



<http://www.cubesatkit.com/>

# CubeSat Kit™

## Linear EPS

Hardware Revision: C

### Electrical Power System for CubeSat Kit Bus

#### Applications

- CubeSat Kit classroom demonstrations
- CubeSat Kit terrestrial testing
- CubeSat Kit balloon missions

#### Features

- +5V power for CubeSat Kit Bus
- For use with all 104-pin CubeSat Kit Bus modules<sup>1</sup>
- No switching noise – uses automotive-grade LDO linear voltage regulator
- Accepts 4, 5 or 6 AAA cells of any chemistry (carbon zinc, alkaline, NiCad, NiMH, etc.)
- Accepts two 3.7V 1500mAh iPod® Li-Poly batteries as alternate power source
- Replaceable fuse
- FM430 Remove-Before-Flight switch provides complete power disconnect via battery ground lift through CubeSat Kit Bus
- FM430 Launch switch provides +5V power disconnect through CubeSat Kit Bus
- User-selectable battery voltage tap point provided for connection via CubeSat Kit Bus
- Wiring-free module interconnect scheme
- PC/104-size footprint, with +5V and GND on PC/104 J1/J2 connectors
- 2-layer green-soldermask PCB



#### ORDERING INFORMATION

Pumpkin P/N 711-00338

Option Code	Configuration
/00 (standard)	with clips for AAA batteries
/01	without clips for AAA batteries

Contact factory for availability of optional configurations.



#### CAUTION

Electrostatic Sensitive Devices

Handle with Care



<sup>1</sup> The 104-pin CubeSat Kit Bus was introduced with the Rev C FM430 architecture.

## ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Value	Units
Operating temperature <sup>2</sup>	$T_A$	-40 to +85	°C
Maximum battery voltage <sup>3</sup>	$V_{BATT\_MAX}$	26	V
Maximum battery current <sup>4</sup>	$I_{BATT\_MAX}$	1	A

## JUMPER SETTINGS

Name	Function	Default Setting
JP1	Ground ( <b>GND</b> ) connection point	connected
JP2	Connect battery – terminal to s0.	connected
JP3	Connect s4 to ground ( <b>GND</b> ) via <b>JP1</b> .	connected
JP4	Connect battery + terminal to s1	disconnected
JP5	Connect s5 to VBATT	disconnected
JP6	Connect battery – terminal to ground ( <b>GND</b> ) via <b>JP1</b> .	disconnected
JP7	Connect battery + terminal to <b>VBATT</b> directly	connected
JP8	Connect output of 4 AAA's to LDO regulator. Typically used when batteries with 1.5V/cell chemistries (e.g. alkaline) are fitted.	connected
JP9	Connect output of 5 AAA's to LDO regulator. Typically used when batteries with 1.2V/cell chemistries (e.g. NiCad or NiMH) are fitted.	disconnected
JP10	Connect output of 6 AAA's to LDO regulator.	disconnected
JP11	Connect <b>VSENSE</b> to P6.3	disconnected
JP12	Connect <b>VSENSE</b> to P6.4	disconnected
JP13	Connect <b>VSENSE</b> to P6.7	disconnected

**WARNING:** Exercise care when installing batteries and setting jumpers **JP1-JP10**. Large currents may be present, especially when using Lithium-based batteries.

Please note the following. Refer to schematics for more detail.

- **Battery ground lift / connect.** Jumpers **JP1**, **JP2**, **JP3** and **JP6** control how the battery – terminal is connected to ground (**GND**). For a connection through the CubeSat Kit's Remove-Before-Flight switch, connect only **JP1**, **JP2** and **JP3**, leaving jumper **JP6** disconnected. This is the default configuration and allows the user to turn the entire CubeSat Kit module stack on and off via the Remove-Before-Flight Pin. For a direct connection, connect only **JP1** and **JP6**, leaving jumpers **JP2** and **JP3** disconnected.
- **Battery power connect / disconnect:** Jumpers **JP4**, **JP5** and **JP7** control how the battery + terminal is routed to the LDO regulator's input. For a direct connection, connect only **JP7**, leaving jumpers **JP4** and **JP5** disconnected. This is the default configuration and assumes that the batteries are disconnected via the Remove-Before-Flight Pin (see above). For a connection through the CubeSat Kit's Launch switch, connect only **JP4** and **JP5**, leaving jumper **JP7** disconnected.
- **AAA Select:** When AAA batteries are fitted, connect only one jumper (**JP8**, **JP9** or **JP10**) to select the series output of the batteries. Only one jumper must be connected at a time. If iPod batteries are fitted, these jumpers may be left disconnected.
- **Battery Voltage Sense:** Connect only one jumper (**JP11**, **JP12** or **JP13**) at a time if the **VSENSE** functionality is desired. The FM430 will then see **VBATT/3** on P6.3, P6.4 or P6.7, respectively.

<sup>2</sup> For on-board electronics. Temperature limits for batteries chosen by user are likely to be much narrower.

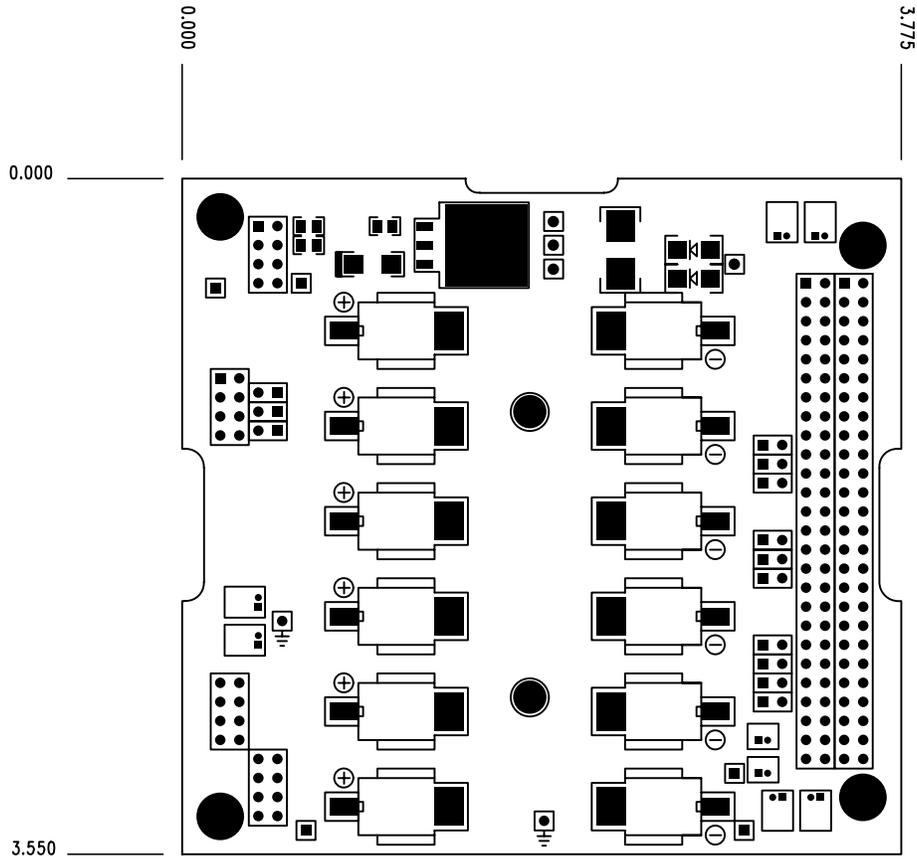
<sup>3</sup> As seen by the on-board LDO regulator.

<sup>4</sup> Limited by a fast-blo 1A fuse.

**PHYSICAL CHARACTERISTICS**

Parameter	Conditions / Notes	Symbol	Min	Typ	Max	Units
Mass <sup>5</sup>	No batteries			58		g
	With 4 AAA alkaline batteries			106		
	With 2 iPod batteries			117		
Height of components above PCB	With option /00				13	mm
	With option /01				11	
Height of components below PCB <sup>6</sup>					2	mm
PCB width	Corner hole pattern matches PC/104			96		mm
PCB length				90		mm
PCB thickness				1.6		mm

**SIMPLIFIED MECHANICAL LAYOUT <sup>7</sup>**



<sup>5</sup> Option /00.

<sup>6</sup> Does not include length of PC/104 stackthrough header pins (H1 & H2) of 10.4mm.

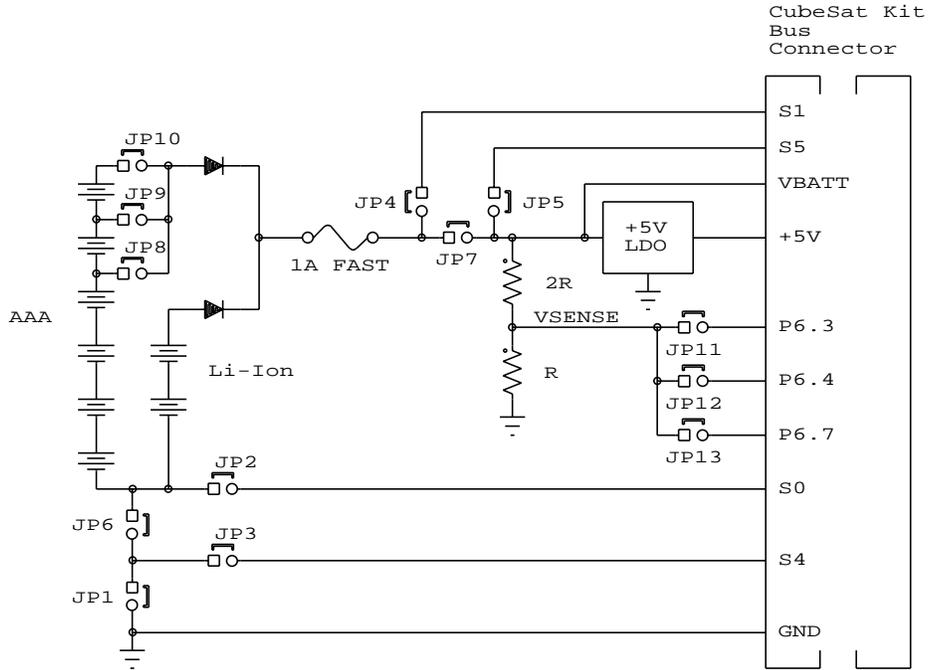
<sup>7</sup> Dimensions in inches.

**ELECTRICAL CHARACTERISTICS**

(T = 25°C, +5V bus = +5V unless otherwise noted)

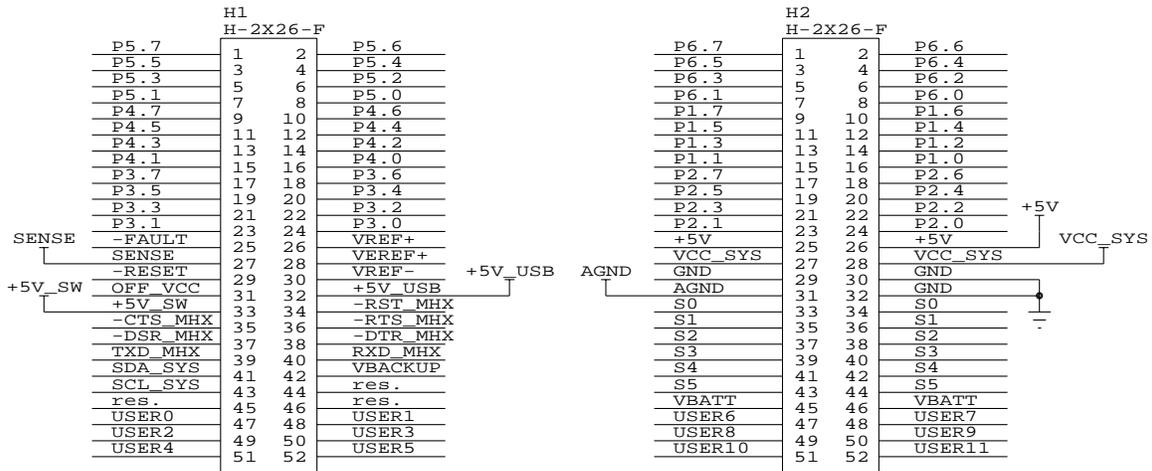
Parameter	Conditions / Notes	Symbol	Min	Typ	Max	Units
+5V voltage		$V_{OUT}$		5.0		V
Quiescent current	$I_{OUT} = 5mA$	$I_Q$		10		mA
Source impedance of $V_{SENSE}$ terminal				66		k $\Omega$

**BLOCK DIAGRAM**



CubeSat Kit Bus PIN DESCRIPTIONS

CubeSat Kit Bus Connectors



CubeSat Kit Bus PIN DESCRIPTIONS – MSP430 I/O Port 1

Name	Pin	I/O	Description
P1.0	H2.16		Not used.
P1.1	H2.15		Not used.
P1.2	H2.14		Not used.
P1.3	H2.13		Not used.
P1.4	H2.12		Not used.
P1.5	H2.11		Not used.
P1.6	H2.10		Not used.
P1.7	H2.9		Not used.

CubeSat Kit Bus PIN DESCRIPTIONS – MSP430 I/O Port 2

Name	Pin	I/O	Description
P2.0	H2.24		Not used.
P2.1	H2.23		Not used.
P2.2	H2.22		Not used.
P2.3	H2.21		Not used.
P2.4	H2.20		Not used.
P2.5	H2.19		Not used.
P2.6	H2.18		Not used.
P2.7	H2.17		Not used.

**CubeSat Kit Bus PIN DESCRIPTIONS – MSP430 I/O Port 3**

Name	Pin	I/O	Description
P3.0	H1.24		Not used.
P3.1	H1.23		Not used.
P3.2	H1.22		Not used.
P3.3	H1.21		Not used.
P3.4	H1.20		Not used.
P3.5	H1.19		Not used.
P3.6	H1.18		Not used.
P3.7	H1.17		Not used.

**CubeSat Kit Bus PIN DESCRIPTIONS – MSP430 I/O Port 4**

Name	Pin	I/O	Description
P4.0	H1.16		Not used.
P4.1	H1.15		Not used.
P4.2	H1.14		Not used.
P4.3	H1.13		Not used.
P4.4	H1.12		Not used.
P4.5	H1.11		Not used.
P4.6	H1.10		Not used.
P4.7	H1.9		Not used.

**CubeSat Kit Bus PIN DESCRIPTIONS – MSP430 I/O Port 5**

Name	Pin	I/O	Description
P5.0	H1.8		Not used.
P5.1	H1.7		Not used.
P5.2	H1.6		Not used.
P5.3	H1.5		Not used.
P5.4	H1.4		Not used.
P5.5	H1.3		Not used.
P5.6	H1.2		Not used.
P5.7	H1.1		Not used.

**CubeSat Kit Bus PIN DESCRIPTIONS – MSP430 I/O Port 6**

Name	Pin	I/O	Description
P6.0	H2.8		Not used.
P6.1	H2.7		Not used.
P6.2	H2.6		Not used.
P6.3	H2.5	O	VSENSE battery voltage sense point. Connected to 1:3 voltage divider from VBATT when jumper JP11 is fitted.
P6.4	H2.4	O	VSENSE battery voltage sense point. Connected to 1:3 voltage divider from VBATT when jumper JP12 is fitted.
P6.5	H2.3		Not used.
P6.6	H2.2		Not used.
P6.7	H2.1	O	VSENSE battery voltage sense point. Connected to 1:3 voltage divider from VBATT when jumper JP13 is fitted.

### CubeSat Kit Bus PIN DESCRIPTIONS – Analog References

Name	Pin	I/O	Description
VREF+	H1.26		Not used.
VREF-	H1.30		Not used.
VEREF+	H1.28		Not used.

### CubeSat Kit Bus PIN DESCRIPTIONS – I2C Bus

Name	Pin	I/O	Description
SDA_SYS	H1.41		Not used.
SCL_SYS	H1.43		Not used.

### CubeSat Kit Bus PIN DESCRIPTIONS – Control & Status

Name	Pin	I/O	Description
-FAULT	H1.25		Not used.
SENSE	H1.27		Not used.
-RESET	H1.29		Not used.
OFF_VCC	H1.31		Not used.

### CubeSat Kit Bus PIN DESCRIPTIONS – RBF and Launch Switches

Name	Pin	I/O	Description
s0	H2.33 H2.34	–	Battery ground lift terminal. Connected to battery – terminal when jumper JP2 is fitted.
s1	H2.35 H2.36	–	Battery power disconnect terminal. Connected to battery + terminal <sup>8</sup> when jumper JP4 is fitted.
s2	H2.37 H2.38		Not used.
s3	H2.39 H2.40		Not used.
s4	H2.41 H2.42	–	Battery ground lift terminal. Connected to GND when jumper JP3 is fitted.
s5	H2.43 H2.44	–	Battery power disconnect terminal. Connected to LDO regulator input when jumper JP5 is fitted.

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<sup>8</sup> Through fuse F1.

### CubeSat Kit Bus PIN DESCRIPTIONS – Power

Name	Pin	I/O	Description
VBATT	H2.45 H2.46	O	Battery voltage. Connected to battery + terminal <sup>9</sup> .
+5V_USB	H1.32		Not used.
+5V	H2.25 H2.26	O	+5V system power from LDO regulator.
+5V_SW	H1.33		Not used.
VBACKUP	H1.42		Not used.
VCC_SYS	H2.27 H2.28		Not used.
AGND	H2.31		Not used.
GND	H2.29 H2.30 H2.32	–	Digital ground.

### CubeSat Kit Bus PIN DESCRIPTIONS – Transceiver Interface

Name	Pin	I/O	Description
-RST_MHX	H1.34		Not used.
-CTS_MHX	H1.35		Not used.
-RTS_MHX	H1.36		Not used.
-DSR_MHX	H1.37		Not used.
-DTR_MHX	H1.38		Not used.
TXD_MHX	H1.39		Not used.
RXD_MHX	H1.40		Not used.

### CubeSat Kit Bus PIN DESCRIPTIONS – User-defined

Name	Pin	I/O	Description
USER0	H1.47		Not used.
USER1	H1.48		Not used.
USER2	H1.49		Not used.
USER3	H1.50		Not used.
USER4	H1.51		Not used.
USER5	H1.52		Not used.
USER6	H2.47		Not used.
USER7	H2.48		Not used.
USER8	H2.49		Not used.
USER9	H2.50		Not used.
USER10	H2.51		Not used.
USER11	H2.52		Not used.

### CubeSat Kit Bus PIN DESCRIPTIONS – Reserved

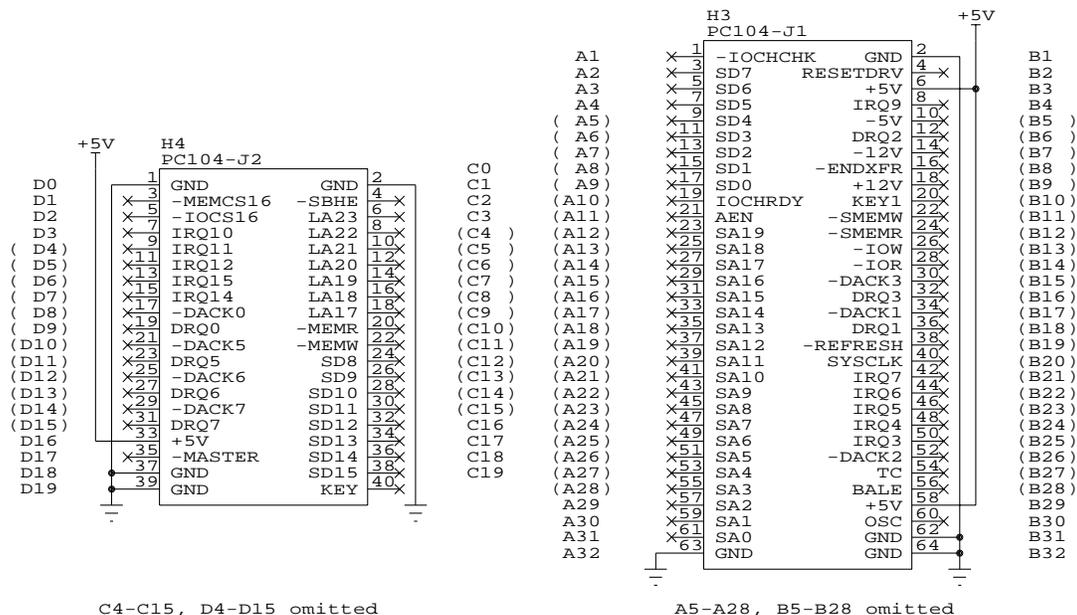
Name	Pin	I/O	Description
res.	H1.44	–	Reserved for future use.
res.	H1.45	–	Reserved for future use.
res.	H1.46	–	Reserved for future use.

<sup>9</sup> Through fuse F1.

## PC/104 System Bus PIN DESCRIPTIONS

### PC/104 System Bus

Only +5V and GND are implemented.



The Linear EPS implements a subset of the PC/104 specification in the form of two connectors that provide only +5V and GND for PC/104 modules. Only a total of 32 pins are implemented, 16 on J1 and 16 on J2. By adding up to 4 8-pin connectors to the Linear EPS, PC/104 modules can be plugged directly into the Linear EPS to obtain +5V power and GND. No other connections between the PC/104 bus and the CubeSat Kit Bus are provided.

## REGULATOR EFFICIENCY

The Linear EPS is designed to provide low-noise +5V power to a stack of CubeSat Kit modules. It uses a linear low-dropout (LDO) regulator with built-in overcurrent, overvoltage and reverse voltage protection. Linear switching regulators have no noise, but are inefficient because of the unavoidable voltage drop across the pass element of the regulator.

## BATTERIES

Batteries are not included.

## AAA BATTERIES

Battery sources for the Linear EPS will exhibit different running times based on the battery chemistry employed, the battery voltage and the load placed on the battery. Some battery technologies have very flat discharge profiles, leading to long life even at elevated (approaching C) discharge rates. Other battery technologies exhibit more linear discharge curves. The user should investigate and experiment with different battery types and configurations to find the best configuration for their situation.

For example, in a low-discharge (C/20) situation, configuring the Linear EPS to use 5 alkaline AAA cells may yield an appreciably longer running time than with 4 AAA cells, simply because the regulator will be able to deliver +5V for a longer time despite the individually deeper discharge of each AAA cell. In a high-discharge situation this approach is not likely to work, as the greater power dissipation across the regulator may send it into thermal shutdown.

## iPod BATTERIES

The Linear EPS can accept the standard Li-Poly battery for 1<sup>st</sup> and 2<sup>nd</sup>-generation iPods. It measures 3.2 x 50 x 85mm and uses a standard 2-pin connector. The underside of the Linear EPS PCB is a completely flat ground plane without any components or protrusions over an area larger than 50 x 85mm. The ground plane also serves as a heatsink for the regulator.

iPod batteries can be attached (e.g. via Velcro®) directly to the underside of the Linear EPS, and connected to connectors **B7** and **B8**. In this configuration, a CubeSat Kit Protoboard Kit (711-00303) should be used below the Linear EPS in order to make room for the iPod batteries.

A simple test with the Linear EPS configured with two iPOD batteries and an FM430 and MaxStream® 900MHz 9XStream transceiver at 100mW output power resulted in approximately 24 hours of runtime before the batteries were exhausted.

### REPLACEMENT FUSES

The replacement fuse is LittleFuse **0453001.MR**, 1A, 250V, very fast-acting. The complete fuse holder is LittleFuse **0154001.DR** and may be easier to acquire (e.g. through [Digi-Key®](#)) than the fuse alone.

### BATTERY RECHARGING

The Linear EPS does not have any provisions for recharging batteries. Rechargeable batteries must be removed from the Linear EPS and recharged with an appropriate charger.

### +3.3V Supply

The Linear EPS provides only a +5V supply to the CubeSat Kit Bus. This is all that is required to run the FM430 Flight Module and any transceiver plugged into it, because the FM430 Flight Module generates its own local +3.3V vcc from the +5V supply. Rev A FM430s feed their vcc directly to the CubeSat Kit Bus. Rev B and C FM430s feed it through the optional 0Ω resistor **R68**. If other modules in the CubeSat Kit Bus module stack require +3.3V, use **R68** or generate it off-board on another module using +5V as the source.

### ENABLING POWER VIA THE REMOVE-BEFORE-FLIGHT PIN

To use the CubeSat Kit Remove-Before-Flight Pin (710-00300) with the Linear EPS and an FM430 Flight Module, the FM430 Flight Module must be either installed in a CubeSat Kit structure or must be outfitted with a Remove-Before-Flight Bracket Kit (711-00330) so as to provide the guide bushing into which the Remove-Before-Flight Pin is fitted.

In both cases, the Remove-Before-Flight switch **sw1** on the FM430 Flight Module must have its **s0** and **s4** terminals wired to the corresponding terminals on the FM430 Flight Module PCB.

## TRADEMARKS

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