000 In-pavement Loop Tester  
 Serial Number ET-0703-0000

Equipment Description The in-pavement loop is a primary source of vehicle detection on the public road network. The device under test (DUT) excites an in-pavement loop coil (typically 100micorhenries) to a resonant state (typically 50-140khz). Upon detecting resonance the device reverse calculates the coil inductance based on frequency, resistance and preset capacitance. The LT1000 generates a <500V DC pulse for typically 100 milliseconds to determine insulation quality. The LT1000 incorporates a highly sensitive receiver circuit which detects in-pavement loop frequencies in the range of 40Khz to 140Khz

- 1) The loop tester (referred to as LT1000) has been constructed such that generated electromagnetic disturbances shall not interfere with other equipment. A report of compliance in relation to IEC1000-4-5/ EN61000-4-5 has been formally recorded.
- 2) The Loop tester (referred to as LT1000) has been constructed to conform to a level of external electromagnetic disturbance immunity relative to equipment defined within ASNZS 4251.1 and CE compliance as stated **electrical Power surge 1kV - rise time 1.2sec/hold 50 secs** for industrial, scientific and medical equipment .

Power Supply	9VDC Battery Source – located internally
Microcontroller	PIC16F876-04 / 11.0592 Mhz Oscillator
Road Loops	Typically 4 Turns of wire 2 Metres x 2 Metres Square roadbased Surge Protection (Lightning Discharge) each roadbased loop 1500 V 1/2 W 100kohms 90V
Communication	No Provision - not used

Signature

Date 1\_ / 08\_ / 2007

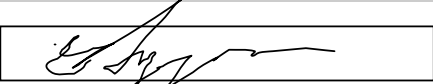
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**CE Conformity Declaration  
 In-pavement Vehicle Detector Loop Tester**

Report No: ETG-140305CE	Date Issued 14 <sup>th</sup> March 2005
Equipment Type:	LT100 In-pavement Loop Tester Serial Number ET-100-010
Equipment Description	The in-pavement loop is a primary source of vehicle detection on the public road network. The device under test (DUT) excites an in-pavement loop coil (typically 100micorhenries) to a resonant state (typically 50khz). Upon detecting resonance the device reverse calculates the coil inductance based on frequency, resistance and preset capacitance.
1)	The loop tester (referred to as TLM-01) has been constructed such that generated electromagnetic disturbances shall not interfere with other equipment. A report of compliance in relation to IEC1000-4-5/ EN61000-4-5.
2)	The Loop tester (referred to as TLM-01) has been constructed to conform to a level of external electromagnetic disturbance immunity relative to equipment defined within ASNZS 4251.1 and CE compliance as stated <b>electrical Power surge 1kV - rise time 1.2sec/hold 50 secs</b> for industrial, scientific and medical equipment.
Power Supply	9VDC battery Source
Microcontroller	PIC16F874 / 11.0592 Mhz Oscillator
Road Loops	Typically 4 Turns of wire 2 Metres x 2 Metres Square roadbased Surge Protection (Lightning Discharge) each roadbased loop 1500 V 1/2 W 100kohms 90V
Communication	No Provision - not used

Signature 

Date 14\_ / 03\_ / 2005

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