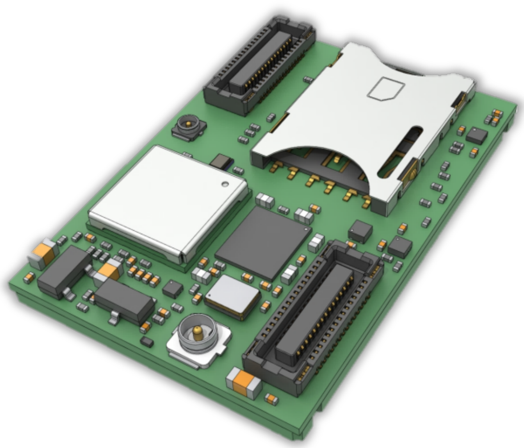
OriginGPS
mini+mighty



OriginIoT™ System
Cellular IoT System

DATASHEET

OriginGPS.com

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ABBREVIATIONS

Abbreviation	Description
APN	Access Point Network
APM™	Advanced Power Management™
ATP™	Adaptive Trickle Power™
DHCP	Dynamic Host Configuration Protocol
FOTA	Firmware Over-the-Air
GPIO	General-Purpose Input/Output
IMEI	International Mobile Equipment Identity
IMS	IP Multimedia Subsystem
IoT	Internet of Things
MPU	Memory Protection Unit
OriginIoT™	Cellular IoT system to accelerate IoT product development
OriginSmart™	Web-based GUI to configure and manage OriginIoT™ systems
PMBus™	Power System Management Protocol™
PTF™	Push to Fix™
RTOS	Real Time Operating System
SMA	SubMiniature version A (RF connector)
SMBus	System Management Bus
TBF	Time Between Fixes
TTFF	Time to First Fix
UID	Unique identifier

Related Documentation

#	Document Name
1	OriginIoT™ Application Kit User Guide
2	OriginSmart™ Web Specifications

Revision History

Revision	Date	Change Description
1.0	June 16, 2018	First release for Rev C. Changes from Rev A: 1. Added analog-to-digital interface operating conditions. 2. UART2 is now internally connected to the cellular module. 3. UART4 is accessible as an external interface for users. Connector J2, pins 13 and 24 are now reserved for future updates.
2.0	November 1, 2019	First release for Rev E. 1. Updated interface and configuration settings. 2. LPUART is now connected to the GPS. 3. The GPS has been updated to the ORG4572-R04 model.
2.1	February 6, 2020	Template update
2.2	April 18, 2021	Added frequencies for ORG2101-NMGL-X model.
2.3	July 4, 2021	Added note on PSM and eDRX support.
2.4	October 28, 2021	Updated add-on options
2.5	January 9, 2022	Updated cellular communication matrix and ordering information
2.6	August 11, 2022	Updated cellular communication information
2.7	December 11, 2022	General feature update and restructuring of component descriptions

Scope

This document describes the features and specifications of the OriginIoT™ cellular IoT system.

Disclaimer

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OriginGPS reserves the right to make changes to its products, specifications and their performance or the contents of this guide, without notice.

OriginGPS reserves the right to conduct, from time to time, and at its sole discretion, firmware upgrades.

If these firmware improvements have no material change on end customers, a Product Change Notification (PCN) will, in most cases, not be issued.

OriginGPS Internet of Things (IoT) products are not recommended for use in lifesaving or life-sustaining applications.

Safety Information

Improper handling or misuse of the product can cause permanent damage.

This product is an electronic sensitive device (ESD) and must be handled with care.

Disposal Information

This product must not be treated as household waste.

For more detailed information about recycling electronic components, contact your local waste-management authority.

Contact Information

contactus@origingps.com www.origingps.com

1. GENERAL

1.1. Introduction

Welcome to the OriginIoT™ Datasheet. The OriginIoT™ is a miniature cellular IoT system that enables the speedy development of IoT products without writing embedded code and without knowledge of RF engineering. This guide assumes you have basic software and hardware knowledge.

The OriginIoT™ system is an analytic, customizable system that collects data from sensors. The data can be transferred to a remote server or cloud platform by the OriginIoT™ system through wireless cellular communication (GSM or LTE).

The multi-purpose OriginIoT™ system can accommodate peripheral devices such as sensors or other components through UART, I2C, or GPIO and combines a cellular communications module and the superior positional accuracy of a standalone GNSS. Peripheral devices are configured over a Web interface, eliminating additional embedded firmware efforts. The ease and flexibility of utilizing the OriginIoT™ system as a basis for a vast array of applications accelerates time-to-market while minimizing the size of your IoT device.

OriginIoT™ systems enable designers to develop IoT products without writing a single line of embedded code and without RF engineering. A new rapid product cycle is created, dramatically cutting development resources.

1.2. Purpose

The purpose of this datasheet is to provide step-by-step instructions on how to use the OriginIoT™ system so that the developer can receive the greatest benefit from using the OriginIoT™ system. This datasheet includes a description of the system functions and capabilities, contingencies and alternate modes of operation, and in-depth procedures for system access and use.

This document describes the specifications and features of the OriginIoT™ cellular IoT system.

2. ABOUT ORIGINGPS

OriginGPS develops, manufactures and supplies the world's smallest GNSS and cellular IoT solutions.

Our high-performance miniature GNSS products provide multiple constellation support to help you track everything valuable to you and your business. The OriginIoT™ system makes IoT-enabling devices affordable and accessible by eliminating the need for additional embedded software and RF engineering knowhow. The low power cellular IoT system reduces project costs and dramatically shortens time-to-market when you develop cellular IoT devices.

OriginGPS' miniature products are ideal for market verticals, such as asset tracking, fleet management, industrial IoT, law enforcement, pet/people tracking, precision agriculture, smart cities, sports and wearables.

3. SYSTEM OVERVIEW

3.1. System Description

The OriginIoT™ system is a miniature, generic cellular IoT system with a GNSS tracker that interfaces to peripheral sensors and devices. The data is transferred through cellular communication, stored in a remote server (cloud), and displayed on a Web GUI.

The system communicates through a GSM or LTE interface (2G, Cat M, Cat NB11) through a cloud-based application.

The OriginIoT™ system functions as a multi-purpose IoT sensor platform that accommodates sensors and other peripheral devices through UART, I2C, ADC or GPIO, with superior positional accuracy over standalone GNSS. Data is configured over a Web interface so that users are not required to develop embedded firmware. The ease and flexibility of developing a vast array of applications based on the OriginIoT™ system quickens time-to-market while minimizing the size of your IoT device.

3.2. System Architecture

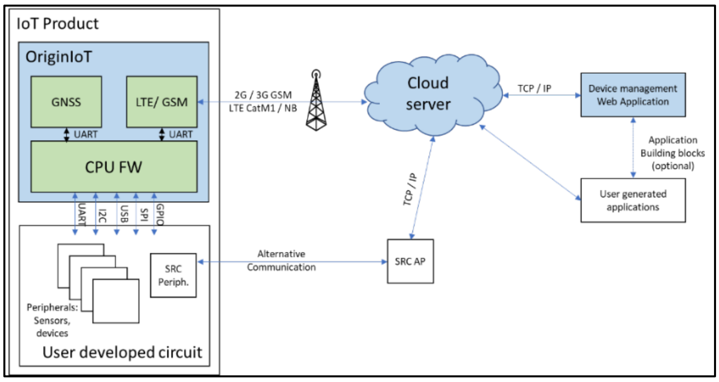


Figure 1. OriginIoT™ Architecture A

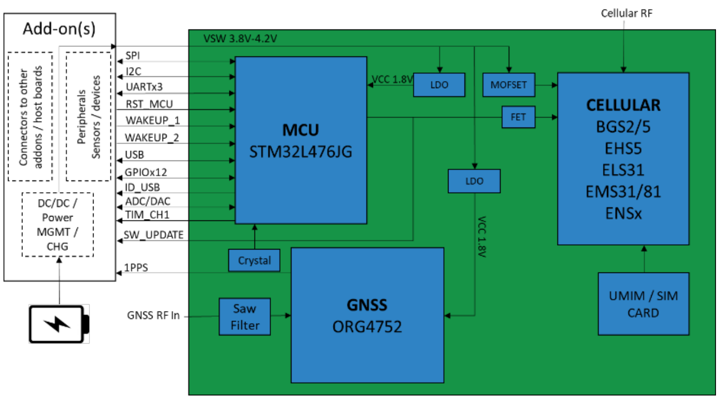


Figure 2. OriginIoT™ Architecture B

3.3. Product Features

The OriginIoT system includes the following features.

- Compatible with wireless communication modules in 2G, LTE Cat M, and LTE Cat NB1 modules, with regional and global coverage
- Future-proof design for next generation wide area networks
- OriginGPS Noise Free Zone (NFZ™) system
- Fully integrating:
  - STMicro ultra-low-power with ARM Cortex-M4 MCU 80 MHz with 1 Mb Flash
  - Thales Cinterion® Industrial M2M product family for GSM and LTE radio technologies (2G GPRS, LTE Cat 1, LTE Cat M, and LTE Cat NB1)
  - OriginGPS Multi Spider (ORG4572-R04) GNSS Receiver module
  - Optional M2M Industrial QUAD robust SMD MIM for outdoor applications (Embedded SIM)
- Hirose connectors for cellular (U.Fl) and GNSS (W.Fl) RF
- GSM/LTE features:
  - Design compatible with GPRS 2G, LTE Cat M, and LTE Cat NB1
  - Multiple band configurations for regional or global coverage
  - Maximum data rate download: 85.6kbps in 2G, 300kbps in Cat M, and 50kbps in Cat NB1
  - Maximum data rate upload: 42.8kbps in 2G, 375kbps in Cat M, and 50kbps in Cat NB1
- GNSS Frequencies:
  - GPS and Galileo L1 1575.42 frequency, C/A code
  - GLONASS L1 FDMA 1598-1606MHz frequency band, SP signal
  - SBAS (WAAS, EGNOS, MSAS) and QZSS support
- GNSS Features:
  - Concurrent multiple constellation tracking
  - 52 channels
  - Ultra-high sensitivity down to -167dBm, enabling Indoor Tracking
  - TTFF (Time to First Fix) of < 1s in 50% of trials under Hot Start conditions
  - High Accuracy of < 1.5m in 50% of trials
  - External 1PPS output
  - NMEA/OSP® protocols

- Low power consumption:
  - ♦ Optimized power budget in LTE Cat M mode
  - ♦ GNSS < 15mW in ATP™ mode
  - ♦ Ultra-low power MCU
- External interfaces to control peripheral devices: I2C, GPIOX12, UARTx2, LPUART, and ADC
- External MCU interfaces: RESET, WAKEUP, and TIMER
- Single voltage supply 3.3-4.8 V
- Miniature dimensions: 27.6 mm x 18.8 mm
- Low height: 5.35 mm - 4.7 mm
- Operating conditions from -40°C to +85°C
- FCC, CE certifications
- RoHS II compliant

3.4. Components

3.4.1. MCU - STM 32L476JG

The STM 32L476JG MCU is an ultra-low power ARM cortex microcontroller unit running OriginSmart™ embedded firmware. Embedded firmware enables the configuration, provisioning of peripherals, and managing of messages to/from peripherals.

MCU Interfaces

- MCU power 1.8V DC
- Digital interfaces to peripherals: I2C bus, LPUART, UARTx2, and GPIOx12
- Interrupt and reset pins – wakeup MCU as defined by add-on circuit
- UART and controls on cellular modules and GNSS
- MCU receives external timing from a crystal oscillator at 12Mhz.

3.4.2. GNSS Module - ORG4752-R04

The OriginIoT™ system features the ORG4572-R04 module, a miniature multi-channel GPS, Galileo, GLONASS or GPS, Galileo, BeiDou with SBAS, QZSS, and other regional overlay systems receivers that continuously track all satellites in view, providing real-time positioning data in industry-standard NMEA format. The ORG4572-R04 module provides outstanding sensitivity and performance, is able to achieve rapid TTFF in less than one second, provides accuracy of approximately one meter, and tracking sensitivity of 167dBm. The ORG4572-R04 module integrates an LNA, SAW filter, TCXO, RTC crystal, and RF shield with the SiRFstarV™ 5e GNSS SoC. The module is able to detect extremely weak satellite signals simultaneously from GPS and GLONASS systems, thereby offering best-in-class positioning availability, unparalleled accuracy, and extremely fast fixes under challenging signal conditions, such as in built-up urban areas or dense foliage. An additional SAW filter has been added as RF-in of GNSS to improve the RF profile.

3.4.3. Cellular Module - EXS82-W

The OriginIoT™ system features a compatible design housing the EXS82-W - a cellular module with a footprint of 27.6 x 18.8 mm from Thales' Cinterion® Industrial M2M family. This module enables the selection from individual cellular radio technologies ranging from 2G GPRS, LTE Cat M, and LTE Cat NB1 with specific regional focus according to the customer's definitions.

3.4.4. SIM Card Options

The ORG2101 has the following options for machine identification:

- ORG2101-XXXX-T
- ORG2101-XXXX-E

The ORG2101-XXXX-T uses a traditional SIM card holder hosting plastic nano SIM card (4FF) for machine identification. The ORG2101-XXXX-E uses an embedded-SIM option that is selected by the customer according to their network provider.

4. COMPONENT DESCRIPTION

4.1. MCU

4.1.1. MCU – STM 32L476JG

The STM 32L476JG MCU is an ultra-low power ARM cortex microcontroller unit running the OriginSmart™ embedded firmware. Embedded firmware enables the configuration, provisioning of peripherals, and managing of messages to/from peripherals.

MCU Interfaces

- MCU power 1.8V DC
- Digital interfaces to peripherals: I2C bus, LPUART, UARTx2, and GPIOx12
- Interrupt and reset pins – wakeup MCU as defined by add-on circuit
- UART and controls on cellular modules and GNSS
- MCU receives external timing from a crystal oscillator at 12Mhz.

4.1.2. ARM® Cortex®-M4 Core with FPU

The ARM® Cortex®-M4 with FPU processor is the latest generation of ARM processors for embedded systems. It was developed to provide a low-cost platform that meets the requirements of MCU implementation with low-power consumption, while delivering outstanding computational performance and advanced responses to interrupts.

The ARM® Cortex®-M4 with FPU 32-bit RISC processor features exceptional code efficiency, delivering the high-performance expected from an ARM core in the memory size usually associated with 8-bit and 16-bit devices.

4.1.3. Adaptive Real-Time Memory Accelerator

The ART Accelerator™ is a memory accelerator optimized for STM32 industry-standard ARM® Cortex®-M4 processors. It balances the inherent performance advantage of the ARM® Cortex®-M4 over Flash memory technologies, which normally require the processor to wait for the Flash memory at higher frequencies.

4.1.4. Memory Protection Unit

The Memory Protection Unit (MPU) is used to manage the CPU access to memory to prevent one task from accidentally corrupting the memory or resources used by another active task. The MPU is especially helpful for applications where some critical or certified code section must be protected against the misbehavior of other tasks. It is managed by an RTOS, which can detect and act against a program accessing memory locations prohibited by the MPU.

4.1.5. Embedded Flash Memory

The STM32L476JG MCU features 1 Mbyte of embedded Flash memory available for storing RTOS, OriginSmart™ embedded firmware, configuration files, and data. The Flash memory is divided into two banks, which enables read-while-write operations. Dual bank boot is also supported, where each bank contains 256 2-Kbyte pages.

4.1.6. Embedded SRAM

STM32L476xx devices feature up to 128 Kbyte of embedded SRAM.

4.1.7. Real-Time Operation System

OriginIoT™ systems are delivered pre-programmed with OriginSmart™ embedded firmware running a free RTOS kernel.

4.1.8. OriginSmart™ Embedded Firmware

OriginIoT™ systems are managed by OriginSmart™ embedded firmware. OriginSmart™ embedded firmware enables IoT device development from a cloud environment through OriginGPS' proprietary messaging protocol. The OriginSmart™ enables speedy and trouble-free development through APIs specified in the *OriginSmart™ API Specification* document.

4.2. Interfaces

4.2.1. General-Purpose Inputs/Outputs (GPIOS)

The OriginIoT™ system enables 12 GPIOs through connector J2. Each of the GPIO pins can be configured by software as output (push-pull or open-drain), as input (with or without pull-up or pull-down), or as a peripheral alternate function.

4.2.2. Analog to Digital Converter (ADC)

The OriginIoT™ system provides an interface to an embedded successive approximation analog-to-digital converter with the following features:

- 12-bit native resolution, with built-in calibration
- 5.33 Msps maximum conversion rate with full resolution
- Low power design

4.2.3. Inter-Integrated Circuit Interface (I2C)

The OriginIoT™ system provides an interface to embedded I2C. You may refer to *OriginSmart™ API Specification* for implementation features. The I2C bus interface handles communications between the microcontroller and the serial I2C bus. It controls all I2C bus-specific sequencing, protocol, arbitration, and timing.

The I2C interface supports:

- I^2C-bus specification and user manual rev. 5 compatibility

- System Management Bus (SMBus) specification rev 2.0 compatibility
- Power System Management Protocol (PMBus™) specification rev 1.1 compatibility

4.2.4. Universal Synchronous/Asynchronous Receiver Transmitter

OriginIoT™ systems have two embedded universal synchronous receiver transmitters:

- USART1, HW connected to the GNSS module
- USART2, HW connected to the cellular module

Two universal asynchronous receiver transmitters:

- UART4, for external devices (connector J1)
- UART5, for external devices (connector J1)

These interfaces provide asynchronous communication, multiprocessor communication mode, single-wire half-duplex communication mode, and have LIN Master/Slave capability, and communicate at speeds of up to 10Mbit/s.

4.2.5. Low-Power Universal Asynchronous Receiver Transmitter

OriginIoT™ systems includes one embedded Low-Power UART. The LPUART supports asynchronous serial communication with minimum power consumption. It supports half-duplex single wire communication and enables multiprocessor communication.

4.3. Cellular Module

4.3.1. Cellular Module

The OriginIoT™ system includes a cellular module from the Thales Cinterion® M2M Industrial product family and can cover the following cellular technologies.

Table 1. Cellular Communication Information

OriginIoT™ System Part Number	Cellular Module	Radio Technology	Regional Focus	Frequency Bands
ORG2101-NMGL-T/E	EXS82-W	LTE-M and NB-IoT with 2G fallback	GLOBAL	LTE Multi-band

4.3.2. Identity Management

The OriginIoT™ system is available in two variants regarding subscriber identity management. ORG2101-XXXX-T accommodates traditional plastic nano SIM card (1.8V in all variants, 3.3V in all variants except ORG2101-CMXX-X). ORG2101-XXXX-E accommodates an industrial QUAD robust SMD MIM (embedded SIM) according to the customer's request.

4.4. GNSS

4.4.1. Operations

- **TTFF (Time to First Fix)**: The period from when the module is powered on until valid position fix is reached.
- **Tracking**: The receiver's ability to maintain valid satellite ephemeris data.
- During tracking, the receiver may stop output valid position solutions.
- **Tracking sensitivity**: The minimum GPS signal power required for tracking.
- **Navigation**: During navigation, the receiver constantly outputs valid position solutions.
- **Hot Start**: Results either from a software reset after a period of continuous navigation or a return from a short idle period that was preceded by a period of continuous navigation. During Hot Start, all critical data (position, velocity, time, and satellite ephemeris) is valid to the specified accuracy and availability in RAM.
- **Signal Reacquisition**: Follows temporary blocking of GNSS signals. An example of a typical reacquisition scenario is driving through a tunnel.
- **Aided Start**: A method of effectively reducing TTFF by providing valid satellite ephemeris data. Aided start functionality is implemented in OriginSmart™ firmware. You may refer to *OriginSmart™ API Specifications* for more details.
- **Warm Start**: Typically results from user-supplied position and time initialization data or continuous RTC operation with an accurate last known position available in RAM. In this state, position and time data are present and valid, but satellite ephemeris data validity has expired.
- **Cold Start**: Occurs when satellite ephemeris data, position and time data are unknown. An example of typical Cold Start scenario includes first power-on application.

4.4.2. Acquisition Times

Table 2. Acquisition Time

Operation[1]	Mode	Value	Unit
Hot Start		< 1	s
Aided Start		< 10	s
Warm Start	GPS + GLONASS	< 26	s
	GPS	< 32	s
Cold Start	GPS + GLONASS	< 27	s
	GPS	< 35	s
Signal Reacquisition		< 1	s

Notes:

1. Tested on ORG4572-R04 EVK. EVK is 24-hrs. static under signal conditions of -130dBm and ambient temp of +25^{0}C.
2. Outage duration ≤ 30s.

4.4.3. Sensitivity

Table 3. Sensitivity

Operation[1]	Mode	Value	Unit
Tracking	GPS	-167	dBm
	GLONASS	-165	dBm
Navigation	GPS	-164	dBm
	GLONASS	-164	dBm
Reacquisition[4]	-	-162	dBm
Hot Start[4]	-	-160	dBm
Aided Start[5]	-	-156	dBm
Cold Start	GPS	-148	dBm

Notes:

1. Tested on ORG4572-R04 EVK. EVK is static, ambient temperature is +25°C, RF signals are conducted.
2. Hibernate state duration ≤ 5m.
3. Aiding using Broadcast Ephemeris (Ephemeris Push™) or Extended Ephemeris (CGEE™ or SGEE™).

Table 4. Accuracy

Parameter[1]		Format (% of samples)	Mode	Value	Unit
Position[2]	Horizontal	CEP (50%)	GPS + GLONASS	< 1.5	m
			GPS + SBAS	< 2.0	m
			GPS	< 2.5	m
		2D RMS (95%)	GPS + GLONASS	< 3.0	m
			GPS + SBAS	< 4.0	m
			GPS	< 5.0	m
	Vertical	VEP (50%)	GPS + GLONASS	< 2.5	m
			GPS + SBAS	< 3.5	m
			GPS	< 4.0	m
		2D RMS (95%)	GPS + GLONASS	< 5.0	m
			GPS + SBAS	< 6.5	m
			GPS	< 7.5	m
Velocity[4]	over ground	50%		< 0.01	m/s
Heading	northward	50%		< 0.01	°
Time[3]		RMS jitter	1 PPS	≤ 30	ns

Notes:
1. Tested on ORG4572-R04 EVK
2. Module is static under signal conditions of -130dBm; ambient temperature is +25°C.
3. EVK is 24-hrs. static; ambient temperature is +25°C.
4. Speed over ground ≤ 30m/s.

4.4.4. Dynamic Constraints

Table 5. Dynamic Constraints

Parameter	Metric	Imperial
Velocity and Altitude[1]	515 m/s and 18,288 m	1,000 knots and 60,000 ft
Velocity	600 m/s	1,166 knots
Altitude	-500 m to 24,000 m	-1,640 ft to 78,734 ft
Acceleration	4 g	
Jerk	5 m/s^3	

Note:
1. Standard dynamic constrains according to regulatory limitations.

5. Power Management

5.1. General

OriginSmart™ firmware provides individual power modes of GNSS, Cellular, and MCU modules by sending user-built messages from a server to the OriginIoT™ system. To learn more about the message structure, review the document *OriginSmart™ API Specifications*.

5.2. OriginIoT™ Implemented MCU Power Modes

5.2.1. Run

The default power mode at wakeup is Run mode, which is changeable to low-power run or DeepSleep mode. The OriginIoT™ system must only be transferred to DeepSleep mode after setting wakeups or scheduled wakeup events (see *OriginSmart™ API Specifications*).

5.2.2. Low Power Run

Low power run mode is achieved by operating the low-power regulator to minimize the operating current. The code can be executed from SRAM or from Flash, and the CPU frequency is limited to 2MHz.

5.2.3. DeepSleep

The DeepSleep mode provides the lowest power consumption mode. The internal regulator, oscillators, and clocks are switched off, while the RTC remains active. Software is not active, nor are interfaces accessible, though operating voltage remains. The OriginIoT™ system exits DeepSleep mode when an external reset, a wakeup pin event (configurable rising or falling edge), or an RTC event occurs (alarm, periodic wakeup, timestamp, tamper). Wakeup and Reset pins are available through J1 pins 21, 23 or 25.

5.3. GNSS

5.3.1. Full-Power Acquisition

The OriginIoT™ system stays in Full-Power Acquisition state until a reliable position solution is made. Switching to GPS-only mode turns off GLONASS RF block, thereby lowering power consumption.

5.3.2. Full-Power Tracking

The OriginIoT™ system enters Full-Power Tracking state only after a reliable position solution is achieved. During this state, processing is less intense compared to Full-Power Acquisition, therefore lowering power consumption. At 5 Hz navigation update rate, Full-Power Tracking state consumes more power compared to the default 1 Hz navigation.

5.3.3. CPU Only

CPU Only is the transitional state of ATP™ power saving mode when the RF and DSP sections are partially powered off. The OriginIoT™ system enters CPU Only state when the satellite measurements have been acquired, but navigation solution still must be computed.

5.3.4. Standby

Standby is the transitional state of ATP™ power saving mode when RF and DSP sections are completely powered off and the baseband clock is stopped.

5.3.5. Hibernate

During this state, RF, DSP and baseband sections are completely powered off, leaving only RTC and Battery-Backed RAM running. The OriginIoT™ system performs a Hot Start if it remains in Hibernate state for more than four hours from the last valid position solution.

5.3.6. Basic Power-Saving Mode

Basic power-saving mode enables users to control the transfers between Full-Power and Hibernate states. Users may condition transfers by tracking duration, accuracy, in-view satellites, or other parameters.

5.3.7. Self-Managed Power-Saving Modes

The GNSS module has several self-managed power-saving modes tailored for individual scenarios. These modes provide several levels of power saving with a degradation level of position accuracy. Initial operation in Full-Power state is a prerequisite for accumulating satellite data to determine location, time, and calibration of reference clocks.

5.3.8. Adaptive Trickle Power (ATP™)

ATP™ mode provides the most accurate position among self-managed modes. This power-saving mode is best suited for applications that require navigation solutions at a fixed rate as well as low power consumption and an ability to track weak signals.

In this mode, the module intelligently cycles between Full-Power state, CPU-Only state (consuming 15 mA), and Standby state (consuming ≤ 0.1 mA), therefore optimizing the current profile for low power operation.

The ATP™ period, equal to the navigation solution update period, can be 1-10 seconds. On-time, including Full-Power Tracking and CPU Only states, can be 200-900ms.

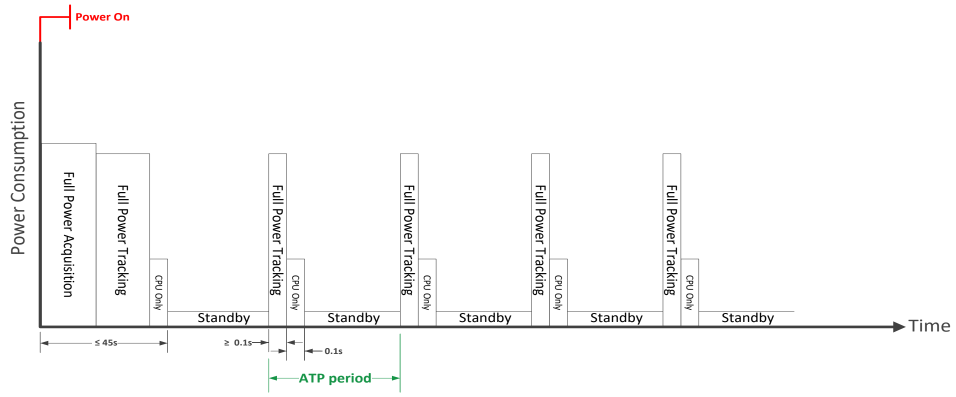


Figure 3. ATP™ Timing

5.3.9. Push to Fix

PTF™ is best suited for applications that require infrequent navigation solutions. In this mode, the GNSS module remains mostly in Hibernate state, drawing less than 54µA of current, and wakes to refresh satellite data in fixed periods. The PTF™ period can be anywhere between 10 seconds and 2 hours.

During a Fix trial, the module will stay in Full-Power state until a Fix position solution is estimated, or a pre-configured timeout has expired.

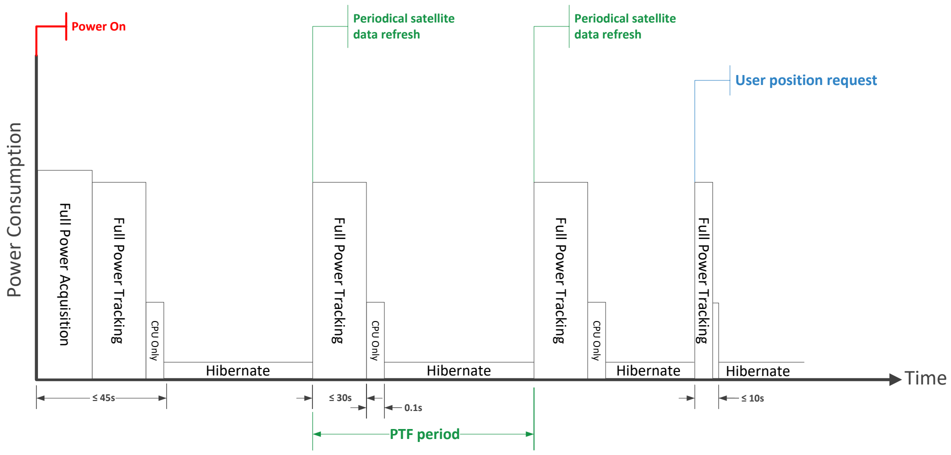


Figure 4. PTF™ Timing

5.3.10. Advanced Power Management

APM™ mode is designed for Aided-GPS wireless applications. APM™ provides power saving while ensuring that the Quality of Solution (QoS) is maintained when signal levels drop.

In APM™ mode, the module intelligently cycles between Full-Power and Hibernate states.

In addition to setting the position report interval, also available is a QoS specification that sets allowable error estimates and selects priorities between position report interval for more power saving.

Users may select between Duty Cycle Priority for more power saving options and Time Between Fixes (TBF) priority with defined or undefined maximum horizontal error.

TBF range is 10-180 seconds, while the Power Duty Cycle range is between 5%-100%.

The maximum position error is configurable between 1.5m to 160m.

The number of APM™ fixes is configurable up to 255 or set to continuous.

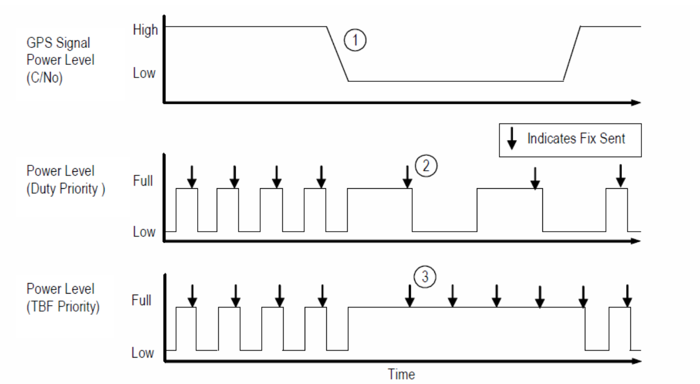


Figure 5. APM™ Timing

Notes:

1. GPS signal level drops (for example, user walks indoor).
2. Lower signal results in longer ON time. To maintain Duty Cycle Priority, OFF time is increased.
3. Lower signal means missed Fix. To maintain future TBFs the module goes into Full-Power state until the signal levels improve.

6. INTERFACE

6.1. Connector-Pin Assignment

Table 6. Pin Out

Con.	Pin	Name	Function	Direction
	1	Reserved	Reserved	Reserved
Connector J1	2	TIM2	MCU Timer 2	Output
	3	Reserved	Reserved	Reserved
	4	Reserved	Reserved	Reserved
	5	Reserved	Reserved	Reserved
	6	GND	System Ground	Power
	7	GND	System Ground	Power
	8	Reserved	Reserved	Reserved
	9	I2C1_SDA	I^2C Serial Data	Bi-directional
	10	Reserved	Reserved	Reserved
	11	I2C1_SCL	I^2C Serial Clock	Bi-directional
	12	UART5_RTS_CONSOLE_CTS	UART 5 Clear to Send – Debug Console	Output
	13	GND	System Ground	Power
	14	UART5_RX_CONSOLE_TX	UART 5 Receive – Debug Console	Input
	15	USART1_RTS	USART 1 Ready to Send	Output
	16	UART5_TX_CONSOLE_RX	UART 5 Transmit – Debug Console	Output
	17	USART1_CTS	USART 1 Clear to Send	Input
	18	USART1_TX	USART 1 Transmit	Output
	19	GND	System Ground	Power
	20	UART5_CTS_CONSOLE_RTS	UART 5 Clear to Send – Debug Console	Input
	21	RST_MCU	MCU Reset	Input
	22	USART1_RX	USART 1 Receive	Input
	23	GPIO_EXTI	General Purpose Interrupt	Bi-directional
	24	1PPS	UTC Time Mark from GNSS Module	Bi-directional
	25	ADC2	Analog to Digital Converter Input 2	Input
	26	GND	System Ground	Power
	27	VSW	System Power	Power
	28	VSW	System Power	Power
	29	VSW	System Power	Power
	30	VSW	System Power	Power

Con.	Pin	Name	Function	Direction
Connector J2	1	GND	System Ground	Power
	2	GND	System Ground	Power
	3	GPIO_EXTI	General Purpose Interrupt	Bi-directional
	4	GPIO_EXTI	General Purpose Interrupt	Bi-directional
	5	Reserved	Reserved	Reserved
	6	GPIO	General Purpose Input/Output	Bi-directional
	7	GPIO	General Purpose Input/Output	Bi-directional
	8	Reserved	Reserved	Reserved
	9	GPIO	General Purpose Input/Output	Bi-directional
	10	Reserved	Reserved	Reserved
	11	GPIO_EXTI	General Purpose Interrupt	Bi-directional
	12	TIM1	MCU Timer 1	Output
	13	GPIO	General Purpose Input/Output	Bi-directional
	14	GPIO	General Purpose Input/Output	Bi-directional
	15	SW_UPDATE_UE	Power Shutdown to Cellular Module After Software Update	Output
	16	GPIO_EXTI	General Purpose Interrupt	Bi-directional
	17	GND	System Ground	Power
	18	GPIO_EXTI	General Purpose Interrupt	Bi-directional
	19	ADC1	Analog to Digital Converter Input from External Device	Input
	20	GPIO	General Purpose Input/Output	Bi-directional
	21	GND	System Ground	Power
	22	GND	System Ground	Power
	23	ADC3	Analog to Digital Converter Input from External Device	Input
	24	VCC1V8MCU	1.8V Power Supply	Power
	25	GND	System Ground	Power
	26	VCC1V8MCU	1.8V Power Supply	Power
	27	VCC3V3	3.3V Power Supply	Power
	28	GND	System Ground	Power
	29	VCC3V3	3.3V Power Supply	Power
	30	GND	System Ground	Power

Notes:

1. All GPIO_EXTI pins can be used as GPIO pins.
2. ADC pins can be used as either GPIO_EXTI pins and/or GPIO pins.

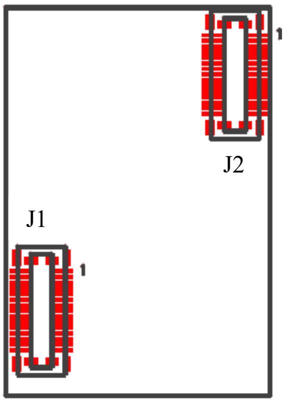


Figure 6. Connector and Pin Number 1 on Board Position (bottom view)

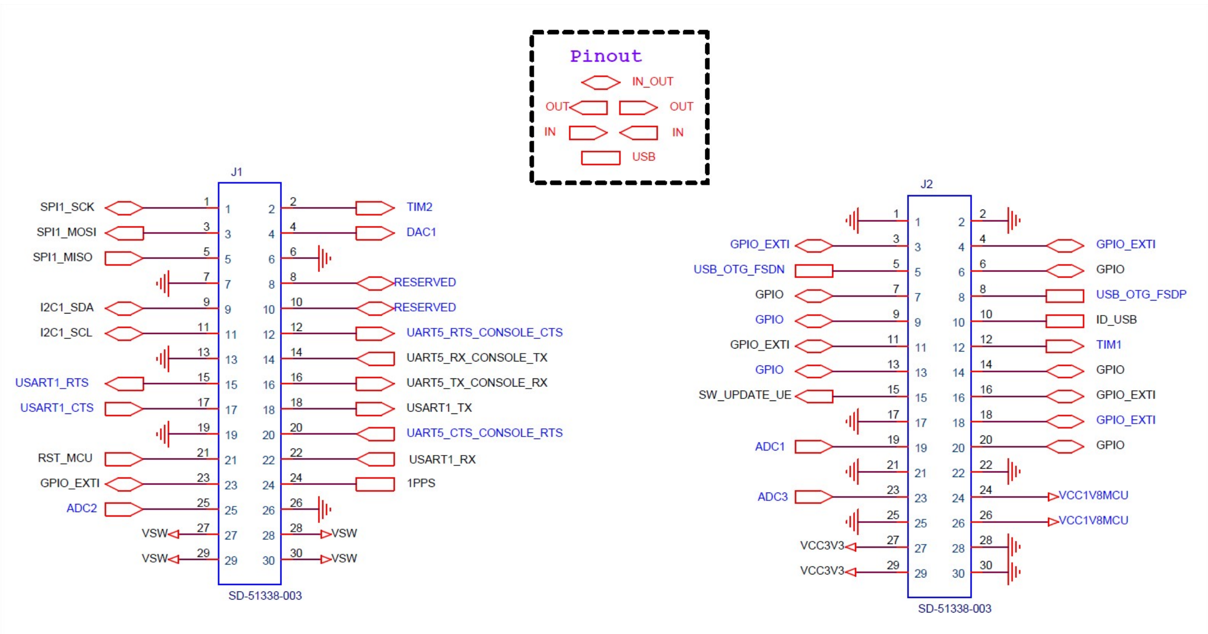


Figure 7. Connector and Pin Schematics

6.2. Power Supply

The power supply should be kept connected in order to maintain MCU ready for wakeup events and keep GNSS satellite data in RAM for fastest possible TTFF.

6.2.1. VSW

The MCU and GNSS module are internally regulated by onboard, low-dropout regulators. The VSW power is 4V ±5%, it provides power directly to the cellular module and MCU/GNSS power regulators. The VSW must be provided from a regulated and constant power supply. Maximum current is 1.6A at peak power of cellular module transmission.

When using a battery, it is recommended to power the module with a buck-boost DC/DC converter (for example, TPS63070 by Texas Instruments).

6.2.2. VCC3V3

The VCC3V3 supplies 3.3V.

6.2.3. Ground

All ground pins must be connected.

6.3. RF Input/Output

6.3.1. Cellular Frequency Bands

The J4 connector is a u.Fl connector for cellular antenna. Make sure that the selected antenna supports the bandwidths you plan to use. See the following table for the bandwidths used in each module.

Table 7. OriginIoT™ Supported Frequency Bands

OriginIoT™ P/N	Frequency Bands
ORG2101-NMGL-X	GSM: 850/900/1800/1900 MHz (Quad Band) LTE Cat. NB1/NB2: (LTE Bands 1, 2, 3, 4, 5, 8, 12, 13, 18, 19, 20, 25, 26, 28, 66, 85)

ESD protection for cellular antenna is implemented on-board.

Dipole antennas are recommended for improving reception and minimizing power supply.

6.3.2. GNSS RF

RF input impedance is 50Ω, and DC is blocked up to ±25V. In the event that Active Antenna implementation is required, the design must be implemented over specific add-ons by users.

- **Passive Antenna**: The OriginIoT™ system supports a passive antenna interface through w.Fl connector J3.

  A short trace of 50Ω controlled impedance (to conduct GNSS signals from the antenna to GNSS components) is already implemented on the circuit board. Users wishing to design boards with passive antennas should pay special attention to the antenna layout.
- **Active Antenna**: Active antenna net gain, including conduction losses, must not exceed +25dB.

  A coax connection must be implemented between the J3 w.Fl connector and the active antenna power control PCB. DC bias voltage for an active antenna can be externally applied on coax connection through bias-T.

6.4. SIM Interface

When using the ORG2101-XXXX-T, a nano SIM card is required (and placed in a nano SIM holder slot) to connect the OriginIoT™ system to cellular networks. The nano SIM holder has an insertion mechanism that prevents the incorrect insertion of the SIM card.

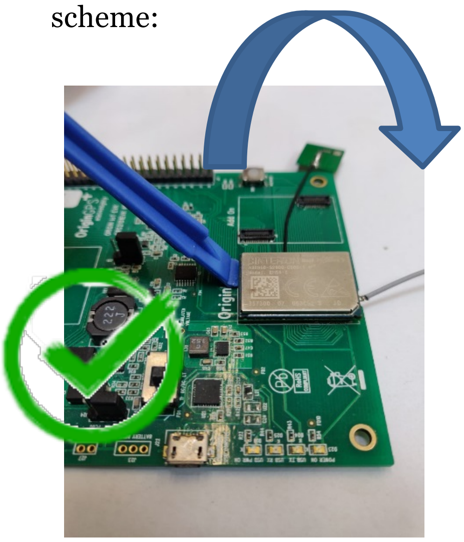
The SIM card holder has no locking mechanism. It is recommended to design a device enclosure with a mechanism that prevents SIM displacement during operation.

The SIM card holder is designed to withstand 1500 mating cycles.

6.5. Safe removal of Signal, Power and RF Connectors

Please note that the OriginIoT™ system is designed for a small number of mating/un-mating cycles when in full production. Users should be extra cautious when connecting and disconnecting J1 and J2 signal and power connectors from the OriginIoT™ application kit or the OriginIoT™ add-on and J3 and J4 from the OriginIoT™ system.

cellular and GNSS antenna connectors. It is recommended to use a plastic target disconnector when disconnecting the OriginIoT™ system from the add-on or from a PCB. Gently insert the target disconnector between the OriginIoT™ system and the target PCB/add-on on one of the short sides adjacent to the connectors and pry it upwards according to the following scheme:



6.6. Control Interface

6.6.1. On/Off, Wakeup, Reset

Applying a power supply to the OriginIoT™ system through VSW starts the MCU. The MCU is responsible for the GNSS module and the cellular module wakeup. This functionality is implemented in OriginSmart™ firmware.

With the power supply connected, the OriginIoT™ system can be switched to lower power modes. The user can wake the OriginIoT™ system in several ways:

- Interrupts from GNSS or external sources (must be set prior to entrance into MCU low power modes)
- Network wake up from a server (available only in power modes with cellular module IDLE)
- Automatic wakeup upon scheduler (must be set prior to entrance to MCU DeepSleep)

To learn more about wakeup functionality, review the *OriginSmart™ API Specification* document.

A Reset pin enables the user to reset the OriginIoT™ system. Set the RST_MCU pin to low for at least 500ms to ensure correct reset.

6.6.2. MCU Software Debugger

The SWDIO and SWCLK pins are used for serial wire debugging and local load of new firmware. It is recommended to connect these pins to a PC using ST-LINK debugger ST-Link/v2 ISOL STM8, and STM32.

The ST-Link debugger must also be connected to ground and 3.3V reference voltage.

You may refer to the *OriginIoT™ Application Kit User Guide* for more details on local firmware uploading.

Firmware update Over-the-Air (FOTA) is enabled by OriginSmart™ firmware. You may refer to *OriginSmart™ API Specification* for details.

6.6.3. Serial Debug Console

A UART5 interface is used by OriginSmart™ firmware for the serial debug console. The OriginSmart™ firmware runs a background serial debug console application that enables users to view commands sent to/from the OriginIoT™ system, test and control the interfaces, evaluate the GNSS module functionality, and set networking parameters.

Review the *OriginIoT™ Application Kit User Guide* to learn how to use the serial debug console.

6.6.4. 1PPS

1 Pulse-Per-Second (1PPS) output provides a pulse signal for timing purposes. PPS output starts when a 3D position solution has been obtained using five or more GNSS satellites and stops when a 3D position solution is lost.

Pulse length (high state) is 200ms with a rising edge less than 30ms synchronized to UTC epoch. The correspondent UTC time message is generated and put into output FIFO 300ms after the PPS signal. The exact time between PPS and UTC time message delivery depends on the message rate, message queue, and communication baud rate.

The 1PPS must be connected to one of the GPIOS or MCU wakeup pins if users wish to use the signal as a wakeup signal.

The 1PPS must not be connected if it is not in use.

6.6.5. Cellular Module Software Update

The SW_UPDATE pin is used to generate cold resets to the cellular module after cellular module software updates and is normally governed by OriginSmart™ firmware. To control this feature externally, review the *OriginSmart™ API Specification* document.

6.7. Data Interface

The OriginIoT™ system has four types of physical interface ports to connect to peripheral devices, each with its own pin – UARTx3, I²C, GPIOx12, and ADCx3.

The OriginIoT™ system transfers data from physical interfaces wirelessly to a remote server using cellular technology (GSM and LTE). Data forwarding, interfaces configurations, and messages for peripheral devices can be controlled from a remote server. See *OriginSmart™ API Specification* for details.

6.7.1. UART

Two External UART interfaces to connect external peripheral devices are available. UART5 is used by the serial debug console. One internal UART interface is used by the GPS and another UART interface is used by the cellular module.

UART communication parameters (baud rate, stop bits, and flow control) are controllable from the remote server.

6.7.2. I²C

One external 2-wire I2C bus is available. The I/O domain is 1.8V. The interface parameters are configurable through a remote server. The OriginIoT™ system acts as a master while peripherals act as slaves.

6.7.3. GPIO

12 General Purpose Input/Output interfaces are available. The I/O domain is 1.8V. Interfaces parameters are configurable through remote server.

6.8. Flash Memory Interface

The OriginIoT™ system enables users to log data into MCU flash memory through specific buffer commands sent from a remote server. The size of available flash memory for data logging is dynamic and is dependent on the firmware version. You may refer to *OriginSmart™ API Specification* for details.

Additional flash memories can be added through one of the provided external interfaces.

7. TYPICAL APPLICATION CIRCUIT

7.1. Power Management Circuit

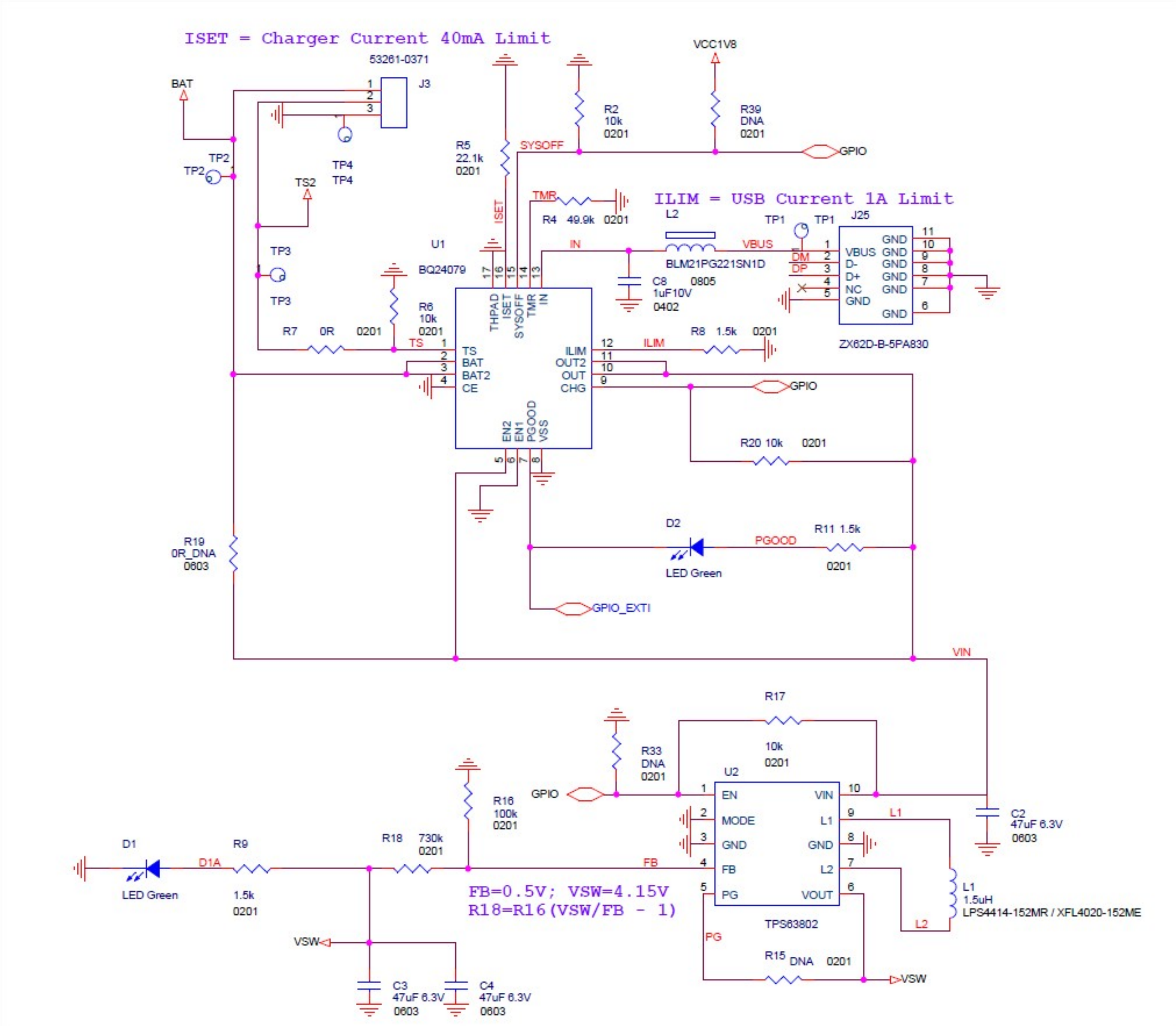


Figure 8. Buck Boost DC-DC and Power + Charging Management Reference Schematic

8. DESIGN CONSIDERATIONS

8.1. Form Factor (Mm)

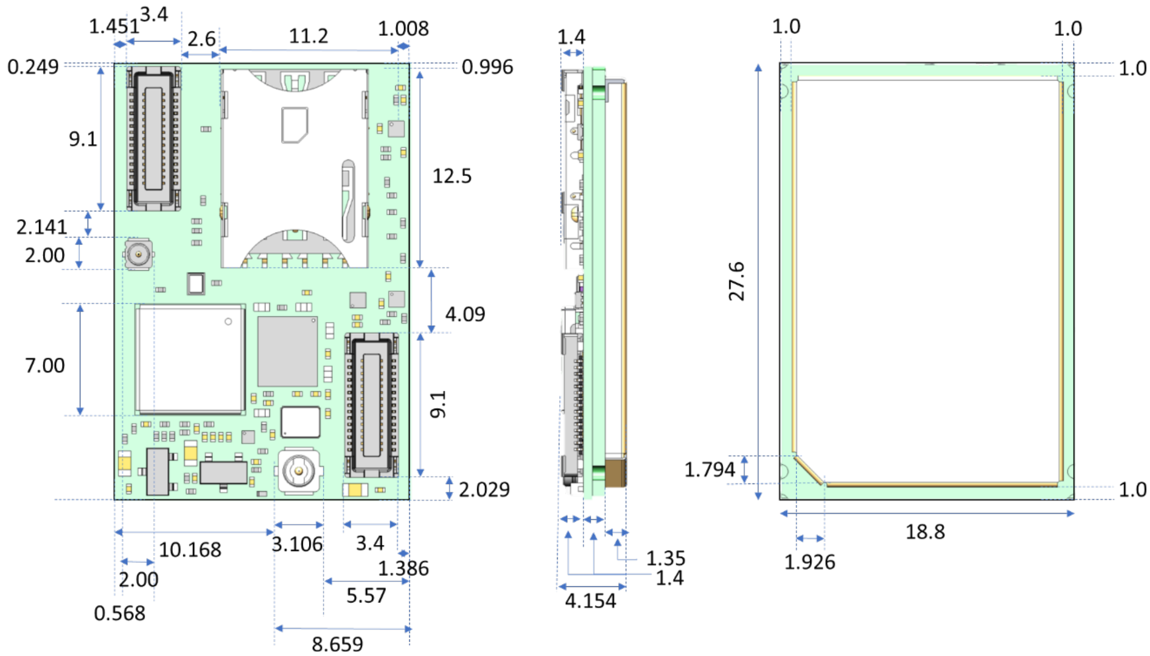


Figure 9. Form Factor in MM

Table 8. System Dimensions

Dimension	Length	Width	Height	Weight	
mm	27.6	18.8	4.154	gr	4.5
inch	1.086	0.74	0.164	oz	0.159

Note: The form factor and mechanical summary shown is applicable for Rev. C versions ORG2101-2GGL-T, ORG2101-3GXX-T, and ORG2101-CMXX-T. Expect minor changes in versions ORG2101-2GEU-X, ORG2101-C1XX-X, and ORG2101-XXXX-E.

8.2. Stackable Add-On Functionality

For extra functionality, users can utilize the OriginIoT™ add-on or design their own custom stackable add-on structure to the OriginIoT™ system.

The recommended PCB layout is as described in the following figure. Plug connectors should be Molex 55909-003 or compatible.

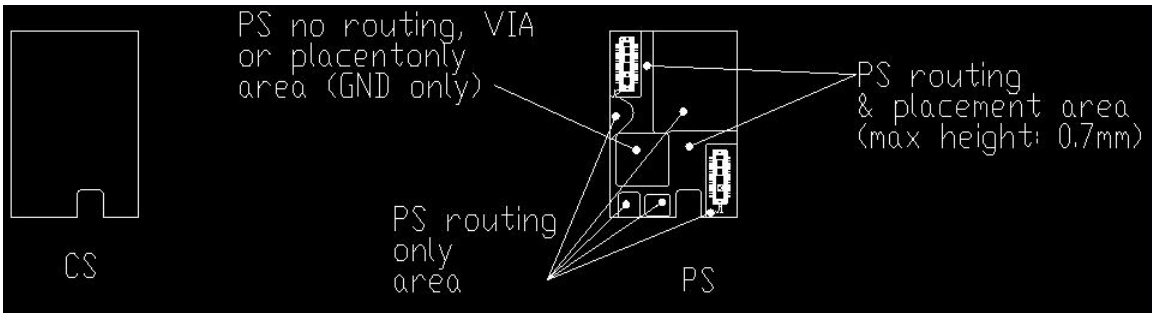


Figure 10. PCB Layout Recommendations and Limitations

8.3. Antennas

8.3.1. GNSS Antenna

The GNSS module incorporated in the OriginIoT™ system operates with received signal levels from as low as -167dBm and can be affected by high absolute levels of RF signals, moderate levels of RF interference near the GNSS bands, and by low levels of RF noise in the GNSS band.

RF interference from nearby electronic circuits or radio transmitters can contain enough energy to desensitize OriginIoT™ system GNSS functionality. These systems may also produce energy levels outside of the GNSS band that are high enough to leak through RF filters and degrade the operation of the radios.

This issue becomes more critical in smaller products, where industrial design constraints limit the size of the products. In environments such as these, transmitters for Wi-Fi, Bluetooth, RFID, and cellular radios may have antennas in close proximity to the GNSS receiver antenna.

1. **Contact OriginGPS for application specific recommendations and design review services.**
2. Antennas for GPS and GLONASS have a wider bandwidth than pure GPS antennas.
3. Some wideband antennas may not have a suitable axial ratio to block reflections of RHCP GPS, and GLONASS signals. These antennas have lower rejection of multipath reflections and tend to degrade the overall performance of the receiver.

8.3.2. Cellular Antenna

ESD protection for the cellular antenna is implemented inside the OriginIoT system.

9. System Operation

9.1. Starting the System

When power is first applied, the OriginIoT™ system and GNSS module automatically receive operating power through 1.8V regulators integrated in the system. The Thales cellular module starts after MCU is running, while the Thales module operating voltage is toggled by internal GPIO from the MCU. The MCU automatically configures the GNSS module to operate at 115,200 baud-rate. Only after the GNSS module is configured, the MCU toggles power to the Thales module using internal GPIOs.

9.2. Interfacing with Web Application

OriginGPS provides a server and Web application for evaluation. Contact your OriginGPS representative to receive log-in credentials to the Web app. See *OriginIoT™ Application Kit User Guide* document for more details.

9.3. Interfacing with Serial Console (APK)

Users can connect the OriginIoT™ system to a serial debug console. The serial console enables users to configure the connection parameters and to view the messages sent from the module to the remote server and vice versa. When using the OriginIoT™ application kit, refer to the *OriginIoT™ Application Kit User Guide* for more details.

9.4. Interfacing Through API

Users can set up a server with TCP data transactions enabled and configure it according to the *OriginSmart™ API Specification* document.

10. FIRMWARE

OriginIoT™ comes with the latest version of OriginSmart™, a firmware that allows transparent access to the sensors connected to OriginIoT™ and manages continuous connectivity to the server.

10.1. Default Configuration

10.1.1. MCU Configuration

The default MCU configuration is the RUN state, which uses an external 12Mhz clock as its internal source. To set the MCU to run in a low power mode, refer to the *OriginSmart™ API Specification* document.

10.1.2. Cellular Configuration

The MCU sends a cellular ON signal automatically after start-up. The cellular configuration is set to connect to port 31000 at server 18.184.85.107, using APN "internet". To change these settings, refer to the *OriginIoT™ Application Kit User Guide*.

10.1.3. GNSS Configuration

Table 9. GNSS Module Default Configuration

UART Settings		460800bps.
UART Data Format		NMEA
Satellite Constellation		GPS + GLONASS + Galileo
NMEA Messages		$GNGGA @ 15 sec.
Firmware Defaults	SBAS	ON
	ABP™	OFF
	Static Navigation	ON
	Track Smoothing	OFF
	Jammer Detector	ON
	Jammer Remover	OFF
	Fast Time Sync	OFF
	Pseudo DR Mode	ON
	Power Saving Mode	OFF
	3SV Solution Mode	ON

10.2. Firmware Update

Firmware updates can be performed in one of two ways:

1. **Locally**: Users must employ APK and ST-Link hardware for this option. You may refer to the *OriginIoT™ Application Kit User Guide* for details.
2. **Over the Air**: The system must be connected to a server for this option. You may refer to *OriginSmart™ API Specification* for details.

11. Handling Information

11.1. Cleaning

If flux cleaning is required, the OriginIoT™ system is designed to withstand a standard cleaning process in a vapor degreaser with the Solvon® n-Propyl Bromide (NPB) solvent and/or washing in DI water.

Avoid cleaning process in ultrasonic degreasers since specific vibrations may cause performance degradation or destruction of internal circuitry.

11.2. Rework

If localized heating is required to rework or repair the OriginIoT™ system, precautionary methods are required to avoid exposure to solder reflow temperatures that can result in permanent damage to the OriginIoT™ system.

12. Compliance

OriginIoT™ systems are manufactured in ISO 9001:2008 accredited facilities.

OriginIoT™ systems are manufactured in ISO 14001:2004 accredited facilities.

OriginIoT™ systems are manufactured in OHSAS 18001:2007 accredited facilities.

OriginIoT™ systems are designed, manufactured, and handled in compliance with the Directive 2011/65/EU of the European Parliament and of the Council of June 2011 on the Restriction of the use of certain Hazardous Substances in electrical and electronic equipment, referred as RoHS II.

OriginIoT™ systems are manufactured and handled in compliance with the applicable substance bans as of Annex XVII of Regulation 1907/2006/
EC on Registration, Evaluation, Authorization, and Restriction of Chemicals including all amendments and candidate list issued by ECHA, referred as REACH.

13. PACKAGING AND DELIVERY

The OriginIoT™ system may be distributed in trays (for dimensions see the following figure). The trays are not designed for machine processing. The modules are meant to be hand-picked for external application.

The trays are packed and shipped in an anti-moisture barrier bag with desiccant and humidity indicator card as well as a transportation box.

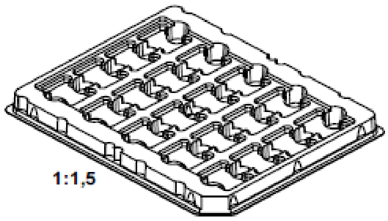


Figure 11. Packaging Tray

14. Ordering Information

14.1. Cellular IoT Module

O	R	G	2	1	0	1	-	N	M	G	L	-	T or E

SIM type selection:

- **T** = Nano SIM card
- **E** = Embedded SIM

14.2. Add-On

O	R	G	2	1	0	1	-	A	D	O	X	-	X
											1		2

1. Version:
   - **2** = Power Management version
2. Type:
   - **M** = Type selection (Table 12 below)

Table 10. OriginIoT™ Add-on

Part Number	Power Management Unit	Battery Charging Circuit	9 Axis Motion Sensor	Pressure Sensor
ORG2101-ADO2-M	✓	✓	✓	✓