

LTM-100 In-Pavement Loop Tester



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2. Loop Detector functional specification
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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.



The LTM1000 in-pavement loop tester

Enhanced features from the LTM100

Loop Location – moving vehicle, audible ‘ping’ when loop detected

Loop ‘winding’ location – handheld 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 bar graph display indicates a vehicle actuation and relevant energy change associated with the actual vehicle detection.

This purpose designed, rugged, portable handheld 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 bar graph display of the actuation



Instructions for 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 1000 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 40-700 Microhenries)
- Resistance: Is the DC resistance of the loop (Typically 1-3ohms)
- 'Q': Is the performance value of the loop (Typically >6)* For vehicle classification > 12 is appropriate
- OPEN CIRCUIT - This message is displayed if the loop is open circuit
- SHORT CIRCUIT - This message 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'). Inductance Schedule – Measurement Tolerance



Inductance Schedule – Measurement Tolerance

!!!!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 an indicative measurement is displayed on the LCD.

Step 1:

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.

Step 2:

Make sure the TESTER is switched OFF – verify the LCD display is BLANK
Connect the RED lead to a single loop wire. Connect the Black wire to an appropriate EARTH connection point.

Step 3:

Switch on the device and select the insulation integrity test. Select the test function again and an audible ‘click from the relay switching will be displayed.

The device will generate the 500V pulse required by the test for a sustained period to enable a resistance measurement to be determined.

An indicative 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 and battery level. This is not a laboratory instrument, and the measurement is an indicative measurement.

This instrument has been Factory Test Certified at the following levels of resistance. 10MegOhm ($\pm 5\%$), 50MegOhm ($\pm 5-10\%$) and 200MegOhm ($\pm 10\%$). A resistor network composed of 0.5watt 10MegOhm resistors is used for this test. It is acknowledged that the environment is reasonably stable and percentage tolerance in resistor values may impact on this test. Insulation Integrity Test Range

- Resistance ≤ 10 Megohm
- Indicates a resistance less than 10MegOhm
- Resistance > 10 MegOhms
- Indicates a resistance greater than 10 MegOhm but less than 200MegOhms
- Resistance > 200 MegOhms
- Indicates a resistance greater than 200MegOhms
-

The measurement range displayed by the instrument allows the operator to make an informed decision about the loop’s insulation integrity as different road authorities have stated variations in accepted winding to earth insulation resistance thresholds.



Note on Insulation Resistance Measurement

The calibration of the instrument provides for a higher tolerance in the resistance range of 5 to 15 MegOhms. The instrument performance significantly decreases in the range less than 5MegOhms. The Insulation Resistance measurement is an indicative measurement of the nominal state of the loop.

The objective of this test function is to provide an objective TEST OK or FAIL status for the loop and feeder cable. Variations in battery level capacity and rapid repetitive testing producing accumulated mutual capacitance resulting from moisture ingress in the cable and field joints will affect readings.

Laboratory testing indicated that the same loop measured after a day's rain, 4 hours since the last rain fell and on a dry day will indicate three different resistance readings.



Instructions for Locating ‘active’ Loops - from a Moving Vehicle

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 driver’s 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.

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

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 wil 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**



When a signal level is detected, these boxes will darken



Addendum

Note on Insulation Resistance measurement

The Insulation Resistance measurement is an indicative measurement of the nominal state of the loop. The objective of this test function is to provide an objective TEST OK or FAIL status for the loop and feeder cable. Variations in battery level capacity and rapid repetitive testing producing accumulated mutual capacitance resulting from moisture ingress in the cable and field joints will effect readings.

Note on the nature of detecting the position of a loop winding

The most sensitive area of a loop is above the loop wire itself as the lines of force are at RIGHT ANGLES to the eddy current circuit producing the largest opposing force. The 'right angle' force however, when measured with the probe field at right angles produces a NULL field. The NULL field is detected by the circuitry and thus the position of the wire is determined. Trawling the probe over the loop other than in a completely horizontal orientation may induce erroneous results as the angle of incidence between the loop field and the device probe field will induce a reading.

Note on the validity of crosstalk compensation by simple adjustment of capacitance

Resonant frequency change is the basis of inductive vehicle detection
is the frequency in radians/sec

For a resonant circuit:

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

Therefore ω , 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. However, this variation is not affected by C. C only affects the absolute value of.

What does all this mean? Changing the resonant frequency point for a fixed inductor (a loop) requires changing the capacitance C. However . . .

Since C is not related to the change in when L changes - it can be stated that doing so is a pointless exercise unless the frequency is be shifted by at least 5Khz and the device must easily accommodate site variations while incurring preset incremental capacitance steps.



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 give it a scientific presence:

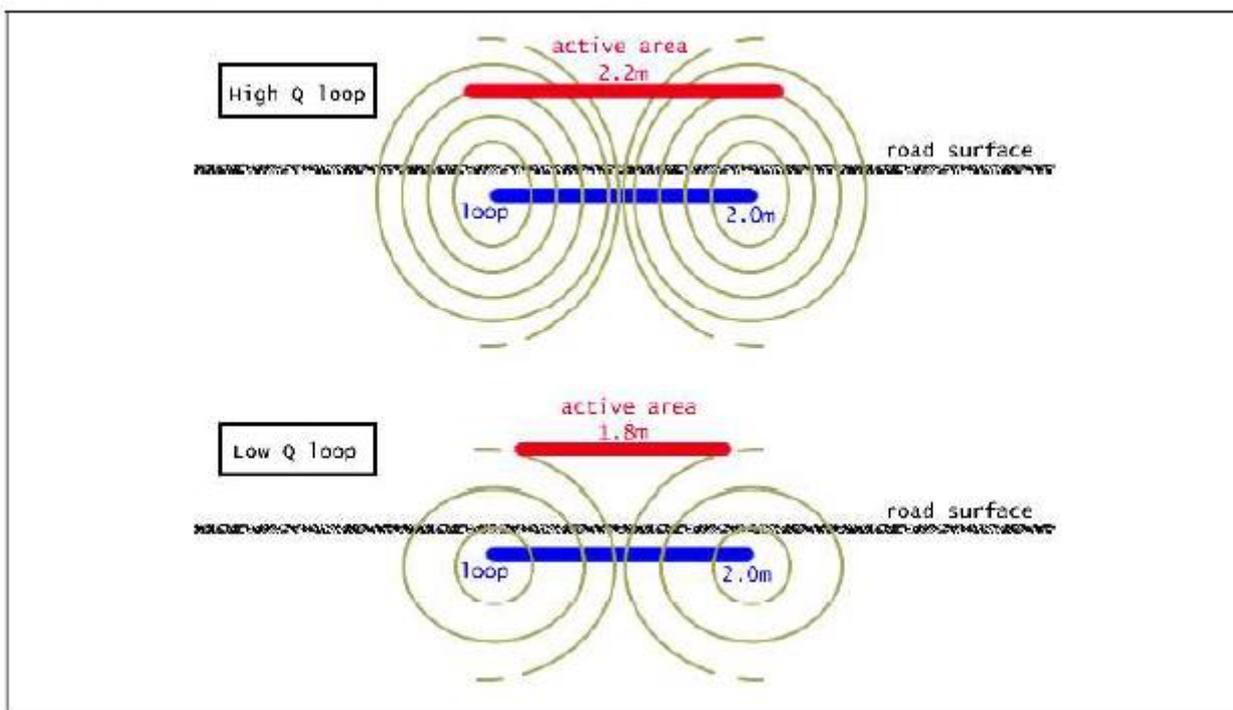
Q (at resonance) = Frequency (radians) X [Multiplied by] inductance (Henries)
 _____ [divided]

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.



Loop Length and Sensitivity

Loop length and sensitivity is associated with the length of the active area of the loop in the direction of travel and the strength of the electromagnetic field and its inherent interaction with the electromagnetic of iron. . 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.

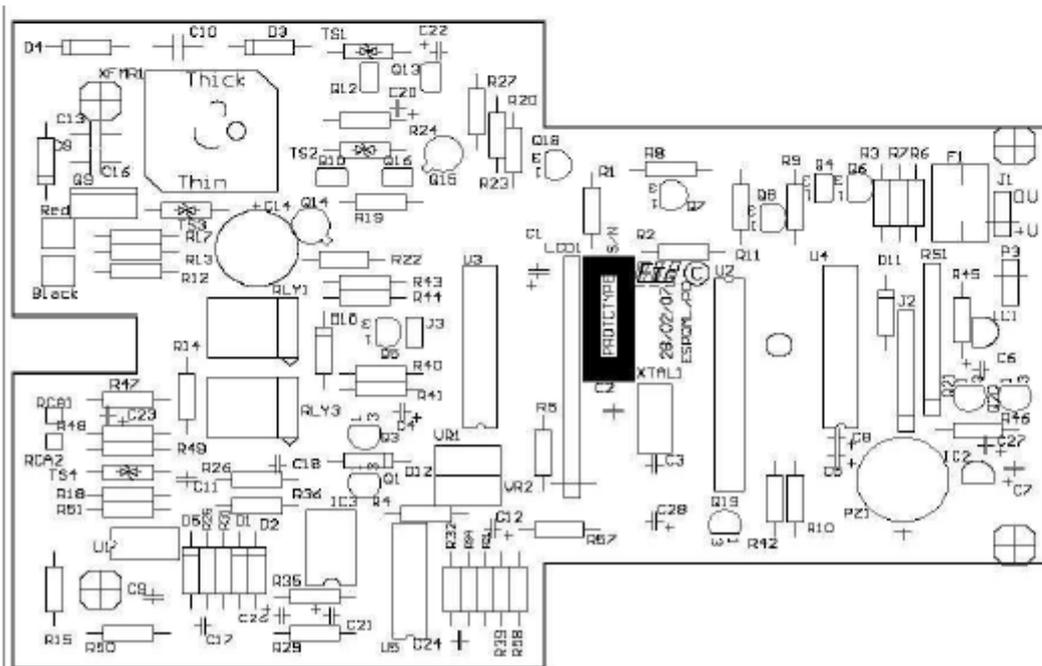
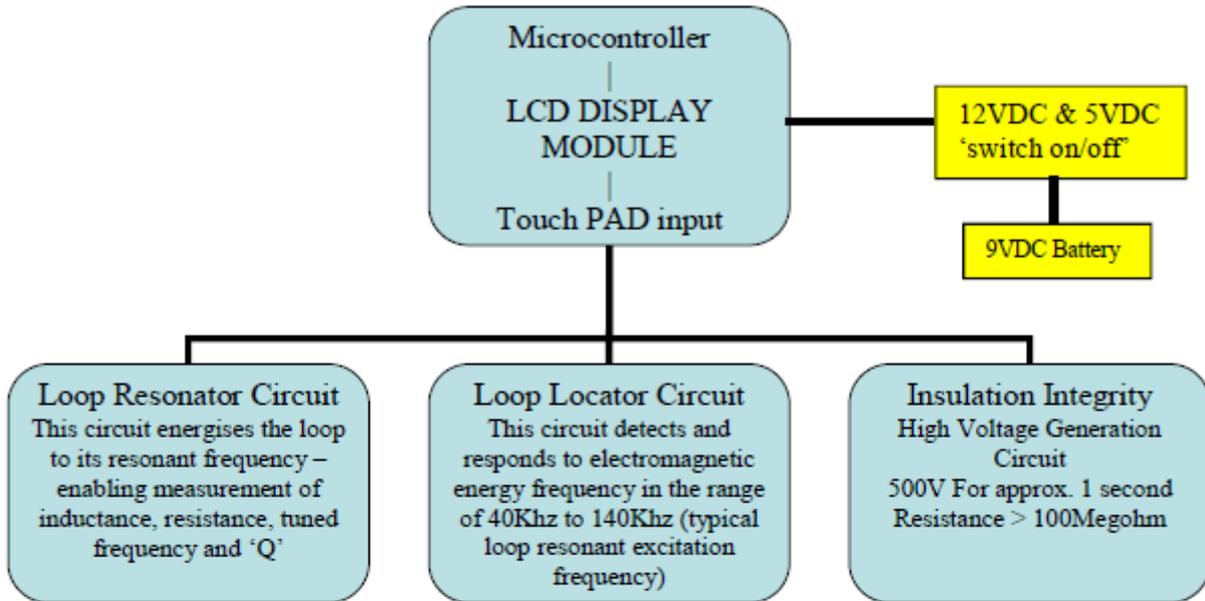
For loops installed according to the specifications given in XL Series loop detector manual, the active area of the loop should be close to the physical loop size. For existing loops with low Q the active area may be diminished.

A low loop 'Q' will affect the performance of the detector both in respect to detecting smaller vehicle and the accuracy achievable by the vehicle detector in measuring the vehicle length. The following example indicates how low 'Q' effects vehicle length measurement and how adjustments in the detector may overcome the measurement error.

The error in the loop length directly affects the error in the vehicle length. For example, if there is an error in the loop length of -0.4m then vehicles will be reported as being 0.4m shorter than they actually are. This error can be minimised by following these steps:

1. Set the detectors to the most sensitive setting possible without crosstalk (crosstalk can only occur between cards)
2. Using the debug mode in the console, observe the lengths of 5 or more Holden or
3. Ford sedans. These cars have a typical length of 4.9m
4. Average the results and subtract 4.9m.
5. The result is the amount by which the loop length value should be modified.
For example: 5 vehicles are measured at 4.1m, 4.3m, 4.0m, 4.0m 4.1m. The average is 4.1m. Subtracting 4.9 gives - 0.8m. Therefore, the loop length should be decreased by 0.8m.





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 loop's 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 General 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: Trans orb 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 –250C to 650C 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 -700 C to +2000 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 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

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