GeoS-5M®

Standard precision GNSS module

Datasheet

Rev. 1.1.1

R&D “GeoStar navigation” Ltd.
Moscow, 2023

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Revision History

#	Updates	Notes
Rev. 1.0 24/05/2017		
1	Initial release	
Rev. 1.1 15/06/2018		
1	NRESET signal description added (chapter 2.14)	
2	Table 6 updated	
3	Chapters 3.1, 3.4 updated	
4	Chapters 3.7, 3.12, 3.13 added	
5	Editorial corrections	
Rev. 1.1.1 25/07/2023		
1	Editorial corrections	

1 Abbreviations

C/A:	Coarse Acquisition
CEP:	Circular Error Probable
CPU:	Central Processor Unit
DOP:	Dilution Of Precision
ESD:	Electro Static Discharge
EVK:	Evaluation Kit
FW:	Firmware
GNSS:	Global Navigation Satellite System
HBM:	Human Body Model
HW:	Hardware
I/O:	Input/Output
LNA:	Low Noise Amplifier
PCB:	Printed Circuit Board
PRN:	Pseudo Random Noise
PVT:	Position Velocity Time
QZSS:	Quasi-Zenith Satellite System
RAIM:	Receiver Autonomous Integrity Monitoring
RF:	Radio Frequency
RLM:	Return Link Message
RLS:	Return Link Service
RMS:	Root Mean Square
RoHS:	Restriction of Hazardous Substances
RTC:	Real Time Clock
SAW:	Surface Acoustic Waves
SBAS:	Satellite Based Augmentation System
SRAM:	Static Random Access Memory
SV:	Space Vehicle
TCXO:	Thermo Compensated Crystal Oscillator
TTFF:	Time To First Fix
2D/3D:	Two-Dimensional/Three-Dimensional

2 General Description

2.1 Overview

GeoS-5M is GPS/GLONASS/GALILEO/QZSS/SBAS module that features 44 parallel tracking channels and enhanced fast acquisition sub-system that provide high sensitivity, improved TTFF, and reduced power consumption as compared to its predecessor GeoS-3M.

The module can operate in autonomous, differential and power-save modes. The interfaces include two full-duplex asynchronous serial ports (UART) with programmable settings. The module supports proprietary binary protocol as well as standard NMEA protocol with output data rate up to 10Hz. In addition to PVT, GeoS-5M outputs one pulse per second signal for precise timing synchronization.

2.2 Key Highlights

- Concurrent processing of GLONASS, GPS, GALILEO and QZSS;
- SBAS support;
- Standalone and code differential modes;
- Tracking and positioning sensitivity: -163dBm;
- Power consumption: <200mW (acquisition), <80mW (tracking);
- Improved out-of-band jamming immunity;
- Embedded Flash memory for storing almanacs, FW settings and extended ephemeris;
- Built-in active antenna bias circuit with monitor and short circuit protection;
- Wide range antenna bias voltage: 1.8V to 3.6V;
- Power-save modes: RELAXED FIX® and FIX-BY-REQUEST®;
- Product options:
    - GeoS-5MR: provides full carrier phase measurements data;
- Hardware compatible with predecessor GeoS-3M;
- Evaluation tools: GeoS-5M EVK.

2.3 Block Diagram

The module comprises following major elements (Figure 1):

- RF front end;
- Digital section;
- SPI Flash memory;
- Two RF SAW filters;
- Reference oscillator (TCXO);
- 32.768KHz crystal;
- ESD protection circuitry (not shown).

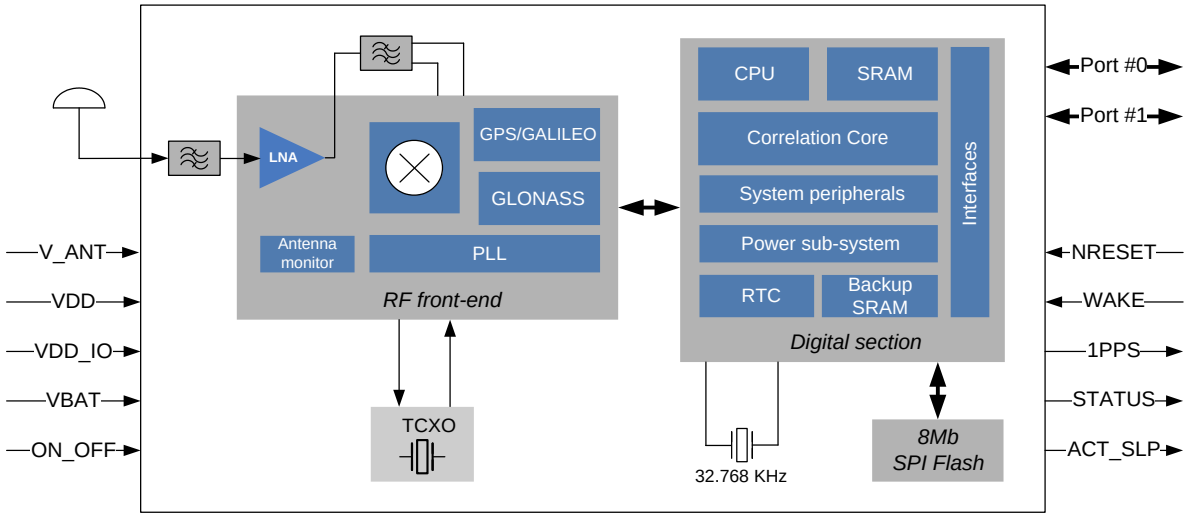

Figure 1. Block diagram

2.3.1 RTC, Backup SRAM

RTC is clocked with 32.768KHz and counts real time. Backup SRAM stores ephemeris, current time and position data. RTC and backup SRAM are allocated in battery power domain and continue operation in case the main power is off. Both blocks are key elements to provide warm/hot start.

2.3.2 Flash Memory

8Mb Flash memory is used for storing following data:

- Firmware code;
- Module configuration and settings;
- Navigation system almanacs;
- Extended ephemeris.

Firmware can be updated via serial port by using binary protocol.

2.4 Module Options

2.4.1 GeoS-5M

GeoS-5M is a basic option which is intended for operation in standard dynamics conditions (velocity up to 515m/s, acceleration up to 4g). This option doesn't provide carrier phase measurements in raw data output.

2.4.2 GeoS-5MR

GeoS-5MR option provides carrier phase measurements in raw data output. This allows using this module in precise positioning (carrier phase differential) systems.

Other parameters including mechanical and electrical specifications, input/output signals and data protocols are identical to those of basic option GeoS-5M.

2.5 Pin Assignment

Table 1. Pin list

Pad #	Type	Name	Function
1		GND	Ground

Pad #	Type	Name	Function
2	I	ANT	Antenna port
3, 4		GND	Ground
5	I	WAKE	Wake-up input
6	O	1PPS	1PPS output
7		NC	Not connected
8	O	ACT_SLP	ACTIVE/SLEEP indicator
9	O	STATUS	Module status indicator
10		NC	Not connected
11	I	RX1	Receive data, Port #1
12	O	TX1	Transmit data, Port #1
13	I	RX0	Receive data, Port #0
14	O	TX0	Transmit data, Port #0
15, 16		NC	Not connected
17, 18		GND	Ground
19	I	NRESET	External reset input
20	I	VDD	Main supply voltage
21	I	VBAT	Backup battery voltage
22	I	ON_OFF	Remote control input
23	I	VDD_IO	I/O supply voltage
24	I	V_ANT	Antenna bias voltage

2.6 Supply Voltages

The module requires two supply voltages:

- Main supply voltage (VDD): 1.8V nominal; 50mV p-p amplitude ripple maximum;
- I/O supply voltage (VDD_IO): 1.7V to 3.6V operating range. Logic levels of I/O signals TX0, TX1, RX0, RX1, 1PPS, WAKE, NRESET, ACT_SLP, STATUS and ON_OFF are referred to I/O supply voltage.

To enable warm/hot start, backup battery voltage should be connected to VBAT pin. If not used, VBAT pin may be left unconnected.

2.7 Biasing Active Antenna. Antenna Monitor

V_ANT pin is intended for applying external antenna supply voltage. The voltage at V_ANT pin comes to antenna monitor circuitry that has integrated power switch with programmable control capability. The power switch output provides bias voltage at ANT pin for feeding active antenna. The bias voltage can be enabled or disabled. If enabled (default), the voltage is available at ANT pin. If disabled, the voltage is removed from ANT pin.

If not used, V_ANT pin may be left unconnected.

Additionally, the antenna monitor circuitry measures antenna load current. The measurement results are compared with predefined thresholds to indicate following antenna status:

- “Not measured”: if antenna bias voltage is disabled;
- “Overload”: the antenna current is higher than 32mA (50mA limit);
- “Open”: the antenna current is lower than 3mA;

- "OK": the current is within operating range from 3mA to 32mA.

The antenna monitor maximum output current is limited to 50mA so that short circuit at antenna port doesn't lead to the module damage and is indicated as "Overload".

1. If antenna bias voltage is not applied to V_ANT (in case of using external bias circuitry), antenna current measurements might be invalid. In such case, it's recommended to disable antenna power;
2. If active antenna has normal operating current less than 3mA or more than 32mA (and doesn't exceed 50mA), the module will operate correctly but will report antenna failure ("Open" or "Overload", respectively). Such report may be ignored.

The antenna monitor introduces some voltage drop so that voltage at ANT port is less than that at V_ANT pin. The voltage drop depends on actual antenna current and is typically 100mV@10mA.

2.8 Power Consumption

At different operation stages the module requires different amount of supply current. Immediately after power-up, the module searches for satellites by activating fast acquisition engines so that power consumption becomes maximum. For those conditions, supply current in Table 12 is specified as "VDD supply current, acquisition". This value can be considered as the highest margin.

As soon as the signals are detected and being tracked, the number of active fast acquisition engines is decreased what leads to lowering power consumption. The module switches off the fast acquisition sub-system completely only after the GNSS almanacs have been collected and all signals are being tracked. For those conditions, supply current in Table 12 is specified as "VDD supply current, tracking". This value can be considered as the lowest margin.

In real conditions, actual supply current will be between the highest and lowest margins and will depend on following conditions:

- Type of start (cold, warm, hot, assisted, reacquisition);
- Received signal levels (weak signals basically require more intensive operation of fast acquisition sub-system and therefore, more supply current);
- Signal reception conditions;
- Availability of fresh GNSS almanacs in the module memory.

2.9 Embedded Supply Voltages Monitor System

The module has three embedded voltage supervisors for monitoring three internal and external voltages as follows:

1. VDD voltage (1.8V);
2. Core voltage (1.2V);
3. Battery power domain voltage (1.2V).

If at least one of VDD either core voltages is below the threshold level (1.6V for VDD and 1.0V for the core), the system reset is generated that retains the module in RESET state. If battery power domain voltage is under 0.9V threshold, then RTC is held in reset.

2.10 Serial Ports

The module has two serial ports (UART) designates as Port #0 and Port #1. The parameters of both ports can be set individually as follows:

- Baud rate, bit/s: 4800, 9600, 19200, 38400, 57600, 115200 (default), 230400, 460800, 921600;
- Stop bits: 1 (default) or 2;
- Parity: no parity (default), even, odd, mark, space.

2.11 Data Protocols

The module supports three data protocols: binary, NMEA and RTCM. Totally five combinations of data protocols are available as listed in Table 2.

RTCM data is differential corrections stream that is used in differential mode to produce code-differential solution. Supported messages: RTCM SC104 v2.3 message types 1, 3, and 31.

Table 2. Assignment of data protocols to serial ports

#	Port #0	Port #1
1	Binary	NMEA
2	NMEA	Binary
3	NMEA	NMEA
4	Binary	RTCM
5	NMEA	RTCM

On default, Port #0 operates with binary data and Port #1 with NMEA.

Reference documents:

- Binary protocol description "GeoS® Binary Data Protocol v4.0";
- NMEA protocol description "GeoS® NMEA Data Protocol v4.0".

2.12 STATUS Output

STATUS pin indicates the current state of the module: SEARCH, NAVIGATION, FAILURE. This is a digital output with different timing diagrams as follows:

1. SEARCH: hardware is OK (no failures found), module is searching for satellites, no fix yet;
2. NAVIGATION: satellites have been acquired and being tracked, valid position fix is available;
3. FAILURE: hardware failure found, no fix.

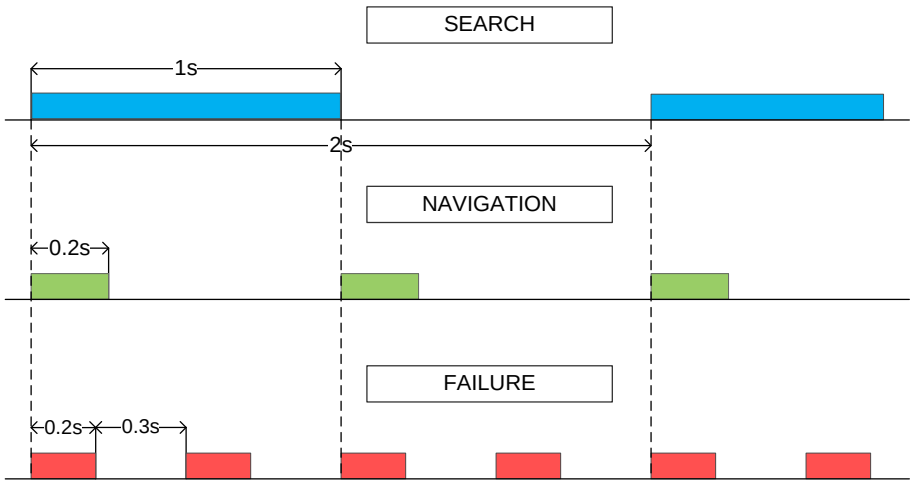

Figure 2. STATUS pin timing diagrams

Pin behavior in power-save modes:

- SLEEP state (ACT_SLP=0): driven low;
- ACTIVE state (ACT_SLP=1): controlled as described above.

2.13 WAKE Input, ACT_SLP Output

WAKE input is used in FIX-BY-REQUEST® mode to wake-up the module. WAKE input is positive edge (low-to-high transition) sensitive. WAKE pin is internally pulled-down.

ACT_SLP output acknowledges ACTIVE or SLEEP states of the module. If the module is in ACTIVE state, ACT_SLP is driven high. If the module is in SLEEP state, ACT_SLP is driven low.

2.14 NRESET Input

NRESET input is used to put the module to RESET state (active low). NRESET input is internally pulled-up. If not used, it may be left unconnected.

If NRESET=0, the module outputs are driven to the following states:

- TX0, TX1: logic high;
- 1PPS: logic low;
- ACT_SLP, STATUS: logic high.

2.15 ON_OFF Control

Driving ON_OFF low switches the module off; driving ON_OFF high or to Z-state switches the module on. ON_OFF input is internally pulled-up. If not used, it may be left unconnected.

If ON_OFF=0, the module outputs are driven to the following states:

- TX0, TX1: logic high;
- 1PPS: logic low;
- ACT_SLP, STATUS: logic high.

If ON_OFF=0, antenna supply voltage at ANT pin is removed.

2.16 Module Operation States

Table 3. Operation states

State	Description	Conditions	Supply current (typ.)
OFF	VDD is applied but the module is not powered (except RTC and backup SRAM). No positioning and communication on serial ports. RTC is running, backup SRAM retains the data what provides warm/hot start after releasing ON_OFF=1	VDD=on VBAT=don't care ON_OFF=0 NRESET=1	150uA (@VDD)
BACKUP	VDD is removed thus the module is not powered (except RTC and backup SRAM). No positioning and communication on serial ports. RTC is running, backup SRAM retains the data what provides warm/hot start after applying VDD and releasing ON/OFF=1	VDD=off VBAT=on ON_OFF=don't care NRESET=don't care	8uA (@VBAT)
RESET	The module is powered. Digital section is reset, CPU is stopped, RF is running. No positioning and communication on serial ports. RTC is running, backup SRAM retains the data what provides warm/hot start after releasing NRESET=1	VDD=on VBAT=don't care NRESET=0 ON_OFF=1	20mA (@VDD)
ACTIVE	The module is powered and works in full-power mode	VDD=on VBAT=don't care NRESET=1 ON_OFF=1	Refer to Table 14

State	Description	Conditions	Supply current (typ.)
SLEEP	The module is powered. RF and most of digital blocks are off. No positioning. The module is keeping time scale from TCXO, communicating on serial ports and waiting for wake-up events	VDD=on VBAT=don't care NRESET=1 ON_OFF=1	Refer to Table 14

2.17 Configuration and Firmware Settings

Table 4. List of configuration and firmware settings

#	Parameter	Default setting
1	GNSS constellation	GPS+GLONASS+GALILEO
2	2D	disabled
3	Operation mode	autonomous or differential
4	DR duration	5 s
5	Kalman filter	on
6	Differential mode	disabled
7	Diff corrections source	auto select
8	PRN SBAS	auto select
9	Output data rate	1 Hz
10	Serial Port #0 and #1 parameters	115200, 1 stop bit, no parity
11	Data protocols	• Port #0: binary • Port #1: NMEA
12	GDOP mask	50
13	Elevation mask	5°
14	Signal level mask	10 dBHz
15	Static navigation threshold	0.3 m/s
16	User dynamics profile	pedestrian-car
17	Survey-in interval	60 minutes
18	Pseudorange measurements in message 0x10	unsmoothed
19	Coordinate system	WGS-84
20	Pseudorange measurements smoothing interval	100 s
21	RAIM (T-RAIM)	disabled
22	DGNSS time-out period	90 s
23	SBAS time-out period	120 s
24	Local time offset relative to UTC	0
25	Power-save modes	disabled
26	Enabled power-save mode	RELAXED FIX®
27	Minimum ACTIVE time duration	2 s
28	Maximum ACTIVE time duration	5 s
29	Time interval between ACTIVE states (RELAXED FIX®)	60 s
30	ACTIVE time after the first fix	3 s

#	Parameter	Default setting
31	Reference ECEF coordinates, m	X=0.0, Y=0.0, Z=0.0
32	1PPS parameters	• enabled • polarity: positive • sync to GPS • duration: 1 ms • shift: 0 ns
33	Antenna power	on
34	SVs	all enabled
35	NMEA messages	• NMEA v2.x • GGA, GSA, GSV, RMC enabled
36	Automatically generated masked messages	disabled

Upon receiving new configuration or FW settings input data, the module immediately saves it to the Flash memory which typically takes less than 1 second.

2.18 Active Antenna Requirements

The module can work with both passive and active antenna. For active antenna, exceeding gain should be less than 25dB. Exceeding gain is defined as antenna LNA gain minus RF cable losses.

3 Functional Description

3.1 Operation Modes

The module can operate in the following modes:

- Autonomous;
- Differential;
- Coordinates hold;
- Survey-in.

In autonomous mode the module calculates position fix with standard (few meter level) accuracy.

Differential mode gives some position accuracy improvement. In this mode, the module can receive and utilize following corrections data:

- Differential corrections stream according to RTCM SC104 v2.3;
- Corrections broadcast by SBAS satellites.

Coordinates hold mode and survey-in mode are intended for timing applications and assume that antenna is stationary. If reference coordinates of the point where the antenna is placed to are accurately known (with accuracy better than 70 m), coordinates hold mode can be used. In this mode, the module requires reference ECEF coordinates of antenna phase center to be input.

If offset between reference and calculated coordinates exceeds 70 m, the module will stay in autonomous mode and will not transit to coordinates hold mode.

If reference coordinates are unknown, the survey-in mode is used which allows obtaining the approximate antenna coordinates by averaging positioning data over specified time interval. As soon as this interval is expired, the module saves averaged coordinates to the Flash memory and switches to coordinates hold mode.

3.2 Coordinate Systems

Three datum selections are available:

- WGS-84 (default);
- PZ-90.11;
- User defined.

3.3 GNSS Constellations

The module can be set to operate on the following GNSS constellations:

- GPS only;
- GLONASS only;
- GALILEO only;
- Any combination of GLONASS, GPS and GALILEO.

QZSS only mode is not supported. QZSS can be used in conjunction with other major navigation systems.

3.4 Differential Mode

3.4.1 RTCM

Supported messages: RTCM SC104 v2.3 types 1, 3 и 31. If differential mode is not disabled, as soon as differential corrections are available at Port #1 and meet required format specification, the module automatically switches to differential mode and calculated code-differential solution.

If corrections are lost, the module continues to apply the latest received valid corrections within specified DGNSS time-out period. As soon as this period is expired, the module automatically switches to autonomous mode.

3.4.2 SBAS

SBAS employs geostationary satellites for transmitting corrections and integrity data. There are five regional augmentation systems:

- WAAS;
- EGNOS;
- SDCM;
- MSAS;
- GAGAN.

Each regional system has its own set of unique PRNs, see Table 5 (actual on May 2018).

Table 5. SBAS PRN assignment

Regional system	SV name	PRN
WAAS	AMR	133
	Galaxy 15	135
	Anik F1R	138
EGNOS	Inmarsat 3F2	120
	Artemis	124
	Inmarsat 3F5	126
SDCM	Luch-5B	125
	Luch-5C	140
	Luch-5A	141
MSAS	MTSAT-1R	129
	MTSAT-2	137
GAGAN	Inmarsat 4F1	127
	GSAT-10	128

The module has three SBAS dedicated tracking channels. For every SBAS channel, the PRN number can be set by the user otherwise the module initiates automatic search of all possible PRNs as defined in its firmware.

If SBAS satellite transmits ephemeris data, it is used in position fix calculation.

Additionally, the module settings allow user to:

- Use transmitted corrections even if SBAS SV operates in test mode;
- Select using SVs in position fix: only those SVs for which corrections are available either all visible SVs regardless corrections availability.

If corrections are lost, the module continues to apply the latest received valid corrections within specified SBAS time-out period. As soon as this period is expired, the module automatically switches to autonomous mode.

RTCM corrections have a higher priority over SBAS corrections.

3.5 RAIM

Any navigation system can potentially have signal errors due to navigation satellite failures that can result in unwanted positioning errors. The purpose of RAIM is to detect, identify and isolate such faults and to protect navigation solution.

RAIM technology is based on measurements redundancy principles and checks satellites measurements consistency. The module reports RAIM check results in its output data.

3.6 1PPS Output

The module outputs One Pulse Per Second signal at 1PPS pad. 1PPS has 1 second period and following programmed parameters:

- 1PPS enabled/1PPS disabled;
- Time scale to which the pulse is synchronized: GPS, GLONASS, UTC(USNO), UTC(SU);
- Polarity: positive/negative. For positive polarity, 1PPS rising edge (low-to-high transition) is synchronized to selected time scale. For negative polarity, 1PPS falling edge (high-to-low transition) is synchronized to selected time scale;
- Duration: 10us to 2ms;
- Offset: within ±0,5s.

1PPS is generated with resolution of 61ns which yields from 16.369MHz internal reference (TCXO).

3.7 Support of GALILEO SAR RLS

GALILEO SAR service together with COSPAS-SARSAT system provides users with Return Link Service (RLS). Once the signals transmitted by distress radio beacons are detected, COSPAS-SARSAT Mission Control Centres receive the beacon location information and distribute the acknowledgement of the signal reception by using GALILEO RLS.

When receiving GALILEO signals, the module decodes RLM messages which contain unique distress beacon number (15HEX ID) and outputs this data in binary and NMEA format. Maximum number of different 15HEX IDs being transmitted per one second is 10.

3.8 Output Data Rate

Output data rate can be set to 1 (default), 2, 5 or 10Hz.

3.9 User Dynamics Profiles

Table 6. Dynamics profiles

Profile	Limits
Pedestrian/Car	Horizontal speed limit – 75m/s Vertical speed limit – 15m/s Altitude limit – 10000m Acceleration – up to 0.5g
Marine	Horizontal speed limit – 30m/s Vertical speed limit – 5m/s Altitude limit – 500m Acceleration – up to 0.5g
Airborne	Horizontal speed limit – 515m/s Vertical speed limit – 100m/s Altitude limit – 18000m Acceleration – up to 4g, 2D disabled

3.10 Power-save Modes

The module supports two power-save modes: RELAXED FIX® and FIX-BY-REQUEST®. These modes are alternative to full-power, or continuous, mode.

RELAXED FIX® mode features periodic cycling of ACTIVE and SLEEP states on internal timing so that the output data rate is much less than normal 1Hz.

FIX-BY-REQUEST® mode features transition from SLEEP to ACTIVE state (wake-up) on user's request.

3.11 Binary Messages

Table 7. The list of output messages

Message	Message
Automatically generated messages	
0x00	GALILEO SAR RLM
0x08	GALILEO Almanac
0x0A	GALILEO Ephemeris
0x0E	SBAS Satellite Orbit Parameters
0x10	Raw Measurements
0x11	GPS Sub-frame Data
0x12	GLONASS Sub-frame Data
0x13	Navigation Solution State Vector
0x14	Timing Parameters
0x15	Geographic Coordinates: Extended Dataset
0x16	SBAS Message
0x17	GALILEO Sub-frame Data
0x18	GPS/QZSS Almanac
0x19	GLONASS Almanac
0x1A	GPS/QZSS Ephemeris
0x1B	GLONASS Ephemeris
0x1C	GPS Ionospheric Parameters
0x1D	GPS Time to UTC Conversion Parameters
0x1E	GLONASS Time to UTC Conversion Parameters
0x1F	GST-UTC Conversion Parameters
0x20	Geographic Coordinates: Basic Dataset
0x21	Receiver Telemetry
0x22	In View/Active SVs
0x3E	Receiver Power-up Message
Responses to settings	
0x3F	Message Reception Acknowledgement
Responses to queries	
0x80	Reference ECEF Coordinates
0x81	Serial Ports Parameters

Message	Message
0x82	Receiver Operation Mode
0x83	Navigation Solution Parameters
0x84	Output Data Rate
0x85	DGNSS Parameters
0x86	SBAS Parameters
0x87	Power-save Modes Parameters
0x88	GPS/QZSS Almanac(1)
0x89	GLONASS Almanac
0x8A	GPS/QZSS Ephemeris(1)
0x8B	GLONASS Ephemeris
0x8C	1PPS Parameters
0x8D	Enable/Disable SV Status
0x8E	NMEA Messages Configuration
0x8F	Binary Message Mask
0x90	Data Protocols Configuration
0x93	Local Time Offset, Leap Second
0x94	Coordinate System
0x95	Receiver Configuration File
0x98	GALILEO Almanac
0x9A	GALILEO Ephemeris
0x9C	GPS Ionospheric Parameters
0x9D	GPS Time to UTC Conversion Parameters
0x9E	GLONASS Time to UTC Conversion Parameters
0x9F	GST-UTC Conversion Parameters
0xAE	SBAS Satellite Orbit Parameters
	Responses to commands
0xC1	Receiver Type, Firmware Version
0xC3	Storing Data to Flash Report
0xC4	Response to Enter/Quit Power-save Mode
0xC6	Serial Port Number
0xC7	Antenna Power Status

Table 8. The list of input messages

Message ID	Message
	Settings
0x40	Set Reference ECEF Coordinates
0x41	Set Serial Ports Parameters
0x42	Set Receiver Operation Mode
0x43	Set Navigation Solution Parameters

Message ID	Message
0x44	Set Output Data Rate
0x45	DGNSS Control
0x46	SBAS Control
0x47	Set Power-save Modes Parameters
0x48	Load GPS/QZSS Almanac
0x49	Load GLONASS Almanac
0x4A	Load GPS/QZSS Ephemeris
0x4B	Load GLONASS Ephemeris
0x4C	Set 1PPS Parameters
0x4D	Enable/Disable SV
0x4E	Set NMEA Messages Configuration
0x4F	Set Binary Message Mask
0x50	Set Data Protocols Configuration
0x53	Set Local Time Offset and Leap Second
0x54	Set Coordinate System
0x55	Load Receiver Configuration File
0x58	Load GALILEO Almanac
0x5A	Load GALILEO Epemeris
	Queries
0x80	Query Reference ECEF Coordinates
0x81	Query Serial Ports Parameters
0x82	Query Receiver Operation Mode
0x83	Query Navigation Solution Parameters
0x84	Query Output Data Rate
0x85	Query DGNSS Parameters
0x86	Query SBAS Parameters
0x87	Query Power-save Modes Parameters
0x88	Query GPS Almanac
0x89	Query GLONASS Almanac
0x8A	Query GPS Ephemeris
0x8B	Query GLONASS Ephemeris
0x8C	Query 1PPS Parameters
0x8D	Query Enable/Disable SV Status
0x8E	Query NMEA Messages Configuration
0x8F	Query Binary Message Mask
0x90	Query Data Protocols Configuration
0x93	Query Local Time Offset and Leap Second
0x94	Query Coordinate System

Message ID	Message
0x95	Query Receiver Configuration File
0x98	Query GALILEO Almanac
0x9A	Query GALILEO Ephemeris
0x9C	Query GPS Ionospheric Parameters
0x9D	Query GPS Time to UTC Conversion Parameters
0x9E	Query GLONASS Time to UTC Conversion Parameters
0x9F	Query GST-UTC Conversion Parameters
0xAE	Query SBAS Satellite Orbit Parameters
	Commands
0xC1	Request Receiver Type and Firmware Version
0xC2	Restart Receiver
0xC3	Save Almanacs to Flash
0xC4	Enter/Quit Power-save Mode
0xC5	Switch to NMEA
0xC6	Request Serial Port Number
0xC7	Enable/Disable Antenna Power

3.12 NMEA Messages

Table 9. The list of NMEA messages

Mnemonics	Message
	Standard output messages
GGA	Global Positioning System Fix Data
GLL	Geographic Position – Lattitude/Longitude
GNS	GNSS Fix Data
GSA	GNSS DOP and Active Satellites
GSV	GNSS Satellites In View
RMC	Recommended Minimum Specific GNSS Data
VTG	Course Over Ground and Ground Speed
ZDA	Time and Date
DTM	Datum Reference
RLM	Return Link Message
	Proprietary output messages
RQUERY	FW Version, Receiver Telemetry and Configuration
NQUERY	Enabled NMEA Messages
	Proprietary input messages
SWPROT	Switch to Binary Protocol
SAVEFL	Save Almanacs to Flash
CSTART	Cold Start

Mnemonics	Message
WSTART	Warm Start
HSTART	Hot Start
RQUERY	Request FW Version, Receiver Telemetry and Configuration
NQUERY	Request Enabled NMEA Messages
BDR---	Ser Serial Port Baud Rate
STOP--	Set Serial Port Stop Bits
GGA ON, GGAOFF	Enable/Disable GGA/GNS Message
GLL ON, GLLOFF	Enable/Disable GLL Message
GSA ON, GSAOFF	Enable/Disable GSA Message
GSV ON, GSVOFF	Enable/Disable GSV Message
RMC ON, RMCOFF	Enable/Disable RMC Message
VTG ON, VTGOFF	Enable/Disable VTG Message
ZDA ON, ZDAOFF	Enable/Disable ZDA Message
DTM ON, DTMOFF	Enable/Disable DTM Message
RLM ON, RLMOFF	Enable/Disable RLM Message
NMEAV2, NMEAV4	Выбор версии стандарта NMEA
RATE--	Set Output Data Rate
PSM ON, PSMOFF	Enter/Quit Power-save Mode/Wake-up
ELEV--	Set Elevation Angle Mask
DATP90, DATW84	Set PZ-90.11 Datum Set WGS-84 Datum
NVSGPS, NVSGLN, NVSMIX	Set GPS Only Mode Set GLONASS Only Mode Set Mixed GLONASS+GPS+GALILEO Mode

The module outputs standard NMEA sentences according to two versions of NMEA 0183 standard – v2.x (with some extensions) and v4.10. The difference between message formats is as follows:

- v2.x:
  - GGA output;
  - GGA, GLL, GSV, RMC, VTG, ZDA, DTM, RLM, all proprietary messages: talker ID – only GP;
  - GSA: talker IDs – GP for GPS, GL for GLONASS, GA for GALILEO, GQ for QZSS.
- v4.10:
  - GNS output;

- Up to five GNS messages with talker IDs GN, GP, GL, GA, GQ;
- Up to four GSA messages with talker IDs GN, GP, GL, GA;
- GSV: talker IDs – GP for GPS, GL for GLONASS, GA for GALILEO, GQ for QZSS;
- GLL, RMC, VTG, ZDA: talker IDs – GN for any mixed mode, GP for GPS, GL for GLONASS, GA for GALILEO;
- DTM, RLM, all proprietary messages: talker ID – only GP.

4 Specifications

Table 10. Performance characteristics

#	Parameter	Value	Notes
1	Channels	44	
2	Signals	L1 GPS C/A, GLONASS C/A, GALILEO E1B/C, QZSS, SBAS	
3	Horizontal position accuracy, m • Autonomous[1, 2] • SBAS[1, 2] • Differential[2]	 <2.5 <2.0 <1.5	CEP 50% HDOP<2, VDOP<3
4	Altitude accuracy, autonomous, m[1, 2]	<4.0	RMS HDOP<2, VDOP<3
5	Velocity accuracy (horizontal), m/s[2] • Autonomous	 <0.02	RMS HDOP<2, VDOP<3
6	1PPS accuracy	<30[2]	RMS HDOP<2, VDOP<3
7	TTFF, s • Cold start[2] • Cold start[3] • Warm start[2] • Hot start[2] • Reacquisition[2, 4]	 27 33 25 2 1	Typical values
8	Sensitivity, dBm • Acquisition, cold start • Acquisition, hot start • Tracking and navigation	 -147 -155 -163	With external LNA
9	Dynamics • Acceleration, g • Velocity limit, m/s • Altitude limit, m	 <4 515 18000	
10	Output data rate, Hz	1/2/5/10	
11	Interfaces	2xUART, LVCMOS	
12	Size, mm	14.3x13.7x2.6	
13	Weight, g	<1.5	
14	Operating temperature, °C	-40…+85	

Notes:

1. *Standard dynamics conditions;*
2. *GLONASS+GPS, @-130dBm;*
3. *GLONASS+GPS, @-140dBm;*
4. *10s signal off time.*

4.1 Electrical Parameters

The stresses beyond “Absolute maximum ratings” may lead to the module damage

Table 11. Absolute maximum ratings

Parameter	Value		Unit	Notes
	MIN	MAX		

Parameter	Value		Unit	Notes
	MIN	MAX		
V_{DD}	-0.3	2.5	V	
V_{DD_IO}	-0.5	4.6	V	
V_{BAT}	-0.3	4.0	V	
V_{ANT}	-0.3	3.75	V	
Input voltage level (V_I)(1)	-0.5	2.5	V	V_{DD_IO}=1.8V
	-0.5	4.6		V_{DD_IO}=3.3V
Output short circuit current (I_O)(2)	-12	12	mA	V_{DD_IO}=1.8V
	-24	24		V_{DD_IO}=3.3V
Antenna short circuit current (I_{ANT})	-	50	mA	
RF input power	-	10	dBm	ANT pad
ESD voltage level		2000	V	HBM
Storage temperature (T_{STG})	-40	+85	°C	

Notes:

1. *WAKE, NRESET, RX0, RX1, ON_OFF;*
2. *1PPS, ACT_SLP, STATUS, TX0, TX1.*

Table 12. DC and AC operating electrical characteristics

Parameter	Symbol	Value			Unit	Conditions
		MIN	TYP	MAX		
Main supply voltage	V_{DD}	1.7	1.8	1.9	V	
I/O supply voltage	V_{DD_IO}	1.7	-	3.6	V	
Backup battery voltage	V_{BAT}	1.6	-	3.7	V	
Antenna supply voltage	V_{ANT}	1.8	-	3.6	V	
VDD supply current, acquisition	I_{DD_ACQ}	-	75	-	mA	V_{DD}=1.8V GLONASS+GPS+QZSS+SBAS
		-	110	-		V_{DD}=1.8V GLONASS+GPS+QZSS+GALILEO+SBAS
VDD supply current, tracking	I_{DD_TRQ}	-	42	-	mA	V_{DD}=1.8V GLONASS+GPS+QZSS+SBAS
		-	48	-		V_{DD}=1.8V GLONASS+GPS+QZSS+GALILEO+SBAS
VDD supply current, OFF state	I_{DD_OFF}	-	150	250	uA	ON_OFF=0
VDD supply current, RESET state	I_{DD_RESET}	-	20	22	mA	NRESET=0
VDD supply current, SLEEP state	I_{DD_TRQ}	-	5.5	-	mA	
VDD supply current, power-save mode	I_{DD_SLEEP}	-	10.5	-	mA	ACTIVE:SLEEP=1:10
VDD_IO supply current	I_{DD_IO}	-	-	5	uA	No load
Backup supply current	I_{BAT}	-	8	-	uA	V_{DD} off @+25°C
		-	28	-		V_{DD} off @+85°C
Antenna bias voltage drop	V_{ANT_DRO}	-	100	150	mV	I_{ANT}=10mA

Parameter	Symbol	Value			Unit	Conditions
		MIN	TYP	MAX		
(between V_ANT and ANT pins)	P		200	240		I_{ANT}=20mA
			300	340		I_{ANT}=30mA
Antenna current	I_{ANT}	3	-	32	mA	
Output low-level voltage (1)	V_{OL}	-	-	0.4	V	V_{DD_IO}=1.8V, I_{OL}=3.6mA
				0.4		V_{DD_IO}=3.3V, I_{OL}=8mA
Output high-level voltage(1)	V_{OH}	0.75*V_{DD_IO}	-	-	V	V_{DD_IO}=1.8V, I_{OH}=-3.6mA
		2.4				V_{DD_IO}=3.3V, I_{OH}=-8mA
Output low-level voltage(1)	V_{OL}	-	-	0.1	V	V_{DD_IO}=1.8V, I_{OL}=0.1mA
				0.1		V_{DD_IO}=3.3V, I_{OL}=0.1mA
Output high-level voltage(1)	V_{OH}	V_{DD_IO}-0.1	-		V	V_{DD_IO}=1.8V, I_{OH}=-0.1mA
		V_{DDIO}-0.1				V_{DD_IO}=3.3V, I_{OH}=-0.1mA
Output low-level current(1)	I_{OL}	-	-	3.6	mA	V_{DD_IO}=1.8V
				8		V_{DD_IO}=3.3V
Output high-level current(1)	I_{OH}	-	-	-3.6	mA	V_{DD_IO}=1.8V
				-8		V_{DD_IO}=3.3V
Input low-level voltage(2)	V_{IL}	-	-	0.3*V_{DD_IO}	V	V_{DD_IO}=1.8V
				0.8		V_{DD_IO}=3.3V
Input high-level voltage(2)	V_{IH}	0.7*V_{DD_IO}	-	-	V	V_{DD_IO}=1.8V
		2.0				V_{DD_IO}=3.3V
Pull-down resistance(3)	R_{PD}	-	210	-	KΩ	V_{DD_IO}=1.8V
			75			V_{DD_IO}=3.3V
Pull-up resistance(4)	R_{PU}	-	200	-	KΩ	V_{DD_IO}=1.8V
			75			V_{DD_IO}=3.3V
RF						
Effective noise figure	NF	-	5	-	dB	

Notes:

1. *1PPS, ACT_SLP, STATUS, TX0, TX1;*
2. *WAKE, NRESET, RX0, RX1, ON_OFF;*
3. *WAKE;*
4. *NRESET, RX0, RX1, ON_OFF.*

5 Mechanical Specifications

5.1 Outline Drawing

Dimensions: mm.

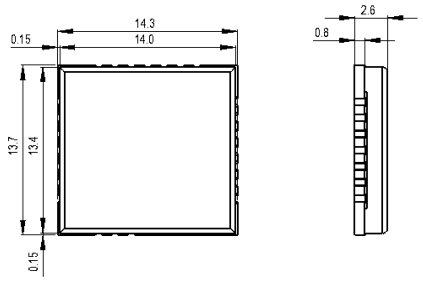

Figure 3. Outline drawing

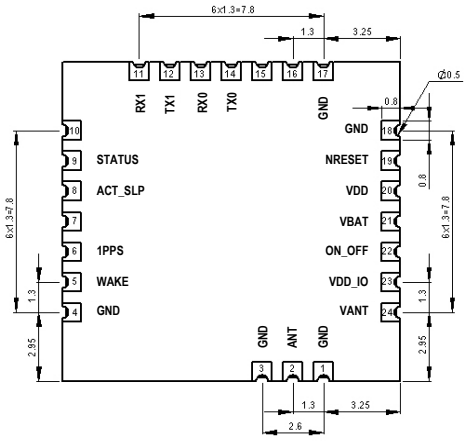

Figure 4. Pad allocations (bottom view)

5.2 Recommended PCB Footprint

Dimensions: mm.

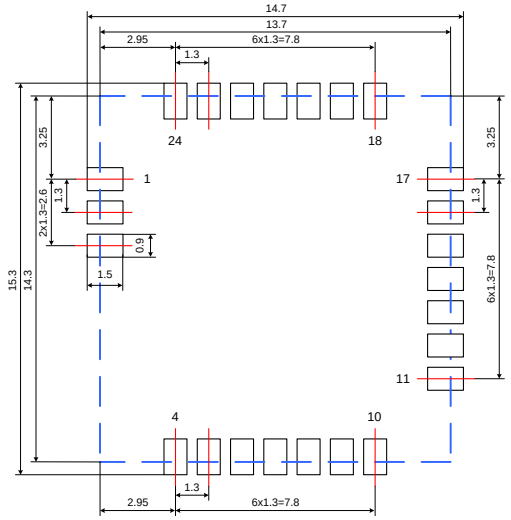

Figure 5. Recommended PCB footprint

PCB routing guidelines:

1. Antenna should be connected to ANT pad via micro-strip line. Its length should be kept as short as possible and impedance as close as possible to 50 Ohm;
2. Ground pads should be connected to the PCB ground in shortest way;
3. PCB signal lines should be moved from antenna input as far as possible;
4. Avoid routing signals (especially clock and high-speed) beneath the module.

5.3 Marking

Marking details (Figure 6):

- GeoS-5M: product name;
- 51110000001: serial number;
- wwyy: production time code (week, year);
- Pad #1 identifier;
- QR code.

Figure 6. Marking example

6 Handling

6.1 Package

Dimensions: mm.

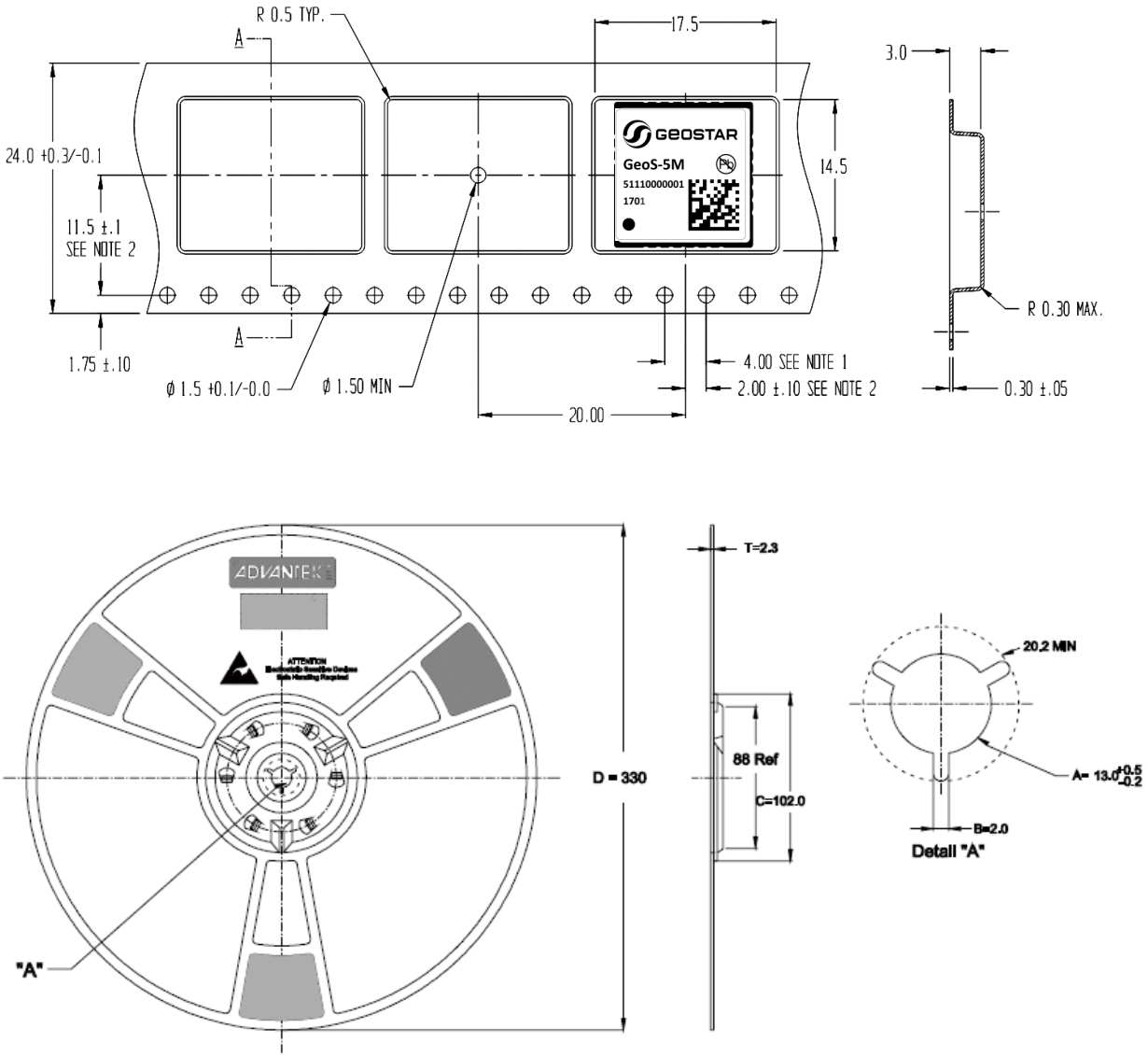

Figure 7. Package details: 1000pcs/reel

6.2 ESD Handling

GeoS-5M is ESD sensitive device

Although the module contains built-in ESD protection circuitries, conventional precautions should be taken during transportation, storage and assembly into the user's equipment. Refer to IEC 61340-5-1 and 61340-5-2 for general rules of ESD protection.

6.3 RoHS Compliance

The product is manufactured in compliance with RoHS directive (2011/65/EU RoHS).

7 Recommendations on HW Connections

7.1 Typical Connection Diagrams

Typical connection diagram is depicted in Figure 8.

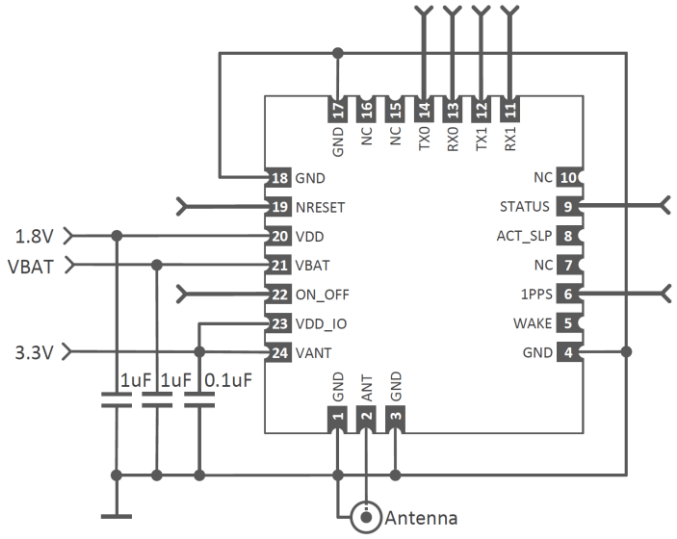

Figure 8. Typical connection diagram

Figure 9 illustrates simplified connections scheme in which backup battery and antenna supply voltage are not applied. It's assumed that active antenna is powered through external bias circuit.

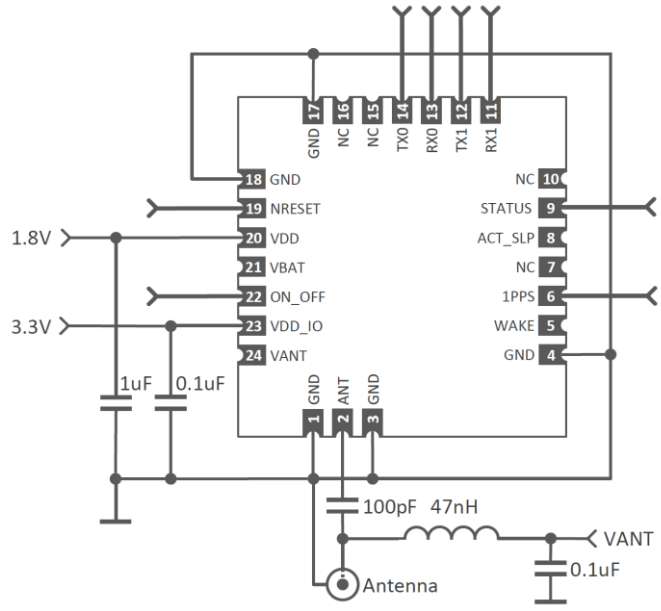

Figure 9. Simplified connection diagram

7.2 VDD and VDD_IO Sequencing

VDD and VDD_IO can be applied in any sequence under following restrictions: logic high in input signals should be applied simultaneously with VDD_IO rising. If VDD_IO=0, input signals must be driven low or put to Z-state.

7.3 Requirements to VDD Regulator

Since the supply current varies significantly during operation from the lowest to the highest limit indicated in Table 12, it's recommended to use DC-DC regulator for VDD with maximum load capability of at least 200mA.