n-ART EPS

Electrical Power System (EPS)

Interface Control Document

DOCUMENT CONTROL	
Name	n-ART EPS Interface Control Document
Version	1.0
Author	Mustafa Erdem Baş Mustafa Karataş
Content	Interface Properties of n-ART EPS
Date	21.09.2020
Pages	18

REVISION CONTROL		
First Issue Ver. 1.00	Date	18.02.2021
	Updated Content	Some minor changes applied.
	Prepared by	Mustafa Erdem Baş Mustafa Karataş
	Reviewed by	Enes Erdoğan
	Approved by	Murat Süer

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1 Introduction and Scope

This document provides necessary information on the features, operation, handling, and storage of n-ART EPS products, a power management board for use on CubeSats, MicroSats, and other non-standard spacecrafts.

n-ART EPS manages all the conversion and distribution processes of useable electrical energy generated by solar panels to charge batteries and supply satellite subsystems.

n-ART EPS has different options for Engineering and Flight Models. Highly efficient DC/DC converters supply 3,3 V, and 5 V power bus as standard, with output capability, limited to standard bus connector current capacity, low-ripple, high accuracy, and fast transient response. n-ART EPS provides the third additional voltage as an option from 8 V to 35 V.

2 Overview

- ✓ n-ART EPS Electric Power Subsystem (EPS) is one of the most powerful EPS for CubeSats and provides superior life cycle, depth of discharge, efficiency and reliability compared to its alternatives.
- ✓ n-ART EPS provides 3 individuals highly efficient MPTT's to supply the CubeSat or another non-standard spacecraft.
- ✓ Power bus is monitored and controlled continuously by digital circuits and accessible via data bus.
- ✓ Components used on the system are selected from previous missions and/or thoroughly tested on TVAC to ensure best performance and high reliability on orbit.

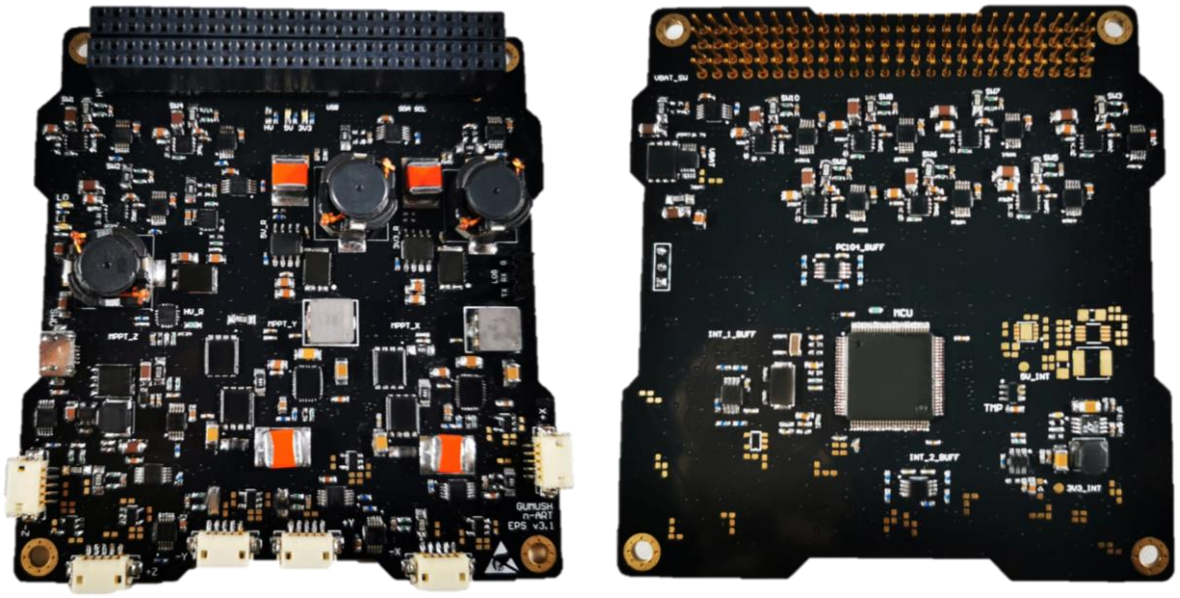

Figure 1: n-ART EPS

General properties of n-ART EPS are given in the table below.

Table 1: General Properties of n-ART EPS

Properties	Values
Communication Interface	I2C
Independent Output Supply Units	10 Units (1A Max.)
Microcontroller Architecture	ARM Cortex M4
Battery Compatibility	Li-Ion / Li-Po
Watchdog Timer (WT)	1 Unit
Power Outputs	3.3V, 5V, Optional V, Vbat
Microcontroller Software Architecture	Real Time Operating System
USB Charge Interface	Yes (H1.32)
Maximum Power Point Tracking (MPPT) Regulator	3 Units
Solar Panel Temperature Sensor Connection	6 Units
Solar Panel Light Sensor Connection	6 Units
Reset Option	Hardware
Protections	Over Current Over/Low Voltage Latch-Up Over Temperature Over Load

2.1 Basic Functional Schematics

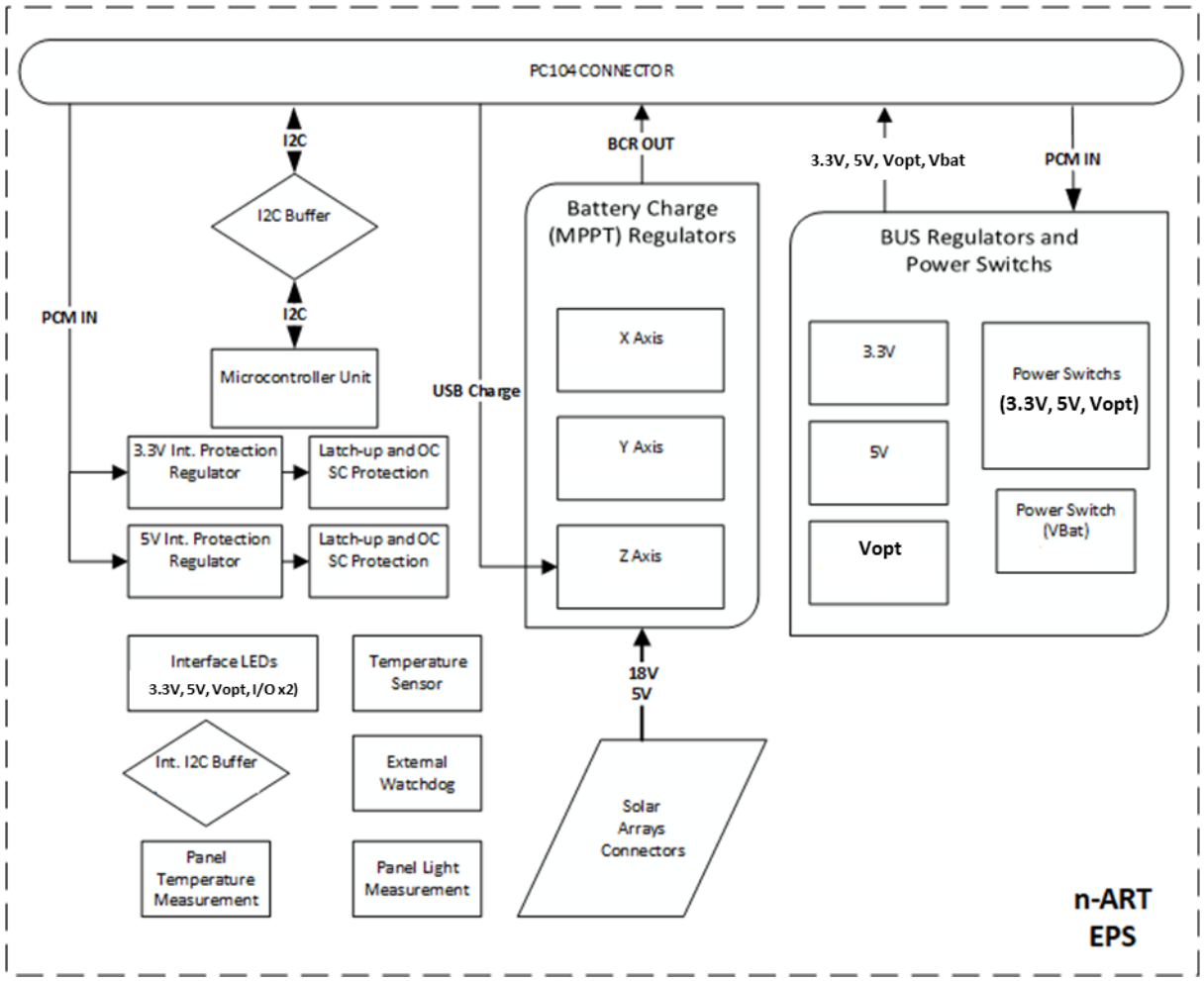

Figure 2: Basic Schematics of n-ART EPS

3 Maximum Ratings

Table 2: Maximum Ratings of n-ART EPS

Properties		Values
Input Voltage	3U Solar Panel Input	30 V
	1U Solar Panel Input	6 V
	Battery	8.4 V
Output Voltages		V_{bat} (6.2-8.4 V) 3.3 V 5 V Vopt (8 – 35 V)
Operating Temperature Range		-30 to +60 °C
Storage Temperature Range		-40 to +70 °C
Vacuum		10^{-5} Torr
Vibration		Random Vibration Sine Vibration Structural Loads Ref: NASA GEVS: GSFC-STD-7000A (Qualification Level Verification)

4 Characteristics and Interfaces

4.1 Electrical Characteristics and Interfaces

4.1.1 Electrical Properties

Table 3: Electrical Characteristic Table

Electrical Properties	Value
Supply Voltage	V_{bat} (6.2-8.4 V)
Average Power Consumption	~0.25 W
System Efficiency	~%90
Supply Output Short Circuit Currents	9A(3.3V), 9A(5V), 1.5A(Vopt)
Highest Supply Output Currents	5A(3.3V), 5A(5V), 1A(Vopt) ,5A(V_{bat})
Highest Total Output Power	40W
Highest Supply Output Voltage Ripple	<%3
MPPT Output Current	3A (Highest)

Description	Min.	Typ.	Max.
Buck Converter			
Input Voltage	5.5 V	--	36 V
Switching Frequency	--	500 kHz	--
Efficiency	85%	90%	92%
Boost Converter			
Input Voltage	2.9 V	--	32 V
Switching Frequency	100 kHz	600 kHz	1.2 MHz
Efficiency	80%	85%	90%
Unregulated Battery Bus			
Output Voltage	--	V_{bat} (6.2-8.4V)	--
Output Current	--	--	
Efficiency	97%	97%	97%

Description	Min.	Typ.	Max.
3.3 V Bus			
Output Voltage	3.2 V	3.3 V	3.4 V
Output Current	--	--	5 A
Operating Frequency	400 kHz	500 kHz	600 kHz
Efficiency	--	94%	--
5 V Bus			
Output Voltage	4.85 V	5 V	5.15 V
Output Current	--	--	5 A
Operating Frequency	400 kHz	500 kHz	600 kHz
Efficiency	--	94%	--
28 V Bus			
Output Voltage	27.16 V	28 V	28.84 V
Output Current	--	--	1 A
Operating Frequency	460 kHz	577 kHz	740 kHz
Efficiency	--	94%	--

4.1.2 Electrical Interfaces

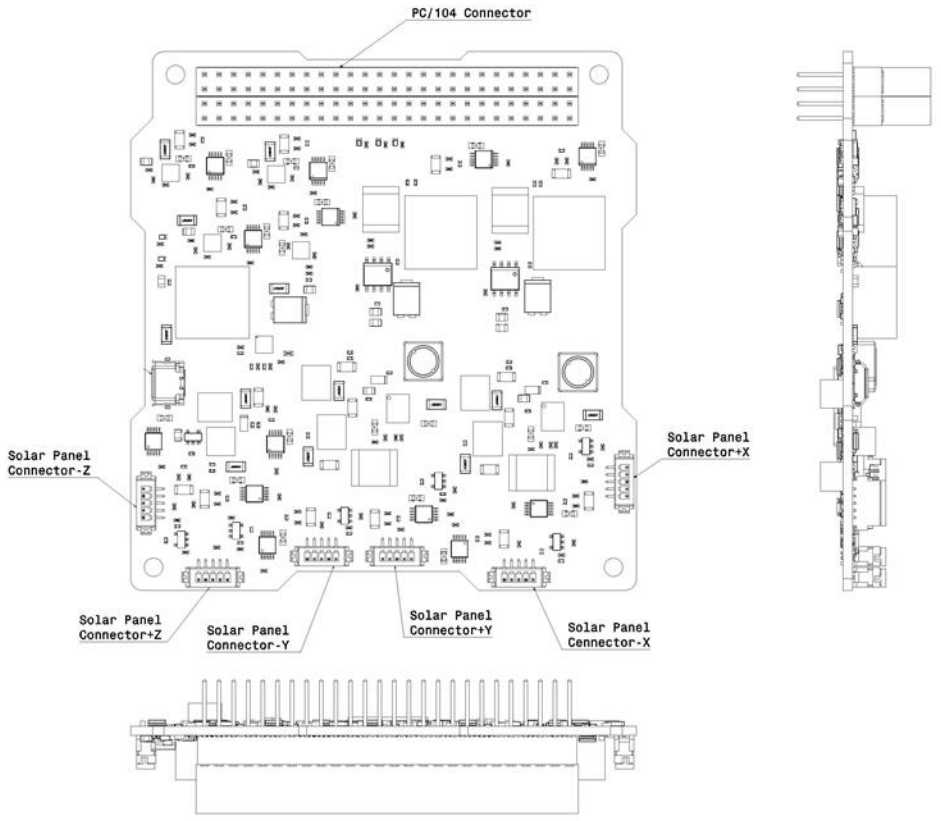

Figure 3: Schematics of n-ART EPS Electrical Interface

4.2 Data and Communication Interface

Table 4: Data Interface Specifications

Description	Value
Data Bus	I2C
Node Address	0x33
Address Scheme	7 bit
Voltage Level	3.3 V
PC 104 Connector	Yes
Solar Panel Connector	6 Units

4.2.1 Command Overview List with Data Byte List

Command Name	Command Code	Read Size (byte)	Equation	Unit	Default
Get Card ID	0x00	1	-	-	0xEE
3.3V Bus Voltage	0x01	2	data*125/100	mV	-
3.3V Bus Current	0x02	2	data*3/10	mA	-
5V Bus Voltage	0x03	2	data*125/100	mV	-
5V Bus Current	0x04	2	data*3/10	mA	-
12V Bus Voltage	0x05	2	data*125/100	mV	-
12V Bus Current	0x06	2	data*3/10	mA	-
Battery Bus Voltage	0x07	2	data*125/100	mV	-
Battery Bus Current	0x08	2	data*3/10	mA	-
Temperature	0x09	2	data*625/100	mC	-

4.2.2 Connector Pin-Out

Connector Locations are given in the schematics below.

Table 5: PC104 Connector Header Pin-Outs

H2	2	4	6	SW1 8	SW2 10	SW4 12	GND 14	SW7 16	SW8 18	SW10 20	GND 22	12V 24	5V 26	3V3 28	GND 30	GND 32	34	PCM 36	38	40	BCR 42	BCR 44	VBAT 46	GND 48	50	52
	1	3	5	7	GND 9	SW3 11	SW5 13	SW6 15	GND 17	SW9 19	GND 21	12V 23	5V 25	3V3 27	GND 29	31	33	PCM 35	37	39	BCR 41	BCR 43	VBAT 45	GND 47	49	51
H1	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	USB Chg 32	34	36	38	40	42	44	46	48	50	52
	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	SDA 41	SCL 43	45	47	49	51

	Power Distribution Switch
	Supply
	GND
	USB Charge
	I2C

Table 6: PC104 BUS Pin Descriptions

Name	Pin	Description
SW1	H2.8	Power Distribution Switch
SW2	H2.10	Power Distribution Switch
SW3	H2.11	Power Distribution Switch
SW4	H2.12	Power Distribution Switch
SW5	H2.13	Power Distribution Switch
SW6	H2.15	Power Distribution Switch
SW7	H2.16	Power Distribution Switch
SW8	H2.18	Power Distribution Switch
SW9	H2.19	Power Distribution Switch
SW10	H2.20	Power Distribution Switch
GND	H2.9	Ground
GND	H2.17	Ground
GND	H2.21	Ground
GND	H2.22	Ground
GND	H2.29	Ground
GND	H2.30	Ground
GND	H2.32	Ground
GND	H2.47	Ground
GND	H2.48	Ground
PC104_SDA	H1.41	I2C Data
PC104_SCL	H1.43	I2C Clock

Solar Panel Connectors

There are six solar panel connectors for each axis (+x, -x, +y, -y, +z, -z).

4.3 Mechanical Characteristics and Interfaces

4.3.1 Mechanical Drawing

External dimensions of n-ART EPS are given in Figure 4.

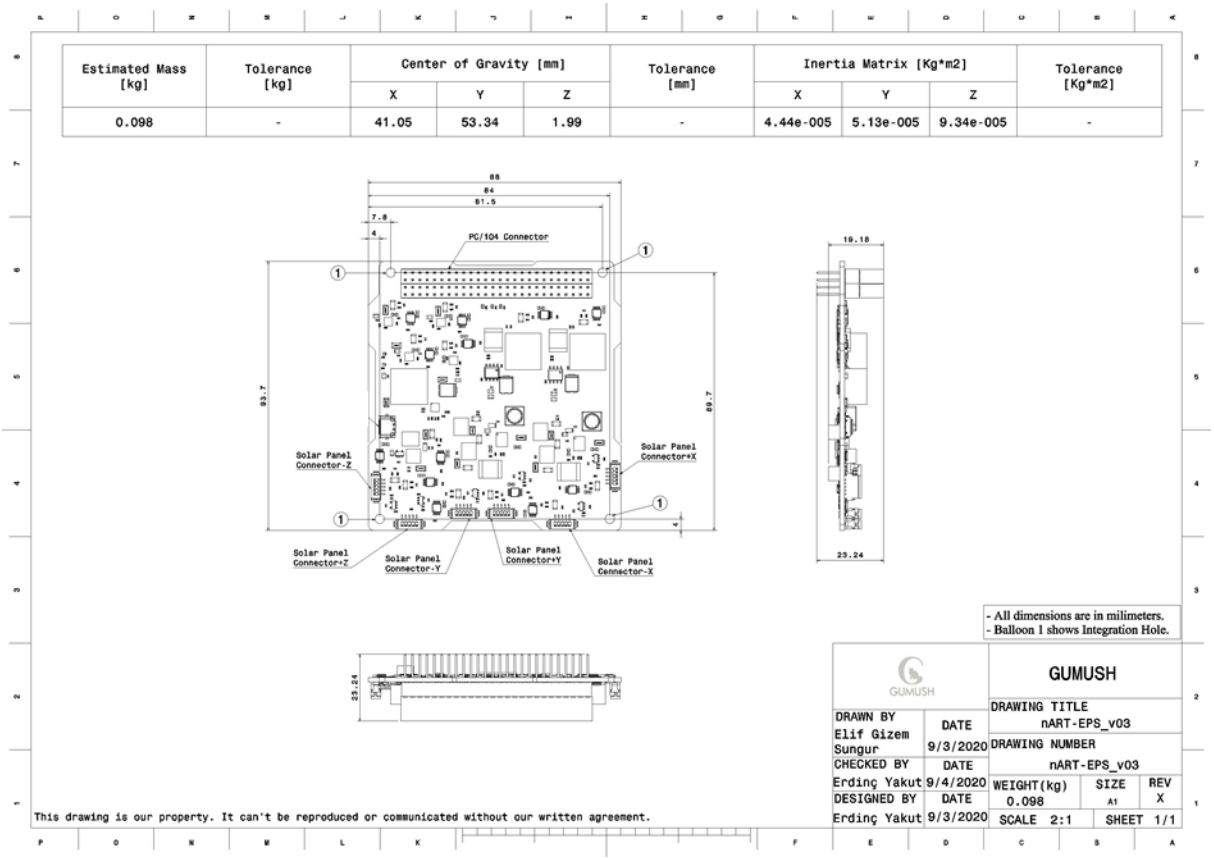

Figure 4: n-ART EPS Mechanical Drawing

4.3.2 Mechanical Properties

Table 7: Mechanical Properties of n-ART EPS

Mechanical Properties	Value
Mass	~ 98 g
Connector	PC104
Dimensions	93.7 x 88.0 x 19.2 mm^3

5 Protections

5.1 Over Current Protection

To secure the spacecraft and subsystems from unexpected current levels, the over current protection does not allow to draw more current from the batteries than they are eligible to.

5.2 Over Voltage Protection

The over voltage protection feature protects the batteries from a possible over charge condition.

If the voltage across the batteries reaches the maximum safe, then the protection makes sure it stops the charging. Charging process is able to started again when the batteries are discharged to the over voltage threshold minus a hysteresis band.

n-ART EPS over voltage protection limit levels are given below;

- For Battery: 8.3 V
- For 1U Solar Panel: 10 V
- For 3U Solar Panel: 22 V

5.3 Under Voltage Protection

The under-voltage protection feature protects the batteries from an under-charge condition.

If the voltage across the batteries reaches the minimum safe, then the protection makes sure turn of the power and supply batteries until the batteries are charged to a safe level.

n-ART EPS under voltage protection limit levels are given below:

- For Battery: 6.2 V

6 Qualification

6.1 Environmental & Functional Testing

A full campaign of tests at qualification level was performed on n-ART EPS Engineering Model.

Qualification tests level and duration follow the ESA standard ECSS-E-ST-10-03C. Tests performed:

- ✓ Thermal Cycling
- ✓ Thermal Vacuum
- ✓ Random Vibration
- ✓ Sine Vibration
- ✓ Functional Tests

Flight Model tests can be performed and reports are provided upon request.

6.2 Flight Heritage

n-ART EPS has no flight heritage at this moment and TRL level is 7.

7 Disclaimer

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