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CubeSat Kit™

FM430 Flight Module

Hardware Revision: C

Single Board Computer for Harsh Environments

Applications

- CubeSat nanosatellite C&DH, COM, mass storage and battery / power switching
- General-purpose low-power computing in a PC/104-size form factor

Features

- +5V single supply, 3.3V I/O
- Flight MCU is TI's single-chip 16-bit MSP430 ultralow-power RISC microcontroller with 50-60KB Flash, 2-10KB RAM, 48 I/O pins, 2 USART, 2 SPI, 1 I2C, 12-bit ADC, 12-bit DAC, 3 DMA, multiple timers, on-board temperature sensor & multiple clock sources
- Stackable 104-pin CubeSat Kit Bus connectors includes complete Flight MCU's I/O space, user-assignable signals and more
- On-board low-dropout regulator and reset supervisor for maximum reliability
- Support for a wide range of transceivers
- SD Card socket for mass storage (32MB – 2GB)
- USB 2.0 device interface for pre-launch communications, battery charging and power
- Extensible to multiprocessor architectures, with Flight MCU NMI pin on bus
- Direct wiring for 10A Remove-Before-Flight and Launch switches
- Comprehensive overcurrent, overvoltage & undervoltage (reset) protection
- Independent latchup (device overcurrent) protection on critical subsystems
- Bus override for critical power and data/control paths
- Power consumption can be monitored externally
- Wiring-free module interconnect scheme
- PC/104-size footprint, with +5V and GND on PC/104 J1/J2 connectors
- 6-layer gold-plated PCB with dual ground planes for enhanced signal integrity
- Compatible with Pumpkin's Salvo™ RTOS and HCC-Embedded's EFFS-THIN SD Card file FAT file system for ease of programming
- Backwards compatible with Rev. A and Rev. B FM430 Flight Module



ORDERING INFORMATION

Pumpkin P/N 710-00252

Option Code	MSP430 Flight MCU	Flash & RAM	CubeSat Kit Bus Connector ¹
/00 (standard)	'F1612	55KB 5KB	non-stackthrough
/01	'F1611	50KB 10KB	non-stackthrough
/02	'F169	60KB 2KB	non-stackthrough
/10	'F1612	55KB 5KB	stackthrough
/11	'F1611	50KB 10KB	stackthrough
/12	'F169	60KB 2KB	stackthrough

Contact factory for availability of optional configurations. Shown with optional MHX transceiver.



CAUTION

Electrostatic Sensitive Devices

Handle with Care



¹ Stackthrough connectors are used in CubeSat Kit configurations where the FM430 is not in Slot 0.

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Value	Units
Operating temperature ²	T_A	-40 to +85	°C
Voltage on +5v bus		-0.3 to +6	V
Voltage on - FAULT open-collector output		-0.3 to +6	V
Voltage at external +5V power connector ³		-20 to +20	V
Voltage on any MSP430 I/O pin		-0.3 to +3.6	V
Diode current at any MSP430 terminal		-2 to +2	mA
DC current through any pin of CubeSat Kit Bus Connector	$I_{PIN\ MAX}$	3	A
DC current through external +5V power connector ⁴	$I_{EXT\ MAX}$	4	A
DC current through Remove-Before-Flight or Launch Switches ⁵	$I_{SW\ MAX}$	10	A
MSP430 operating frequency	$f_{OP\ MAX}$	7.4	MHz

² Does not include any SD card fitted to the FM430. Typical SD card operating temperatures are -20°C to + 65°C.

³ Voltages greater than 0V and less than +5.5V are passed through to +5V on the CubeSat Kit Bus.

⁴ Limited by a fast-blo 4A fuse.

⁵ Make only. Not rated for repetitive make and break cycles of dc current.

PHYSICAL CHARACTERISTICS

Parameter	Conditions / Notes	Symbol	Min	Typ	Max	Units
Mass ⁶	Without MHX standoffs and 10mm CubeSat Kit Bus Connector extender (for use with 15mm standoffs)			74		g
	With MHX standoffs and 10mm CubeSat Kit Bus Connector extender (for use with 25mm standoffs)			90		g
Height of components above PCB	Without MHX transceiver or 10mm CubeSat Kit Bus Connector extenders fitted				11.4	mm
	With MHX transceiver and 10mm CubeSat Kit Bus Connector extender fitted				24.5	mm
Height of components below PCB					3.5	mm
PCB width	Corner hole pattern matches PC/104			96		mm
PCB length				90		mm
PCB thickness				1.6		mm
Mating external power jack dimensions	Outer diameter				5.5	mm
	Internal diameter		2.1			mm
CubeSat Kit Bus Connector terminal pitch	Horizontal or vertical distance to nearest terminal			2.54		mm
Switch terminal mounting hole diameter	For C, NO & NC switch terminals			2.54		mm

⁶ With Remove-Before-Flight Switch and cover fitted. No SD Card in socket.

ELECTRICAL CHARACTERISTICS

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

Parameter	Conditions / Notes	Symbol	Min	Typ	Max	Units
Reset voltage	+5V reduced until MCU resets	$V_{\text{RESET_MAX}}$			3.1	V
Maximum external +5V voltage	External +5V increased until protection circuitry forces disconnect	$V_{\text{EXT_TRIP}}$			5.5	V
Operating current	LPM0, MCLK = DCO	I_{OP}		2		mA
	LMP4, all control outputs inactive	I_{SLEEP}		36	40	µA
Low-frequency clock frequency	LFXTAL	$f_{\text{CLK_LF}}$	32.768 ± 0.001			kHz
DCO clock frequency	DCOCLK	$f_{\text{CLK_DCO}}$	680	760	840	kHz
High-frequency clock frequency	HFXTAL	$f_{\text{CLK_HF}}$	7.3728 ± 0.0001			MHz
USB bus current ⁷	Powered over USB	$I_{\text{USB_MAX}}$			500	mA
Overcurrent trip point for VCC supply	Sourced from +5V bus supply	$I_{\text{TRIP_VCC}}$		220		mA
Overcurrent trip point for SD Card socket	Sourced from on-board VCC (+3.3V) supply	$I_{\text{TRIP_SD}}$		170		mA
Overcurrent trip point for MHX transceiver socket	Sourced from +5V bus supply	$I_{\text{TRIP_MHX}}$		820		mA
Time to switch between +5V and +5V_USB power sources	Automatic				1	µS

For more information on TI's MSP430 ultralow-power microcontrollers, see the TI datasheets.

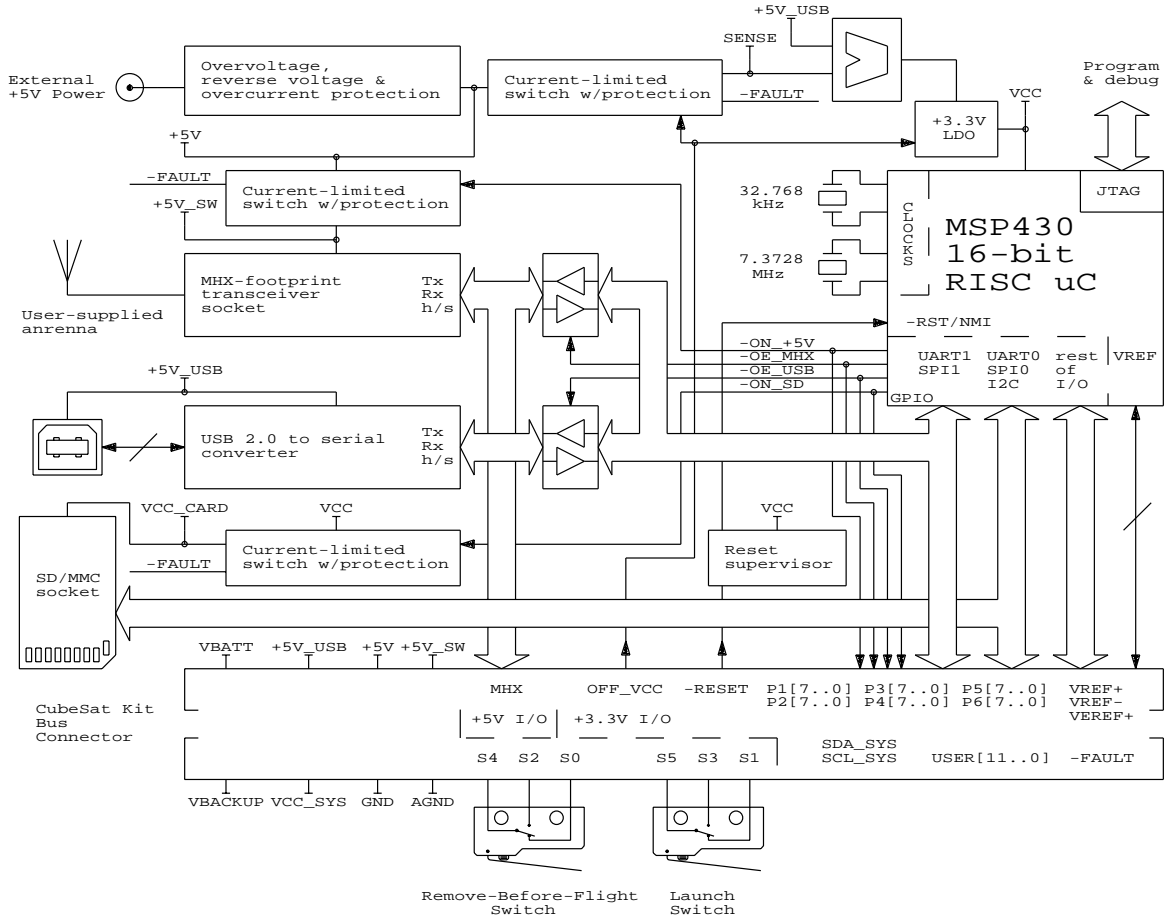
USB DEVICE CHARACTERISTICS

Parameter	Conditions / Notes	Value
Speed ⁸	USB 2.0 compatible	Low Speed (1.5Mbps) Full Speed (12Mbps)
Vendor ID (VID)		0403
Product ID (PID)		F020
Reported options	Unique serial number	/0330
Required driver	Provided by Pumpkin	

⁷ The FM430's USB interface is configured at the factory to report a maximum current of 500mA for a bus-powered device to any attached USB host.

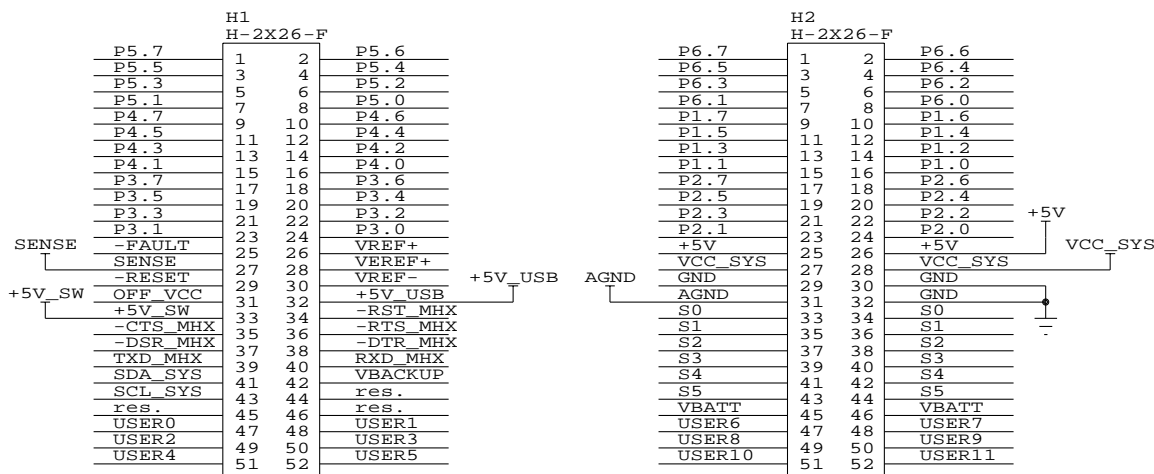
⁸ Actual throughput is dependent on coding in and configuration of MSP430 Flight MCU, and is likely to be much lower.

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	I/O	General-purpose 3.3V I/O. MSP430 Port P1 bit 0. See MSP430 datasheet.
P1.1	H2.15	I/O	General-purpose 3.3V I/O. MSP430 Port P1 bit 1. See MSP430 datasheet.
P1.2	H2.14	I/O	General-purpose 3.3V I/O. MSP430 Port P1 bit 2. See MSP430 datasheet.
P1.3	H2.13	I/O	General-purpose 3.3V I/O. MSP430 Port P1 bit 3. See MSP430 datasheet.
P1.4	H2.12	I/O	General-purpose 3.3V I/O. MSP430 Port P1 bit 4. See MSP430 datasheet.
P1.5	H2.11	I/O	General-purpose 3.3V I/O. MSP430 Port P1 bit 5. See MSP430 datasheet.
P1.6	H2.10	I/O	General-purpose 3.3V I/O. MSP430 Port P1 bit 6. See MSP430 datasheet.
P1.7	H2.9	I/O	General-purpose 3.3V I/O. MSP430 Port P1 bit 7. See MSP430 datasheet. -OE_USB. Normally configured as an output. Controls FM430's USB interface.

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

Name	Pin	I/O	Description
P2.0	H2.24	I/O	General-purpose 3.3V I/O. MSP430 Port P2 bit 0. See MSP430 datasheet.
P2.1	H2.23	I/O	General-purpose 3.3V I/O. MSP430 Port P2 bit 1. See MSP430 datasheet.
P2.2	H2.22	I/O	General-purpose 3.3V I/O. MSP430 Port P2 bit 2. See MSP430 datasheet.
P2.3	H2.21	I/O	General-purpose 3.3V I/O. MSP430 Port P2 bit 3. See MSP430 datasheet.
P2.4	H2.20	I/O	General-purpose 3.3V I/O. MSP430 Port P2 bit 4. See MSP430 datasheet.
P2.5	H2.19	I/O	General-purpose 3.3V I/O. MSP430 Port P2 bit 5. See MSP430 datasheet.
P2.6	H2.18	I/O	General-purpose 3.3V I/O. MSP430 Port P2 bit 6. See MSP430 datasheet.
P2.7	H2.17	I/O	General-purpose 3.3V I/O. MSP430 Port P2 bit 7. See MSP430 datasheet.

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

Name	Pin	I/O	Description
P3.0	H1.24	I/O	General-purpose 3.3V I/O. MSP430 Port P3 bit 0. See MSP430 datasheet. -CS_SD/ON_I2C. Normally configured as an output. Controls SD card interface and off-board I2C isolator.
P3.1	H1.23	I/O	General-purpose 3.3V I/O. MSP430 Port P3 bit 1. See MSP430 datasheet. SIMO/SDA. Normally configured as an output. SPI data out and I2C data.
P3.2	H1.22	I/O	General-purpose 3.3V I/O. MSP430 Port P3 bit 2. See MSP430 datasheet. SOMI. Normally configured as an input. SPI data in.
P3.3	H1.21	I/O	General-purpose 3.3V I/O. MSP430 Port P3 bit 3. See MSP430 datasheet. SCLK/SCK. Normally configured as an output. SPI clock and I2C clock.
P3.4	H1.20	I/O	General-purpose 3.3V I/O. MSP430 Port P3 bit 4. See MSP430 datasheet.
P3.5	H1.19	I/O	General-purpose 3.3V I/O. MSP430 Port P3 bit 5. See MSP430 datasheet.
P3.6	H1.18	I/O	General-purpose 3.3V I/O. MSP430 Port P3 bit 6. See MSP430 datasheet. RXD/TXD. Normally configured as an output. Tx data out to transceiver or USB.
P3.7	H1.17	I/O	General-purpose 3.3V I/O. MSP430 Port P3 bit 7. See MSP430 datasheet. TXD/RXD. Normally configured as an input. Rx data in from transceiver or USB.

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

Name	Pin	I/O	Description
P4.0	H1.16	I/O	General-purpose 3.3V I/O. MSP430 Port P4 bit 0. See MSP430 datasheet.
P4.1	H1.15	I/O	General-purpose 3.3V I/O. MSP430 Port P4 bit 1. See MSP430 datasheet.
P4.2	H1.14	I/O	General-purpose 3.3V I/O. MSP430 Port P4 bit 2. See MSP430 datasheet.
P4.3	H1.13	I/O	General-purpose 3.3V I/O. MSP430 Port P4 bit 3. See MSP430 datasheet.
P4.4	H1.12	I/O	General-purpose 3.3V I/O. MSP430 Port P4 bit 4. See MSP430 datasheet.
P4.5	H1.11	I/O	General-purpose 3.3V I/O. MSP430 Port P4 bit 5. See MSP430 datasheet. -ON_SD. Normally configured as an output. Controls FM430's SD card interface.
P4.6	H1.10	I/O	General-purpose 3.3V I/O. MSP430 Port P4 bit 6. See MSP430 datasheet. -ON_+5V. Normally configured as an output. Controls FM430's +5V_SW circuitry.
P4.7	H1.9	I/O	General-purpose 3.3V I/O. MSP430 Port P4 bit 7. See MSP430 datasheet.

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

Name	Pin	I/O	Description
P5.0	H1.8	I/O	General-purpose 3.3V I/O. MSP430 Port P5 bit 0. See MSP430 datasheet.
P5.1	H1.7	I/O	General-purpose 3.3V I/O. MSP430 Port P5 bit 1. See MSP430 datasheet.
P5.2	H1.6	I/O	General-purpose 3.3V I/O. MSP430 Port P5 bit 2. See MSP430 datasheet.
P5.3	H1.5	I/O	General-purpose 3.3V I/O. MSP430 Port P5 bit 3. See MSP430 datasheet.
P5.4	H1.4	I/O	General-purpose 3.3V I/O. MSP430 Port P5 bit 4. See MSP430 datasheet.
P5.5	H1.3	I/O	General-purpose 3.3V I/O. MSP430 Port P5 bit 5. See MSP430 datasheet.
P5.6	H1.2	I/O	General-purpose 3.3V I/O. MSP430 Port P5 bit 6. See MSP430 datasheet.
P5.7	H1.1	I/O	General-purpose 3.3V I/O. MSP430 Port P5 bit 7. See MSP430 datasheet.

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

Name	Pin	I/O	Description
P6.0	H2.8	I/O	General-purpose 3.3V I/O. MSP430 Port P6 bit 0. See MSP430 datasheet. -RTS / -CTS . Hardware handshaking for USB (-RTS) & MHX (-CTS), respectively.
P6.1	H2.7	I/O	General-purpose 3.3V I/O. MSP430 Port P6 bit 1. See MSP430 datasheet.
P6.2	H2.6	I/O	General-purpose 3.3V I/O. MSP430 Port P6 bit 2. See MSP430 datasheet.
P6.3	H2.5	I/O	General-purpose 3.3V I/O. MSP430 Port P6 bit 3. See MSP430 datasheet. -CTS / -RTS . Hardware handshaking for USB (-CTS) & MHX (-RTS), respectively.
P6.4	H2.4	I/O	General-purpose 3.3V I/O. MSP430 Port P6 bit 4. See MSP430 datasheet.
P6.5	H2.3	I/O	General-purpose 3.3V I/O. MSP430 Port P6 bit 5. See MSP430 datasheet.
P6.6	H2.2	I/O	General-purpose 3.3V I/O. MSP430 Port P6 bit 6. See MSP430 datasheet. -OE_MHX . Normally configured as an output. Controls FM430's transceiver interface.
P6.7	H2.1	I/O	General-purpose 3.3V I/O. MSP430 Port P6 bit 7. See MSP430 datasheet.

CubeSat Kit Bus PIN DESCRIPTIONS – Analog References

Name	Pin	I/O	Description
VREF+	H1.26	O	MSP430 VREF+ pin. See MSP430 datasheet.
VREF-	H1.30	I/O	MSP430 VREF- pin. See MSP430 datasheet.
VEREF+	H1.28	I	MSP430 Veref+ pin. See MSP430 datasheet.

CubeSat Kit Bus PIN DESCRIPTIONS – I2C Bus

Name	Pin	I/O	Description
SDA_SYS	H1.41	I/O	Isolated I2C data. This signal is generated off-board.
SCL_SYS	H1.43	O	Isolated I2C clock. This signal is generated off-board.

CubeSat Kit Bus PIN DESCRIPTIONS – Control & Status

Name	Pin	I/O	Description
-FAULT	H1.25	O	Open-Collector output. Active LOW. Active when an overcurrent fault condition is detected by any of the FM430's three latchup prevention overcurrent switches. With series 4.7kΩ resistor. Normally pulled up externally to VCC_SYS or +5V.
SENSE	H1.27	O	Can be used to measure FM430's current consumption. The current used by the FM430 from the +5V supply to generate +3.3V on-board is $(+5V - SENSE) / 75m\Omega$. Can also be used to bypass the primary latchup prevention in case of its failure by feeding +5V directly into SENSE.
-RESET	H1.29	I	Reset signal to FM430's reset supervisor. Active LOW. Pulled high to FM430's VCC via 30kΩ. An active signal will pull Flight MCU's -RST/NMI pin LOW, normally causing a reset. Can be used as a non-maskable interrupt to the Flight MCU by configuring it in software.
OFF_VCC	H1.31	I	Control signal to FM430. Active HIGH. When active, turns off all +3.3V electronics powered on the FM430. Pulled low to GND via 100kΩ.

CubeSat Kit Bus PIN DESCRIPTIONS – RBF and Launch Switches

Name	Pin	I/O	Description
s0	H2.33 H2.34	–	Switch terminal. Normally connected to RBF Switch normally closed (NC) terminal.
s1	H2.35 H2.36	–	Switch terminal. Normally connected to Launch Switch normally closed (NC) terminal.
s2	H2.37 H2.38	–	Switch terminal. Normally connected to RBF Switch normally open (NO) terminal.
s3	H2.39 H2.40	–	Switch terminal. Normally connected to Launch Switch normally open (NO) terminal.
s4	H2.41 H2.42	–	Switch terminal. Normally connected to RBF Switch common (C) terminal.
s5	H2.43 H2.44	–	Switch terminal. Normally connected to Launch Switch common (C) terminal.

CubeSat Kit Bus PIN DESCRIPTIONS – Power

Name	Pin	I/O	Description
VBATT	H2.45 H2.46	–	Battery voltage. EPS-dependent. Typically +7V to +10V.
+5V_USB	H1.32	–	+5V power USB power. Present whenever FM430 is connected to a USB host.
+5V	H2.25 H2.26	–	+5V system power. From EPS. All FM430 power is sourced from +5v.
+5V_SW	H1.33	–	+5V power. Derived from +5v system power. Used by transceiver. Under control of the Flight MCU. The current used by the MHX transceiver from the +5V supply is $(+5v - +5v_sw) / 75m\Omega$. Can be overridden by feeding +5v directly into +5v_sw.
VBACKUP	H1.42	–	Battery backup voltage (e.g. for RTC's). From EPS or other module. Typically +3V to +3.6V.
VCC_SYS	H2.27 H2.28	–	+3.3V system power. Normally generated by EPS. Not normally connected to FM430's local VCC. ⁹
AGND	H2.31	–	Analog ground. Connected to digital ground (GND) at the FM430 Flight MCU.
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	I	+5V reset input to transceiver. Active LOW.
-CTS_MHX	H1.35	O	+5V clear-to-send output from transceiver. Active LOW.
-RTS_MHX	H1.36	I	+5V request-to-send input to transceiver. Active LOW.
-DSR_MHX	H1.37	O	+5V data set ready output from transceiver. Active LOW.
-DTR_MHX	H1.38	I	+5V data transmit ready input to transceiver. Active LOW.
TXD_MHX	H1.39	I	+5V transmit data input to transceiver. Idles HIGH.
RXD_MHX	H1.40	O	+5V receive data output from transceiver. Idles HIGH.

⁹ For maximum compatibility with earlier revisions of the FM430, vcc_sys can be driven from the FM430's vcc via a 0Ω resistor for those applications where the EPS does not provide +3.3V and only a very small amount of +3.3V is required off-board.

CubeSat Kit Bus PIN DESCRIPTIONS – User-defined

Name	Pin	I/O	Description
USER0	H1.47	I/O	User-defined.
USER1	H1.48	I/O	User-defined.
USER2	H1.49	I/O	User-defined.
USER3	H1.50	I/O	User-defined.
USER4	H1.51	I/O	User-defined.
USER5	H1.52	I/O	User-defined.
USER6	H2.47	I/O	User-defined.
USER7	H2.48	I/O	User-defined.
USER8	H2.49	I/O	User-defined.
USER9	H2.50	I/O	User-defined.
USER10	H2.51	I/O	User-defined.
USER11	H2.52	I/O	User-defined.

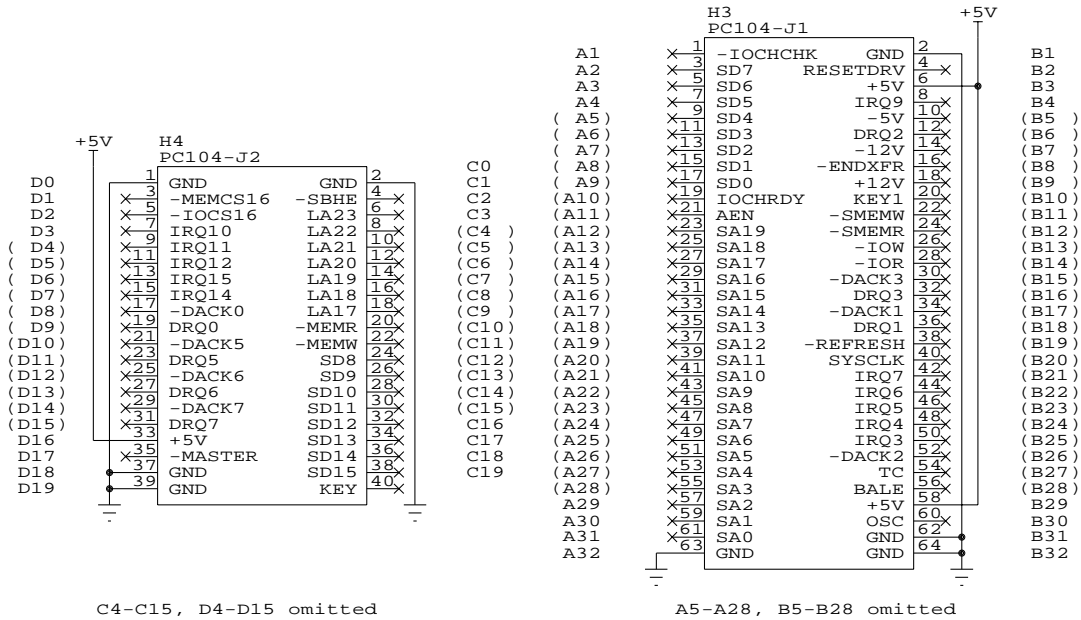
CubeSat Kit Bus PIN DESCRIPTIONS – Reserved

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.

PC/104 System Bus PIN DESCRIPTIONS

PC/104 System Bus

Only +5V and GND are implemented.



The FM430 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 FM430, PC/104 modules can be plugged directly into the FM430 to obtain +5V power and GND. No other connections between the PC/104 bus and the CubeSat Kit Bus are provided.

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