ETG – In-Pavement Loop Tester
Model Number: LT-100M

Original Revision 1.0 June 2004 doc: man_lt100m_1.doc
Current Revision 1.0e May 2007 doc: man_lt100m_1f.doc

Contents

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

The LT-100M in-pavement loop tester

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' and Tuned frequency. 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 device has an LCD panel for displaying relevant loop parameters. The device has a single power-on switch and for night-time use a push button actuation based back light switch 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. Pressing 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.

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 parameters

- 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 operation incorporating an analogue bargraph display of the actuation

Instructions for Field Use

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 shortcircuit the connectors which 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').

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

Resonant frequency change is the basis of inductive vehicle detection
ω is the frequency in radians/sec
For a resonant circuit:
$\omega = 1 / \text{SQRT}(LC)$
therefore ω is proportional to 1/SQRT(L) or L^-0.5

Therefore any variation in L of X% translates to a much smaller variation of ω. However, this variation is not affected by C. C only affects the absolute value of ω.
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 ω when L changes we can say that doing so is a pointless exercise.

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

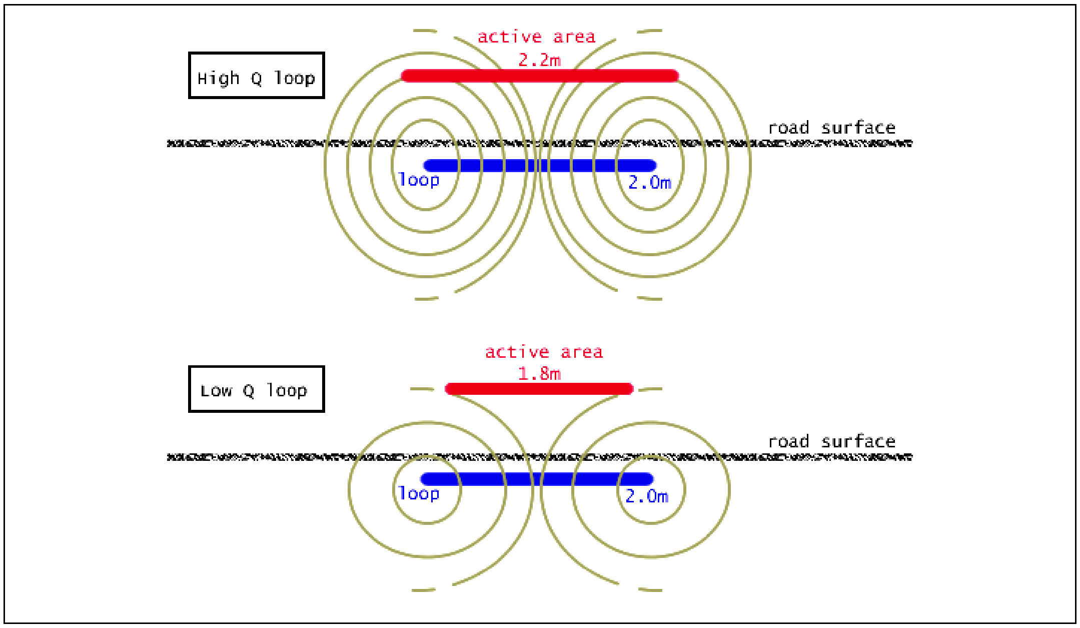
*'Q' for normal vehicle detection may be as low as 6 however for vehicle classification applications and accurate speed detection 'Q' should be greater than 15.

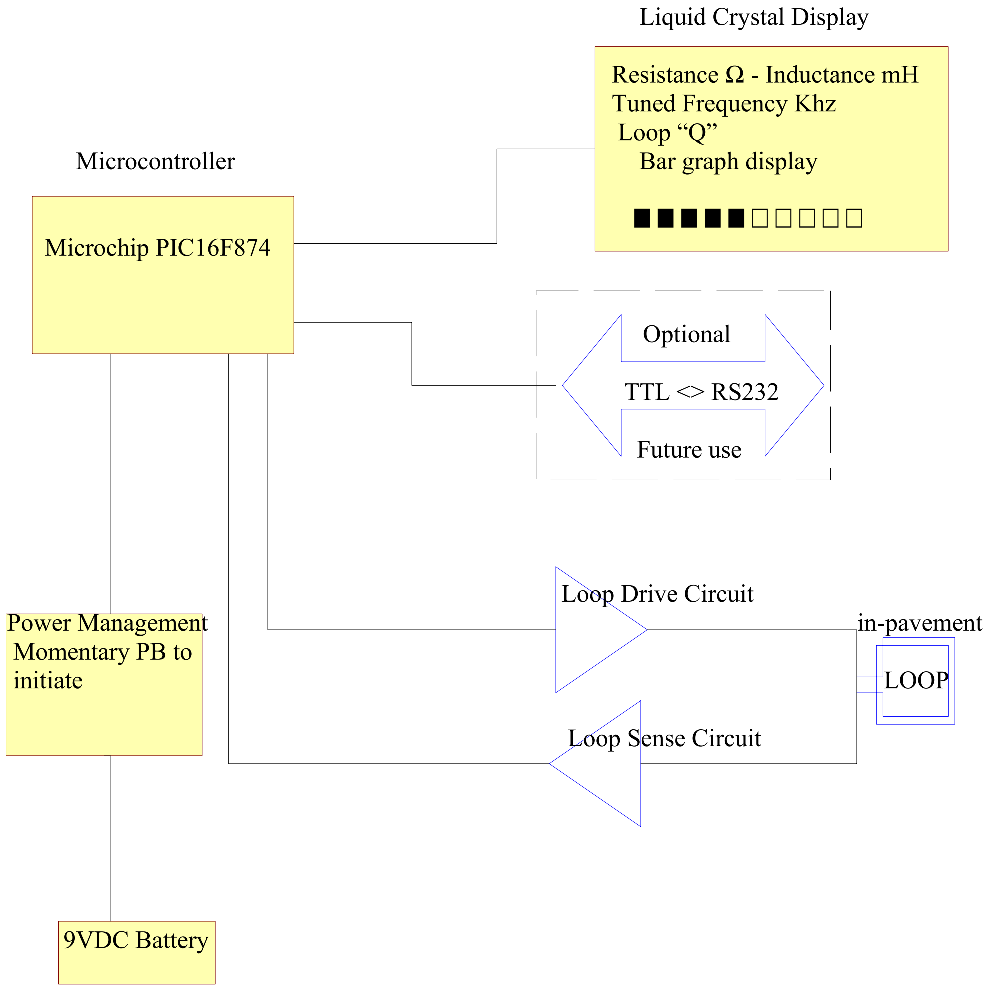
Q or the performance of the loop is effectively the relationship between inductance of the loop and resistance / impedance in the feeder cable hence longer feeders (higher impedance/resistance) need more inductance in the loop for compensation.

The following formula and reference gives it a scientific presence:
Q (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.





This figure provides 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. 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 within the resonance equation. The LCD is used to display the resultant electrical characteristics. A serial port has been included for planned future use where an 'unmanned' site could monitor parameter variation and report this to a logging device which could log date, time, loop variations and other characteristics.

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 aaplicable)
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^{0}C to 65^{0}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 –70^0 C to +200^0 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 LT1000 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.
LT-100M 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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CE Conformity Declaration
In-pavement Vehicle Detector Loop Tester

Report No: ETG-140305CE — Date Issued 14th 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 e**lectrical Power surge 1kV - rise time 1.2sec/hold 50 secs** 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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