SkyFox Labs™

Your easy way to space.

Space-Friendly™

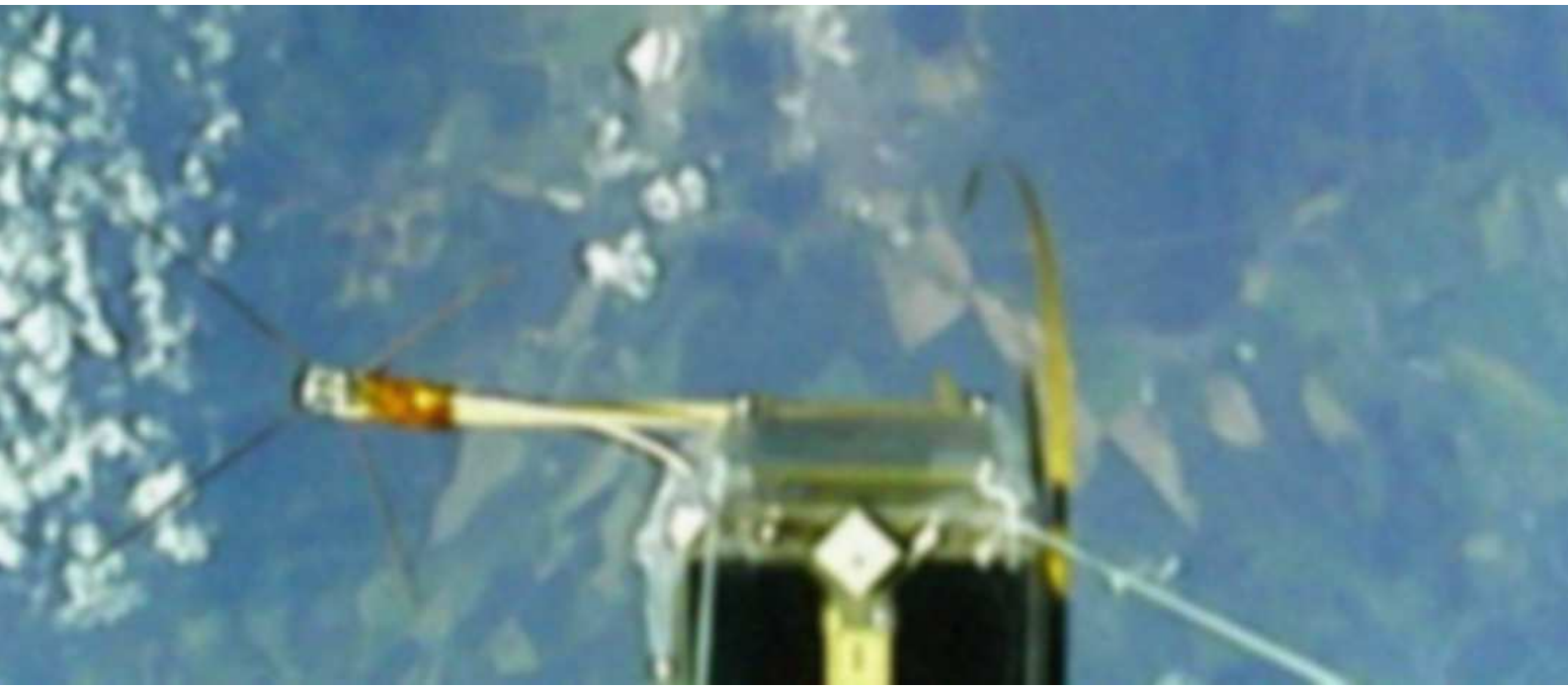
CubeSat Magnetometer & Gyroscope

piMAGGYRO

Product Datasheet

Rev. A/2026

Intended for **small satellite science**.



Made in Czech Republic, a country with space heritage since 1978.

PRODUCT DATA SHEET piMAGGYRO

FEATURES

- World's First CubeSat Magnetometer & Gyroscope Non-Deployable Integrated Sensor System
- Solid State Low Power MAR (Magnetic and Angular Rate) sensors
- Simple to use, no settings needed
- 10 Hz data rate
- OVERFLUX Alarm (total field higher than 80 μT)
- OVERRATE Alarm (angular rate higher than 100°/s)
- Alarm reaction time 25 ms
- Fixed Length Serialized Data output over UART
- Measurement range:
  - Magnetic Field ± 300 000 nT per axis
  - Angular Rate ± 250°/s per axis
- ERROR signal indicating
  - measured values over sensor ranges
  - temperature over -40°C to +85°C
- Power consumption
  - 50 mW (typical), 3.3 V @ 25°C
- Easy-to-Implement Data Interface
  - UART 115200-8-N-1, LVCMOS levels
- Serial Output sentences, divided by CR+LF contains:
  - 3× Magnetic Field Vector components
  - 1× Total Magnetic Field
  - 3× Angular Rate components
  - 1× Temperature telemetry
  - 1× Voltage telemetry
  - 1× Uptime telemetry
- Interrupt signal indicating serial stream
- External Reset input
- Power Supply input
  - +2.8 to +3.6 V with UVLO
- Ultra Low Dimensions
  - 53×32×(+14, -2) mm
  - STEP model available
- Low Package Mass: 33 grams only
- Wide operating temperature range
  - -40˚C to +85˚C
- Connector
  - 2 mm pitch, 2×5 pin header

APPLICATIONS

- Space or Terrestrial Geomagnetic Field Monitoring
- High Altitude Balloons measurement and STEM
- Magnetic Field Educational Toolkit
- Geomagnetic Field mapping in 3D together with GNSS
- Spacecraft Magnetic Cleanliness verification tool during AIV, AIT and Operations
- Space Weather Monitoring

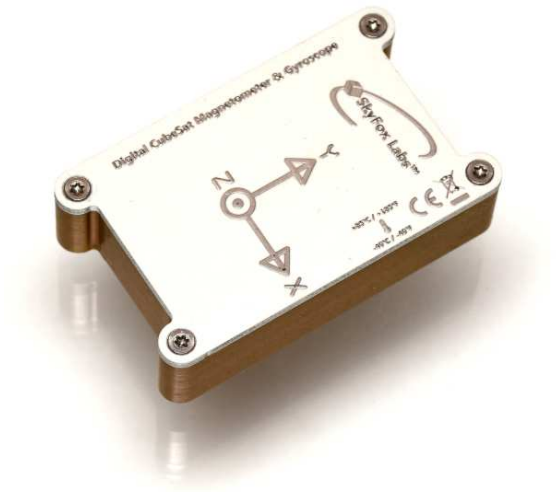


Fig. 1 Digital CubeSat Magnetometer & Gyroscope piMAGGYRO/FM, Flight Model.

GENERAL DESCRIPTION

The piMAGGYRO is the World's First Space-Friendly™ Non Deployable Tri-axial Digital CubeSat Magnetometer and Gyroscope with Telemetry Engine designed to provide in-situ magnetic field measurements in orbit, together with angular rate sensing at ~760 m spatial resolution. B_X, B_Y, B_Z, B_T and ω_X, ω_Y, ω_Z magnetic field and angular rate components respectively are provided at 10 Hz update rate, together with the unit temperature, input voltage and uptime sampling in 100 ms steps by the internal time stamping.

The unit can activate OVERFLUX Alarm, OVERRATE Alarm and ERROR signals in order to inform the upper level system available through GPIO interface within 25 ms reaction time about artificially disturbed Geomagnetic field (local magnetic field disturbance via MTQs, current surges, motors, etc.), too dangerous tumbling rate for most of the satellites in orbit (after the propellant leak, micrometeoroid impact, aero drag, deployable mechanism activation, Geomagnetic synchronization lock, etc.) or about exceeding the expected sensor data ranges. The Engineering Model and Evaluation Kit together with Demo Parsing Software is available for AIV/AIT activities.

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TABLE OF CONTENTS

ABSOLUTE MAXIMUM RATINGS

V_{DD} to GND……..-0.3 V to +3.6 V
DC Input Voltage: V_I ..... -0.3 V to V_{DD} + 0.3 V (≤ 3.6 V max.)
DC Output Voltage: V_O ....-0.3 V to V_{DD} + 0.3 V (≤ 3.6 V max.)
DC Input Current: I_I at V_I < 0 V or V_I > V_{DD} .....±20 mA
DC Output Current: I_O at V_O < 0 V or V_O > V_{DD}.....±20 mA

Other Pins to GND:..... -0.3 V to +(V_{DD} +0.3) V

Operating Temperature Range:……..…-40°C to +85°C
Storage Temperature Range:……...-45°C to +90°C

NOTE: Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under specification conditions is not implied. Exposure to absolute maximum rated conditions for extended periods may affect device reliability. Voltage values are with respect to system ground terminal.

PARAMETRIC SPECIFICATION

T_A = −40°C to +85°C, V_{DD} = 3.3 V, unless otherwise noted.

Parameter	Symbol	Min	Typ	Max	Units	Notes/Conditions
Operating Supply Voltage	V_{DD}	2.8	3.3	3.6	V	Unit is not 5V tolerant. 2.7V undervoltage lockout.
Operating Supply Current	I_D		14		mA	
Active Operating Power	P_{Nom}		50		mW	
Magnetic Field Range per axis	B_{Range}	-300		+300	µT	Total magnetic field intensity provided is equal to 519.615 µT.
Magnetic Field Resolution	$B_{Resolution}$		6		nT	Per each axis.
Magnetic Field Noise	$B_{Resolution}$		20	35	nT_{RMS}	Total magnetic field noise.
Magnetic Noise Density	$B_{MagNoise}$		5		nT/ √ Hz	
Angular Rate Range	DPS_{Range}	-250		+250	°/s (dps)	Range of each X, Y, Z axis.
Angular Rate Resolution	$DPS_{Resolution}$		1		°/s (dps)	Per each X, Y, Z axis.
Angular Random Walk	ARW		0.005		dps/ √ Hz	0.3 degrees per square root hour
Zero Rate Output Tolerance	ZRO		±0.8	±1.9	°/s (dps)	Maximum rated in full temperature range.
Gyro Noise Density	ND		0.005	0.01	dps/ √ Hz	
Temperature Sensor Range	T_{RANGE}	-60		+99	°C	Temperature sensor range higher than operational range. Limit for data output.
Sample Rate	$f_{SampleRate}$		10		Hz	
OVERFLUX Alarm	B_{Alarm}			80	µT	Threshold of total magnetic field strength to trigger OVERFLUX signal. Level oriented signal. Update rate of the signal is 25 ms.
OVERRATE Alarm	DPS_{Alarm}			100	°/s	Threshold of angular rate to trigger OVERRATE signal. Level oriented signal. Update rate of the signal is 25 ms.
Startup time	$T_{STARTUP}$	1		2	s	Time for initial packet transmission and proper DC biasing of analog chain. First datagram sent over UART within $T_{STARTUP}$.
Interrupt signal pre-/post- timing	$T_{INTERRUPT}$		100		µs	Data is transmitted after the interrupt signal goes low. Interrupt signal goes high after packet is sent within $T_{INTERRUPT}$ time.
Error Alarm	$ERROR_{Alarm}$					Temperature over the -40 to +85°C range, Angular rate signal reported higher than 250°/s per axis, total magnetic field exceeding 519615 nT activates the signal. Level oriented signal. Update rate of the signal 25 ms
UART Output Data Bitrate	f_{UART}		115200		bps	115200-8-N-1 UART Data Format.
UART Voltage Signalling		2.8	3.3	3.6	V	Single ended 3.3V LVCMOS level signalling.
Internal Clock Timebase Oscillator	$Xtal$		7372800		Hz	20 ppm Frequency Tolerance + 50 ppm Frequency Stability over the temp. range.
Packet Output Frequency	$f_{PacketRate}$		10		Hz	Timing derived from crystal oscillator.
Datagram Length	$f_{PacketRate}$		69		B	Fixed Length data + CR+LF, ~6 ms.

CONNECTOR DESCRIPTION

The piMAGGYRO unit is connected to the target system via the System Interface dual row 2×5 pin connector header with miniature 2 mm pitch passing through the hosting board. Each pin, its function and direction or manner of use is indicated in the Tab.: 1 below. The connector location within the Flight and Engineering Model is displayed in Fig. 2.

Tab.: 1 **The piMAGGYRO Pin Description**, NOTE: Minimum required interface pins are highlighted.

Pin	Name	I/O, Power or Do Not Connect	Description
1	**VDD**	**Power**	**Main Power Input. +3.3V** typical.
2	/INTERRUPT	O	**Interrupt Signal Output.** In multiplexed systems, this signal may serve as interrupt of the host system. Data packet transmission is announced by INTERRUPT signal low. After the final byte is send, INTERRUPT signal goes high with $T_{INTERRUPT}$. LVCMOS compatible.
3	**GND**	**Power**	**Ground potential.** Unit casing (including all screws) is galvanically connected to this pin internally.
4	/ERROR	O	**Error Signal Output.** Error signal goes low when the temperature over the -40 to +85°C range, Angular rate signal reported higher than 250°/s per axis, total magnetic field exceeding 519615 nT is detected. Level oriented signal, 25 ms signal update rate. LVCMOS compatible.
5	**GND**	**Power**	**Ground potential.** Unit casing (including all screws) is galvanically connected to this pin internally.
6	/OVERFLUX	O	**Total Magnetic Field over Natural Geomagnetic Range in LEO detected.** Signal is activated when the Total Magnetic Field measured is higher than 80 µT, 25 ms signal update rate. Active low. LVCMOS compatible.
7	/OVERRATE	O	**Angular Rate per Axis exceeding predefined Limit detected.** Signal is activated when the Angular Rate is higher than ± 100°/s in any axis, 25 ms signal update rate. Active low. LVCMOS compatible.
8	RXD	I	**Serial Data Input.** Telecommand Input. Reserved for future use. LVCMOS compatible.
9	/RESET	I	**System reset.** Active Low. Pin could be used to force digital signal processing core reset. Internal 10 kOhm pullup. LVCMOS compatible.
10	**TXD**	**O**	**Serial Data Output.** Data is sent out of this pin in format 115200-8-N-1, with a period of 100 milliseconds. Interrupt signal (Pin 2 - INTERRUPT) is announcing packet transmission before and after data is sent. LVCMOS compatible.
Chassis	**GND**	**Power**	**Ground potential.** Unit casing (including all screws) is galvanically connected to this pin internally.

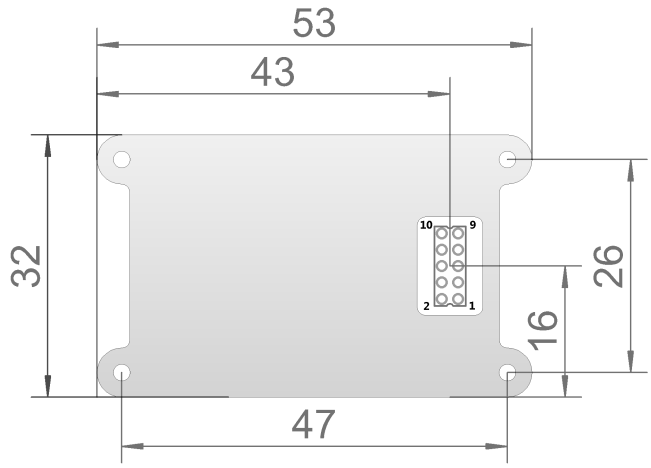

Fig. 2 **The piMAGGYRO Dimensions, Connector pinout and recommended footprint.** NOTE: The piMAGGYRO is displayed from the TOP side. Pins from the through hole connector are aiming down through and below the system PCB. The SMD mount connector type HARWIN M22-6360542 is recommended. Dimensions are shown in millimeters. The unit is mount using four M2×8 screws (including 1.6 mm system PCB). Detailed STEP model available.

PROTOCOLS

The physical communication is realized via the standard UART data interface. The baud rate is set to **115200 bps, no parity, 8 data bits, 1 stop bit (115200-8-N-1)**. Logical levels are equal to LVCMOS levels as defined in JEDEC JESD8C.01 standard. The piMAGGYRO provides serialized stream of measured magnetic field, angular rates, unit temperature, input voltage readings and unit uptime data approximatelly 1-2 seconds after the unit startup / power cycle / reset. Initial info/product FW version text is provided immediatelly after unit startup / power cycle / reset.

The unit does not need any telecommand to automatically produce the measured data/sentences, thus the RXD pin can be also left unconnected. Reception of data via RXD pin is reserved for future use.

The /OVERFLUX Alarm signal is triggered (goes log. 0) within 25 ms period after measuring, calculating and detecting the total magnetic field intensity (B) exceeding predefined (fixed) threshold of 80 μT, which is expected to be a maximum geomagnetic field detected during operations in LEO over polar cusps. Higher total magnetic field values may indicate magnetic contamination of the spacecraft or local electromagnetic field disturbances. It holds and is released (goes log. 1) 25 ms since the threshold is not exceeded.

The /OVERRATE Alarm signal is triggered (goes log. 0) within 25 ms period after calculating and detecting the angular rate is exceeding predefined (fixed) threshold of 100°/s which is expected to be a cautious angular rate of spacecraft freeflyer in typical orbit operations. It holds and is released (goes log. 1) 25 ms since the threshold is not exceeded.

The /ERROR signal is triggered (goes log. 0) when the temperature measured is over the -40 to +85°C, Angular rate reported higher than 250°/s per axis in each axis (ω_x = ±250 and ω_y = ±250 and ω_z = ±250), or total magnetic field exceeding 519615 nT (B_X = ±300 and B_Y = ±300 and B_Z = ±300) in each axis is detected. It holds and is released (goes log. 1) 25 ms since all conditions of error thresholds are not exceeded.

Each data packet sent out of the piMAGGYRO is acompanied with /INTERRUPT signal announcing upper level system about the planned, progressing and ended serial stream using log. 0. This signal may be used for upper level multiplexing of UART bus in case of sharing with multiple users. At least 100 μs is provided prior and after the serial stream on /INTERRUPT signal.

OUTPUT DATA DESCRIPTION

The unit provides serialized information about three magnetic vector components, followed by a derived total magnetic field (B_T). The angular rates are sent separately in X, Y and Z component. Upcoming item is temperature sensor readout in °C, followed by voltage measurement (V) and the unit/sample uptime in 100 ms resolution. Output is represented by conventional ASCII character form and thus could be easily displayed using computer with any serial terminal software for COM port data reception. Data is initiated by $ character, ended by # character and termindated by CR+LF characters, the only unprintable characters located at the end of each dataset. There are no other binary data in the stream for easy parsing and error detection.

The physical communication is realized via the standard bidirectional UART data interface. Uplink for telecommands is reserved for future use. The bitrate is set to **115200 bps, no parity, 8 data bits, 1 stop bit (115200-8-N-1)**. Logical levels are equal to LVCMOS levels as defined in JEDEC JESD8C.01 standard.

Each output data item has a fixed lenght, according to its respective purpose, i.e. in case of temperature, the +1°C is indicated as +01°C, -1°C as -01°C and 0°C as +00°C, respectively.

EXAMPLE DATA OUTPUT SINCE POWER UP

(Data listed below are collected ~approx. 2 sec. since the unit power up).

```
⇐⏎
|======================|⇐⏎
|    piMAGGYRO v1.2     |⇐⏎
|     Flight Model      |⇐⏎
| (c) SkyFox Labs, 2026 |⇐⏎
|======================|⇐⏎
⇐⏎
$-006866;-012091;+028473;031686;+000;+000;+000;+27;3.25;00000000.0#⇐⏎
$-006860;-012207;+028424;031685;+000;+000;+000;+27;3.26;00000000.1#⇐⏎
$-006915;-012281;+028375;031682;+000;+000;+000;+27;3.26;00000000.2#⇐⏎
$-006867;-012335;+028339;031660;+000;+000;+000;+27;3.26;00000000.3#⇐⏎
$-006799;-012384;+028265;031599;-001;+000;+001;+27;3.26;00000000.4#⇐⏎
$-006708;-012451;+028119;031475;+000;+000;+000;+27;3.26;00000000.5#⇐⏎
$-006653;-012475;+028095;031451;+000;+000;+000;+27;3.26;00000000.6#⇐⏎
$-006684;-012476;+028076;031441;-001;+000;+001;+27;3.26;00000000.7#⇐⏎
```

DIGITAL OUTPUT EXAMPLE

```
$-007043;-013898;+030774;034493;+000;+000;+000;+25;3.26;00001354.4#⇐↵
```

`$`	packet initial character (0x24h), fixed position
`-`	signum character (+ or -), 0 is indicated as +000000 positive number, fixed position
`007043`	$\mathbf{B_X}$ magnetic field vector component in nanoTesla (7.043 µT), fixed length, 6 digits, fixed position, aligned with **+Y axis**
`;`	semicolon character (0x3Bh), fixed position
`-`	signum character (+ or -), 0 is indicated as +000000 positive number, fixed position
`013898`	$\mathbf{B_Y}$ magnetic field vector component in nanoTesla (13.898 µT), fixed length, 6 digits, fixed position, aligned with **+X axis**
`;`	semicolon character (0x3Bh), fixed position
`+`	signum character (+ or -), 0 is indicated as + positive number, fixed position
`030774`	$\mathbf{B_Z}$ magnetic field vector component in nanoTesla (30.774 µT), fixed length, 6 digits, fixed position, aligned with **-Z axis**
`;`	semicolon character (0x3Bh), fixed position
`034493`	$\mathbf{B_T}$ total magnetic field in nanoTesla (34.493 µT), fixed length, 6 digits, fixed position, always positive, with no signum character
`;`	semicolon character (0x3Bh), fixed position
`+`	signum character (+ or -), 0 is indicated as + positive number, fixed position
`000`	ω_x angular rate in X axis, fixed length, 3 digits, fixed position, aligned with **Pitch**
`;`	semicolon character (0x3Bh), fixed position
`+`	signum character (+ or -), 0 is indicated as + positive number, fixed position
`000`	ω_y angular rate in Y axis, fixed length, 3 digits, fixed position, aligned with **Roll**
`;`	semicolon character (0x3Bh), fixed position
`+`	signum character (+ or -), 0 is indicated as + positive number, fixed position
`000`	ω_z angular rate in Z axis, fixed length, 3 digits, fixed position, aligned with **Yaw**
`;`	semicolon character (0x3Bh), fixed position
`+`	signum character (+ or -), 0 is indicated as + positive number, fixed position
`25`	**Unit Temperature** in °C, fixed length, 2 digits, fixed position
`;`	semicolon character (0x3Bh), fixed position
`3.26`	**Input Voltage** in Volts, fixed length, 3 digits with 1 fixed decimal point, fixed position
`;`	semicolon character (0x3Bh), fixed position
`00001354.4`	unit **Uptime** and sample number, fixed length, 9 digits with 1 fixed decimal point, fixed position, range 00000000.0 to 99999999.9 seconds (3 years, 2 month period)
⇐	CR character (0x0Dh)
↵	LF character (0x0Ah)

TIMING DIAGRAM

Serialized data is available at the TXD output pin as per timing in Fig. 3. Packet transmission is notified by /INTERRUPT signal. No commanding or setting is needed to use the piMAGGYRO. Data received on RXD pin are ignored and serves for future use.

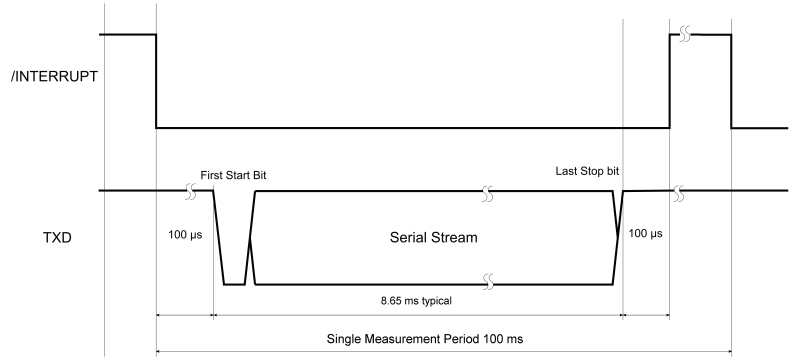

Fig. 3 The piMAGGYRO /INTERRUPT and TXD output signals timing diagram, single measurement period.

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EVALUATION KIT

The piMAGGYRO Evaluation Kit in a standard PC/104+ PCB form factor in Fig. 4 has been developed to support the device implementation together with the serial data parsing and signal recognition software development in engineering and breadboarding phases. It enables user to easily connect and power the unit from the USB or the PC/104+ stack connector, collect the data over the serial link established by the FTDI Serial-to-USB cable. Current consumption measurement and output data waveforms can be captured by conventional ammeter and scope using current sensing and serial port pin headers. The extension header is available for a direct connection to the unit, when mechanically mounted. Schematic diagram is mentioned in Fig. 6.

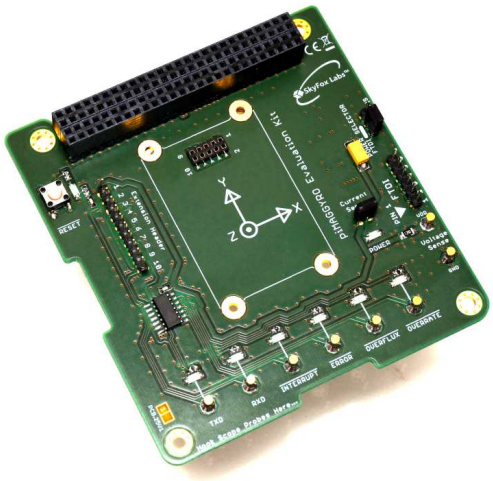

Fig. 4 The piMAGGYRO PC/104+ Evaluation Kit.

For the piMAGGYRO data parsing purposes the piMAGGYRO Eval Kit TM/TC Demo Software application for Windows® environment has been developed. The program can visualize the trend of all the measured values and display the unit activity, such as the voltage, temperature or uptime in seconds. In Fig. 5 the screenshot of the active application is provided.

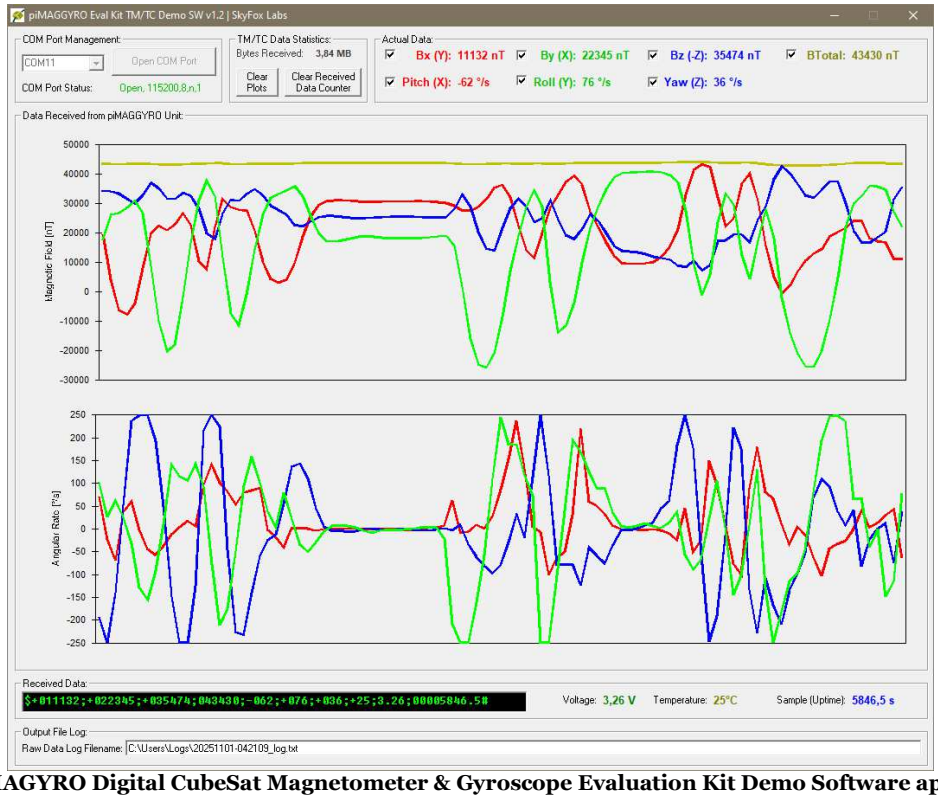

Fig. 5 piMAGYRO Digital CubeSat Magnetometer & Gyroscope Evaluation Kit Demo Software application.

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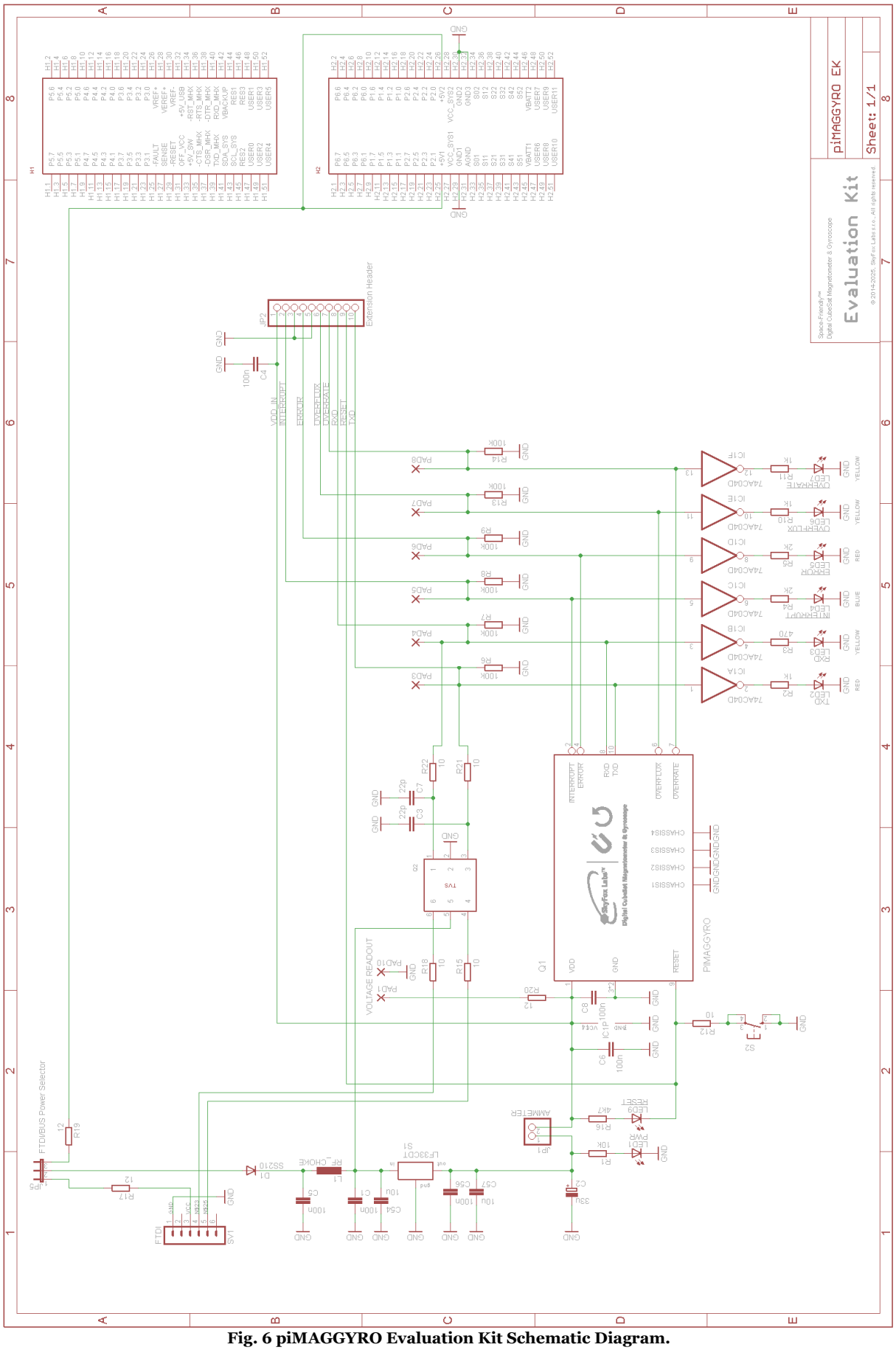

Fig. 6 piMAGGYRO Evaluation Kit Schematic Diagram.

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APPLICATION NOTES & RECOMMENDATIONS

EMC CONSIDERATIONS

The electromagnetic susceptibility and compatibility is critical for implementation of any subsystems sensitive to electromagnetic radiation. Proper ground planes and PCB design rules minimizing the radiated and conducted emissions shall be applied within the whole small satellite structure, including custom payloads, conventional (Communication and Data Handling, Power Supply and Power Distribution, Onboard Computer, Attitude Determination and Control) and third party electronic subsystems which may disturb local magnetic field around the sensor. Vibrations induced by deployable mechanisms, actuators, motors and engines or deployment mechanism carousels, ratchets, etc. can all affect the readout of angular rate steady states.

SENSOR LOCATION

Sensor is located within the volume of the aluminium housing as depicted in Fig. 7 below.

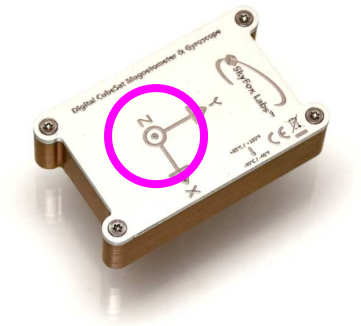

Fig. 7 Sensor location depicted in Z axis, 7 mm above/below top/bottom part of the piMAGGYRO housing.

SYSTEM COORDINATES

There are different coordinate systems usually used in avionics and aerospace sensor systems. The North East Down (or NED) system, where X axis is aligned with forward direction, Y axis aligned with right viewing direction and Z axis aligned with direction towards the Earth center (ground) is typically used in AHRS systems for the magnetic field vector components coordinates. The CubeSat structure coordinate system is different from the NED system and is naturally depicted on the TOP cover of the piMAGGYRO. Their implementation is depicted in Fig. 8.

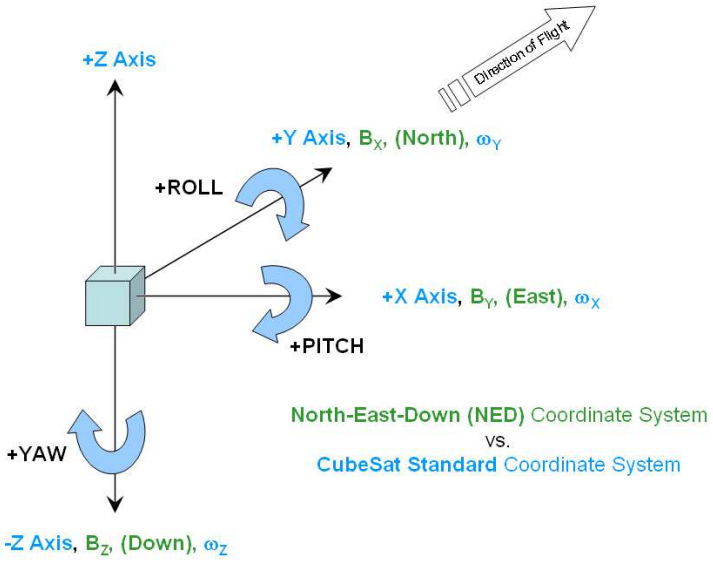

Fig. 8 piMAGGYRO Coordinate system for Magnetic Field vector components and Angular Rate sensor axes.

QUALITY ASSURANCE

GENERAL INFORMATION

Since the piMAGGYRO has been designed for the operation in space environment as a specially featured electronic device based on Commercial Off-the-Shelf (COTS) components, the special care is taken to follow the standardized space-grade product assembly procedures, materials and components where possible (i.e. no Radiation Hardened integrated circuits or parts are used). It is recommended to control the possible single event latchups of the unit based on overcurrent/overload monitoring on the unit main power input. Maximum recommended Latchup Current Limit is specified as 70 mA, over the period of 10 milliseconds.

MATERIALS

Components are soldered on the FR4 PCB, using 60/40% (Tin/Lead) compound, PCB conformal coating surface finish is applied to prevent outgassing. The NASA approved 3M Scotch Weld Epoxy adhesive is used for radiation shielding screws and components fixings. The aerospace-grade NC-machined 6061-T6 Aluminium alloy is used for the product housing.

Vacuum-proof electronic components from ESA and NASA-preferred vendors are used (i.e. no electrolytic capacitors) in industrial temperature grade, where possible.

PACKAGING & SHIPPING

Once the piMAGGYRO successfully passes the screening test, it is finally cleaned, optically inspected and shipped encapsulated in ESD protective packaging.

EXPORT CONTROL

Since the country of origin of this product (the Czech Republic) is a valid participating member of the Wassennaar Agreement (http://www.wassenaar.org) and agrees with the Missile Technology Control Regime (http://www.mtcr.info) and the **piMAGGYRO/FM, piMAGGYRO/EM, piMAGGYRO/EK (Space-grade Flight Model, Engineering Model, Evaluation Kit)** functional parameters are considered as a regulated goods, the export is controlled and needs special Export License approved by the Ministry of Industry and Trade of the Czech Republic (the local control entity). The request for the Export License has to be submitted by the manufacturer to the local control entity, based on the binding order, including all the information as: the characteristics of goods, target country (territory), detailed end-user and target application information, etc.

DISCLAIMER

THIS MAGNETIC FIELD AND ANGULAR RATE SENSOR INSTRUMENT DEVICE HAS BEEN DEVELOPED WITH IDEA TO SUPPORT THE SMALL SATELLITE COMMUNITY EFFORT IN SPACE RELATED RESEARCH, ENGINEERING AND PEACEFUL CONQUEST OF SPACE. THE MANUFACTURER RESERVES ALL RIGHTS TO DECLINE THE ORDER OF THIS PRODUCT OR PROVIDE ANY FURTER INFORMATION TO END USERS ASSUMING TO VIOLATE ANY LOCAL OR GLOBAL NATIONAL LAWS BY THIS DEVICE OR INFORMATION MENTIONED IN THIS AND RELATED DOCUMENTS. MANUFACTURER DOES NOT ASSUME ANY LIABILITY ARISING OUT OF THE APPLICATION OR USE OF THIS PRODUCT OR CIRCUIT DESCRIBED HEREIN; NEITHER DOES IT CONVEY ANY LICENSE UNDER ITS PATENT RIGHTS, NOR THE RIGHTS OF OTHERS. MANUFACTURER RESERVES THE RIGHT TO MAKE CHANGES OF THIS PRODUCT DATASHEET WITHOUT FURTHER NOTICE.

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