

Introduction to the IFM Nano Thruster

For **15 years**, FOTEC has followed a **technology push from ESA** developing a FEEP propulsion technology for a precise orbit control of scientific satellites in formation flight. This very mature and worldwide unique technology is meeting a **strong need in an emerging market of satellite constellations** (hundreds of small satellites performing a task together). ENPULSION has been founded as a Spin-Out together with FOTEC to meet this market demand by preparing to **scale the production of this thruster to several hundred units per year**.



PRODUCT FEATURES

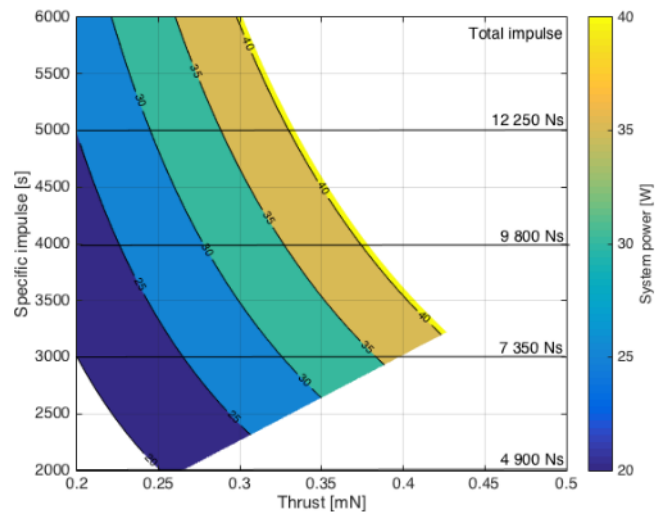
MATURE TECHNOLOGY	The IFM Nano Thruster is a mature technology, developed under ESA contracts for 15 years. In this time more than 100 emitter have been tested and an ongoing lifetime test has demonstrated more than 17.000 h of firing without degradation of the emitter performance.
DYNAMIC PRECISE THRUST CONTROL	The thrust can be controlled through the electrode voltages, providing excellent controllability over the full thrust range and a low thrust noise.
CONTROLLABLE SPECIFIC IMPULSE UP TO 6000 S	Due to the efficient ionization process, which allows the capacity to ionize up to 60% of the evaporated Indium atoms, the IFM Nano Thruster can provide a higher specific impulse than any other ion propulsion system currently on the market.
REDUNDANT NEUTRALIZER CATHODES	As the IFM Nano thruster expels an ion current of up to 4 mA, the module needs means to prevent spacecraft charging. This is achieved by the use of two cold-redundant electron sources acting as neutralizers. Such an electron source consists of a Tantalum disc which is heated up to 2,200 K and biased to -200 V. Once electrons have left the neutralizer, they will be pulled towards the positive potential of the ion plume. The PPU is able to measure and control this charge balancing electron current.
SAFE AND INERT SYSTEM COMPLIANT WITH ALL LAUNCHER REQUIREMENTS	The IFM Nano contains no moving parts and the propellant is in its solid state at room temperature. Avoiding any liquid and reactive propellants as well as pressurized tanks significantly simplifies handling, integration and launch procedures.
COMPACT BUILDING BLOCKS	The IFM Nano thruster module is used as a compact pre-qualified building block in order to provide custom solutions at a commodity price and ultra-short lead times Although, building blocks are completely self-contained propulsion systems, the whole cluster can be operated as a single plug-and-play unit.
THRUST VECTORING	By clustering the IFM Nano modules, one may take advantage of the significant thrust vectoring capabilities for use in small satellites and/or micro satellites.

PROPERTIES AND PERFORMANCE



While the required power to operate the IFM Nano Thruster starts at around 8 W, at higher thrust levels one can choose between high thrust and high specific impulse operation. The IFM Nano Thruster can operate at an Isp range of 2000 to 6000 s. At any given thrust point, higher Isp operation will increase the total impulse, while it will also increase the power demand. The thruster can be operated along the full dynamic range throughout the mission. That means, that high Isp and low Isp maneuvers can be included in a mission planning, as well as high thrust orbit maneuver and low thrust precision control maneuvers.

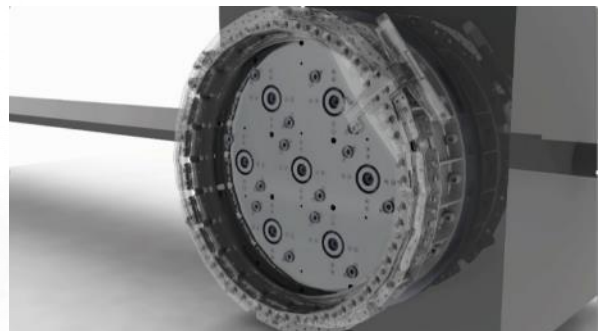
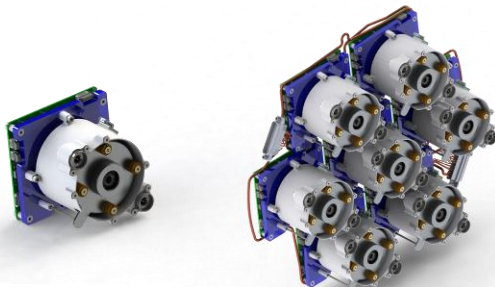
PARAMETER	VALUE
Dynamic thrust range	10 μ N to 0.4 mN
Nominal thrust	350 μ N
Specific impulse	2,000 to 6000 s
Propellant mass	230 g
Total impulse	more than 5,000 Ns
Power at nominal thrust	40 W incl. neutralizer
Outside dimensions	97.6 x 97.6 x 82.5 mm
Mass (dry / wet)	670 / 900 g
Total system power	8 – 40 W
Hot standby power	3.5 W
Command interface	RS422/RS485
Temperature envelope (non-operational)	-40 to 105°
Temperature envelope (operational)	-20 to 40 °C
Supply voltage	12V, 28 V, other voltages upon request

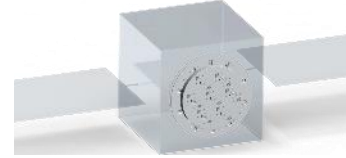
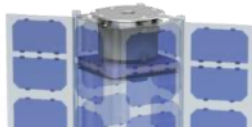


Depending on available power, the user can choose from any operational point

MODULARITY

The IFM Nano Thruster can be clustered in order to **meet any specific mission need**. As we are using a number of pre-qualified modules (building blocks), this customization can be done **without increasing the cost or lead times of the thruster**.





Number of Modules	1	2	3	4	5	6	7
Total Impulse	> 5000 Ns	> 10000 Ns	> 15000 Ns	> 20000 Ns	> 25000 Ns	> 30000 Ns	> 35000 Ns
System Mass (wet)	1 kg	2* kg	3* kg	4* kg	5* kg	6* kg	7* kg
System Volume	0.6 dm ³	1.2 dm ³	1.8 dm ³	2.4 dm ³	3 dm ³	3.6 dm ³	4.2 dm ³

* Additional mass for brackets or housings might be necessary depending on the accomodation of the thruster modules on the spacecraft.

		Δv [m/s]						
Spacecraft Mass [kg]	2	2879						
	3	2141	3480					
	5	1415	2456	3254	3886			
	10	766	1415	1972	2456	2879	3254	3587
	15	525	993	1415	1795	2141	2456	2744
	20	399	766	1103	1415	1703	1972	2222
	30	270	525	766	993	1209	1415	1610
	40	204	399	586	766	938	1103	1262
	50	164	322	475	623	766	904	1038
	70	118	232	344	453	560	664	766
100	83	164	244	322	399	475	549	
150	55	110	164	217	270	322	374	
200	42	83	123	164	204	244	283	

