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standalone positioning receiver IC working simultaneously on multiple constellations (GPS/Galileo/Glonass/BeiDou/QZSS).

The Teseo-LIV3F modules bring the proven accuracy and robustness of Teseo chips to the reach of everyone: the embedded firmware and the complete evaluation environment save development time, while the compactness and cost-effectiveness of this solution make it ideal for several applications, such as insurance, goods tracking, drones, tolling, anti-theft systems, people and pet location, vehicle tracking, emergency calls, fleet management, vehicle sharing, diagnostics and public transportation.

Within its 9.7x10.1 mm tiny size, Teseo-LIV3F is offering superior accuracy thanks to the on board 26 MHz Temperature Compensated Crystal Oscillator (TCXO) and a reduced Time To First Fix (TTFF) relying to its dedicated 32 KHz Real Time Clock (RTC) oscillator.

Thanks to the embedded 16 Mbit flash Teseo-LIV3F offers many extra features such as data logging, 7 days autonomous assisted GNSS, FW reconfigurability as well as FW upgrades.

Teseo-LIV3F provides also the Autonomous Assisted GNSS able to predict satellite data based on previous observation of satellite.

Teseo-LIV3F module, being a certified solution, optimizes the time to market of the final applications with a temperature operating range from -40°C to 85°C.

Features

- Simultaneously multiconstellation
- -163 dBm navigation sensitivity
- 1.5 m CEP accuracy positioning
- 16 Mbit embedded Flash for data logging and FW upgrade
- 2.1 V to 4.3 V supply voltage range
- Tiny LCC 18 pin package (9.7x10.1)
- Operating temperature (-40°, 85°C)
- Free FW configuration
- 17 μ W standby current and 75 mW tracking power consumption

Description

The Teseo-LIV3F module is an easy to use Global Navigation Satellite System (GNSS) standalone module, embedding TeseoIII single die

Table 1. Device summary

Order code	Marking	Temperature range [°C]	Package	Packaging
Teseo-LIV3F	Teseo-LIV3F	-40°C, 85°C	LCC-18 (9.7 mmx10.1 mm)	Tape and reel

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1 Description

1.1 GNSS performance

Receiver specification:

- GPS L1C/A
- SBAS L1C/A
- QZSS L1C/A
- GLONASS L1OF
- BeiDou B1
- Galileo E1B/C

Table 2. GNSS performance

Parameter	GNSS	GPS & GLONASS	GPS & BeiDou	GPS & Galileo	Unit
Time To First Fix ⁽¹⁾	Cold start	<32	<36	<30	s
	Warm start	<25	<29	<26	
	Hot start	<1.5	<2.5	<2	
Sensitivity ^{(2),(3),(4),(5)}	Tracking	-163	-163	-163	dBm
	Navigation ⁽⁶⁾	-158	-158	-158	
	Reacquisition ^{(7),(8)}	-156	-156	-156	
	Cold start	-147	-147	-147	
	Warm start	-148	-148	-148	
	Hot start	-154	-151	-154	
Max fix rate	—	10	10	10	Hz
Velocity accuracy ⁽⁹⁾	—	0.01	—	0.01	m/s
Velocity accuracy ⁽¹⁰⁾	—	0.1	—	0.1	m/s
Heading accuracy ⁽⁹⁾	—	0.01	—	0.01	°
Heading accuracy ⁽¹⁰⁾	—	2.3	—	2.4	°
Horizontal position accuracy ⁽¹¹⁾	Autonomous	<1.8 ⁽¹¹⁾	<1.5 ⁽¹¹⁾	—	m
	SBAS	<1.5 ⁽¹¹⁾	—	—	
Accuracy of time pulse	RMS 99%	—	—	—	
Frequency of time pulse	—	—	—	—	—
Operational limits ⁽¹²⁾	Dynamic ⁽¹³⁾	<4.5g	<4g	<4.5g	—
	Altitude ⁽¹⁴⁾	18000	18000	18000	m
	Velocity ⁽¹⁴⁾	515	515	515	m/s

1. All satellites at -130 dBm - TTFF@50%.

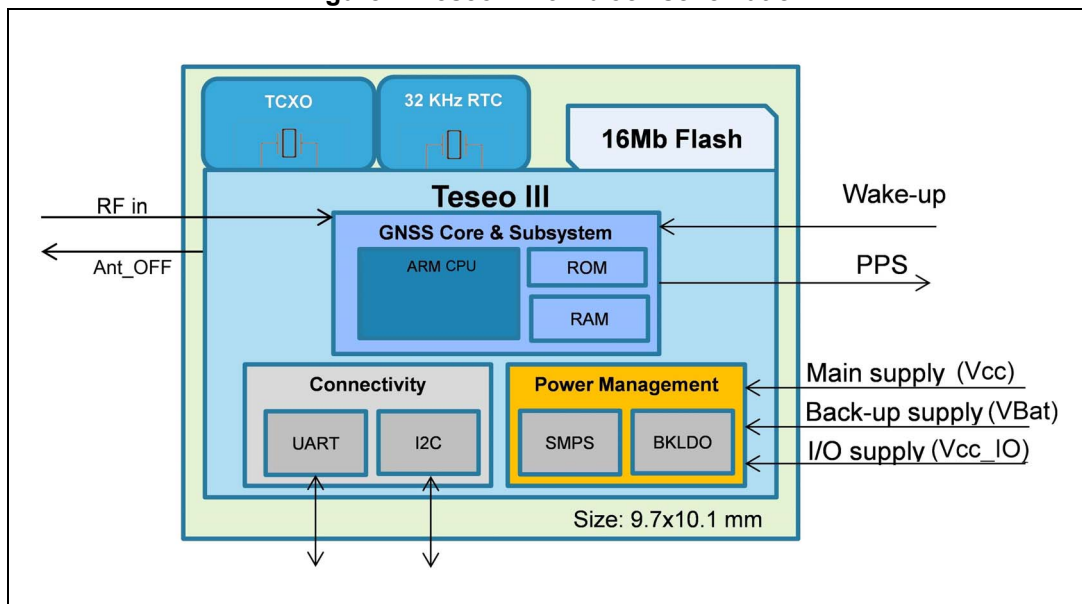
2. Demonstrated with a good external LNA.

3. For hot start, all sats have the same signal level except one (pilot sat @-145 dBm).

4. For BEIDOU tracking sensitivity refers to MEO sats. For GEO the tracking sensitivity is -151 dBm For GALILEO the signal level refers to both pilot and data components.
5. For GALILEO the signal level refers to both pilot and data components.
6. Configurable Value.
7. All satellites at same signal level.
8. Minimum level to get valid fix after reacquisition.
9. 50% @ 30 m/s - linear path.
10. 50% @0.5 g - figure8 shape path.
11. CEP 50%, 24h static, Roof Antenna.
12. Verified the limit checking the fix availability.
13. Special configuration for high dynamic scenario.
14. ITAR limits.

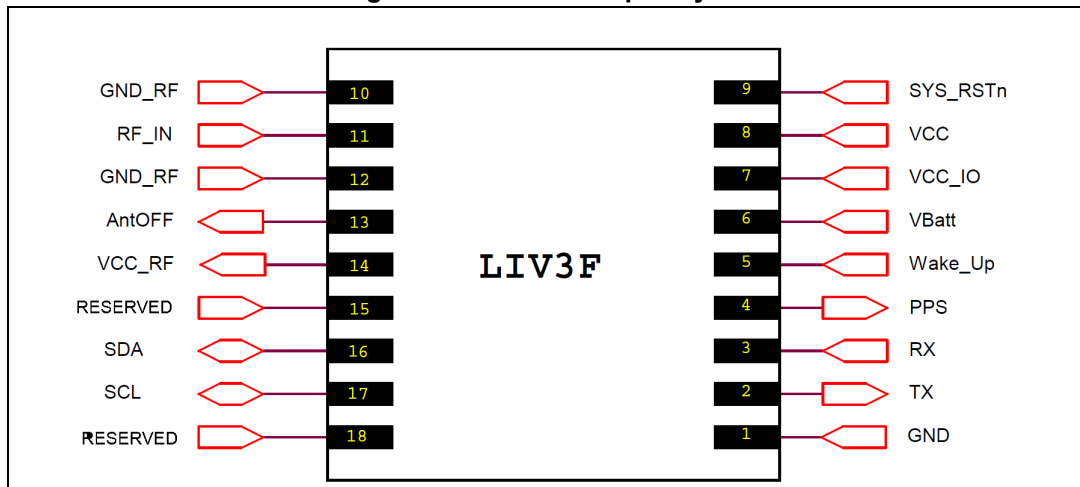
1.2 Block diagram

Figure 1. Teseo-LIV3F block schematic



1.3 Pin configuration

Figure 2. Teseo-LIV3F pin layout



1.4 Pin out description

Table 3. Teseo-LIV3F pin out description

No	Name	I/O	Description
1	GND	Ground	Ground
2	TX	O	Serial Port Tx (if not used, must be left floating)
3	RX	I	Serial Port Rx
4	1PPS	O	Time pulse (1PPS) (if not used, must be left floating)
5	Wake-Up	I	External Interrupt Pin (if not used, must be left floating)
6	Vbatt	I	Backup voltage supply
7	VCC_IO	I	IO Supply Voltage (3.3 V)
8	VCC	I	Supply voltage (from 2.1 V to 4.2 V)
9	SYS_RSTn	I	RESET_N (if not used, must be left floating)
10	GND_RF	I	Ground
11	RF_IN	I	GNSS signal Input
12	GND_RF	Ground	Ground
13	Ant_OFF	O	External Antenna Control (if not used, must be left floating)
14	VCC_RF	O	Output Voltage RF section. (if not used, must be left floating) Note: Can be used to supply external active antenna
15	Reserved	I	Reserved (must be left floating)
16	SDA	I/O	I2C Data (if not used, must be left floating)

Table 3. Teseo-LIV3F pin out description (continued)

No	Name	I/O	Description
17	SCL	I/O	I2C Clock (if not used, must be left floating)
18	Reserved	I	Reserved (must be left floating)

2 Supported GNSS constellations

The embedded FW supports all the GNSS constellations (GPS, GLONASS, GALIELO, BEIDOU and QZSS). The user can select what the application needs by FW configuration, by default GPS+GLONASS are selected.

2.1 GPS

The Teseo-LIV3F GNSS module is designed to receive and to track the L1C/A signals provided at 1575.42 MHz by the Global Positioning System (GPS). The Teseo-LIV3F can receive and process GPS concurrently with Galileo and GLONASS or BeiDou (the last two are mutually exclusive).

2.2 GLONASS

The Teseo-LIV3F module can receive and process GLONASS concurrently with GPS and Galileo. The Russian GLONASS satellite system (ГЛОУАСС; GLOBal NAVigation Satellite System) is an alternative to US's GPS and EU's Galileo.

2.3 BeiDou

The Teseo-LIV3F modules can receive and process BeiDou concurrently with GPS and Galileo. B1 signals provided at 1561.098 MHz by the BeiDou Navigation Satellite System can be tracked by Teseo-LIV3F positioning modules. The ability to receive and track BeiDou B1 satellite signals in conjunction with GPS results in higher coverage, improved reliability and better accuracy especially in the difficult urban environment of the big far east cities like Shanghai, Taipei, Singapore.

2.4 Galileo

The Teseo-LIV3F can receive and process Galileo concurrently with GPS and GLONASS or BeiDou (the last two are mutually exclusive).

3 Augmentation systems

3.1 Satellite-Based augmentation system

Teseo-LIV3F supports SBAS. SBAS is a Wide Area Differential GPS (WADGPS), it's a system which provides differential GPS corrections data; SBAS includes the WAAS within the United States, the EGNOS within Europe, the Multifunctional Transport Satellite (MTSAT)-based MSAS within Japan and Southeast Asia, and the GPS and GEO Augmented Navigation (GAGAN) system in India.

SBAS data correction is used in the GNSS algorithm to provide a better position estimation.

The overall SBAS differential correction mechanism can be conceived as built in 2 phases:

- The "Acquire and Tracking" phase
- The "Decoding" phase

The "Acquire and Track" phase relates to the capacity of the acquisition engine to reliably track the configured SBAS satellite; during decoding phase the SBAS message can be decoded to fetch the differential corrections.

The current longitude limits for each service are:

- WAAS -180 to -25 degrees
- EGNOS -25 degrees to +50 degrees
- GAGAN +50 degrees to +100 degrees
- MSAS +100 degrees to +180 degrees

The Teseo-LIV3F software with SBAS capability implements a command interface at the NMEA level to allow interaction with the SBAS library. It supports commands to enable/disable the SBAS functionality.

3.2 QZSS

The Quasi-Zenith Satellite System (QZSS) is a Japanese regional communication services and positioning information for the mobile environment in the GPS L1C/A band. QZSS in conjunction with GPS signals provides GNSS augmentation service for the Pacific region covering Japan and Australia. QZSS satellites are placed in a periodic Highly Elliptical Orbit (HEO); these orbits allow the satellites to "dwell" for more than 12 hours a day at an elevation above 70° (it means that they appear almost overhead most of the time).

3.3 Differential GPS

Teseo-LIV3F supports Differential-GPS data according to RTCM (Radio Technical Commission for Maritime Services) 2.3.

Differential-GPS data improves position accuracy.

Teseo-LIV3F supports the following RTCM message.

Table 4. Supported RTCM message on Teseo-LIV3F

Message Type	Description
1	Differential GPS Corrections
9	GPS Partial Correction Set
31	Differential GLONASS Corrections
34	GLONASS Partial Correction Set

4 Assisted GNSS

GNSS receivers need accurate satellite position data from at least 4 satellites to produce a fix.

Accurate satellite data -ephemeris data- is valid for 4hrs only for GPS and 30 min only for GLONASS.

After that time a receiver must download new ephemeris data.

Ephemeris download can take from dozens of seconds to several minutes, hours or can fail to download.

Assisted-AGPS is a mechanism to provide ephemeris assistance from external source, this reduces considerably the time to get fix especially in critical environments when the ephemeris download time could be very long.

Teseo-LIV3F supports three types of Assisted GNSS.

4.1 ST Assisted GPS

The ST Assisted GPS[®] (STAGPS) software is able to provide predicted ephemeris to the GNSS engine in a time frame less than the usual time (about 30 seconds) needed to download real ephemeris from the sky. This reduces considerably the time to get fix especially in critical environments when the ephemeris download time could be very long.

STAGPS autonomous solution works using the past real ephemeris (downloaded from the sky and stored in its internal database) to extrapolate the parameter of future ephemeris (up to 5 days of prediction). For these reason the STAGPS[®] autonomous performances (in terms of position accuracy using predicted ephemeris) are strictly dependent on the real ephemeris database content. In normal usage of STAGPS[®] autonomous, the system automatically uploads the real ephemeris into its database as soon as new ephemeris are downloaded from the sky. This means that the global content of the real ephemeris input database is determined by the history of the device running periods in the past.

The Teseo-LIV3F software with STAGPS[®] capability implements a command interface at the NMEA level to allow interaction with the STAGPS[®] library. It supports commands to enable/disable the STAGPS[®] functionality or to upload ephemeris and seed into the STAGPS[®] working memory. Most of the implemented commands could be used for testing the STAGPS[®] performance in different working scenarios.

4.2 Predictive AGNSS

ST-Assisted GPS[™] when used in systems with network data access is able to provide full-constellation long-term prediction taking advantage of an assistance server.

This unique solution combines the advantage of universal assistance data protocol with lightweight data access, by needing only about 8 KB bi-weekly data transfers to maintain fast and accurate GPS performance.

Starting from this downloaded payload called "seed" ST-Assisted GPS[™] is capable of generating at the client satellite orbit predictions for up to 14 days, with very high accuracy, for the complete GPS constellation and GLONASS constellation.

An unique feature of ST- Assisted GPS is the dual-mode ability to seamless fall back from the 14-days server-based prediction to 5-days autonomous prediction capability which self-sustains on the field depending on usage patterns. This is very useful to keep quality of the GNSS experience should a connected device loose its ability to contact the server for coverage or roaming issues or any other wireless connectivity problem.

4.3 RealTime AGPS

RealTime Assisted GPS (RT-AGPS) solution is a server based Assisted GPS, therefore it requires a network connection to download assistance data from the server.

RT-AGPS works downloading by an assistance server the real time ephemeris data. Server access is allowed thanks to internal keyword provided by Teseo-LIV3F to the Host processor and the acquired real-time data have to be provided to Teseo-LIV3F.

Proprietary NMEA commands are supported on Teseo-LIV3F to acquire the credential access to the external server and to inject the data to Teseo-LIV3F.

STMicroelectronics partner provides available server solution access for free on Teseo-LIV3F solution.

RealTime A-GPS allows continuous /real-time satellite position determination.

5 Clock generation

5.1 Temperature-Compensated Crystal Oscillator (TCXO)

Highly stable 26 MHz oscillator controls the down conversion process in RF block of the Teseo-LIV3F. Characteristics of this component are important factors for higher sensitivity to maximize performances especially in weak-signal environments, as well as to minimize TFFF (Time To First Fix) and better navigation stability.

5.2 Real Time Clock (RTC)

This is an always-on power domain dedicated to RTC logic (backup system) with 32 Kbyte SRAM and supplied with a dedicated voltage regulator.

The RTC provides a high resolution clock which can be used for GPS. It keeps the time when the system is inactive and it's internally used to wake up the system when in low power mode. It has a clock trimming feature to compensate for the accuracy of the 32.768 kHz crystal and a secured time update.

6 I/O interfaces

Teseo-LIV3F supports two I/O interfaces:

- UART
- I2C

both interfaces support NMEA protocol.

6.1 UART

The Universal Asynchronous Receiver/Transmitter (UART) supports much of the functionality of the industry-standard 16C650 UART.

The UART performs serial-to-parallel conversion on data asynchronously received from a peripheral device on RX0 pin, and parallel-to-serial conversion on data written by CPU for transmission on TX0 pin. The transmit and receive paths are buffered with internal FIFO memories allowing up to 64 data byte for transmission, and 64 data byte with 4-bit status (break, frame, parity, and overrun) for receive.

6.2 I2C

Teseo-LIV3F includes a slave I2C interface configurable; I2C is a two-wire communication interface invented by Philips Semiconductor.

Unlike all other interfaces, I2C is not able to communicate in full-duplex mode; it uses only two bidirectional open-drain lines, Serial Data Line on pin SDA and Serial Clock Line on pin SCL, pulled up with resistors.

Teseo-LIV3F receiver always acts as slave and it cannot initiate data transmission on the bus; host has to periodically pull the receiver to check about data availability.

The main features are:

- Normal speed (100 KHz) and Fast speed (400 KHz) supported
- I2C-slave address configurable using the firmware configurator

7 FW update support

The Teseo-LIV3F receiver module can be updated with new firmware releases. The latest firmware version is available at www.st.com and it can be installed on Teseo-LIV3F using the available PC Tool Teseo-Suite Light.

Detailed information is available on Teseo-LIV3F software user manual.

8 FW configuration

All configuration parameters are grouped in a data block. Each field is addressed by a unique ID. The IDs are made by three digits: the most significant one represents the parameter type and the others are used to identify different parameters of the same type. Default setting of configuration data block is hard coded into the binary image file.

A new configuration can be built using the PC Tool Teseo-Suite Light, available at www.st.com or using runtime configuration commands raised by the host.

9 Power mode

Standby mode, is the mode where only low power backup domain is running. It means VBAT must be always maintained. It allows to have very low current consumption and fast GNSS reacquisition at the end of the standby time due to RTC.

Teseo-LIV3F offers two different ways of standby:

- Hardware standby
- Software standby

9.1 Hardware standby

This standby is ensured by switching OFF VCC (pin 6) and VCC_IO (pin 7) supplies and setting SYS_RESETn (pin 9) to 0 V. It can be activated asynchronously from GNSS binary with one GPIO switching OFF the supplies from a host.

During this standby only VBAT (pin 6) is kept ON.

It ensures a current below 6 μ A. During this standby mode VCC_RF (pin 14) is OFF.

9.2 Software standby

Software standby is activated by the internal binary.

Software standby can be:

- Host driven standby: where the host raises a NMEA commands to force Teseo-LIV3F in standby; host can woken up Teseo-LIV3F using the Wakeup pin (pin 5);
- Periodic standby: where Teseo-LIV3F enters and exits from standby using internal RTC. Periodic fixes are from 5 seconds up to 24 hours between 2 fixes.

It ensures a current below 12 μ A on Teseo-LIV3F. Be careful that VCC_RF is ON during this standby, then in case of active antenna or external LNA, it is important to switch them OFF.

10 Timing

Teseo-LIV3F receivers can be used to provide highly accurate time information. The Teseo-LIV3F Timing module includes a specific Time Mode, which assumes a known antenna position and calculates a time pulse synchronized to either GPS /UTC(USNO) /GLONASS/UTC(SU).

Teseo-LIV3F provides an accurate one pulse-per-second.

11 Data logging

Data logging allows the Teseo-LIV3F receiver to locally save the resolved GNSS position to the flash in order to be retrieved on demand from the host.

Teseo-LIV3F supports only one datalog at a time.

Datalogging can be enabled, disabled and erased using proprietary NMEA runtime commands.

Datalogging subsystem supports both:

- Circular buffer
- Standard buffer

The recorded data is configurable; datalogging supports three types of data logged.

Each type has a different size and different data logged. All the data logged types have: timestamp, latitude and longitude while other fields depend by the type. See [Table 5](#) for details.

Table 5. Datalog type description

Type	Size	Altitude	Odometer	Geo	Quality	Qual_idx	Fix	Speed
1	12	—	—	X	—	X	X	—
2	16	X	—	X	X	—	X	X
3	20	X	X	X	X	—	X	X

Teseo-LIV3F can support until 12 hours logging using log-type 1 and fix rate at 1 Hz.

Detailed information is available on Teseo-LIV3F software user manual.

12 Geofencing

Geofence feature allows the Teseo-LIV3F receiver to raise an autonomous NMEA message when the resolved GNSS position is close to a specific circle, entering or exiting from a circle.

Teseo-LIV3F receiver supports at least 8 circular areas where 4 circular areas are configurable in the firmware.

Geofencing alarm can be notified over proprietary NMEA message.

Geofencing can be configured and enabled in the firmware configurator or using the specific geofencing configuration command.

Detailed information is available on Teseo-LIV3F software user manual.

13 Odometer

Teseo-LIV3F receiver supports Odometer feature.

Odometer provides information on the travelled distance using only positioning information.

Odometer can be configured using specific odometer commands during the runtime.

While enabled the odometer reports the ground distance from the last reset.

Odometer is also able to raise an autonomous message alarm when a programmed distance is reached.

Detailed information is available on Teseo-LIV3F software user manual.

14 Electrical characteristics

14.1 Parameter conditions

Unless otherwise specified, all voltages are referred to GND.

14.2 Minimum and maximum values

Unless otherwise specified the minimum and maximum values are guaranteed in the worst conditions of ambient temperature, supply voltage and frequencies by tests in production on 100% of the devices with an ambient temperature at $T_c = 25^\circ\text{C}$.

14.3 Typical values

Unless otherwise specified, typical data are based on $T_c = 25^\circ\text{C}$, $V_{CC}=3.3\text{ V}$, $V_{CC_IO}=3.3\text{ V}$. They are given only as design guidelines and are not tested.

Unless otherwise specified, all typical curves are given only as design guidelines and are not tested.

14.4 Absolute maximum ratings

This product contains devices to protect the inputs against damage due to high static voltages, however it is advisable to take normal precautions to avoid application of any voltage higher than the specified maximum rated voltages.

Table 6. Voltage characteristics

Symbol	Parameter	Min	Max	Unit
VCC	Digital supply voltage	2.1	4.3	V
VBAT	Backup LDO input supply voltage	2.1	4.3	V

Table 7. Thermal characteristics

Symbol	Parameter	Min	Max	Unit
Tope	Operative ambient temperature	-40	85	$^\circ\text{C}$

Table 8. Power consumption

Symbol	Parameter	Test condition	Typ	Unit
Pw	Power consumption in standard condition	G2 = GPS only; T _c = 25 °C; VCC = 2.1 V; VCC_IO = 3.3 V	72	mW
		G2 = GPS/Glonass; T _c = 25 °C; VCC = 2.1 V; VCC_IO = 3.3 V	90	mW
		G2 = GPS/Beidou; T _c = 25 °C; VCC = 2.1 V; VCC_IO = 3.3 V	85	mW
PWStandby	Power consumption STANDBY mode	RTC running = 32.768 KHz; T _c = 25 °C; VCC = VCC_IO = 0 V Vbat = 3.3 V	29	μW

14.5 Recommended DC operating conditions

Table 9. Recommended DC operating conditions

Symbol	Parameter	Min	Typ	Max	Unit
VCC	Power supply pins	2.1	3.3	4.3	V
VCC_Bat	Power supply pins for backup internal logic	2.1	3.3	4.3	V
VCC_IO	IO Supply Voltage	3.0	3.3	3.60	V