pixhawk®

DS-012 Pixhawk Autopilot v6X Standard

Revision: 0.5.0
Revision date: September 05, 2023

Abstract

This document is the formal version of the Pixhawk industry standard that includes all aspects of the hardware standard required to build compatible autopilots.

Table of contents

Document Revisions

Revision	Date	Editor	Reviewer	Comments
0.1.0		Lorenz Meier	David Sidrane	Initial specification
0.2.0		Lorenz Meier	David Sidrane	Removed requirement for temperature calibration
0.3.0	7/23/2022	David Sidrane	Ramón Roche	Add Sensor Set 5
0.4.0	12/08/2022	David Sidrane	Ramón Roche	Added VxX IMU pinout, and Mechanical design considerations
0.5.0	09/05/2023	Ramón Roche	Alex Klimaj	Updated pinout to match FMUv6X latest

Contact and Public Developer Call

This standard is being developed on a public developer call.
For further questions, please contact the maintainer of the standard, lorenz@px4.io.

Trademark Guideline

Pixhawk is a registered trademark and is used to mark and protect the consistent use of this standard. The requirements for this are covered in this document: Trademark Guideline

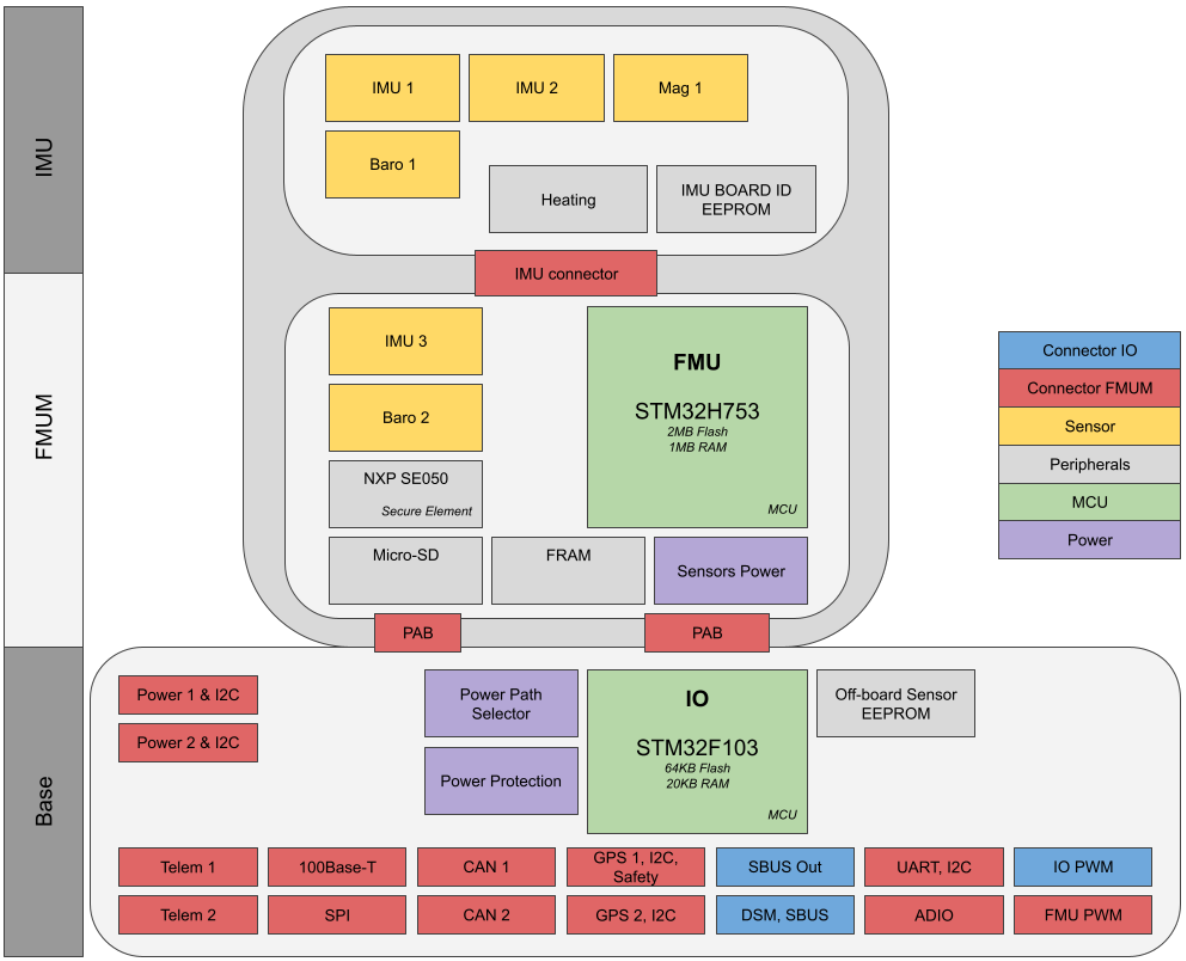
License and Disclaimer

Related Standards

- DS-009 Pixhawk Connector Standard
- DS-010 Pixhawk Autopilot Bus Standard

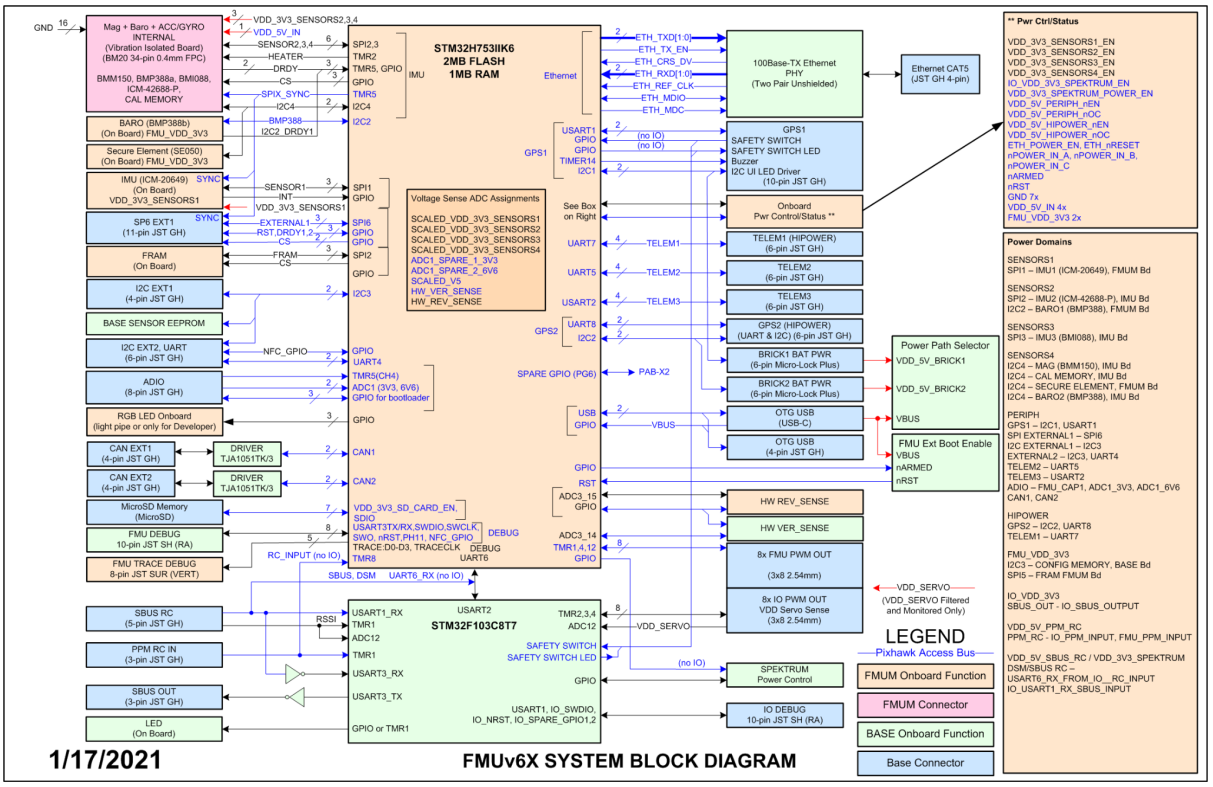
FMUv6X Summary

Overview



NOTE: FMUv6X has the same architecture as v5X, but is based on STM32H7.

Detailed Block Diagram



The FMUv6X generation brings the proven features from FMUv6 to a hardened form factor.

- Secure element for secure authentication of the drone (SE050, I2C4)
- Ethernet interface for high-speed mission computer integration
- Three redundancy domains: Completely isolated sensor domains with separate buses and separate power control.
- Redundant sensors on separate buses, allowing continuous operation while losing a complete redundancy domain.
    - Bosch BMI088 (TBC) (vibration isolated)
    - TDK Invensense ICM-42688-P (TBC) (vibration isolated)
    - TDK Invensense ICM-20649 (TBC)
    - Bosch BMM150 compass
    - Bosch BMP388 pressure sensor
    - GPS external mag + baro #1
    - GPS external mag + baro #2
    - High accuracy barbed baro
    - Calibration EEPROM for baseboard sensors
    - On-IMU calibration EEPROM memory for high-accuracy sensors
- Automated sensor calibration eliminating varying signals and temperature
- Operating temperature -40 to +85°C
- FRAM memory for configuration data (SPI2)
- Extensive power monitoring
    - Two smart batteries on SMBus or more on UAVCAN

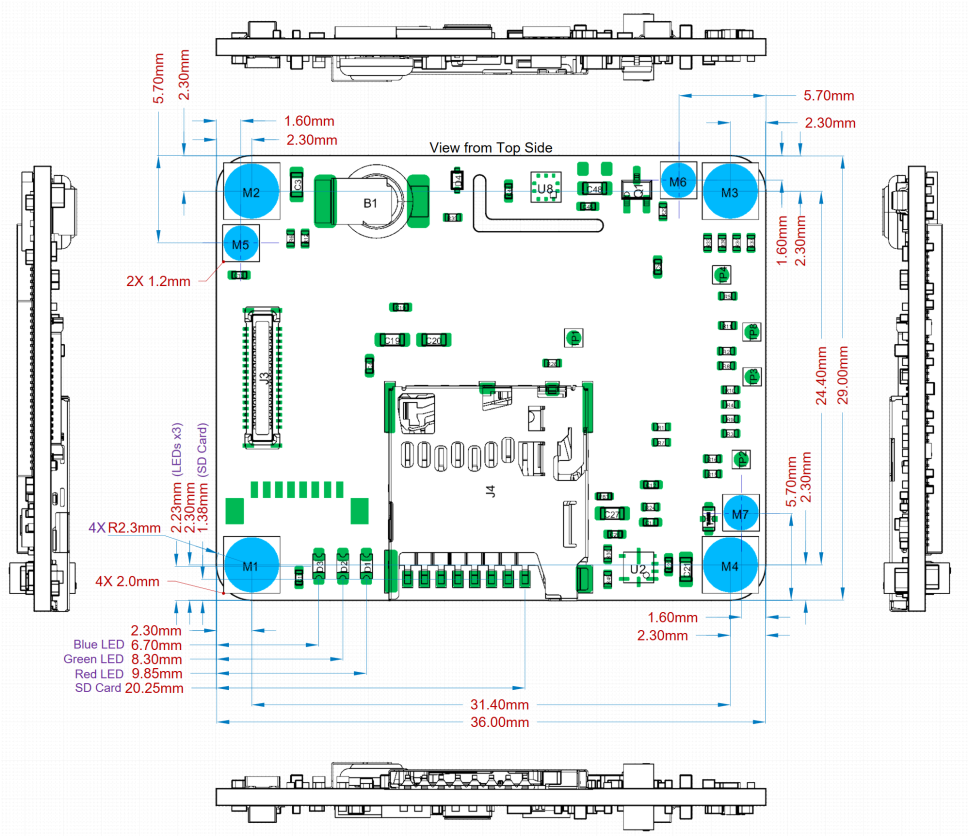
    - 5V rail monitoring
    - 3.3V rail monitoring for CPU
    - 3.3V rail monitoring for each sensor domain
- External sensor bus (SPI5)
- Redundant power supply: The autopilot can be powered from up to three power sources and every sensor set is powered by an independent LDO with independent power control
- Battery-backed real time clock for running security applications without GPS coverage
- For NFC one external I2C port needs to have an additional GPIO line and 5V to supply the external NFC reader.

Mechanical Design

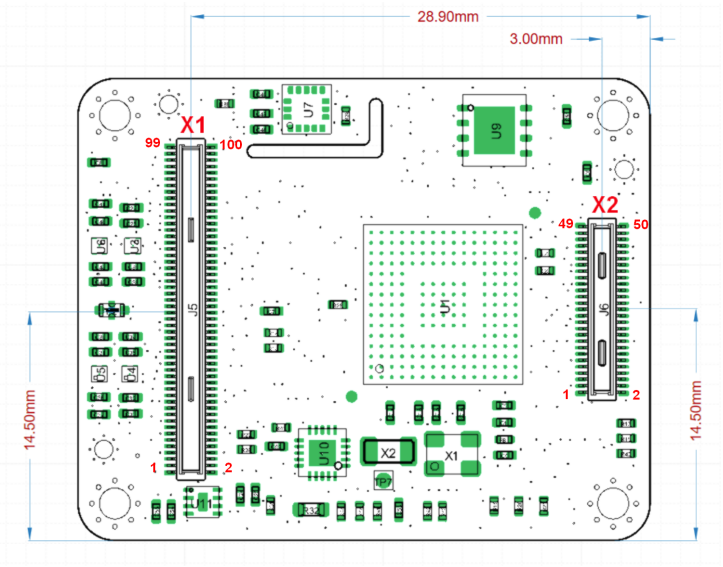
For mechanical compatibility across vendors the following is advised. Locate centers of Red, Green, and Blue LEDs and SD Card connector pin 1 as shown in the Top View FMUM above.

For mechanical case compatibility across vendors the following is advised. The outer case dimensions shall be **no greater than 31.8mm x 38.8mm**. This allows a total of 1.4mm to be used for case wall thickness and clearance to FMUM pcb. It is necessary to provide heat sinking of the FMUM microprocessor. This can be accomplished by using a metal top case that thermally interfaces to the FMUM microprocessor.

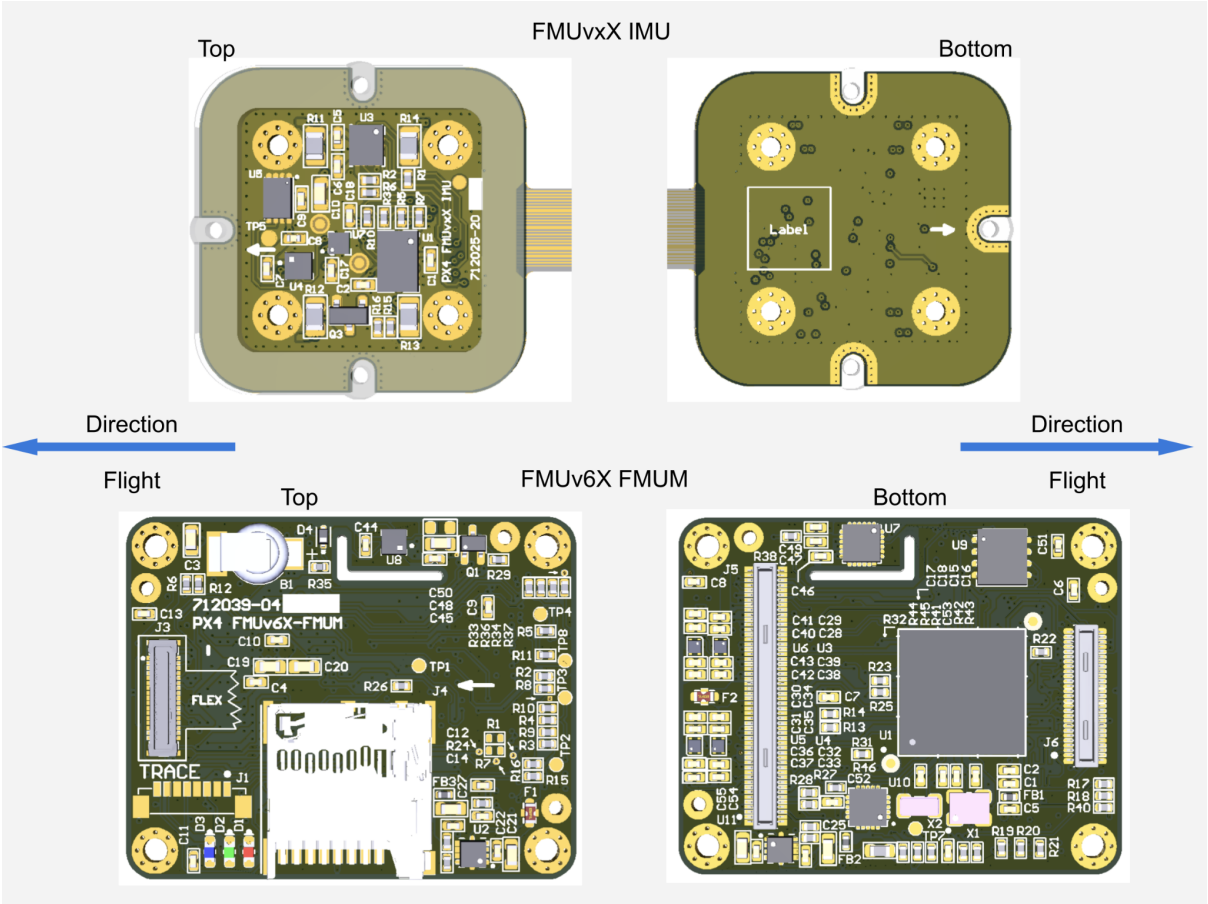
Top view of FMUM



Bottom view of FMU SOM



Sensors Locations



Sensor Sets

Sensor sets comprised an FMU set of sensors and an IMU set of sensors. These are revisioned in pairs. (Rev 1, Rev 2, Rev 3)

Sensor Set (Rev 1)

FMU Sensor Set (Rev 1)

FMU Board

Name	Sensor Type	Bus	Chip Select/ 7 Bit Addr	DRDY	Power Domain
U7 (IMU3)	ICM20649	SPI1	CS1	DRDY1	1
U8 (BARO2)	BMP388	I2C2	0x76 @00=0x50	DRDY1	2
U9 (FRAM)	FM25V02A-DG	SPI5	CS1	NA	FMU VDD 3.3
U10 (SE)	SE050C1HQ1/Z01SCZ	I2C4	0x48	NA	4

IMU Sensor Set (Rev 1)

IMU Board

Name	Sensor Type	Bus	Chip Select/ 7 Bit Addr	DRDY	Power Domain
U1 (IMU1)	BMI088 ACCEL	SPI3	CS1	NA	3
U1 (IMU1)	BMI088 GYRO	SPI3	CS2	DRDY2 INT3	3
~~U2 (MAG2) Not installed~~	~~LIS2MDLTR **DNP**~~	~~I2C4~~	~~0x1e~~	~~NA~~	~~4~~
U3 (IMU2)	ICM-42688-P	SPI2	CS1	DRDY2 INT2	2
U4 (BARO1)	BMP388	I2C4	0x77 @00=0x50	NA	4
U5	EEPROM	I2C4	0x50	N/A	4
~~U6 (IMU2) Not installed~~	ICM20602 **DNP**	SPI2	CS1	DRDY2 INT2	2
U7 (MAG1)	BMM150	I2C4	0x10	NA	4

Sensor Set (Rev 2)

FMU Sensor (Rev 2)

FMU Board

Name	Sensor Type	Bus	Chip Select/ 7 Bit Addr	DRDY	Power Domain
U7 (IMU3)	ICM20649	SPI1	CS1	DRDY1	1
U8 (BARO2)	BMP388	I2C2	0x76 @00=0x50	DRDY1	2
U9 (FRAM)	FM25V02A-DG	SPI5	CS1	NA	FMU VDD 3.3
U10 (SE)	SE050C1HQ1/Z01SCZ	I2C4	0x48	NA	4

IMU Sensor Set (Rev 2)

IMU Board

Name	Sensor Type	Bus	Chip Select/ 7 Bit Addr	DRDY	Power Domain
U1 (IMU1)	ICM20649 ACCEL	SPI3	CS1	DRDY2 INT3	3
~~U2 (MAG2)~~	~~VCM5883~~ ~~**DNP**~~	~~I2C4~~	~~0x0C~~	~~NA~~	~~4~~
U3 (IMU2)	ICM-42688-P	SPI2	CS1	DRDY2 INT2	2
U4 (BARO1)	BMP388	I2C4	0x77 @00=0x50	NA	4
U5	EEPROM	I2C4	0x50	N/A	4
~~U6 (IMU2) Not installed~~	~~ICM20602~~ ~~**DNP**~~	~~SPI2~~	~~CS1~~	~~DRDY2 INT2~~	~~2~~
U7	BMM150	I2C4	0x10	NA	4

Sensor Set (Rev 3)

FMU Sensor (Rev 3)

FMU Board

Name	Sensor Type	Bus	Chip Select/ 7 Bit Addr	DRDY	Power Domain
U7 (IMU3)	ICM42670-P	SPI1	CS1	DRDY1	1
U8 (BARO2)	BMP388	I2C2	0x76 @00=0x50	DRDY1	2
U9 (FRAM)	FM25V02A-DG	SPI5	CS1	NA	FMU VDD 3.3
U10 (SE)	SE050C1HQ1/Z01SCZ	I2C4	0x48	NA	4

IMU Sensor Set (Rev 3)

IMU Board

Name	Sensor Type	Bus	Chip Select/ 7 Bit Addr	DRDY	Power Domain
U1 (IMU1)	BMI088 ACCEL	SPI3	CS1	NA	3
U1 (IMU1)	BMI088 GYRO	SPI3	CS2	DRDY2 INT3	3
~~U2 (MAG2)~~	~~VCM5883 **DNP**~~	~~I2C4~~	~~0x0C~~	~~NA~~	~~4~~
U3 (IMU2)	ICM-42688-P	SPI2	CS1	DRDY2 INT2	2
U4 (BARO1)	BMP388	I2C4	0x77 @00=0x50	NA	4
U5	EEPROM	I2C4	0x50	N/A	4
~~U6 (IMU2) Not installed~~	~~ICM20602 **DNP**~~	~~SPI2~~	~~CS1~~	~~DRDY2 INT2~~	~~2~~
U7	BMM150	I2C4	0x10	NA	4

Sensor Set (Rev 4)

FMU Sensor (Rev 4)

FMU Board

Name	Sensor Type	Bus	Chip Select/ 7 Bit Addr	DRDY	Power Domain
U7 (IMU3)	ICM42670-P	SPI1	CS1	DRDY1	1
U8 (BARO2)	BMP388	I2C2	0x76 @00=0x50	DRDY1	2
U9 (FRAM)	FM25V02A-DG	SPI5	CS1	NA	FMU VDD 3.3
U10 (SE)	SE050C1HQ1/Z01SCZ	I2C4	0x48	NA	4

IMU Sensor Set (Rev 4)

IMU Board

Name	Sensor Type	Bus	Chip Select/ 7 Bit Addr	DRDY	Power Domain
U1 (IMU1)	ICM20649 ACCEL	SPI3	CS1	DRDY2 INT3	3
~~U2 (MAG2)~~	~~VCM5883~~ ~~**DNP**~~	~~I2C4~~	~~0x0C~~	~~NA~~	~~4~~
U3 (IMU2)	ICM-42688-P	SPI2	CS1	DRDY2 INT2	2
U4 (BARO1)	BMP388	I2C4	0x77 @00=0x50	NA	4
U5	EEPROM	I2C4	0x50	N/A	4
~~U6 (IMU2) Not installed~~	~~ICM20602~~ ~~**DNP**~~	~~SPI2~~	~~CS1~~	~~DRDY2 INT2~~	~~2~~
U7	BMM150	I2C4	0x10	NA	4

Sensor Set (Rev 5)

FMU Sensor (Rev 5)

FMU Board

Name	Sensor Type	Bus	Chip Select/ 7 Bit Addr	DRDY	Power Domain
U9 (IMU3)	ICM42649	SPI1	CS1	DRDY1	1
U5 (BARO2)	CP-20100	I2C2	0x63 @0xefc8=0x08	DRDY1	2
U7 (FRAM)	FM25V02A-DG	SPI5	CS1	NA	FMU VDD 3.3
U10 (SE)	SE050C1HQ1/Z 01SCZ	I2C4	0x48	NA	4

IMU Sensor Set (Rev 5)

IMU Board

Name	Sensor Type	Bus	Chip Select/ 7 Bit Addr	DRDY	Power Domain
U3 (IMU1)	BMI088 ACCEL	SPI3	CS1	NA	3
U3 (IMU1)	BMI088 GYRO	SPI3	CS2	DRDY2 INT3	3
~~U2 (MAG2)~~	~~VCM5883 **DNP**~~	~~I2C4~~	~~0x0C~~	~~NA~~	~~4~~
U1 (IMU2)	ICM-42688-P	SPI2	CS1	DRDY2 INT2	2
U2 (BARO1)	ICP-20100	I2C4	0x63 @0xefc8=0x08	NA	4
U5	EEPROM	I2C4	0x50	N/A	4
~~U6 (IMU2) Not installed~~	~~ICM20602 **DNP**~~	~~SPI2~~	~~CS1~~	~~DRDY2 INT2~~	~~2~~
~~U6~~	~~BMM150~~	~~I2C4~~	~~0x10~~	~~NA~~	~~4~~
U4	RM3100	I2C4	0x20	NA	4

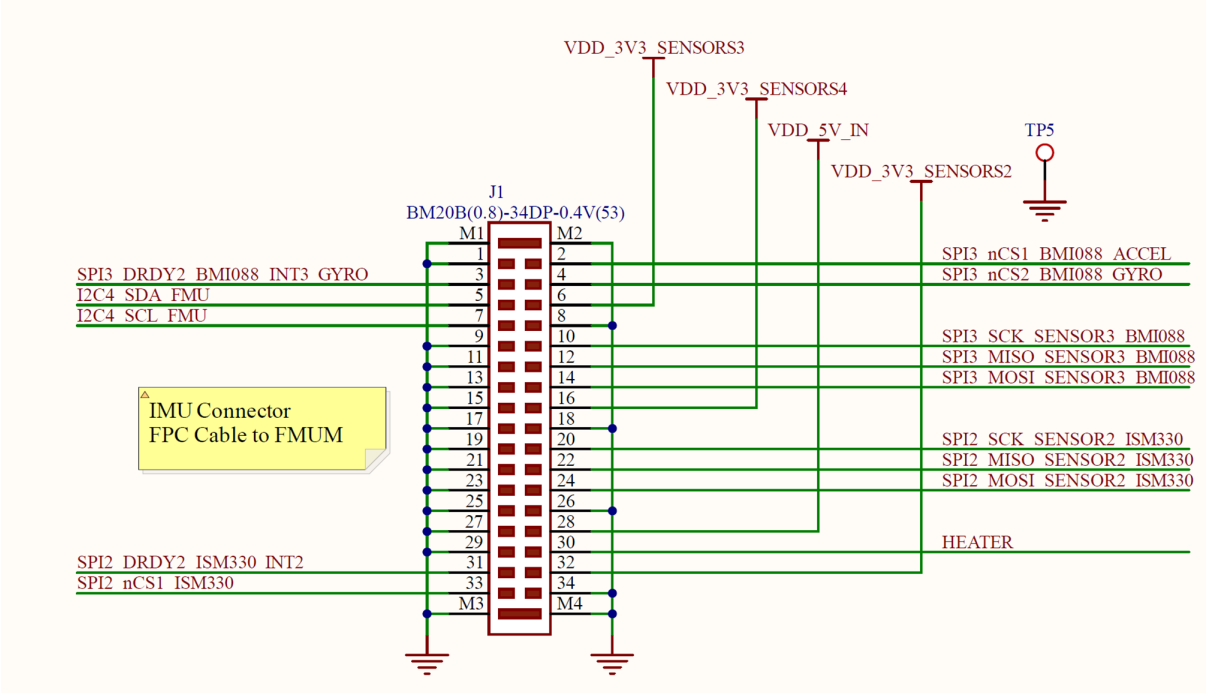
Note: When referring to the pinout chart the CS Names are formed by BUS**n**_CS**n**_DEVICE: SPI**1**_nCS**1**_ICM20602
DRDY Names are formed by BUS**n**_DRDY**n**_DEVICE_INT**n**: SPI**2**_DRDY**2**_ISM330_INT**2**

Note: device names may reflect legacy devices names. What matters is the BUSn,CSn,DRDYn and the INTn.

IMU Pinout of FMUM's IMU connector (FMUvxX)

The signal's name device type (I.E BMI088_xxx) are for reference only. See Sensor Sets for the devices located on a designated bus.

Pin 1 location and direction of flex cable can be seen in FMUv6X Sensors Locations section.



Full FMUv6X Pinout

The official pinout is covered in this pinout sheet.

PA	0	ADC1_IN16	A	SCALED_VDD_3V3_SENSORS1
PA	1	ETH_REF_CLK	E	ETH_REF_CLK
PA	2	ETH_MDIO	E	ETH_MDIO
PA	3	USART2_RX	U	USART2_RX_TELEM3
PA	4	ADC1_INP18	A	SCALED_VDD_3V3_SENSORS2
PA	5	SPI1_SCK	S	SPI1_SCK_SENSOR1_ICM20602
PA	6	SPI6_MISO	S	SPI6_MISO_EXTERNAL1
PA	7	ETH_CRS_DV	E	ETH_CRS_DV
PA	8	I2C3_SCL	I	I2C3_SCL_BASE_MS5611_BARBED_EXTERNAL1
PA	9	USB_OTG_FS_VBUS	B	VBUS_SENSE
PA	10	TIM1_CH3	T	SPI2_DRDY2_ISM330_INT2
PA	11	USB_OTG_FS_DM	B	USB_D_N
PA	12	USB_OTG_FS_DP	B	USB_D_P
PA	13	SWDIO	D	FMU_SWDIO
PA	14	SWCLK	D	FMU_SWCLK
PA	15	PA15	G	SPI6_nCS2_EXTERNAL1
PB	0	ADC1_INP9	A	SCALED_VDD_3V3_SENSORS3
PB	1	ADC1_INP5	A	SCALED_V5
PB	2	SPI3_MOSI	S	SPI3_MOSI_SENSOR3_BMI088
PB	3	SPI6_SCK	S	SPI6_SCK_EXTERNAL1
PB	4	SDMMC2_D3	SD	SDMMC2_D3
PB	5	SPI1_MOSI	S	SPI1_MOSI_SENSOR1_ICM20602
PB	6	USART1_TX	U	USART1_TX_GPS1
PB	7	USART1_RX	U	USART1_RX_GPS1
PB	8	I2C1_SCL	I	I2C1_SCL_BASE_GPS1_MAG_LED_PM1
PB	9	I2C1_SDA	I	I2C1_SDA_BASE_GPS1_MAG_LED_PM1
PB	10	TIM2_CH3	T	HEATER
PB	11	ETH_TX_EN	E	ETH_TX_EN
PB	12	FDCAN2_RX	C	CAN2_RX
PB	13	FDCAN2_TX	C	CAN2_TX
PB	14	SDMMC2_D0	SD	SDMMC2_D0

PB	15	SDMMC2_D1	SD	SDMMC2_D1
PC	0	PC0	G	NFC_GPIO
PC	1	ETH_MDC	E	ETH_MDC
PC	2	ADC3_INP0	A	ADC3_6V6
PC	3	ADC3_INP1	A	ADC3_3V3
PC	4	ETH_RXD0	E	ETH_RXD0
PC	5	ETH_RXD1	E	ETH_RXD1
PC	6	USART6_TX	U	USART6_TX_TO_IO__NC
PC	7	USART6_RX	U	USART6_RX_FROM_IO__RC_INPUT
PC	8	UART5_RTS	V	UART5_RTS_TELEM2
PC	9	UART5_CTS	V	UART5_CTS_TELEM2
PC	10	SPI3_SCK	S	SPI3_SCK_SENSOR3_BMI088
PC	11	SPI3_MISO	S	SPI3_MISO_SENSOR3_BMI088
PC	12	UART5_TX	V	UART5_TX_TELEM2
PC	13	PC13	G	VDD_3V3_SD_CARD_EN
PC	14	OSC32_IN	X	32KHZ_IN
PC	15	OSC32_OUT	X	32KHZ_OUT
PD	0	FDCAN1_RX	C	CAN1_RX
PD	1	FDCAN1_TX	C	CAN1_TX
PD	2	UART5_RX	V	UART5_RX_TELEM2
PD	3	USART2_CTS	U	USART2_CTS_TELEM3
PD	4	USART2_RTS	U	USART2_RTS_TELEM3
PD	5	USART2_TX	U	USART2_TX_TELEM3
PD	6	SDMMC2_CLK	SD	SDMMC2_CLK
PD	7	SDMMC2_CMD	SD	SDMMC2_CMD
PD	8	USART3_TX	U	USART3_TX_DEBUG
PD	9	USART3_RX	U	USART3_RX_DEBUG
PD	10	PD10	G	FMU_nSAFETY_SWITCH_LED_OUT
PD	11	PD11	G	SPI6_DRDY1_EXTERNAL1
PD	12	PD12	G	SPI6_DRDY2_EXTERNAL1
PD	13	TIM4_CH2	T	FMU_CH5
PD	14	TIM4_CH3	T	FMU_CH6
PD	15	PD15	G	PD15(PH11)
PE	0	UART8_RX	V	UART8_RX_GPS2

PE	1	UART8_TX	V	UART8_TX_GPS2
PE	2	PE2	D	TRACECLK
PE	3	PE3	G	nLED_RED
PE	4	PE4	G	nLED_GREEN
PE	5	PE5	G	nLED_BLUE
PE	6	PE6	G	nARMED
PE	7	PE7	G	VDD_3V3_SENSORS3_EN
PE	8	UART7_TX	V	UART7_TX_TELEM1
PE	9	TIM1_CH1	V	SPIX_SYNC
PE	10	UART7_CTS	V	UART7_CTS_TELEM1
PE	11	TIM1_CH2	T	FMU_CAP1
PE	12	SPI4_SCK	S	SPI4_SCK_SENSOR4_BMM150
PE	13	SPI4_MISO	S	SPI4_MISO_SENSOR4_BMM150
PE	14	SPI4_MOSI	S	SPI4_MOSI_SENSOR4_BMM150
PE	15	PE15	G	VDD_5V_PERIPH_nOC
PF	0	I2C2_SDA	I	I2C2_SDA_BASE_GPS2_MAG_LED_PM2
PF	1	I2C2_SCL	I	I2C2_SCL_BASE_GPS2_MAG_LED_PM2
PF	2	PF2	G	SPI1_DRDY1_ICM20602
PF	3	PF3	G	SPI4_DRDY1_BMM150_DRDY
PF	4	PF4	G	VDD_3V3_SENSORS2_EN
PF	5	PF5	G	FMU_SAFETY_SWITCH_IN
PF	6	UART7_RX	V	UART7_RX_TELEM1
PF	7	SPI5_SCK	S	SPI5_SCK_FRAM
PF	8	UART7_RTS	V	UART7_RTS_TELEM1
PF	9	TIM14_CH1	T	BUZZER_1
PF	10	PF10	G	SPI6_nRESET_EXTERNAL1
PF	11	SPI5_MOSI	S	SPI5_MOSI_FRAM
PF	12	ADC1_INP6	A	SCALED_VDD_3V3_SENSORS4
PF	13	PF13	G	VDD_5V_HIPOWER_nOC
PF	14	I2C4_SCL	I	I2C4_SCL_FMU
PF	15	I2C4_SDA	I	I2C4_SDA_FMU
PG	0	PG0	G	HW_VER_REV_DRIVE
PG	1	PG1	G	nPOWER_IN_A
PG	2	PG2	G	nPOWER_IN_B

PG	3	PG3	G	nPOWER_IN_C
PG	4	PG4	G	VDD_5V_PERIPH_nEN
PG	5	PG5	G	I2C2_DRDY1_BMP388
PG	6	PG6	G	PG6
PG	7	PG7	G	SPI5_nCS1_FRAM
PG	8	PG8	G	VDD_3V3_SENSORS4_EN
PG	9	SPI1_MISO	S	SPI1_MISO_SENSOR1_ICM20602
PG	10	PG10	G	VDD_5V_HIPOWER_nEN
PG	11	SDMMC2_D2	SD	SDMMC2_D2
PG	12	ETH_TXD1	E	ETH_TXD1
PG	13	ETH_TXD0	E	ETH_TXD0
PG	14	SPI6_MOSI	S	SPI6_MOSI_EXTERNAL1
PG	15	PG15	G	ETH_POWER_EN
PH	0	OSC_IN	X	16_MHZ_IN
PH	1	OSC_OUT	X	16_MHZ_OUT
PH	2	PH2	G	VDD_3V3_SPEKTRUM_POWER_EN
PH	3	ADC3_INP14	A	HW_VER_SENSE
PH	4	ADC3_INP15	A	HW_REV_SENSE
PH	5	PH5	G	SPI2_nCS1_ISM330
PH	6	TIM12_CH1	T	FMU_CH7
PH	7	SPI5_MISO	S	SPI5_MISO_FRAM
PH	8	I2C3_SDA	I	I2C3_SDA_BASE_MS5611_BARBED_EXTERNAL1
PH	9	TIM12_CH2	T	FMU_CH8
PH	10	TIM5_CH1	T	FMU_CH4
PH	11	TIM5_CH2	T	FMU_CH3
PH	12	TIM5_CH3	T	FMU_CH2
PH	13	UART4_TX	V	UART4_TX
PH	14	UART4_RX	V	UART4_RX
PH	15	PH15	G	SPI4_nCS1_BMM150
PI	0	TIM5_CH4	T	FMU_CH1
PI	1	SPI2_SCK	S	SPI2_SCK_SENSOR2_ISM330
PI	2	SPI2_MISO	S	SPI2_MISO_SENSOR2_ISM330
PI	3	SPI2_MOSI	S	SPI2_MOSI_SENSOR2_ISM330
PI	4	PI4	G	SPI3_nCS1_BMI088_ACCEL

PI	5	TIM8_CH1_IN	T	FMU_PPM_INPUT
PI	6	PI6	G	SPI3_DRDY1_BMI088_INT1_ACCEL
PI	7	PI7	G	SPI3_DRDY2_BMI088_INT3_GYRO
PI	8	PI8	G	SPI3_nCS2_BMI088_GYRO
PI	9	PI9	G	SPI1_nCS1_ICM20602
PI	10	PI10	G	SPI6_nCS1_EXTERNAL1
PI	11	PI11	G	VDD_3V3_SENSORS1_EN