User Manual

LP-V001

Leopard CAT M
Wireless Communication
Device

December
2018

R1.2

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Author	Revision	Changes	Date
	1.0	Initial version	2018 Dec 20
	1.1	Update to RF Performance Table	2018 Dec 27
	1.2	Correct Doc Title and add usage	2019 Jan 29

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1 Introduction

The LP-V001 is a self-contained automotive wireless communication device that combines LTE CAT M cellular connectivity with GPS location. The device is typically installed in a vehicle, either in-dash or under the hood with minimum distance from the human body not less than 20cm. It is primarily a location reporting device that responds to requests (user, server) and events (timers, geo-fences). Data reports consist of a single record that contains all location data and system status.

The device comes pre-configured from the factory. It is ready to use. The LP-V001 appears to a user or a server application as an endpoint device. It can be queried, updated and configured either through a serial connection, an over the air IP connection, or through SMS messaging. The LP-V001 presents itself over these connections as an enhanced cellular modem with attached functional elements. These elements include:

- GPS location engine
- Accelerometer
- Input/outputs dedicated for ignition, relay, buzzer, and general purpose
- Serial UART port
- Timers
- Watchdog lockup protection
- Power management
- Event reporting
- Voltage monitoring

Access to these elements and general purpose interface is done through an extended AT command set. Configuration parameters are stored to flash memory and are automatically used on the next power up event. For more details, please reference the AT Command document.

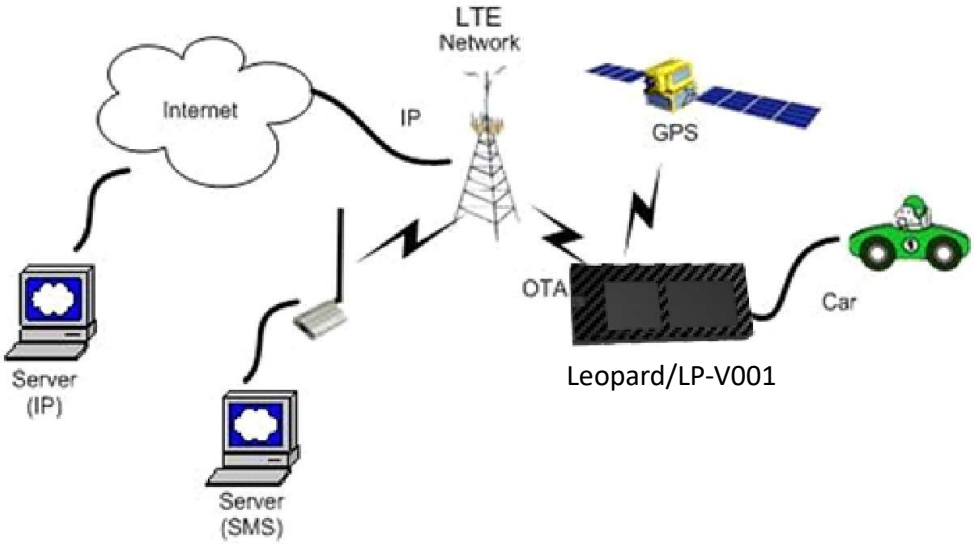


Figure 1 This product is based on the Asiatelco LM91-MV (4G LTE CATM) baseband module. Antennas for cellular and GPS are internal to the device.

2 Hardware Design

2.1 Basic Hardware

Items	Requirement
Cellular Modem	Based on Asiatelco LM91-MV baseband module.
Cellular Network Interface	Support for LTE B13
Frequency	B13(MHZ): TX(777-787) RX(746-766)
Cellular Antenna	Internal single antenna
GPS Antenna	Dedicate high performance ceramic antenna
UIM requirement	Support： 3FF SIM Interrupt Mode No Support： Hot Plug/Unplug
Battery Monitor	Internal analog input
Build in battery manager	Yes
Interface	Debug UART
	12V DC Input（1A current）, Ground
	Relay Drive (Open Drain , 500mA current)
	Dedicated Output for buzzer control
	Ignition Input
	GPIO
Dedicate Timers	Yes
Watchdog	External HW via MCU
Motion Detect	Supported（GPS/G-Sensor）
LED	2 LED Supported 1- RED; 1- Green
Battery	Optional built in battery（80mAH Lion）
Working Time	4 hours
Power switch	No
Power Cable color	8 colors
Power Cable connector type	8-pin connector
Power Consumption	< 5Watts

The LP-V001 provides support for specialized hardware features through extended AT commands. The features supported include the following:

GPS

GPS location functionality is provided by the device GPS receiver. NMEA GPS records can be extracted in real time from the unit via the UART connection using special debug commands that are outside the scope of this document.

GPIO

One dedicated input, two dedicated outputs, and one general purpose IO are presented to the external environment on the main connector. They are capable of providing system interrupts to generate a report or drive logic levels to external devices. These lines are 2.8V logic level and are 16V tolerant. These pins default to input and are pulled down representing 0 when disconnected. They should be asserted to a known value if used.

LED's

Two LED status indicators are provided to verify correct installation and operation. The status LEDs are color coded and directly convey the status of the cellular and GPS subsystems as described in the table below. Their valid operation also indicates operational status and power.

LED	Function	Status
Red	GPS	**On:** GPS satellites acquired and Locked **Flash Slow**: GPS satellite search is in progress **30 Sec Blink**: Device in low power mode **Off:** No power or GPS subsystem fault
Green	Cellular Connection	**On:** Indicates LTE connection is made **Flash Slow**: LTE subsystem initialization in progress **Flash Fast**: LTE initialization but no data connection available **Off:** No power, Low power mode or LTE subsystem fault

The LP-V001 provides user control allowing the LEDs to be extinguished once installation is verified. This feature reduces power and further conceals the LP-V001 Tracker from untrained parties wishing to defeat its operation.

UART

There is one UART provided. A debug UART port is provided for AT commands, data interaction and optionally for application specific control.

Relay Driver

A 500mA sink capable output pin is provided. This pin is meant to drive a relay coil indented to interrupt the starter solenoid relay for the ignition circuit to a car.

Power and Battery

The battery monitor is internal analog input scaled such that the DC value of the power input pin to the LP-V001 system is measured. This value is scaled to span the most significant 8 bits of the A/D and consequently covers a scale from 0 to 28 Volts.

Timers

Timers resident on the baseband chip generate periodic interrupts for power down wakeup, watchdog support, periodic report generation and other timer related functions.

Watchdog

The Asiatelco LM91-MV provides internal software Watchdog. Also the LP-V001 includes an MCU that acts as a failsafe external watchdog. The MCU power cycles the system, if no activity is detected for 1 hour.

Accelerometer

The accelerometer can be used for motion detection and driver behavior monitoring.

2.2 Basic RF Performance

Items	Requirements	Remark
TRP free space	B13: >= 18 dBm	TRP free space
TIS free space	Main: <= -90dBm Div: <= -88dBm	TIS free space
Antenna loss	<= -4dB	TRP-TX Power Conducted
Antenna Loss	<= -4dB	RX receive sensitivity conducted – TIS

Board RF Specification	
LTE_B13_RX	
Frequency range	746MHz ~ 756MHz
Sensitivity	-96dBm (10MHZ_50RB_Downlink)
Dynamic range	-23 ~ -96dBm
LTE_B13 _TX	
Frequency range	777MHz ~ 787MHz
Maximum Frequency error	±10Hz
Maximum output power	23±1.5dBm
Minimum control output power	<-43dBm
ACLR	UTRA2: 45.48 UTRA1: 41.41 E-UTRA1:39.43 UTRA2: 44.87 UTRA1: 41.51 E-UTRA2:38.25
OBW	1.06MHZ (10MHZ Nominal)
IQ OFFSET	< -54.7dbc
EVM	<4.5%
GPS	
Frequency Support	L1-band (1.57542GHz) Channels: 210 PRN, 66 Search, 22 Simultaneous tracking

Sensitivity	Sensitivity (UHIS): Tracking: -156dBm Reacquisition: -153dBm Acquisition: -144dBm
Tracking Time Requirement	Acquisition time: Hot: <2s Warm: <15s Cold: <60s Reacquisition: 2s - 10s Depends on signal level

2.3 Certification and Safety

Items	Requirement
Drop Design	1.2 meter 6 direction standard drop test
Temperature Range	-20 to 40°C Operation -50 to +100° C Storage
Humidity:	20% to 90% Operation 10% to 95% Storage
Altitude:	-500 to +18,000m
Vehicle ISO Test	ISO7637-2-2004; ISO7637-3-2007; ISO10605-2008; ISO16750-2-2010
FCC Certification	FCC 47 CFR Part 15 and Part 18
Other Certifications	Industry Canada (optional)
ESD Requirement	10KV non-Conductive
Operator Certifications	Verizon

3 Software Features

3.1 Basic Software

Items	Requirement
Network Interface	LTE B13
IP Stack	IPV4/IPV6
Upgrade Method	Remote update/ PC tool
Remote Update	Supported – including OMA DM
Power Modes	Supported
AT Commands	Supported
Report	Supported：1000 records
Drivers	GPIO, LED, GPS, UART, Accelerometer
GPIOs	Interrupt for Ignition Status, Buzzer, Relay
LEDs	GPS Status, Network Status
Watch Dog	Supported
Reset	Soft reset, hard reset, GPS reset, RF reset
Startup Banner	Supported

3.2 Remote Update

The LP-V001 supports OTA field upgrades of the resident application. An over the air TFTP (Trivial File Transfer Protocol) connection is made over an IP connection. A replacement file is then transferred from a server to the LP-V001 and that file replaces the previous application image.

3.3 Power Modes

The LP-V001 device supports several power modes that are set by AT commands. In full power mode the GPS is active and the cellular subsystem will maintain a persistent cellular connection whenever service is available. IP connection is maintained according to the configuration of the device.

The device can be put in low power mode whenever it runs on a backup battery or if the external battery is low or if it is not moving. In low power mode the GPS is not running and the LED's are off. The device would return to full power whenever an event occurs that triggers a report. Those events include:

- Periodic report
- GPIO change
- IP change
- Battery threshold
- Heartbeat
- Watchdog
- Power-up

- Ignition
- Trip start and stop

Any hardware or software reset will return the device to full power mode.

3.4 AT Commands

Extended AT commands are specific to the LP-V001 device. They are closely based on commands that are as similar as possible industry common devices and are essentially subsets of standard LP-V001 commands. Native AT commands supported by the AsiaTelco LM91-MV modules are also available via the serial and USB interfaces.

3.5 Ack'ed Mode

UDP is not a 100% reliable connection and occasional reports or command/responses may be lost. Since all commands have responses, the server can repeat any command to which there is no response. In order to assure reliable reception of reports, LP-V001 devices can be configured either in Normal or Ack'ed mode to send the reports. In the Normal mode the reports are simply sent "as is" with no acknowledgment from the server. In the Ack'ed mode every report sent is expected to be acknowledged by the server by sending back an ACK message back. If acknowledgement is not received within the specified timeout, the report is re-sent. If the report is not acknowledged after the specified number of attempts, it is queued. If acknowledgement is received after the report is queued (i.e. past timeout of the last attempt), it is ignored.

Report is not considered "complete" until its acknowledgement is received. Thus, if report X is sent and report X+1 is triggered while waiting for acknowledgement of X, report X+1 will be queued until such acknowledgement is received and only then sent. The LP-V001 will attempt to re-send queued report(s) every time a new report is triggered. If there is more than one report queued, the reports will attempt to be sent in the order of triggering and only once the report is acknowledged, the next report is attempted. This assures that reports are sent and received in order

Ack'ed mode assures that all reports are received, but adds overhead in time and data. Report that is not acknowledged is sent again and eventually will be queued and sent again. The number and frequency of re-tries is configurable via the Report Acknowledgement command.

3.6 Event Report Format

Reports are encoded as binary hex. It is also echoed to the debug UART in ASCII format.

3.7 Reset

There are a number of resets available on the device. Soft reset only restarts the software running on the device. Hard reset is caused by resetting the whole basband module via a reset pin. There is also an option to reset the GPS and the cellular sub-systems individually.

3.7.1 Context Preservation

When a self-initiated reset is performed due to Network Watchdog or by the Reset command (modes 0,1), the context of the system is being preserved and is restored after the reset. The context includes all the periodic timers, the report queue, the odometer, etc. This allows to reset the unit as a troubleshooting or preventive measure without losing reports that are already in the queue or are pending on running timers. Note that the reset process may cause 1-2min of inaccuracy in the timers and should not be considered as very precise.

3.8 Startup Banner

After a reset a startup banner is printed through the UART only.

4 Test Method

4.1 Hardware

Test Item	Description
Baseband Function Test	• Power Input Test • Power Consumption and Current Test • Heat Dissipation Test • UART Stability Test • GPIO Level Test • LED Stability Test • Drop Down Test • ESD Test • High/Low Temperature Test • Humidity Test
RF Test	• RF Performance Test • GPS Performance Test • Antenna Performance Test

4.2 Software Test

Test Environment Construct

- Message Test environment

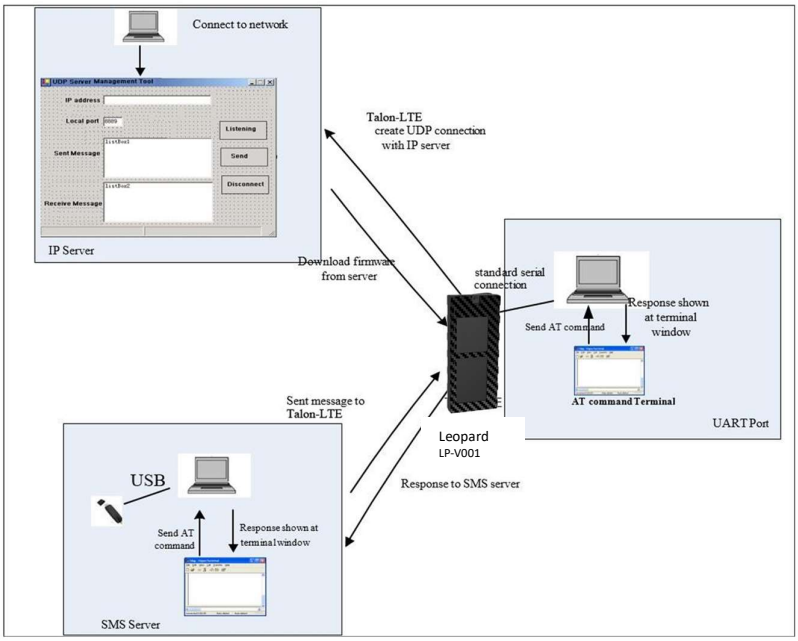
1. USB dongle and PC as message server
2. Send message to LP-V001

- UDP Test environment

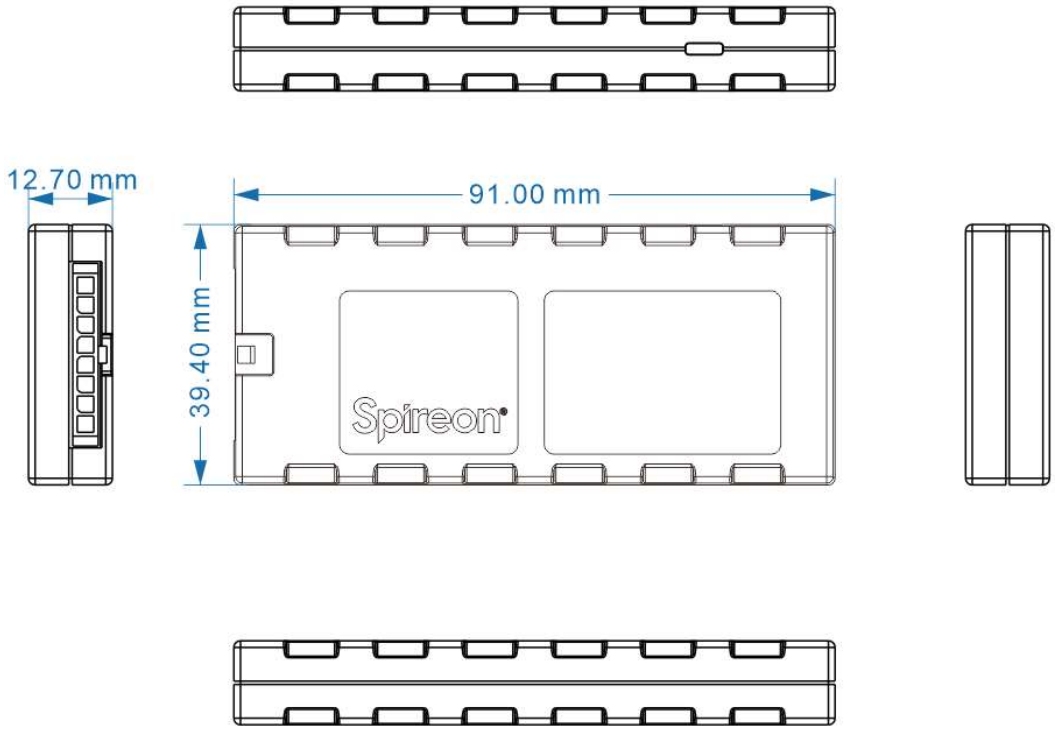
1. Connect dongle to PC and create dialup as ip server
2. LP-V001 create IP connection to server

- UART Test environment

1. Connect LP-V001 to PC with com serial cable
2. Open Terminal tool and send at command
3. Response can be shown at terminal window



Mechanical Structure (mm)



FCC Statement

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

-- Reorient or relocate the receiving antenna.

-- Increase the separation between the equipment and receiver.

-- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.

-- Consult the dealer or an experienced radio/TV technician for help.

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

RF Exposure Warning Statements:

The antenna(s) used for this transmitter must be installed to provide a separation distance of at least 20 cm from all persons during the normal operations.

IC STATEMENT

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

In order to avoid the possibility of exceeding the IC radio frequency exposure limits, human proximity to the antenna shall not be less than 20cm (8 inches) during normal operation.

Afin d'éviter la possibilité de dépasser les limites d'exposition aux fréquences radio de la IC CNR102, la proximité humaine à l'antenne ne doit pas être inférieure à 20 cm (8 pouces) pendant le fonctionnement normal.