SkyFox Labs™

Your easy way to space.

Space-Friendly™

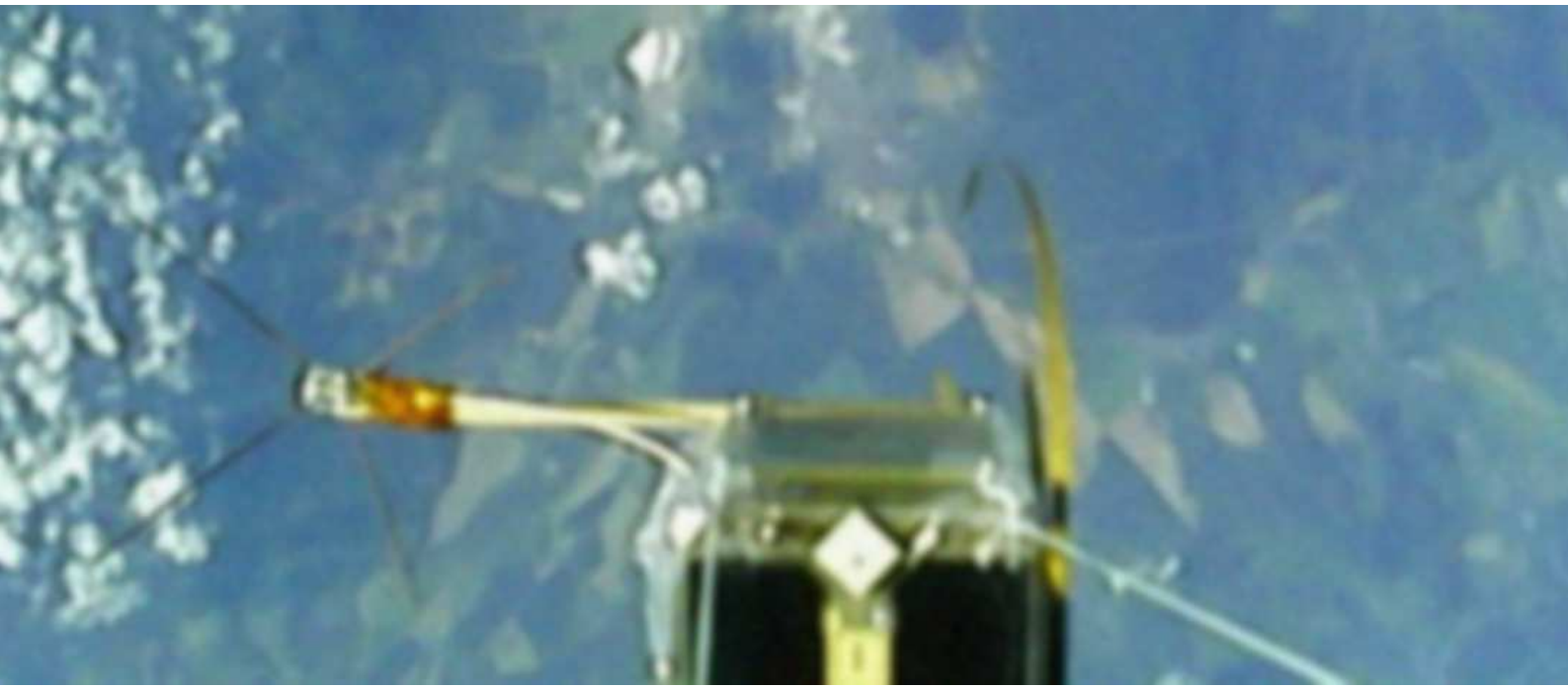
CubeSat **Space Weather Monitor**

piPLASMA

Product Datasheet

Rev. A/2024

Intended to cover all **CubeSat Project** needs.



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

PRODUCT DATA SHEET piPLASMA

FEATURES

- **World's First CubeSat Space Weather Monitor**
- **Ion Plasma Langmuir Probe instrument**
- **Langmuir Probe Negative Bias and Preamplifier**
- **Photoelectric Effect Sensor Input and sensing**
- **Solid State Low Power Dosimeter/Geiger Counter**
- **Low Power CubeSat GPS Receiver with DROP (Dead Reckoning Orbital Propagator)**
- **50nT$_{RMS}$ 3-axis AMR Magnetometer**
- **±250°/s (DPS) 3-axis MEMS Angular Rate Sensor**
- **Two ~0.07 Am^2 Magnetorquer Rods with bipolar drivers in X-Y standard CubeSat coordinates**
- **Sample rates 4 Hz, 1 Hz, 0.25 Hz, 0.0625 Hz**
- **Ion Density measurements spatial resolution down to 1.9 km at SSO LEO velocity**
- **Housekeeping Measurements Engine**
- **Straightforward use – Plug-and-play device**
- **Allow Nonstop Operation with conventional 1U CubeSat power budget**
- **Power consumption**
  125 mW (typical), 3.3 V @ 25°C
- **GPS L1 C/A signal, 15 channels, LEO operation**
  Altitudes up to 3600 km
- **Velocity**
  up to 9 km/s (Flight Model)
  up to 0.5 km/s (Engineering Model)
- **Cold start time in LEO (Time-to-First Fix t_{TTFF})**
  80 seconds (typical)
- **Sensitivity**
  Acquisition 38 dBc-Hz, Tracking 25 dBc-Hz
  Short term fading 18 dBc-Hz
- **Protocols**
  Base64 Encoded Output, 1-Byte Command
- **Easy-to-Implement Data Interface**
  UART 9600-8-N-1, 3V3-CMOS levels
- **Position update rate**
  1 Hz
- **2.9 to 3.6V power supply**
- **Low Dimensions, PC/104+ 95.9×90.2×32 mm**
- **Wide temperature range**
  -40˚C to +85˚C
- **Connectors**
  PC/104+ pin header (System Interface)
  3× MCX (GPS Antenna, Langmuir Probe, Photoelectric sensor)
- **Supports High Gain Passive and Active GPS Antennas, DC Bias Output (3.3V @ 50mA)**

APPLICATIONS

- **Space Weather Monitoring on Small Satellites**
- **CubeSats, PocketQube, Pico- Nano- Micro-Sats**
- **Space Science and Engineering**

Fig. 1 PC/104+ CubeSat Space Weather Monitor, Flight Model, Top side view.

GENERAL DESCRIPTION

The piPLASMA is the World's First Space-Friendly™ CubeSat Space Weather Monitor unit intended for in-situ orbital environment measurements. The system consist of the full Langmuir Probe instrument electronics, 3-axis AMR magnetometer, 3-axis MEMS angular rate sensor (gyroscope), solid-state low power Dosimeter/Geiger Counter in non-magnetic finish, ultra low power 15 channel CubeSat GPS L1 receiver with DROP (Dead-Reckoning Orbital Propagator) and a set of two magnetorquer rods to validate the magnetic field measurements and Coarse Attitude Control in X-Y plane, with drivers.

Flight heritage optimized firmware uses the SkyFox Labs' proprietary DROP (Dead Reckoning Orbital Propagator) algorithm to compensate for orbital regions affected by terrestrial jammers penetrating to LEO regions causing GPS signal outage as well as for signal fading caused by improper antenna pointing or satellite tumbling without the need for uplink data.

The Engineering Model (EM) with the same mechanical and electrical properties is available with software limitation to maximum velocity (500 m/s). Red Remove Before Flight Finish is applied to prevent interchange with the Flight Model unit.

Issue rev. A, 2024, info@skyfoxlabs.com, U Studanky 620/13. CZ-17000, Prague, Czech Republic, EU,

TABLE OF CONTENTS

ABSOLUTE MAXIMUM RATINGS

V_{DD} to GND.....-0.3 V to +4.2 V
DC Input Voltage: V_I ..... -0.3 V to V_{DD} + 0.3 V (≤ 4.2 V max.)
DC Output Voltage: V_O ....-0.3 V to V_{DD} + 0.3 V (≤ 4.2 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
Maximum RF Input Power:..... +15 dBm
Maximum Output Current to the Active Antenna:.....50 mA
Operating Temperature Range:.....-40°C to +85°C
Storage Temperature Range:.....-55°C to +100°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, Active 35×35 mm GPS patch antenna with LNA preamplifier used, unless otherwise noted.

Parameter	Symbol	Min	Typ	Max	Units	Notes/Conditions
Operating Supply Votlage	V_{DD}	2.9	3.3	3.6	V	
Operating Supply Current	I_D	50	155	185	mA	The maximum operational current of up to 185 mA is drawn when GPS and both MTQs are active with full operational mode after the GPS startup boot time of ~30 sec.
Active Antenna Current Feed Capability	I_{Ant}	0		20	mA	Use of an active antenna is recommended for improving the C/N_0 (SNR).
Operating Power Consumption with Active GPS Antenna	$P_{Oper\text{-}Act}$	165	512	610	mW	Minimum power is consumed with GPS and MTQs off.
Acquisition Sensitivity	$P_{RF\_IN\text{-}Acq}$		38		dBc-Hz	SNR required to acquire the GPS signal.
Elevation Mask Filter	ε		3		°	Sats below the mask excluded from PVT.
Tracking Sensitivity	$P_{RF\_IN\text{-}Trck}$	18	25		dBc-Hz	SNR to keep tracking the satellites in view.
PVT Calculation Filter			30		dBc-Hz	Sats below the level excluded from PVT.
Operating Frequency	f_{RFIN}		1575.42		MHz	GPS L1, C/A code.
Operating Bandwidth	BW		2		MHz	
Time-to-First-Fix	t_{TTFF}		80		s	The piNAV-NG Cold Start time.
Warm Start Time	t_{WST}		50		s	The piNAV-NG DROP Warm Start time.
Horizontal Position Accuracy (2σ)	HPA			10	m	No multipath signals (ionosphere and troposphere delay excluded), HDOP <3 caused by the noise and mutual acceleration of the LEO and GPS satellite ±16 m/s^2.
Dynamic Stress Position Error	$DSPE$			2	m	Caused by the satellite movement in LEO orbit.
Operating Velocity	v	0		9	km/s	For Flight Model only. Otherwise maximum of 500 m/s.
Operating Altitudes	h			3600	Km	Above the WGS84. All orbit inclinations.
Operating Acceleration	a	0		5	g	
Velocity Calculation Accuracy (2σ)	VCE			0.1+1‰·v	m/s	
Radiation sensor energy range	E	~0.2		10	MeV	Probability of capture is given by the sensor geometry, cross section and dose rate.
Doserate range per hour	$\dot{D}$	0.01		9000	µSv/h	Maximum dose rate given by system bandwidth.
Dosimeter Energy range	E	~0.2		10	MeV	Probability of capture is given by the sensor geometry, cross section and dose rate.
Langmuir Probe Impedance range	Z	0		250	GΩ	Maximum sensitivity in maximum resolution and x10 gain.
Magnetorquer Magnetic Moment	M			~0.07	Am^2	N = 4000 turns, l = 55 mm, I = 27 mA.
3-axis AMR Magnetometer RMS Noise	B		50		nT	1 LSB.
3-axis MEMS Gyroscope Range				±250	°/s	

Issue rev. A, 2024, info@skyfoxlabs.com, U Studanky 620/13, CZ-17000, Prague, Czech Republic, EU,

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 **piPLASMA/FM, piPLASMA/EM (Space-grade Flight Model, Engineering Model)** functional parameters are considered as a regulated (Dual Use) 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.

Issue rev. A, 2024, info@skyfoxlabs.com, U Studanky 620/13, CZ-17000, Prague, Czech Republic, EU,

DISCLAIMER

THIS 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. THE UNIT MUST NOT BE USED IN ANY SAFETY-CRITICAL APPLICATION, OR MILITARY-RELATED, OR BY ARMED FORCES, OR BY POLICE GUARDS, OR IN NUCLEAR FACILITIES, OR IN RELATION TO OIL AND GAS MINING, ON LAUNCHERS, MISSILES, TARGET DRONES, WEAPONS OF MASS DESTRUCTION, OR GOVERNMENTAL END USE OR END USER. SAFETY-CRITICAL SYSTEMS ARE THOSE SYSTEMS WHOSE FAILURE COULD RESULT IN LOSS OF LIFE, SIGNIFICANT PROPERTY DAMAGE OR DAMAGE TO THE ENVIRONMENT. THE LIST CONTAINS MOST IMPORTANT AREAS OF PROHIBITED USE AND IS NOT COMPLETE. FOR MORE DETAILS, PLEASE CONTACT FACTORY.

Prague, Czech Republic