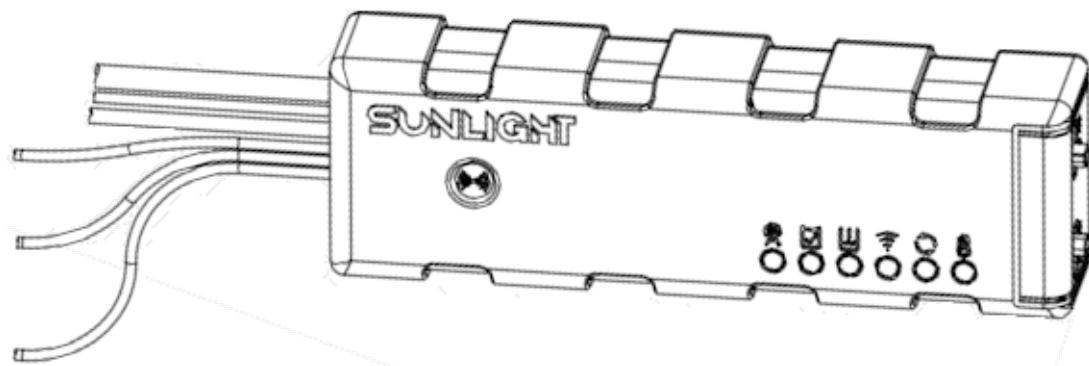


OXYGEN BROADBAND S.A.**SUNLIGHT BMS LEAD****KnoWi****H/W and S/W Technical Specification**

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1) REVISION HISTORY

Revision	Date	Author	Comments
1.0	13/4/2021	M. Petouris	First release.
1.0	28/4/2021	P.Paravoliasis	Additions and detailed description.

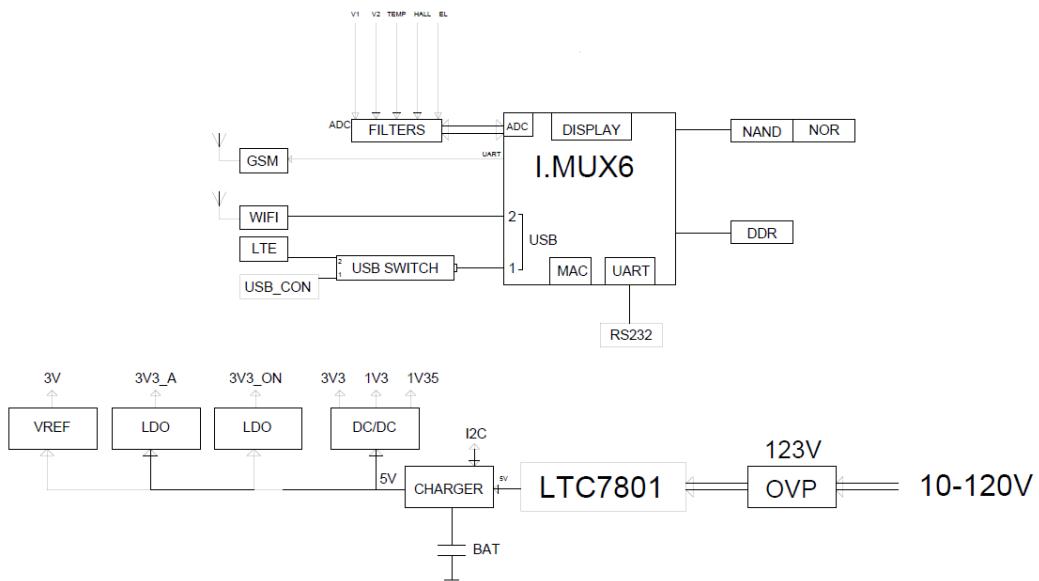


BMS LEAD device.

2) INTRODUCTION

The **Sunlight BMS LEAD** device is designed to be used in industrial environment and warehouses, both indoors and outdoors. It is used only for monitoring battery cells and transmitting the information and data requested to the cloud service of the client. Operation of the device should be only performed by specialized and trained personnel.

This document describes the **Sunlight BMS Lead** product based on the NXP I.MX 6ULL single-core processor with ARM Cortex-A7 Core. The following diagram depicts the building blocks of the I.MX 6 chipset.

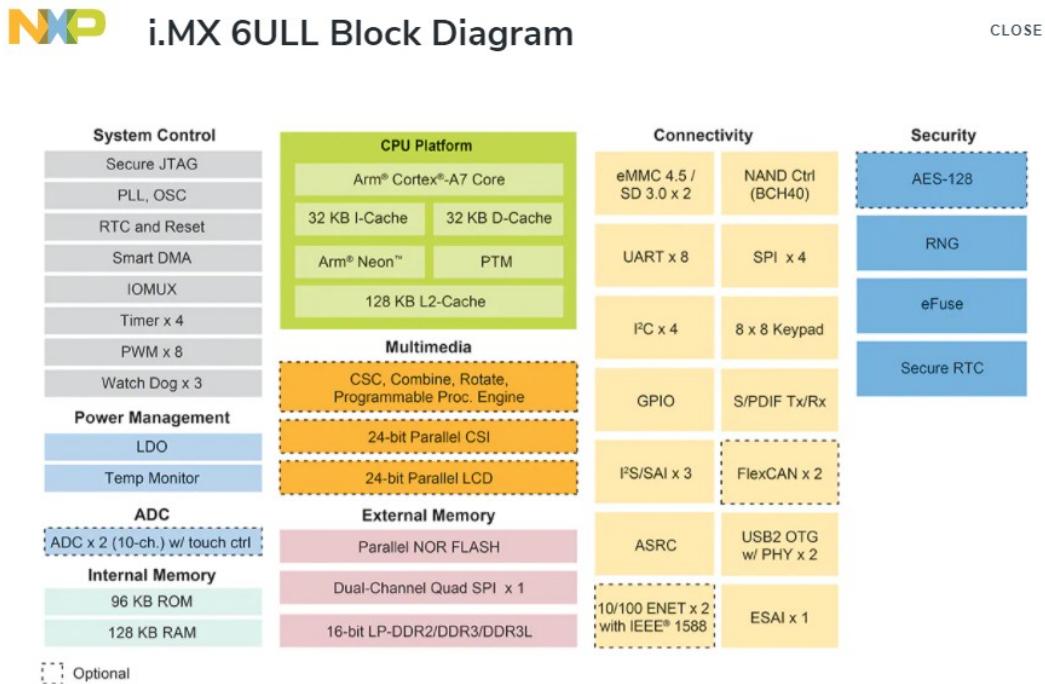


The i.MX 6ULL is a power efficient and cost-optimized applications processor family featuring an advanced implementation of a single Arm Cortex-A7 core, which operates at speeds up to 528 MHz.

The EG91 is an LTE CAT1 module, delivering maximum downlink rates of 10Mbps and uplink rates of 5Mbps under LTE. It is also backward-compatible with existing UMTS/HSPA+ networks.

The 6223E is a 2.4G WIFI/Bluetooth module, operates at 2.4GHz and support IEEE standards, IEEE 802.11b, IEEE 802.11g, IEEE 802.11n, IEEE 802.11d, IEEE 802.11e, IEEE 802.11h, IEEE 802.11i. It is fully qualified for BT2.1,BT3.0 and BT4.0 dual mode. Support also BT pairing.

I.MX 6ULL



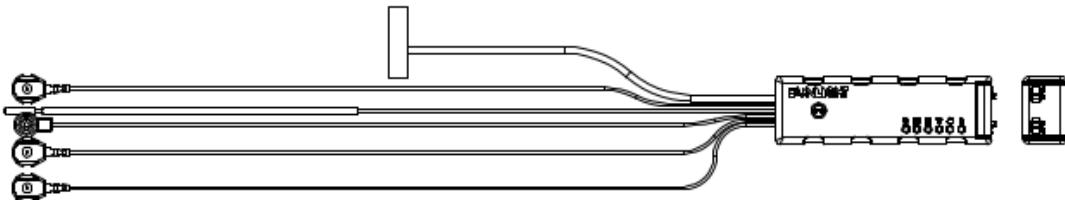
Peripheral to the NXP chipset, the device also has the EG91 GSM/GPS LTE module from Quectel, the LINK6223E wifi module from FNLink, a USB2.0 A-type interface, a Temperature sensor, a Hall sensor, an electrolyte sensor, a DDR3L 1Gbit IC, a QSPI serial flash 16Mbit and a serial NAND Flash 2Gbit. The device also has an Internal Li-Ion battery at 300 mAh.

3) HARDWARE FEATURES

3.1. Silicon Chips

Function	Description
CPU	NXP i.MX 6ULL Cortex-A7 Core Industrial grade
LTE-CAT1	Quectel EG91 (-EX, -NAX, -AUX) GSM/GPS Module -EX : FDD LTE : B1/B3/B7/B8/B20/B28 , WCDMA B1/B8, GSM 900/1800 MHz , -NAX FDD LTE : B2/B4/B5/B12/B13/B25/B26, WCDMA B2/B4/B5 -AUX FDD LTE : B1/B2/B3/B4/B5/B7/B8/B28/B66, WCDMA : B1/B2/B5/B8 GSM : B2/B3/B5/B8 GPS,GLONASS,BeiDou/Compass,Galileo, QZSS
WIFI	FNLink LN_6223E Module 2.4 GHz, IEEE 802.11bgndehi, Bluettoth 2.1, 3.0, 4.2 up to 150 Mbps up/down PHY rates
Temperature Sensor	NXFT15XH103FA2B150, NTC Thermistor, 10kOhm,-40°C +125°C,1%
Hall Sensor	Imax=1000A, 1%, 1.5mV/1A, 0.75mV precision step
Electrolyte Sensor	10cm Lead stick, on/off sense
DDR3L Memory	1Gbit
QSPI FLASH	16Mb
NAND Memory	2Gb NAND Flash (Internal memory used for storage)

3.2. Physical Ports / Switches



BMS LEAD device with cables.

Cable sequence in order of appearance from top to bottom.

Label	No	Type	Color	Description
Touch pad	1	Touch sensor	-	Wake up from Hibernation
USB	1	Type A Female	white	USB 2.0 Host interface for connection of peripheral devices
Cable with sensor	1	Dual Core	Black	Hall sensor
Cable	1	Single Core	Yellow	Half Voltage sensor cable
Cable with sensor	1	Dual Core	Black	Temperature sensor
Cable with sensor	1	Single Core	Blue	Electrolyte sensor
Cable	1	Single Core	Black	Negative power supply cable
Cable	1	Single Core	Red	Positive power supply cable

3.3. LED Indicators



➤ LEDs in order of appearance on the LED panel from left to right :
 GSM, EL_OK, EL_LOW, WIFI, PAIR, TEMP_HIGH

Name	Color	Status	Indication
GSM	GREEN	On	LTE interface active
		off	LTE interface deactivated
EL_OK	GREEN	On	Electrolyte level OK
		Off	-
EL_LOW	RED	On	Electrolyte low level
		Off	No warning
WIFI	GREEN	On	WIFI module active
		Off	WIFI module deactivated
PAIR	GREEN	On	Bluetooth pairing
		Off	No pairing
TEMP HIGH	RED	On	Extreme temperature
		Blinking	High Temperature
		Off	No warning

3.4. Power Supply

Internal DC/DC Switching power supply

Input: 12-120VDC

Power consumption: 1.48W Normal mode
 0.061W Hibernate mode

3.5. Measurements

Analog measurements:

- Cell Temperature with +- 1°C precision from -40°C to +125°C.
- Cell Electrolyte low level indication
- Full Voltage level 0-150 Volt, with 0.2% precision and 750uV step
- Half Cell Voltage level 0-150 Volt, with 0.2% precision and 750uV step
- Cell Charge discharge Current. Measures currents from -1000A to 1000A, 1% precision, 0.5A precision step.

3.6. Certifications / Safety / Environmental

Function	Description
FCC SDoC	47 CFR FCC PART 15, Subpart B, Class A
CE-RED: (Directive 2014/53/EU)	ETSI EN 300 328 ETSI EN 301 511 ETSI EN 301 908-1 ETSI EN 301 908-2 ETSI EN 301 908-13 ETSI EN 303 413 ETSI EN 301 489-1 ETSI EN 301 489-17 ETSI EN 301 489-19 ETSI EN 301 489-52 EN 62311 EN 50665 EN 62368-1
CE-RoHS: (Directive 2011/65/EU)	EN 63000
Production	Quality assurance, thermal test
Temperature Range	Battery temperature range for standard applications: 10°C to 45°C for continuous operation 45°C to 55°C for less than 5% of the operating time 55°C to 60°C for less than 1% of the operating time Operaton: -10 to +45°C Storage: -20 to +95°C
Humidity Range	Operation: 10 to 90% RH Storage: 5 to 95% RH
MTBF	Over 35,000 hours
Warranty	36 months

3.7. Statements

FCC Statement:

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.
- (2) This device must accept any interference received, including interference that may cause undesired operation.

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

WARNING:

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

RF Exposure

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum 20cm distance between the radiator & your body.

3.8. Strength of Materials

- The resistance specifications of the BMS for spraying with sulfuric acid is :
The battery surface is exposed to acid sprays and splashes:
 - the external parts shall endure short term exposure (for several days) at the same acid concentration.

Test: the specimen is sprayed with acid 40%w/w from all directions and then is left in the oven at 55oC for 2 days.

It shall not show signs of corrosion and acid penetration.

- Ingress Protection
The device is IP 66 compliant.

3.9. Other

- 6 layers PCB, ROHS, Main Board
- 4 layers PCB, ROHS, Daughter Board (LTE Module)

4) SOFTWARE FEATURES

The main S/W applications running on the device include:

- Full IPv6 support, including tunneling (IPv4-over-IPv6, IPv6-over-IPv4)
- Dynamic backup operation between different WAN connections
- Netfilter iptables with layer-7 filtering enabled
- SSL libraries
- SSH server/client
- OpenVPN server/client
- IPSec server/client
- PPTP server/client
- L2TP server/client
- Routing daemon for dynamic routing protocols (RIP, OSPF, BGP)
- DHCP server/client
- HTTP server
- UPnP daemon
- FTP server
- File server
- DNS proxy
- DynDNS client
- Perl interpreter
- URL filtering application

5) SOFTWARE OPERATION

General guidelines.

The BMS collects a series of data using a set of sensors. The data consist of Current, Voltage of the battery cell and also half Voltage in the middle of the cell. Also Temperature and electrolyte levels are measured. Depending on these measurements the remaining Ah and Kwh are calculated, as well as the battery status. Periodically these values and other battery status indications are recorded in files and all together are sent to an external server for further analysis.

STATE MACHINE

The BMS can be in one of the 5 following states :

- Charge Active : High level positive Current to the battery resulting in the charge of the battery cell.
- Charge Idle : The battery is at a state of charge but the positive current is low.
- Discharge Active : High level negative current from the battery results in battery discharge.
- Discharge Idle : The battery is at a state of discharge but the current is low intensity.
- Storage : Both the positive and negative current is of negligence level for a long period of time so the battery is at storage state.

In order to pass to status Charge Idle the battery must be in Charge Active state and the mean current for a given time period must be less than 1A/100Ah.

In order for battery going to status Discharge-Idle the battery must be at Discharge Active status and no current sample above 1A/100Ah is received for the given time period.

The battery can fall to Charge Active state when :

- a) The status is Charge Idle and the mean current for at least one minute is at 5A/100Ah
- b) To be in Discharge state and current is greater than 5A/100Ah for at least one minute.

For the battery status Discharge Active to occur the battery must :

- a) Be at Discharge Idle state and have a mean current for one minute greater than 1A/100Ah.
- b) Be at charge state and have a mean discharge current for one minute greater than 2A/100Ah.

A new cycle starts every time the BMS goes from Charge state to Discharge state.

The battery has also the following proper function states :

- Overdischarge False : (Correct function)
- Overdischarge True : The battery cell is almost empty.

- Level Normal : the electrolyte level is normal.
- Level Fill Soon : The electrolyte level is low.
- Level Fill Now : The electrolyte level is low for a long period of time.

As well as this the following temperature status are available :

- Temp Normal : Normal Temperature
- Temp Over : High Temperature
- Temp Xtrm : Extremely high temperature.

Communication

The BMS communicates with the server in regular time intervals. The communication is performed using HTTPS Protocol and POST method is used. The measurements are transported using JSON form. Using the same methods the user can send commands to the BMS and those can be executed when communication is established.

Detailed Function

The BMS receives measurements from its sensors periodically. Current and Voltages are measured every 100 msec, electrolyte level every one sec and temperature every 10 sec. After each measurement it refreshes the various counters :

- Ah Charge (per cycle and total)
- Ah Discharge (per cycle and total)
- Kwh Charge (per cycle and total)
- Kwh Discharge (per cycle and total)
- Minimum and Maximum current values (per cycle and total)
- Minimum and Maximum Voltage values (per cycle and total)
- Minimum and Maximum Temperature values (per cycle and total)
- State of Charge (Percentage of Battery charged)
- Hours in different temperature levels.

Afterwards the battery status is refreshed depending on the measurements described above. At each cycle change the corresponding counters are stored and the exact time that the BMS was in Discharge State within the full cycle.

Forklift Pair

Periodically the BMS checks if the battery is near a forklift. When a change occurs regarding the pairing with a forklift device, the BMS stores all counters and starts over. Each measurement stored will have the serial number of the forklift.

Events & Alarms

To monitor the battery and analyse its use the BMS stores certain events and alarms. The events present are :

- Event for change from charge active to charge idle
- Event for change from charge active to discharge active
- Event for change from charge idle to charge active
- Event for change from charge idle to discharge active
- Event for change from discharge active to charge active
- Event for change from discharge active to discharge idle
- Event for change from discharge idle to charge active
- Event for change from discharge idle to discharge active
- Event for a full charge
- Event for a new cycle start
- Event for change from storage to charge idle
- Event for change from storage to discharge idle
- Event for change from storage to any other status
- Event for an error resulting in BMS restart
- Event for disconnection of the internal BMS battery
- Event for error in receive of a measurement
- Event for internal storage depletion
- Event for an error when pairing the BMS to a forklift
- Event for the failure of a measurement storage

Also the following alarms are recorded

- Alarm for High Temperature
- Alarm for Extreme Temperature
- Alarm for Low Electrolyte level
- Alarm for Battery Overdischarge
- Alarm for Battery Disconnection
- Alarm for Voltage Imbalance

Recording of Measurements

Periodically the BMS stores the measurements received by the sensors as well as the counters calculated by them. Specifically it records the Voltage instant values, the temperature and the Electrolyte levels. For the Current it stores the mean value of the samples collected in the last minute. Finally it calculates and records the Internal Impedance of the Battery according to the specifications.

The data storage is capable of storing recorded data for up to ten (10) years time period. When about 8% of free space is available on the device, then stored data will begin to erase, starting from oldest to newest data stored (FIFO logic).

Control from WEB page.

The BMS has a web page where the user can receive and download the recorded measurements or change the parameter values relevant to the function of the battery as well as those related to its general functions.(e.g. Network settings)

Restore from errors

The BMS is equipped with various mechanism to restore to proper function after any error in order to avoid any recorded data loss. In that case an event is recorded so the user can investigate the error further.