Frey M1 Module

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Version 2.0

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Charpt 1. Revision History

Changes to the original manual are listed below:

Version	Date	Description
1.00	2016/06/21	Initial release
2.00	2016/7/18	Update FCC statement

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Charpt 2. Introduction

This document defines the specification for FREY M1. FREY M1 is a smart module for handheld device and builds in Bluetooth, WiFi and GPS function. It also can support SD card, LCM , Touch Screen , Audio , dual camera , Flash LED , Accelerometer / Magnetometer / Gyroscope / Proximity & Light Sensor functions through application design board.

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Charpt 3. Product Concept

3.1. Main Feature

3.1.1. Chipset on module

- Digital processor : APQ8052 (ARM Cortex-A53 octa cores)
  - Quad core at 1.516 GHz, 512 kB L2 cache
  - Quad core at 1.209 GHz, 512 kB L2 cache
- Power management : PM8952 and PMI8952
- WLAN/BT/FM : WCN3680B
  - WLAN IEEE 802.11a/b/g/n/ac dual bands
  - Bluetooth V2.1BER/EDR+3.0HS+4.1 LE
  - FM RDS & RBDS, RX only
- GPS : WGR7640
  - GPS, Glonass , Galileo or Beidou

3.1.2. Memory

- eMCP , 2GB LPDDR3 RAM plus 16GB eMMC Flash ROM

3.1.3. Multimedia

- Display interface：
  - Support one 4-lane MIPI DSI port , FHD (1920 × 1200) 60 fps
- Camera interface：
  - Support 4-lane + 4-lane or 4-lane + 2-lane + 1-lane MIPI CSI port
  - Two Flash LED interface
- Graphics：
  - Qualcomm® Adreno™ 405
- Touch screen：
  - Capacitive panels via external IC by I2C

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3.1.4. Audio (PM8952 codec)

- Support two Microphones interface with noise cancellation
- Support one speaker interface
- Support one receiver interface
- Support one audio jack interface
- Support one vibrator control interface

3.1.5. Expansion Slot Interface

- One micro SD Memory slot interface with SDHC
- UIM interface x1

3.1.6. USB

- Support one USB OTG

3.1.7. Keypad

- Support 5x5 Key matrix

3.1.8. Dimension

- 44 x 33.6 x 2.7 mm

3.1.9. Operation temperature

Item	Min.	Typ.	Max.	Unit
Normal temperature range	+15	+25	+55	°C
Extreme temperature range	-30		+70	°C

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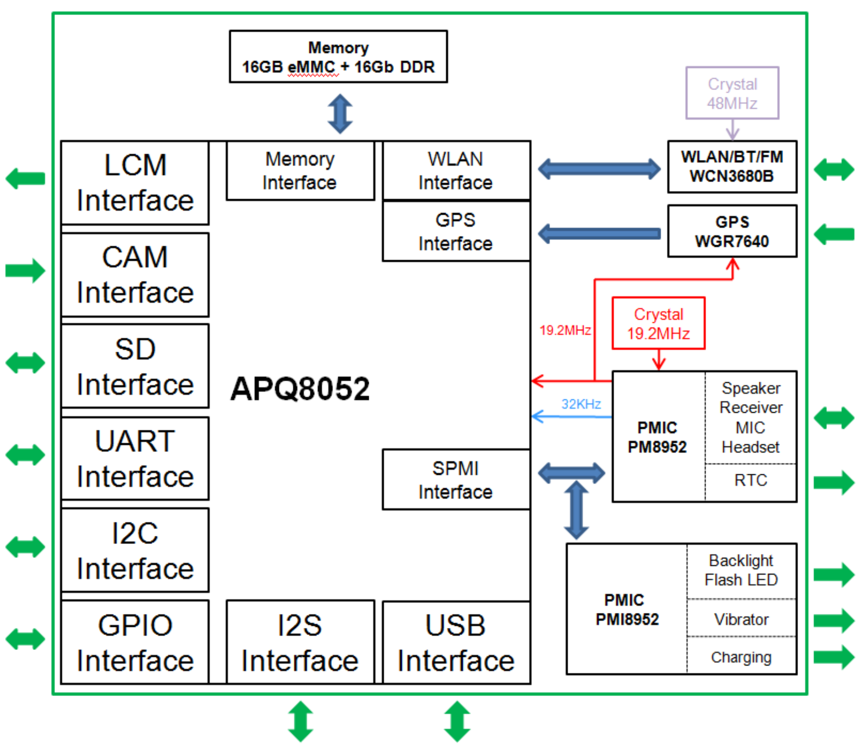
3.2. Module Block Diagram



3.3. Pin Definition

AI : Analog input ; AO : Analog output ;

DI : Digital input ; DO : Digital output

PI : Power input ; PO : Power output

Pin Number	Pin Name	Wakeup	Pad Type	Functional description
Power				
W18	USB_VBUS_IN		PI, PO	Input power from selected source, or output during USB-OTG.
W19	USB_VBUS_IN		PI, PO	Input power from selected source, or output during USB-OTG.
X18	USB_VBUS_IN		PI, PO	Input power from selected source, or output during

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				USB-OTG.
X19	USB_VBUS_IN		PI, PO	Input power from selected source, or output during USB-OTG.
T18	VBATT		PI, PO	Battery power supply
T19	VBATT		PI, PO	Battery power supply
U18	VBATT		PI, PO	Battery power supply
U19	VBATT		PI, PO	Battery power supply
Z18	VPH_PWR		PI, PO	Primary system power supply node
Z19	VPH_PWR		PI, PO	Primary system power supply node
AA18	VPH_PWR		PI, PO	Primary system power supply node
AA19	VPH_PWR		PI, PO	Primary system power supply node
U16	VREG_L1		PO	LDO output
F16	VREG_L4		PO	LDO output
C15	VREG_L5		PO	LDO output
F12	VREG_L6		PO	LDO output
C19	VREG_L10		PO	LDO output
D17	VREG_L11		PO	LDO output
E13	VREG_L12		PO	LDO output
C18	VREG_L14		PO	LDO output
C16	VREG_L16		PO	LDO output
E16	VREG_L17		PO	LDO output
D19	VREG_L18		PO	LDO output
D18	VREG_L22		PO	LDO output
T17	VREG_L23		PO	LDO output
U17	PMI8952_VBIAS		PO	Dedicated voltage source for battery-related resistor networks, not use for other purpose.
X20	SYSON		PO	LDO output that supplies SCHG FET drivers
RTC Battery				

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P20	VCOIN		PI, PO	For RTC battery.
Clock				
F17	PM8952_BB_CLK2		DO	Buffered baseband (low-power) XO clock 2
System				
W17	KYPD_PWR_N		DI	Internal pull-up to dVdd; keep C load < 10 pF. Dual function: 1. Keypad power on; initiates power on when grounded 2. Can be configured as stage 2 or stage 3 reset if held LOW longer
X15	RESIN_N		DI	PMIC reset input ; initiates stage 2 or stage 3 reset if held LOW
W20	PMI8952_CHG_EN		DI	Charger enable
V20	CHG_VBAT_SNS		AI	Sensed battery voltage for charger circuits
T20	BATT_ID		AI	Battery ID input to ADC; also detects missing battery
Y16	CS_MINUS		AI	Current sense resistor — minus side (low side)
V15	CS_PLUS		AI	Current sense resistor — plus side (high side)
V16	BATT_MINUS		AI	Battery minus (-) terminal sense input
U15	BATT_PLUS		AI	Battery plus (+) terminal sense input
X17	BATT_THERM		AI	Battery temperature input to ADC (measures pack temperature) , default NTC is 47KΩ±1% in EVB battery .

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V17	PA_THERM		AI	AMUX input – PA thermistor divider
V19	PMI8952_USB_EN		DO	Enable USB path from external power multiplexer
Y18	PMI8952_USB_SNS		AI	USB input voltage sense pin from external power multiplexer
V18	PMI8952_DC_EN		DO	Enable 2nd power path from external power multiplexer
Y19	PMI8952_DC_SNS		AI	2nd power voltage sense to determine in or out of valid range
Z16	NC		NC	Keep it floating and doesn't connect to GND.
Audio				
H18	MIC_BIAS1		AO	Microphone bias #1
I18	MIC_BIAS2		AO	Microphone bias #2
H19	MIC1_IN_M		AI	Microphone input 1, minus
H20	MIC1_IN_P		AI	Microphone input 1, plus
M19	MIC2_IN		AI	Microphone input 2
L18	MIC3_IN		AI	Microphone input 3
K18	GND_CFILT		GND	Microphone bias filter ground
J19	HPH_L		AO	Headphone output, left channel
J20	HPH_R		AO	Headphone output, right channel
K20	HPH_REF		AI	Headphone ground reference
N18	HS_DET		AI	Headset detection
L20	EARO_M		AO	Earpiece output, minus (-)
L19	EARO_P		AO	Earpiece output, plus (+)
N20	SPKR_DRV_M		AO	Class-D speaker driver output, minus (-)
N19	SPKR_DRV_P		AO	Class-D speaker driver

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				output, plus (+)
Vibrator				
Y15	HAP_OUT_N		AO	Vibrator driver output negative
Y14	HAP_OUT_P		AO	Vibrator driver output positive
SD				
V1	SDC2_CLK		DO	Secure digital controller 2 clock
X2	SDC2_CMD		DI,DO	Secure digital controller 2 command
W1	SDC2_DATA_0		DI,DO	Secure digital controller 2 data bit 0
V2	SDC2_DATA_1		DI,DO	Secure digital controller 2 data bit 1
V3	SDC2_DATA_2		DI,DO	Secure digital controller 2 data bit 2
W2	SDC2_DATA_3		DI,DO	Secure digital controller 2 data bit 3
USB				
Z15	PMI8952_USB_ID		AI, AO	Dual function: 1. OTG mode enable (programmable polarity; can also be controlled by OTG enable bit) 2. OTG ID monitor to detect the OTG ID resistor value.
H13	USB_HS_DM		DI,DO	USB HS data minus
H14	USB_HS_DP		DI,DO	USB HS data plus
R19	PMI_USB_DM		DI	USB data minus for power source detection only; modem IC handles data transactions
R18	PMI_USB_DP		DI	USB data plus for power source detection only; modem IC handles data

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				transactions
LED driver				
X9	VREG_WLED_ANODE		PO	LCM WLED boost output
Y13	WLED_SINK1		AO	WLED low-side current sink input, string 1
Z14	WLED_SINK2		AO	WLED low-side current sink input, string 2
Y12	WLED_SINK3		AO	WLED low-side current sink input, string 3
Z12	WLED_SINK4		AO	WLED low-side current sink input, string 4
W14	WLED_CABC		DI	Content adaptive backlight control (CABC); PWM signal from display controller for dynamic dimming of LCD
X16	FLASH_LED1		AO	High-side current source for flash/torch LED1 anode
Z17	FLASH_LED2		AO	High-side current source for flash/torch LED2 anode
Y17	CHARGE_LED_RED		AO	Current sink for charging indication
Display				
V14	VREG_DISP_N5V		PO	Regulated output for the display's negative bias
V13	VREG_DISP_P5V		PO	Regulated output for the display's positive bias
U14	NC		NC	Keep it floating and doesn't connect to GND.
K2	MIPI_DSI_CLK_N		DO	MIPI DSI clock negative
K3	MIPI_DSI_CLK_P		DO	MIPI DSI clock positive
J2	MIPI_DSI_LN0_N		DO	MIPI DSI data0 negative
J3	MIPI_DSI_LN0_P		DO	MIPI DSI data0 positive
I2	MIPI_DSI_LN1_N		DO	MIPI DSI data1 negative
I1	MIPI_DSI_LN1_P		DO	MIPI DSI data1 positive

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K1	MIPI_DSI_LN2_N		DO	MIPI DSI data2 negative
J1	MIPI_DSI_LN2_P		DO	MIPI DSI data2 positive
L2	MIPI_DSI_LN3_N		DO	MIPI DSI data3 negative
L3	MIPI_DSI_LN3_P		DO	MIPI DSI data3 positive
CAMERA				
P3	MIPI_CSI0_CLK_N		DI	MIPI CSI clock negative
P2	MIPI_CSI0_CLK_P		DI	MIPI CSI0 clock positive
Q2	MIPI_CSI0_LN0_N		DI	MIPI CSI0 data0 negative
Q3	MIPI_CSI0_LN0_P		DI	MIPI CSI0 data0 positive
R2	MIPI_CSI0_LN2_N		DI	MIPI CSI0 data1 negative
S2	MIPI_CSI0_LN2_P		DI	MIPI CSI0 data1 positive
S1	MIPI_CSI0_LN3_N		DI	MIPI CSI0 data2 negative
R1	MIPI_CSI0_LN3_P		DI	MIPI CSI0 data2 positive
Q1	MIPI_CSI0_LN4_N		DI	MIPI CSI0 data3 negative
P1	MIPI_CSI0_LN4_P		DI	MIPI CSI0 data3 positive
N3	MIPI_CSI1_CLK_N		DI	MIPI CSI1 clock negative
N2	MIPI_CSI1_CLK_P		DI	MIPI CSI1 clock positive
O3	MIPI_CSI1_LN0_N		DI	MIPI CSI1 data0 negative
O2	MIPI_CSI1_LN0_P		DI	MIPI CSI1 data0 positive
N1	MIPI_CSI1_LN2_N		DI	MIPI CSI1 data1 negative
O1	MIPI_CSI1_LN2_P		DI	MIPI CSI1 data1 positive
M3	MIPI_CSI1_LN3_N		DI	MIPI CSI1 data2 negative
M2	MIPI_CSI1_LN3_P		DI	MIPI CSI1 data2 positive
L1	MIPI_CSI1_LN4_N		DI	MIPI CSI1 data3 negative
M1	MIPI_CSI1_LN4_P		DI	MIPI CSI1 data3 positive
Antenna				
A2	WLAN_BT_ANT		ANT	WLAN/BT antenna
A19	GPS_ANT		ANT	GPS antenna
A13	FM_ANT		ANT	FM RX antenna
MPP(Multi-Purpose Pin)				
X14	PMI8952_MPP_1		MPP	1. Configurable as digital I/Os 2. Analog multiplexer inputs 3. Even MPPs configurable as current sinks; odd MPPs

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				configurable as analog outputs
X13	PMI8952_MPP_2		MPP	1. Configurable as digital I/Os 2. Analog multiplexer inputs 3. Even MPPs configurable as current sinks; odd MPPs configurable as analog outputs
W13	PMI8952_MPP_3		MPP	1. Configurable as digital I/Os 2. Analog multiplexer inputs 3. Even MPPs configurable as current sinks; odd MPPs configurable as analog outputs
G16	PM8952_MPP_02		MPP	1. Configurable as digital I/Os 2. Level-translating bidirectional I/Os 3. Analog multiplexer inputs 4. Even MPPs can be current sinks and odd MPPs can be VREF buffer outputs
F15	PM8952_MPP_03		MPP	1. Configurable as digital I/Os 2. Level-translating bidirectional I/Os 3. Analog multiplexer inputs 4. Even MPPs can be current sinks and odd MPPs can be VREF buffer outputs
G15	PM8952_MPP_04		MPP	1. Configurable as digital I/Os

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				2. Level-translating bidirectional I/Os 3. Analog multiplexer inputs 4. Even MPPs can be current sinks and odd MPPs can be VREF buffer outputs
GPIO				
E2	GPIO_0		GPIO	1. Configurable I/O 2. BLSP1_SPI_MOSI 3. BLSP1_UART_TX
F2	GPIO_1		GPIO	1. Configurable I/O 2. BLSP3_SPI_CS_N 3. BLSP3_I2C_SDA 4. GP_CLK_2B
E3	GPIO_2	V	GPIO	1. Configurable I/O 2. BLSP8_SPI_MISO
F3	GPIO_3		GPIO	1. Configurable I/O 2. BLSP1_SPI_CLK 3. BLSP1_UART_RFR_N 4. BLSP1_I2C_SCL
U4	GPIO_4		GPIO	1. Configurable I/O 2. BLSP2_SPI_MOSI 3. BLSP2_UART_TX
T4	GPIO_5	V	GPIO	1. Configurable I/O 2. BLSP2_SPI_MISO 3. BLSP2_UART_RX 4. LDO_EN
X3	GPIO_6		GPIO	1. Configurable I/O 2. BLSP2_SPI_CS_N 3. BLSP2_UART_CTS_N 4. BLSP2_I2C_SDA 5. GP_CLK_1B
W3	GPIO_7		GPIO	1. Configurable I/O 2. BLSP2_SPI_CLK 3. BLSP2_UART_RFR_N

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				4. BLSP2_I2C_SCL 5. GP_PDM_2A
I3	GPIO_8		GPIO	1. Configurable I/O
H2	GPIO_9		GPIO	1. Configurable I/O
G3	GPIO_10	V	GPIO	1. Configurable I/O 2. BLSP1_SPI_MISO 3. BLSP1_UART_RX
G2	GPIO_11		GPIO	1. Configurable I/O 2. BLSP3_SPI_CLK 3. BLSP3_I2C_SCL 4. GP_CLK_3B
D4	GPIO_12	V	GPIO	1. Configurable I/O 2. BLSP4_SPI_MOSI 3. MI2S_2_D0
D1	GPIO_13	V	GPIO	1. Configurable I/O 2. BLSP4_SPI_MISO 3. MI2S_2_D1
F1	GPIO_14		GPIO	1. Configurable I/O 2. BLSP4_SPI_CS_N 3. BLSP4_I2C_SDA
E1	GPIO_15		GPIO	1. Configurable I/O 2. BLSP4_SPI_CLK 3. BLSP4_I2C_SCL
E4	GPIO_16		GPIO	1. Configurable I/O 2. BLSP5_SPI_MOSI 3. BLSP5_UART_TX
G4	GPIO_17	V	GPIO	1. Configurable I/O 2. BLSP5_SPI_MISO 3. BLSP5_UART_RX
B4	GPIO_18		GPIO	1. Configurable I/O 2. BLSP5_SPI_CS_N 3. BLSP5_UART_CTS_N 4. BLSP5_I2C_SDA
C4	GPIO_19		GPIO	1. Configurable I/O 2. BLSP5_SPI_CLK 3. BLSP5_UART_RFR_N

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				4. BLSP5_I2C_SCL
V9	GPIO_20		GPIO	1. Configurable I/O 2. BLSP6_SPI_MOSI 3. BLSP6_UART_TX 4. GP_PDM_1B
W9	GPIO_21	V	GPIO	1. Configurable I/O 2. BLSP6_SPI_MISO 3. BLSP6_UART_RX
T15	GPIO_22		GPIO	1. Configurable I/O 2. BLSP6_SPI_CS_N 3. BLSP6_UART_CTS_N 4. BLSP6_I2C_SDA
T16	GPIO_23		GPIO	1. Configurable I/O
C1	GPIO_24		GPIO	1. Configurable I/O 2. SDE_VSYNC_P
G1	GPIO_25	V	GPIO	1. Configurable I/O 2. SDE_VSYNC_S 3. PRI_MI2S_MCLK_A 4. SEC_MI2S_MCLK_A
T12	GPIO_26		GPIO	1. Configurable I/O
Y9	GPIO_27		GPIO	1. Configurable I/O 2. CAM_MCLK1
T13	GPIO_28			1. Configurable I/O 2. CAM_MCLK2
Y11	GPIO_29		GPIO	1. Configurable I/O 2. BLSP6_SPI_CS2_N 3. GP_CLK1
Z11	GPIO_30		GPIO	1. Configurable I/O 2. CCI_I2C0_SCL
W10	GPIO_31	V	GPIO	1. Configurable I/O 2. CCI_I2C1_SDA
Y8	GPIO_32		GPIO	1. Configurable I/O 2. CCI_I2C1_SCL
T8	GPIO_33		GPIO	1. Configurable I/O 2. CCI_TIMER0
X10	GPIO_35	V	GPIO	1. Configurable I/O

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W11	GPIO_36	V	GPIO	1. Configurable I/O
W8	GPIO_37	V	GPIO	1. Configurable I/O
V8	GPIO_38	V	GPIO	1. Configurable I/O
Z8	GPIO_39		GPIO	1. Configurable I/O 2. CCI_ASYNC0 3. GP_MN
Z13	GPIO_40		GPIO	1. Configurable I/O
X11	GPIO_41		GPIO	1. Configurable I/O 2. SD_WRITE_PROTECT
Z10	GPIO_42	V	GPIO	1. Configurable I/O 2. GP_CLK_1A
Y10	GPIO_43	V	GPIO	1. Configurable I/O 2. GP_CLK_2A
V12	GPIO_44	V	GPIO	1. Configurable I/O 2. GP_CLK_3A
T9	GPIO_45	V	GPIO	1. Configurable I/O 2. GP_PDM_1A
V10	GPIO_46	V	GPIO	1. Configurable I/O 2. GP_CLK0
X12	GPIO_47		GPIO	1. Configurable I/O 2. CCI_I2C0_SDA
U9	GPIO_48	V	GPIO	1. Configurable I/O 2. BLSP6_SPI_CS2_N 3. GP_PDM_0B
W12	GPIO_50		GPIO	1. Configurable I/O
F14	GPIO_51		GPIO	1. Configurable I/O
F13	GPIO_52		GPIO	1. Configurable I/O
H12	GPIO_53		GPIO	1. Configurable I/O 2. UIM1_RESET
B11	GPIO_54	V	GPIO	1. Configurable I/O 2. UIM1_PRESENT
G9	GPIO_57		GPIO	1. Configurable I/O 2. UIM2_RESET
F11	GPIO_58	V	GPIO	1. Configurable I/O 2. UIM2_PRESENT
E14	GPIO_59		GPIO	1. Configurable I/O

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E12	GPIO_60		GPIO	1. Configurable I/O
G12	GPIO_61		GPIO	1. Configurable I/O
G11	GPIO_62	V	GPIO	1. Configurable I/O
T11	GPIO_63		GPIO	1. Configurable I/O 2. CAM_MCLK0
U13	GPIO_64		GPIO	1. Configurable I/O
H6	GPIO_65	V	GPIO	1. Configurable I/O
T14	GPIO_67	V	GPIO	1. Configurable I/O
H3	GPIO_68		GPIO	1. Configurable I/O
H4	GPIO_85	V	GPIO	1. Configurable I/O
D5	GPIO_86		GPIO	1. Configurable I/O
E5	GPIO_87		GPIO	1. Configurable I/O
C5	GPIO_88		GPIO	1. Configurable I/O 2. BLSP8_I2C_SDA 3. BLSP8_SPI_CS_N
F6	GPIO_89		GPIO	1. Configurable I/O 2. DMIC0_CLK
H8	GPIO_90	V	GPIO	1. Configurable I/O 2. DMIC0_DATA
A4	GPIO_91		GPIO	1. Configurable I/O 2. MI2S_1_SCK
B5	GPIO_92		GPIO	1. Configurable I/O 2. BLSP7_SPI_MOSI 3. MI2S_1_WS
A5	GPIO_93	V	GPIO	1. Configurable I/O 2. BLSP7_SPI_MISO 3. MI2S_1_D0
D2	GPIO_94		GPIO	1. Configurable I/O 2. WSA_IO_DATA 3. BLSP7_SPI_CS_N 4. BLSP7_I2C_SDA
D3	GPIO_95		GPIO	1. Configurable I/O 2. WSA_IO_CLK 3. BLSP7_SPI_CLK 4. BLSP7_I2C_SCL
C2	GPIO_96		GPIO	1. Configurable I/O

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				2. BLSP8_SPI_MOSI
C6	GPIO_97		GPIO	1. Configurable I/O 2. BLSP1_SPI_CS_N 3. BLSP1_UART_CTS_N 4. BLSP1_I2C_SDA
D6	GPIO_98		GPIO	1. Configurable I/O 2. MI2S_1_D1
C3	GPIO_99		GPIO	1. Configurable I/O 2. BLSP8_I2C_SCL 3. BLSP8_SPI_CLK
D12	GPIO_100		GPIO	1. Configurable I/O 2. GRFC_0
E11	GPIO_101		GPIO	1. Configurable I/O 2. GRFC_1
C10	GPIO_102		GPIO	1. Configurable I/O 2. GRFC_2
D11	GPIO_103		GPIO	1. Configurable I/O 2. GRFC_3
D10	GPIO_104		GPIO	1. Configurable I/O 2. GRFC_4
H10	GPIO_105		GPIO	1. Configurable I/O 2. GRFC_5
B10	GPIO_106		GPIO	1. Configurable I/O
H11	GPIO_110		GPIO	1.Configurable I/O 2. GRFC_10
E10	GPIO_115		GPIO	1.Configurable I/O 2. GRFC_15 3. GSM_TX_PHASE_TXDAC1
F10	GPIO_116		GPIO	1. Configurable I/O 2. GRFC_28
G10	GPIO_117		GPIO	1.Configurable I/O 2. SM_TX_PHASE_TXDAC0 3. GRFC_27

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F8	GPIO_118		GPIO	1.Configurable I/O 2. RFFE1_CLK
E8	GPIO_119		GPIO	1.Configurable I/O 2. RFFE1_DATA
G8	GPIO_120		GPIO	1. Configurable I/O 2. RFFE2_CLK
G7	GPIO_121		GPIO	1. Configurable I/O 2. RFFE2_DATA
G6	GPIO_122		GPIO	1. Configurable I/O 2. RFFE4_CLK
G5	GPIO_123		GPIO	1. Configurable I/O 2. RFFE4_DATA
H5	GPIO_124		GPIO	1. Configurable I/O 2. RFFE5_CLK
F5	GPIO_125		GPIO	1. Configurable I/O 2. RFFE5_DATA
H7	GPIO_126		GPIO	1. Configurable I/O 2. RFFE3_CLK
F4	GPIO_127		GPIO	1. Configurable I/O 2. RFFE3_DATA
W4	GPIO_128		GPIO	1. Configurable I/O
V4	GPIO_129		GPIO	1. Configurable I/O
T3	GPIO_130		GPIO	1. Configurable I/O
X8	GPIO_131		GPIO	1. Configurable I/O
U8	GPIO_132		GPIO	1. Configurable I/O
Z9	GPIO_133		GPIO	1. Configurable I/O
W15	PMI8952_GPIO_1		GPIO	1. Configurable I/O
W16	PMI8952_GPIO_2		GPIO	1. Configurable I/O
D16	PM8952_GPIO_01		GPIO	1. Configurable I/O
D15	PM8952_GPIO_02		GPIO	1. Configurable I/O
H16	PM8952_GPIO_04		GPIO	1. Configurable I/O
C17	PM8952_GPIO_05		GPIO	1. Configurable I/O
E15	PM8952_GPIO_06		GPIO	1. Configurable I/O
P18	PM8952_GPIO_07		GPIO	1. Configurable I/O
P19	PM8952_GPIO_08		GPIO	1. Configurable I/O
GND				

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A1	GND		GND	
A3	GND		GND	
A6	GND		GND	
A7	GND		GND	
A8	GND		GND	
A9	GND		GND	
A10	GND		GND	
A11	GND		GND	
A12	GND		GND	
A14	GND		GND	
A15	GND		GND	
A16	GND		GND	
A17	GND		GND	
A18	GND		GND	
A20	GND		GND	
B1	GND		GND	
B2	GND		GND	
B3	GND		GND	
B6	GND		GND	
B7	GND		GND	
B8	GND		GND	
B9	GND		GND	
B12	GND		GND	
B13	GND		GND	
B14	GND		GND	
B15	GND		GND	
B16	GND		GND	
B17	GND		GND	
B18	GND		GND	
B19	GND		GND	
B20	GND		GND	
C7	GND		GND	
C8	GND		GND	
C9	GND		GND	
C11	GND		GND	

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C12	GND		GND	
C13	GND		GND	
C14	GND		GND	
C20	GND		GND	
D7	GND		GND	
D8	GND		GND	
D9	GND		GND	
D13	GND		GND	
D14	GND		GND	
D20	GND		GND	
E6	GND		GND	
E7	GND		GND	
E9	GND		GND	
E17	GND		GND	
E18	GND		GND	
E19	GND		GND	
E20	GND		GND	
F7	GND		GND	
F9	GND		GND	
F18	GND		GND	
F19	GND		GND	
F20	GND		GND	
G13	GND		GND	
G14	GND		GND	
G17	GND		GND	
G18	GND		GND	
G19	GND		GND	
G20	GND		GND	
H1	GND		GND	
H9	GND		GND	
H15	GND		GND	
H17	GND		GND	
I19	GND		GND	
I20	GND		GND	
J18	GND		GND	

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K19	GND		GND	
M18	GND		GND	
M20	GND		GND	
O18	GND		GND	
O19	GND		GND	
O20	GND		GND	
Q18	GND		GND	
Q19	GND		GND	
Q20	GND		GND	
R3	GND		GND	
R20	GND		GND	
S3	GND		GND	
S18	GND		GND	
S19	GND		GND	
S20	GND		GND	
T1	GND		GND	
T2	GND		GND	
T5	GND		GND	
T6	GND		GND	
T7	GND		GND	
T10	GND		GND	
U1	GND		GND	
U2	GND		GND	
U3	GND		GND	
U5	GND		GND	
U6	GND		GND	
U7	GND		GND	
U10	GND		GND	
U11	GND		GND	
U12	GND		GND	
U20	GND		GND	
V5	GND		GND	
V6	GND		GND	
V7	GND		GND	
V11	GND		GND	

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W5	GND		GND	
W6	GND		GND	
W7	GND		GND	
X1	GND		GND	
X4	GND		GND	
X5	GND		GND	
X6	GND		GND	
X7	GND		GND	
Y1	GND		GND	
Y2	GND		GND	
Y3	GND		GND	
Y4	GND		GND	
Y5	GND		GND	
Y6	GND		GND	
Y7	GND		GND	
Y20	GND		GND	
Z1	GND		GND	
Z2	GND		GND	
Z3	GND		GND	
Z4	GND		GND	
Z5	GND		GND	
Z6	GND		GND	
Z7	GND		GND	
Z20	GND		GND	
AA1	GND		GND	
AA2	GND		GND	
AA3	GND		GND	
AA4	GND		GND	
AA5	GND		GND	
AA6	GND		GND	
AA7	GND		GND	
AA8	GND		GND	
AA9	GND		GND	
AA10	GND		GND	
AA11	GND		GND	

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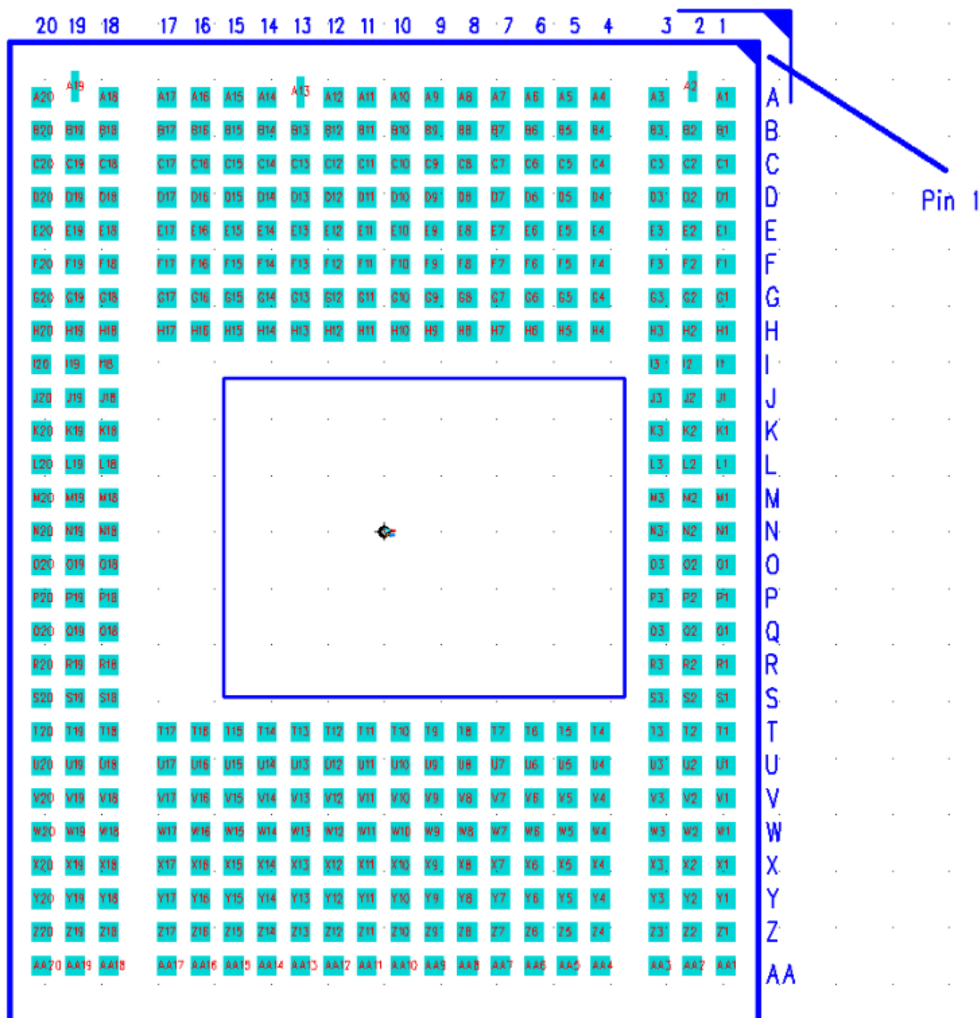
AA12	GND		GND	
AA13	GND		GND	
AA14	GND		GND	
AA15	GND		GND	
AA16	GND		GND	
AA17	GND		GND	
AA20	GND		GND	

3.4. Pad assignments (Top view)



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3.5. Electrical Specification

3.5.1. Input power specification

Absolute maximum rating:

Operating FREY M1 under conditions beyond its absolute maximum ratings may damage the device. Absolute maximum ratings are limiting values to be considered individually when all other parameters are within their specified operating ranges. Functional operation and specification compliance under any absolute maximum condition, or after exposure to any of these conditions, is not guaranteed or implied. Exposure may affect device reliability.

Parameter	Min.	Max.	Units
USB_VBUS_IN	0	25	V
VPH_PWR	0	6	V
CHG_OUT (VBAT) Steady state	0	5	V
CHG_OUT (VBAT) Transient (< 10 ms)	0	6	V

Operation condition:

Operating conditions include parameters that are under the control of the user : power supply voltage and ambient temperature. The FREY M1 meets all performance specifications listed in this document when used and/or stored within the operating conditions, unless otherwise noted in those sections (provided the absolute maximum ratings have never been exceeded).

Parameter	Min.	Max.	Units
USB_VBUS_IN	4.0	10	V
VPH_PWR	3.5	4.5	V
CHG_OUT (VBAT)	3.5	4.5	V

Note : There is battery detection algorithm in FREY M1 , user need to implement battery ID and thermal pin on the system , otherwise system can't be powered on successfully .

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Battery charger:

The FREY M1 features a fully programmable switch-mode battery charger, input power and output power controller for terminal devices. The device is designed to be used in conjunction with systems using single-cell Li-ion and Li-polymer battery packs.

Parameter	Conditions	Min	Typ	Max	Units
Peak switching current	USB_IN = 9.0 V	-	4	-	A
Maximum DC output current	USB_IN = 9.0 V	-	3	-	A
Switching frequency		0.95	1.0	1.05	MHz
OTG output voltage		4.85	5.00	5.15	V
Charger-specific digital I/O characteristics					
High-level input voltage (VIH)	All charger digital interface pads except CHG_EN	1.5	-	-	V
Low-level input voltage (VIL)		-	-	0.5	V
CHG_EN high-level input voltage (VIH)		1.3	-	-	V
CHG_EN low-level input voltage (VIL)		-	-	0.3	V

3.5.2. Output power specification

Output power	Circuit type	Default voltage (V)	Specified voltage range (V)[6]	Rated current (mA)	Expected use
VREG_L1	NMOS LDO	1.000	1.000	200	RFICs
VREG_L4	PMOS LDO	1.800	1.800	450	RFICs and GPS eLNA
VREG_L5	PMOS LDO	1.800	1.800	300	Most digital I/Os, LPDDR and eMMC

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VREG_L6	PMOS LDO	1.800	1.800	300	APQ DSI PLL and OTP, Camera, Touch screen, Display, and sensors
VREG_L10	PMOS LDO	2.850	2.850	150	Sensors
VREG_L11	PMOS LDO	2.950	2.950	800	Micro SD
VREG_L12	PMOS LDO	2.950	1.800/2.950	150	APQ pad group 2 and SDC2
VREG_L14	PMOS LDO	1.800	1.800/3.300	50	APQ pad group 5, dual-voltage UIM1, and NFC
VREG_L16	PMOS LDO	1.800	1.800	5	PMIC HKADC
VREG_L17	PMOS LDO	2.850	2.850	600	Camera, Display, and Touch screen
VREG_L18	PMOS LDO	2.700	2.700	150	QTI RF front-end
VREG_L22	PMOS LDO	2.800	2.800	300	Camera – analog
VREG_L23	NMOS LDO	1.200	1.200	300	Camera – digital

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LDO performance specifications

Parameter	Comments	Min	Typ	Max	Units
Output voltage ● All NMOS ● All PMOS	 ● 12.5 mV steps ● 12.5 V steps	 0.375 1.75	 - -	 1.5375 3.3375	 V V
Overall DC voltage output error ● Normal mode ■ At default voltage ■ At non-default voltages ● Low-power mode ■ At default voltage ■ At non-default voltages	Over-voltage, temperature, and process variations plus load and line regulation	 -2 -3 -4 -5	 - - - -	 2 3 4 5	 % % % %
Temperature coefficient		-100	-	100	ppm/°C
NMOS power-supply ripple rejection ● Normal mode ■ 50 Hz–1 kHz ■ 1–10 kHz ■ 10–100 kHz ● Low-power mode ■ 50 Hz–1 kHz ■ 1–100 kHz	PSRR	 60 - - - -	 70 60 50 50 40	 - - - - -	 dB dB dB dB dB
PMOS power-supply ripple rejection ● 50 Hz–1 kHz ● 1–10 kHz ● 10–100 kHz		 43 35 13	 - - -	 - - -	 dB dB dB

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3.5.3. Current consumption

Item	Test condition	Max.	Units
Off mode current	Module is turned off	250	uA
Flight mode current	Module is turned on and in sleep mode and all RF is turned off	4.5	mA
WiFi TX current	2.4G, 11b, 11 Mbps, 15 dBm	250	mA
WiFi RX current	2.4G	130	mA
WiFi TX current	5G, 11a, 54 Mbps, 15 dBm	250	mA
WiFi RX current	5G	130	mA
BT TX current	class 2 , 2dBm	150	mA
BT RX current		130	mA

Note 1. The measurement is at VBAT of module and VBAT=3.8V .

Note 2. WiFi & BT current is measured with IQexl 160.

3.5.4. Digital logic characteristics

Digital I/Os specification

Pad voltage	Usage	Table
1.8 V	Most digital I/Os	Table 3.5.4.1
Dual-V (1.8 V/2.95 V)	SDC2, UIM	Table 3.5.4.2
Dual-V (1.8 V/3.05 V)	USB	Table 3.5.4.3

Table 3.5.4.1 Digital I/O (VDD_P3= VREG_L5)

Parameter		Min.	Max.	Unit
VIH	High-level input voltage	0.65 × VDD_P3	-	V
VIL	Low-level input voltage	-	0.35 × VDD_P3	V
VOH	High-level output voltage	VDD_P3 - 0.45	-	V
VOL	Low-level output voltage	-	0.45	V

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Table 3.5.4.2 SDC2,UIM

Parameter		Min.	Max.	Unit
Common to UIM pads at either voltage (VDD_PX= VREG_L14)				
VIH	High-level input voltage	0.7 × VDD_PX	VDD_PX + 0.3	V
VIL	Low-level input voltage	0	0.2 × VDD_PX	V
VOH	High-level output voltage	0.8 × VDD_PX	VDD_PX	V
VOL	Low-level output voltage	0	0.4	V
SDC2 pads at 2.95 V only(VDD_PX= VREG_L12)				
VIH	High-level input voltage	0.625 × VDD_PX	VDD_PX + 0.3	V
VIL	Low-level input voltage	0	0.25 × VDD_PX	V
VOH	High-level output voltage	0.75 × VDD_PX	VDD_PX	V
VOL	Low-level output voltage	0	0.125 × VDD_PX	V
SDC2 pads at 1.8 V only				
VIH	High-level input voltage	1.27	2	V
VIL	Low-level input voltage	0	0.58	V
VOH	High-level output voltage	1.4	-	V
VOL	Low-level output voltage	0	0.45	V

Table 3.5.4.3 USB

Parameter	Min.	Typ.	Max.	Unit
Supply voltages				
Dual-supply	- -	1.80 3.075	- -	V
USBPHY_SYSCLK				
Frequency	-	19.2	-	MHz
Duty cycle	40	-	60	%
Low-level input voltage (VIL)	-	-	0.85	V
High-level input voltage (VIH)	1.27	-	-	V
USBPHY_VBUS				
Valid USB_HS_VBUS detection voltage	2.0	-	5.25	V

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3.5.5. Coin-cell charging

Parameter	Condition	Min	Typ	Max	Unit
Target regulator voltage(*)	VIN > 3.3 V, ICHG = 100 μA	2.50	3.10	3.25	V

(*) Valid regulator voltage settings are 2.5, 3.0, 3.1, and 3.2 V.

3.5.6. Audio

All audio codec performance data are collected above Vbatt of 3.7 V, unless otherwise specified.

Inputs and Tx processing

All Tx performance parameters are measured with a 1.02 kHz sine wave input signal, capless differential or single-ended inputs, Fs = 48 kHz, 24-bit data, and MCLK = 9.6 MHz or 12.288 MHz.

Parameter	Conditions	Min	Typ	Max	Units
Microphone amplifier gain = 0 dB (minimum gain)					
Input referred noise	Analog input = -200 dBV, A-weighted, bandwidth 20 Hz–20 kHz	-	19.0	25.1	μVrms
Signal-to-noise ratio	Analog input = 0 dBV, A-weighted, bandwidth 20 Hz–20 kHz	92.0	94.0	-	dB
Microphone amplifier gain = 24 dB (maximum gain)					
Input referred noise	Analog input = -200 dBV, A-weighted, bandwidth 20 Hz–20 kHz	-	2.7	4.2	μVrms
Signal-to-noise ratio	Analog input = -24 dBV, A-weighted, bandwidth 20 Hz–20 kHz	84.0	88.0	-	dB
General requirements					
Power supply rejection	100 mVpp sine wave imposed on PMIC vph_pwr				

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	input; analog input = 0 Vrms, terminated with 0 Ω Terminate inputs with 0 Ω; gain = 0 dB 0 < f < 1 kHz 1< f < 5 kHz 5 < f < 20 kHz	75 75 60	95 95 97	- - -	dB dB dB
Input impedance	Input disabled	3	-	-	MΩ
Input capacitance	Capless input	-	-	15	pF

Outputs and Rx processing

Parameter	Conditions	Min	Typ	Max	Units
Earpiece					
Output power	f = 1.02 kHz, 0 dBFS input, 6 dB gain mode, 32 Ω	120.0	127.0	-	mW
	f = 1.02 kHz, -1.5 dBFS input, 6 dB gain mode, 16 Ω	160.0	172.0	-	mW
	f = 1.02 kHz, -3.5 dBFS input, 6 dB gain mode, 10.67 Ω	150.0	160.0	-	mW
Output load	Supported output load	10.7	32.0	50000	Ω
Output capacitance	Total capacitance between EARO_P and EARO_M, including PCB capacitance and EMI	-	-	500	pF
Disabled output impedance	Measured externally with amplifier disabled	1.0	-	-	M Ω
Output common mode voltage	Measured externally with amplifier disabled	1.52	1.60	1.68	V
Headphone					

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Output power	f = 1.02 kHz, 0 dB FS, 16 Ω load; VDD_CP = 1.95 V, 0 dB gain mode	60.0	63.0	-	mW
	f = 1.02 kHz, 0 dB FS, 32 Ω load; VDD_CP = 1.95 V, 0 dB gain mode	27.0	30.8	-	mW
Output load	Supported output load	13.0	16.0	50000	Ω
Output capacitance	Total capacitance on HPH output (single-ended), including PCB capacitance and EMI	-	-	1000	pF
Disabled output impedance	Measured externally, with amplifier disabled	1.0	-	-	MΩ
Mono speaker					
Output power	Vdd = 5 V , f = 1 kHz THD + N < 8.7%; 15 μH + 8 Ω +15 μH THD+N ≤ 1%; 15 μH + 8 Ω + 15 μH THD+N ≤ 1%; 15 μH + 4 Ω + 15 μH	- 1200 1500	1700 1400 2150	- - -	mW mW mW
Power supply rejection	200 mVpp sine wave imposed on PMIC_VBATT; digital input = -999 dBFS2 f = 217 Hz f = 1 kHz f = 10 kHz f = 20 kHz	60.0 60.0 40.0 40.0	85.0 86.0 86.0 82.0	- - - -	dB dB dB dB
Efficiency	Vdd = 5 V Pout = 1 W, 15 μH + 8 Ω + 15 μH Pout = 2 W, 15 μH + 4 Ω + 15 μH	73.0 60.0	82.0 77.0	- -	% %

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3.5.7. Vibrator

Parameter	Conditions	Min	Typ	Max	Units
Operational input voltage	Connected at VDD_HAP (VH below)	2.5	3.6	4.75	V
Output voltage Peak, no load Average (V_HA) Maximum drive Accuracy	At HAP_OUT_P and HAP_OUT_N Differential, over one PWM cycle Differential, over one PWM cycle Duty cycle < 95%	- 0 1.2 -	- - - 50	VH 3.6 3.6 -	V V V mV
Output current limit R_ERM or R_load = 20 R_ERM or R_load = 10	Cycle-to-cycle limit	300 600	400 800	500 1000	mA mA
Internal PWM frequency Programmable options Accuracy	253 kHz, 505 kHz, 739 kHz, 1076 kHz	253 -	503 -	1076 +/-16	KHz %

3.5.8. Display ± bias

FREY M1 provides the plus and minus bias voltages for LCD displays; pertinent performance specifications are listed as below.

Display plus bias

Parameter	Conditions	Min	Typ	Max	Units
Operational input voltage	Connected at VDD_DIS_P	2.5	-	4.75	V
Output voltage (VDIS_P_OUT)		5.0	5.5	6.1	V

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Range, no load to 150 mA Resolution		-	100	-	mV
Output current		-	-	150	mA
Efficiency	I_out = 30 mA	-	92	-	%
Switching frequency (default)		-	1.48	-	MHz

NOTE: All specifications apply at VDD_DIS_x = 3.6 V , T = -30 to +85ºC, VDIS_P_OUT = 5.5 V, L = 4.7 μH, and C = 10 μF (capacitance value de-rated from 22 μF nominal) .

Display minus bias

Parameter	Conditions	Min	Typ	Max	Units
Operational input voltage	Connected at VDD_DIS_N	2.5	-	4.75	V
Output voltage (VDIS_N_OUT) Range, no load to 150 mA Resolution		-1.4 -	- 100	-6.0 -	V mV
Output current		-	-	150	mA
Efficiency	I_out = 50 mA	-	84	-	%
Switching frequency (default)		-	1.48	-	MHz

NOTE: All specifications apply at VDD_DIS_x = 3.6 V, T = -30 to +85ºC, VDIS_N_OUT = -5.5 V, L = 4.7 μH, C = 10 μF (capacitance value de-rated from 22 μF nominal) .

3.5.9. Flash drivers (including torch mode)

Parameter	Conditions	Min	Typ	Max	Units
Driver input voltage VDD_FLASH Flash disabled Flash enabled VDD_TORCH	Expected source is PMI's DC_IN_OUT	2.5 - -	- - 3.6	10 5.8 5.5	V V V

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	Expected source is PMI's VREG_BST_BYP				
Output current per LED Flash Torch		- -	- -	1000 200	mA mA

NOTE: All specifications apply at VPH_PWR = 3.6 V, T = -30 to +85ºC unless noted otherwise.

3.5.10. Display backlight (WLEDs)

The FREY M1 supports WLEDs with a boost converter that generates the high voltage needed for powering a string of WLEDs, plus four output drivers for sinking the current from WLED strings.

Parameter	Conditions	Min	Typ	Max	Units
Operational input voltage	VPH_PWR	2.5	-	4.75	V
Input voltage for full brightness 2 strings (~16 WLEDs) 4 strings (~28 WLEDs)	I_led = 20 mA per string V_out = 28 V across panel V_out = 24 V across panel	2.8 3.6	- -	- -	V V
Output voltage		6.0	-	28.5	V
Over-current protection	Programmable, set to 980 mA	830	980	1200	mA
Switching frequency		0.6	0.8	1.6	MHz
Efficiency Peak Average Light load	VDD = 3.6 V, 25°C, F_sw = 0.8 MHz I_out = 15 mA/string (x4), 13.5 V out I_out = 5 to 25 mA/string (x4) I_out = 1 to 5 mA/string (x4); PSM en	- - -	86 80 75	- - -	% % %
Full-scale current range	Programmable range, 2.5 mA step	0	-	30	mA
CABC frequency		20	-	40	KHz

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3.5.11. System clock (BB_CLK)

Parameter	Comment	Min	Typ	Max	Units
Operating frequency			19.2		MHz
Output levels ● Logic high (VOH) ● Logic low (VOL)		 1.17 -	 - -	 - 0.63	 V V

3.5.12. RF Transmit and Receiver Specifications

RF Operation Frequency Band

Band	Min	Max
WIFI 2.4G	2412MHz	2472MHz
WiFi 5G	5180MHz	5825MHz
BT	2402MHz	2480MHz
GPS	1574.40MHz	1576.44MHz
Glonass	1598MHz	1606MHz

WIFI

Considering SAR regulatory, limit WiFi Tx power at certain level.

Parameter	Bandwidth	Mode	Rate (Mbps)	Data Rate	2.4G			Unit
					Min	Typical	Max	
TX output power level	HT20	11b	11	CCK-11	13	15	17	dBm
		11g	54	OFDM-54	11	13	15	dBm
		11n	65	MCS7	10	12	14	dBm
Constellation Error (EVM)	HT20	11b	11	CCK-11	-	-18	-	dB
		11g	54	OFDM-54	-	-24	-	dB
		11n	65	MCS7	-	-26	-	dB
Sensitivity	HT20	11b	11	CCK-11	-	-89	-	dBm
		11g	54	OFDM-54	-	-74	-	dBm
		11n	65	MCS7	-	-70	-	dBm

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Parameter	Bandwidth	Mode	Rate (Mbps)	Data Rate	5G			Unit
					Min	Typical	Max	
TX output power level	HT20	11a	54	OFDM-54	13	15	17	dBm
		11n	65	MCS7	10	12	14	dBm
		11ac	78	MAC8	10	12	14	dBm
	HT40	11n	135	MCS7	10	12	14	dBm
		11ac	180	MCS9	10	12	14	dBm
	HT80	11ac	433	MCS9	9	11	13	dBm
Constellation Error (EVM)	HT20	11a	54	OFDM-54	-	-24	-	dB
		11n	65	MCS7	-	-25	-	dB
		11ac	78	MCS8	-	-28	-	dB
	HT40	11n	135	MCS7	-	-25	-	dB
		11ac	180	MCS9	-	-28	-	dB
	HT80	11ac	390	MCS9	-	-32	-	dB
Sensitivity	HT20	11a	54	OFDM-54	-	-70	-	dBm
		11n	65	MCS7	-	-68	-	dBm
		11ac	78	MCS8	-	-58	-	dBm
	HT40	11n	135	MCS7	-	-58	-	dBm
		11ac	180	MCS9	-	-53	-	dBm
	HT80	11ac	380	MCS9	-	-51	-	dBm

Bluetooth

Parameters	Min	Typ	Max	Uint
RCV/CA/01/C (Single Sensitivity)	-	-87	-	dBm
RCV/CA/07/C (EDR Sensitivity) 2Mbps Packet Length: 2-DH1	-	-87	-	dBm
RCV/CA/07/C (EDR Sensitivity)	-	-87	-	dBm

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3Mbps Packet Length: 3-DH1				
TRM/CA/01/C Output power(class1)	0	8	12	dBm
TRM/CA/01/C Output power(class2)	-6	0	4	dBm

GPS

Test Items	Test condition	Min	Typical	Max	Unit
CN ration	Satellites@-130dBm	-	38	40	dBm
Sensitivity		-	-145	-	dBm

3.5.13. Electrostatic Discharge

The module is not protected against Electrostatic Discharge (ESD) in general. Consequently, it is subject to ESD handling precautions that typically apply to ESD sensitive components. Proper ESD handling and packaging procedures must be applied throughout the processing, handling and operation of any application that incorporates a FREY M1 module.

Electrostatic discharge (ESD) may lead to irreversible damage for the module. It is therefore advisable to develop measures and methods to counter ESD and to use these to control the electrostatic environment at manufacturing sites.

Specification	
ANSI/ESDA/JEDEC JS-001-2011	± 1KV Human Body Model (HBM)
JESD22-A114-F	± 500V Charge Device Model (CDM)
EN301-489	± 4KV (Indirect discharge) *
	± 8KV (Air discharge) **

Note * : Indirect discharge with coupling metal plane .

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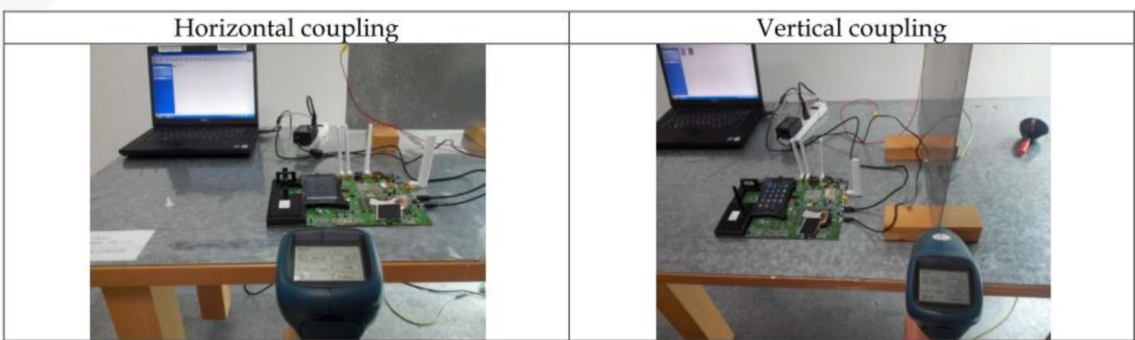
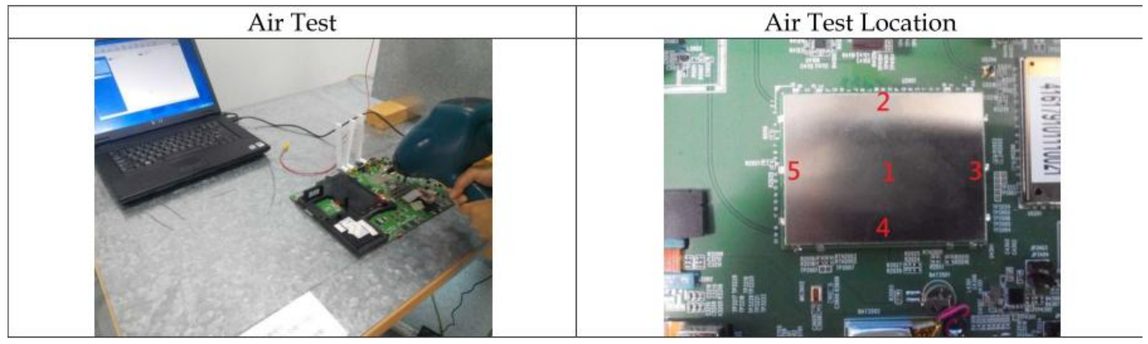


Note ** : Air discharge on location 1,2,3,4,5 on module , module is mounted on EVB .



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Charpt 4. Module Mounting Issues

Frey M1 modules have been designed with an easy integration into SMT processes in mind. Some module mounting issues are discussed in more detail in the sections below.
Please note that Frey M1 modules are specified for one soldering cycle only. Once removed from the application, the module will very likely be destroyed and cannot be soldered onto another application. Please also note that the modules are not sealed and should therefore not be subjected to any post SMT wash or to any environments where condensation could occur.

4.1. Solder Paste

A variety of solder paste types can be used to realize connections to external applications. Soldering using lead free eutectic SnAgCu alloy can be done without any special restrictions, because of its maximum allowed temperature of 245°C.
ENIG finish of the modules soldering pads ensures good wetting properties even after 12 month of storage.
However, there are some restrictions that should be noted before selecting the solder paste:
Due to the fact that the top side of the modules is assembled using standard eutectic SnAgCu alloy, no higher melting alloys should be used (even though remelting of top side solder joints also happens with eutectic SnAgCu).
Higher temperatures mean more stress to materials than lower temperatures: Increasing the reflow temperature increases the growth of intermetallics, especially if the temperature lies above the melting point of that alloy. Large intermetallics are commonly considered a reliability risk. They should therefore be kept as small as possible.

4.2. Stencil Printing

4.2.1. General Stencil Considerations

The higher the stand off formed by the solder paste volume, the better the reliability for land grid array (=LGA) based connections. The solder paste volume in a stencil printing process is formed by aperture size (area) and stencil height:

VolumeSolder paste = AreaAperture x HeightStencil

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It is recommended that customers do their own testing to determine the optimal solder paste volume. This volume can be applied by stencil printing with different stencil heights to fit your existing assembly needs. The volume is kept constant by varying the aperture size accordingly.

The most common thicknesses 110μm and 150μm (stainless steel, laser cut) have been tested with good results with regard to printing process, soldering process and reliability testing. Similar results are expected with stencil thicknesses in between.

Different solder paste volumes have been tested too but with much lower volume there is a trend to poor solder joints and a risk for open joints. Much larger solder joints tend to form solder balling in the vicinity of the solder joints.

4.2.2. Used Parameters and Recommendations

For stencil printing, a stainless steel stencil, laser cut (or similar technology) should be used. Parameters must be optimized depending on actual application board design, equipment und solder paste.

To simulate different applications, two different stencil thicknesses of 110μm and 150μm were used while keeping the solder paste volume constant by variation of the apertures.

If the results for all tested versions were found to be good. For exact pad and aperture dimensions, as well as module geometry and footprint design

4.2.3. Pick and Place

FREY M1 well be put into the antistatic tray plate. One antistatic tray plate will have 15 Frey M1 modules, and one moisture barrier bag will have max 5 antistatic tray plates

4.2.4. Reflow Profile

Short profiles are recommended for reflow soldering processes in order to prevent top side solder joints from growing large intermetallic compounds. Peak zone temperature should be adjusted high enough to ensure proper wetting and optimized forming of solder joints. On the other hand, a plateau during preheating can help to reduce voiding behavior. Generally speaking, unnecessary long exposure and exposure to more than 245°C should be avoided.

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As an example and during Frey M1 internal tests, forced convection machines were able to realize a good reflow soldering profile, so there was no need for using vapor phase equipment.

For analyzing and adapting solder profiles a carrier board was prepared with thermocouples (TC) .

In order to get a good overall performance the resulting voiding and the formation of intermetallics as well as other thermal induced degradations must be well balanced. As mentioned above a longer preheating phase can help gasses to escape from solder joints before solidification. To not overstress the assembly, the complete reflow profile should be as short as possible.

Here an optimization considering all components on the application must be performed. The optimization of a reflow profile is a gradual process. It needs to be performed for every paste, equipment and product combination. The presented profiles are only samples and valid for the used pastes, reflow machines and test application boards. Therefore a "ready to use" reflow profile can not be given.

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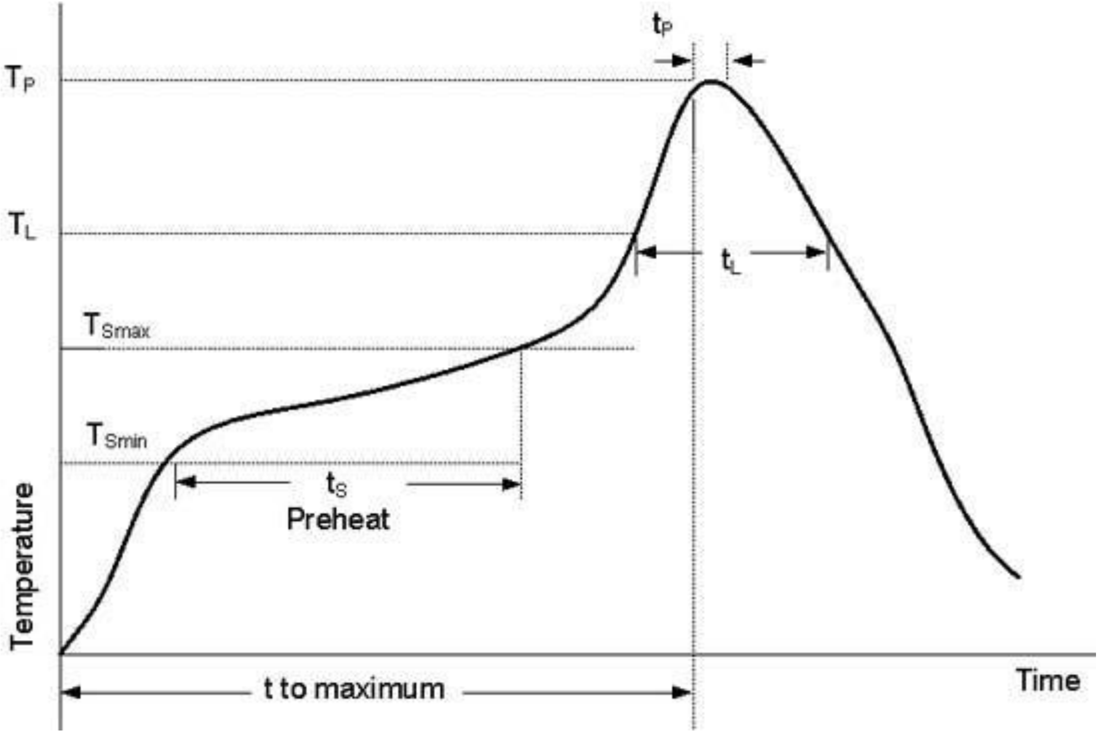
4.3. Soldering Conditions and Temperature

4.3.1. Reflow Profile



Profile Feature	Pb-Free Assembly
Preheat & Soak Temperature Minimum (T_{smin}) Temperature Maximum (T_{smax}) Time (T_{smin} to T_{smax}) (t_S)	150°C 200°C 60-120 seconds
Average ramp up rate (T_{smax} to T_p)	3K/second max.
Liquidous temperature (T_L) Time at liquidous (t_L)	217°C 60-90 seconds
Peak package body temperature (T_p)	245°C +0/-5°C
Time (t_P) within 5 °C of the peak package body temperature (T_P)	30 seconds max.
Average ramp-down rate (TP to T_{Smax})	3 K/second max.

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Time 25°C to maximum temperature	8 minutes max.

4.3.2. Maximum Temperature and Duration

The following limits are recommended for the SMT board-level soldering process to attach the module:

- A maximum module temperature of 245°C. This specifies the temperature as measured at the module's top side.
- A maximum duration of 30 seconds at this temperature.

Please note that while the solder paste manufacturers' recommendations for best temperature and duration for solder reflow should generally be followed, the limits listed above must not be exceeded.

Frey M1 is specified for one soldering cycle only. Once Frey M1 is removed from the application, the module will very likely be destroyed and cannot be soldered onto another application.

4.4. Soldering Process Evaluation

4.4.1. Visual Inspection

As a rule, automated optical inspection (AOI) of solder joints is not suitable for evaluating LGA modules, because most of the I/O pins are hidden underneath the module. Inspection of the outermost I/Os is not sufficient to evaluate soldering. Please reference IPC-A-610 standard.

4.4.2. X-Ray Inspection and Void Content

X-Ray inspection is an appropriate method for evaluating solder joints after reflow. X-Ray images can show wetting problems, missing solder volume or of course bridging.

X-Ray inspection is made somehow more difficult by overlaying module components and by possible bottom side (application) assemblies. However, module connections are characterized by their shape and size, so in most cases they can easily be distinguished from the mentioned overlaying structures.

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The set shows typical X-Ray images of sample modules soldered to an assumed application board including some failure samples. The images are taken from assembly and BLR testing and comprise two different stencil versions (110μm and 150μm thickness).
A good solder joint at Frey M1 signal pins in X-Ray inspection is characterized by a rectangular shape, described by the dimensions of the pad at the module.
Solder joints which have a round footprint in X-Ray image are found in areas with high stand off and are more column like instead of flat. These are good from electrical point of view but indicate processing problems like aslope standing of the module or warpage.
It is recommended to use X-Ray to determine level of voiding. Entrapments of gases can often not be completely avoided, if large flat solder joints are used. Currently there are no standards available defining limits for void content. The available IPC610 standard for ball grid arrays (=BGA) must not be applied to LGAs and hence to the Frey M1 SMT modules.
As seen from the X-Ray images above there is no significant difference in reflow result for the 110μm and 150μm stencils. This is mainly due to the fact, that the resulting volume was kept constant by varying the apertures accordingly. The resulting shape of the solder joint is only influenced by the volume.
Only if solder paste spreading is limited, which can occur with lead free solder on Cu-OSP or immersion tin PCB surfaces, a little difference in solder joint shape can be expected but with no effect on quality or yield. This is a characteristic of lead free solders and not a wetting issue.

4.5. Board Level Reliability Investigation

The board level reliability tests described as follow table

Item No	Test case	International standard
1	Storage Test	IEC60068-2-1 IEC60068-2-2
2	Thermal Cycle	IEC60068-2-3 IEC60068-2-56 IEC60068-2-38 IEC60068-2-30
3	Thermal Stress	IEC60068-2-3

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		IEC60068-2-56 IEC60068-2-38 IEC60068-2-30
4	Thermal Shock	IEC60068-2-14
5	Vibration	IEC60068-2-6 IEC60068-2-59
6	Mechanical Shock	IEC60068-2-27
7	Micro Drop	IEC60068-2-32
8	ESD	IEC61000-4-2
9	Low temperature start test	IEC60068-2-1
10	High temperature start test	IEC60068-2-2

4.6. Desoldering Process

In case of persisting module issues, the module may be desoldered from the application board. Desoldering however should only be the final means of diagnosis after all other possible electrical on-board tests using the implemented test points were not successful. The desoldering process is very similar to the employed soldering process, meaning that it is quite specific for any type of external application.

The intention of desoldering is to provide a possibility to employ the standard RMA process. Even if a further usage of the application board cannot be guaranteed (because of the potential impact on neighboring components throughout the desoldering process), a high reuse probability is expected, if the desoldering process is done in a professional manner. There are a various types of desoldering machines available. The choice of a desoldering machine (e.g., a Martin machine) strongly depends on the layout of the external application board, the size and position of other components close to the module have an impact on the temperature profile and type of heating.

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4.6.1. Preparation of LGA Module

It is recommended to use a vacuum lift system to pick up the desoldered module from the application board. To secure a fixed connection between module shielding and module PCB, additional glue points have to be provided.

4.6.2. Baking of Application Board

For a reliable desoldering process the moisture level has to taken into account. As known from the soldering process, the moisture has to be limited to a certain level to avoid any damages to components. Therefore, the complete application board including the module will have to be baked before the desoldering process begins.

4.6.3. Removal of LGA Module

After preparation (glueing, baking) the module can be desoldered from the application board. The desoldering temperature profile has to be selected that fits to the application and module requirements (e.g., used solder paste, soldered components, PCBs). As recommended for the LGA modules' soldering process, the temperature profile should not exceed a temperature of 245°C

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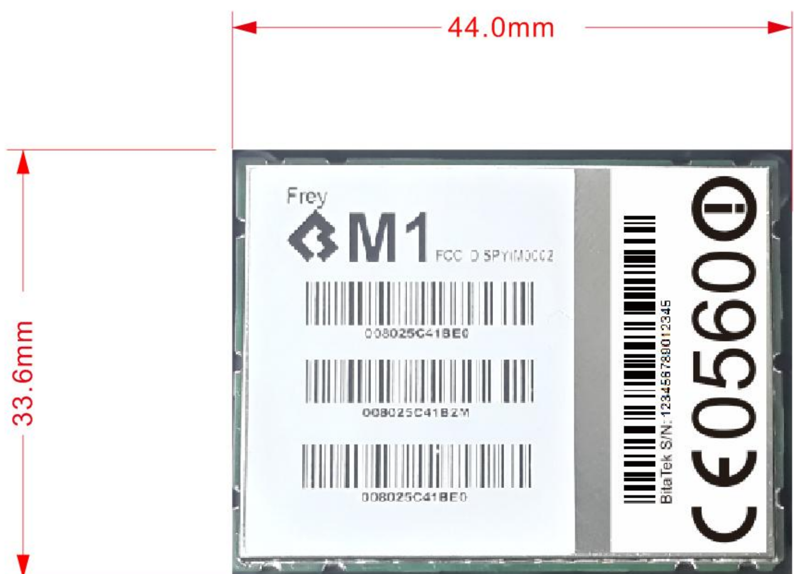
Charpt 5. Packaging

5.1. Mechanical Dimensions of Frey M1

Length: 44mm

Width: 33.6mm

Height: 2.7mm



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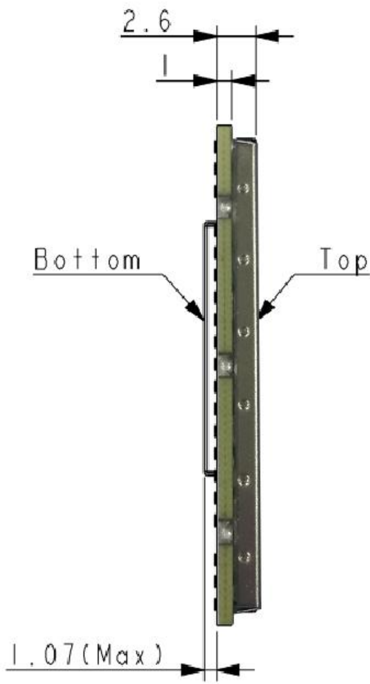

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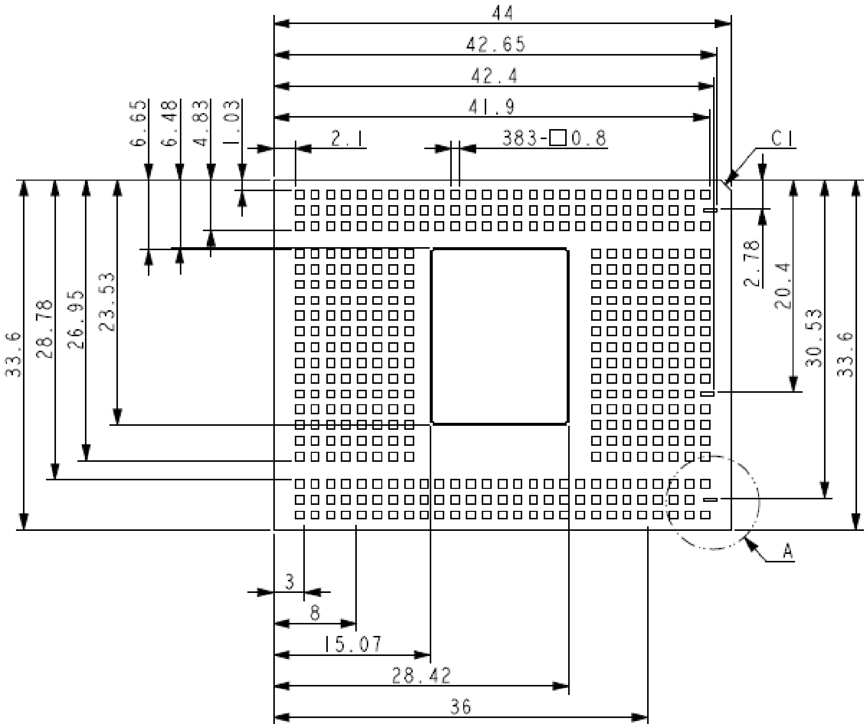

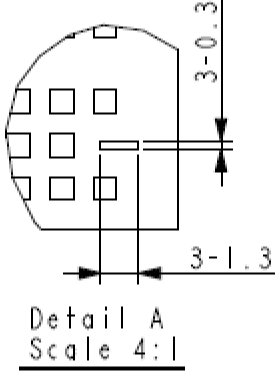

5.2. Shipping Materials

FREY M1 is described below, including the following required shipping materials:

- Moisture barrier bag, including desiccant and humidity indicator card.

FREY M1 well be put into the antistatic tray plate. One antistatic tray plate will have 15 Frey M1 modules, and one moisture barrier bag will have max 5 antistatic tray plates.

The material of tray plate is styrene-butadiene Copolymer(CAS NO. 9003-55-8), the operation temperature range please refence CAS NO 9003-55-8.

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305mm
46 mm
146mm
36 mm
33.65 mm
12
7.0 mm

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5.2.1. Moisture Barrier Bag

Those are stored inside a moisture barrier bag, The bag is ESD protected and delimits moisture transmission. It is vacuum-sealed and should be handled carefully to avoid puncturing or tearing. The bag protects the Frey M1 modules from moisture exposure. It should not be opened until the devices are ready to be soldered onto the application.

The moisture barrier bag size : 420 x 240 MM

The moisture barrier bag thickness : 0.15MM

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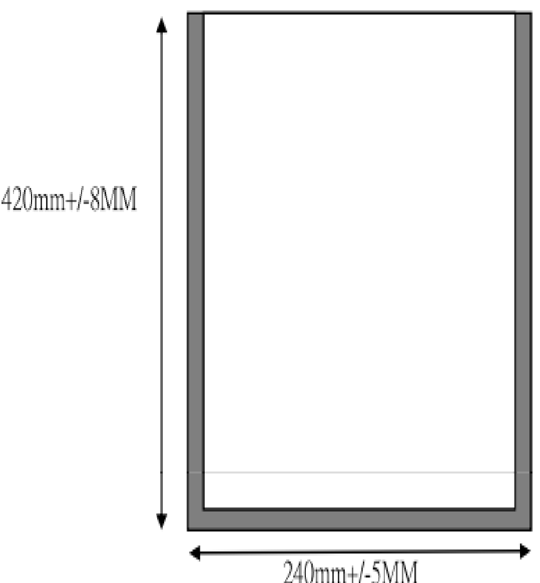

Desiccant size :

The moisture barrier bag s contain one or more desiccant pouches to absorb moisture that may be in the bag. The humidity indicator card described below should be used to determine whether the enclosed components have absorbed an excessive amount of moisture.

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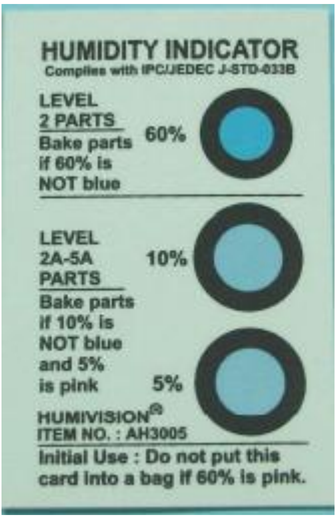
The desiccant pouches should not be baked or reused once removed from the moisture barrier bag.

The humidity indicator card is a moisture indicator and is included in the moisture barrier bag to show the approximate relative humidity level within the bag. A sample humidity card is shown in follow Figure. If the components have been exposed to moisture above the recommended limits, the units will have to be rebaked.



5.3. Packing Label

The label shown in summarizes requirements regarding moisture sensitivity, including shelf life and baking requirements. It is attached to the outside of the moisture barrier bag.

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Caution label

Caution

This bag contains

MOISTURE-SENSITIVE DEVICES

1. Calculated shelf life in sealed bag: 12 months at <40°C and <90% relative humidity (RH)
2. Peak package body temperature: 245°C
3. After bag is opened, devices that will be subjected to reflow solder or other high temperature process must be
   a) Mounted within: 72 hours of factory conditions ≤30°C/60% RH, or
   b) Stored per J-STD-033
4. Devices require bake, before mounting, if:
   a) Humidity Indicator Card reads >10% for level 2a - 5a devices or >60% for level 2 devices when read at 23 ± 5°C
   b) 3a or 3b are not met
5. If baking is required, refer to IPC/JEDEC J-STD-033 for bake procedure

Bag Seal Date:____________________________________

If blank, see adjacent bar code label

Note: Level and body temperature defined by IPC/JEDEC J-STD-020

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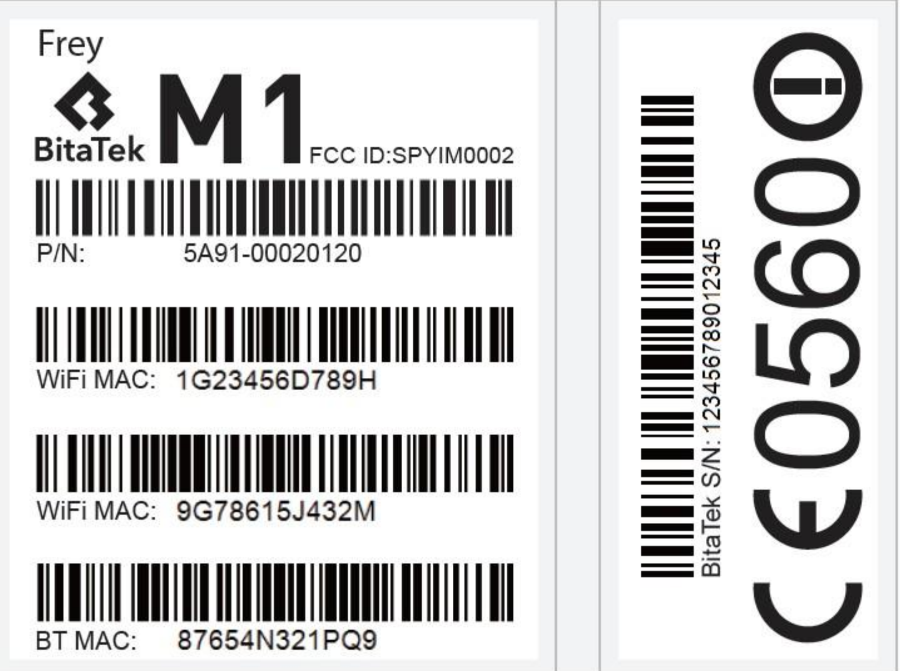
Module label : this label will on the top site of Frey M1.



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Vacuum bag label : It is attached to the outside of the moisture barrier bag.

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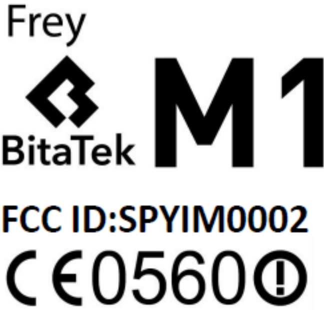
Carton label : It is attached to the outside of the carton



5.4. Storage Conditions

The conditions stated below are only valid for modules in their original packed state in weather protected, non-temperature-controlled storage locations. Normal storage time under these conditions is 12 months maximum. The modules will be delivered in a packaging that meets the requirements Low Temperature Carriers.

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5.5. Moisture Sensitivity Level

Frey M1 comprises components that are susceptible to damage induced by absorbed moisture.

5.6. Durability and Mechanical Handling

5.6.1. Storage Life

Frey M1 modules must be stored in sealed, moisture barrier anti-static bags. The shelf life in a sealed moisture bag is an estimated 12 months. However, such a life span requires a non-condensing atmospheric environment, ambient temperatures below 40°C and a relative humidity below 90%

5.6.2. Processing Life

Frey M1 must be soldered to an application within 72 hours after opening the moisture barrier bag (MBB) it was stored in.
The manufacturing site processing the modules should have ambient temperatures below 30°C and a relative humidity below 60%.

5.6.3. Electrostatic Discharge

Electrostatic discharge (ESD) may lead to irreversible damage for the module. It is therefore advisable to develop measures and methods to counter ESD and to use these to control the electrostatic environment at manufacturing sites.

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Charpt 6. Regulatory and Type Approval Information

It is the responsibility of the application manufacturer to ensure compliance of the final product with all provisions of the applicable directives and standards as well as with the technical specifications provided

Directive

99/05/EC	Directive of the European Parliament and of the council of 9 March 1999 on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity (in short referred to as R&TTE Directive 1999/5/EC). The product is labeled with the CE conformity mark CE0560
2011/65/EC (RoHS 2)	Directive of the European Parliament and of the Council of 27 January 2003 (and revised on 8 June 2011) on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS)
REACH	REACH is a regulation of the European Union, adopted to improve the protection of human health and the environment from the risks that can be posed by chemicals, while enhancing the competitiveness of the EU chemicals industry. It also promotes alternative methods for the hazard assessment of substances in order to reduce the number of tests on animals. REACH stands for Registration, Evaluation, Authorisation and Restriction of Chemicals. It entered into force on 1 June 2007

Standards of European type approval

EN300328 V1.9.1 EN300 328 V1.9.1: 2015	Electromagnetic compatibility and Radio spectrum Matters (ERM); Wideband transmission systems; Data transmission equipment operating in the 2.4GHz ISM band and using wide band modulation techniques; Harmonized EN covering the essential requirements of article 3.2 of R&TTE Directive.
EN301893 V1.8.1	Broadband Radio Access Networks (BRAN); 5GHz high

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EN301 893 V1.8.1: 2015	performance RLAN; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive.
DFS EN301893 V1.8.1 EN301 893 V1.8.1: 2015	**The advantage of 802.11a wireless market and the constant push to open up spectrum for unlicensed use created a requirement for Dynamic Frequency Selection (DFS), a mechanism to use the 5GHz frequency bands already allocated to radar systems without causing interference to those radars.**
EN300 440-1 v1.6.1:2010 EN300 440-2 v1.4.1:2010	Electromagnetic compatibility and Radio spectrum Matters (ERM); Short range devices; Radio equipment to be used in the 1GHz to 40GHz frequency range
EN 301 489–1 v1.9.2 : 2011, EN 301 489–3 v1.6.1 : 2013 EN 301 489–17 v2.2.1 : 2012	Electromagnetic compatibility and Radio spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services
EN 55022 : 2010+AC:2011 EN 61000-4-2 : 2009, EN 61000-4-3 : 2006+A1:2008+A2:2010 EN 55022 : 2010+AC:2011 EN 55024 : 2010, IEC 61000-4-2 : 2008 IEC 61000-4-3 : 2006+A1:2007+A2:2010 IEC 61000-4-8 : 2009	The modified derivative of CISPR 22 and applies to, as the name implies, information technology equipment (ITE).
EN 62311: 2008	**Assessment of electronic and electrical equipment related to human exposure restrictions for electromagnetic fields (0Hz -300GHz)**

Standard of FCC Regulatory Approval

FCC 15C	**Frequency hopping and digitally modulated system**
FCC15E	RADIO FREQUENCY DEVICES -Unlicensed National Information Infrastructure Devices
	Compliance measurement procedures for unlicensed

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DFS	material information infrastructure device operating in the 5.25Ghz ~5.35GHz and 5.47GHz~5.725GHz Bands incorporating dynamic frequency selection
Part 15B	**Radio Frequency Devices**
OET65 (SAR)	operations or devices comply with limits for human exposure to radiofrequency (RF) fields adopted by the Federal Communications

BQB Certificate:

BQB	complies with all the Bluetooth SIG requirements

WiFi Alliance:

WiFi Logo	WiFi Alliance approval

Note: SAR requirements specific to portable mobiles

This requires the Specific Absorption Rate (SAR) of portable Frey M1 applications to be evaluated and approved for compliance with national and/or international regulations. Since the SAR value varies significantly with the individual product design manufacturers are advised to submit their product for approval if designed for portable use. For European markets the relevant directives are mentioned below. It is the responsibility of the manufacturer of the final product to verify whether or not further standards, recommendations or directives are in force outside these areas.

6.1. Safety Precautions

The following safety precautions must be observed during all phases of the operation, usage, service or repair of any cellular terminal or mobile incorporating Frey M1 Manufacturers of the cellular terminal are advised to convey the following safety information to users and operating personnel and to incorporate these guidelines into all manuals supplied with the product. Failure to comply with these precautions violates safety standards of design, manufacture and intended use of the product.

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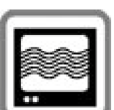
	When in a hospital or other health care facility, observe the restrictions on the use of mobiles. Switch the cellular terminal or mobile off, if instructed to do so by the guidelines posted in sensitive areas. Medical equipment may be sensitive to RF energy. The operation of cardiac pacemakers, other implanted medical equipment and hearing aids can be affected by interference from cellular terminals or mobiles placed close to the device. If in doubt about potential danger, contact the physician or the manufacturer of the device to verify that the equipment is properly shielded. Pacemaker patients are advised to keep their hand-held mobile away from the pacemaker, while it is on.
	Switch off the cellular terminal or mobile before boarding an aircraft. Make sure it cannot be switched on inadvertently. The operation of wireless appliances in an aircraft is forbidden to prevent interference with communications systems. Failure to observe these instructions may lead to the suspension or denial of cellular services to the offender, legal action, or both.
	Do not operate the cellular terminal or mobile in the presence of flammable gases or fumes. Switch off the cellular terminal when you are near petrol stations, fuel depots, chemical plants or where blasting operations are in progress. Operation of any electrical equipment in potentially explosive atmospheres can constitute a safety hazard.
	Your cellular terminal or mobile receives and transmits radio frequency energy while switched on. Remember that interference can occur if it is used close to TV sets, radios, computers or inadequately shielded equipment. Follow any special regulations and always switch off the cellular terminal or mobile wherever forbidden, or when you suspect that it may cause interference or danger.
	IMPORTANT! Cellular terminals or mobiles operate using radio signals and cellular networks. Because of this, connection cannot be guaranteed at all times under all conditions. Therefore, you should never rely solely upon any wireless device for essential communications, for example emergency calls. Remember, in order to make or receive calls, the cellular terminal or mobile must be switched on and in a service area with adequate cellular signal strength. Some networks do not allow for emergency calls if certain network services or

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	phone features are in use (e.g. lock functions, fixed dialing etc.). You may need to deactivate those features before you can make an emergency call. Some networks require that a valid SIM card be properly inserted in the cellular terminal or mobile.

6.2. Safety

European Union notice

This device complies with the R&TTE Directive (1999/5/EC) issued by the Commission of the European Community.

We declare under our sole responsibility that our product and in combination with our accessories, to which this declaration relates is in conformity with the appropriate standards EN 55022/24, EN 301 489-1-3-17, EN62311, EN 300 328, EN301 893, EN300 440 following the provisions of, radio equipment and telecommunication terminal equipment directive 1999/5/EC.

Federal Communications Commission (FCC) Statements

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including any interference that may cause undesired operation of the device.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC rules. These limits are designed to provide reasonable protection

against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation.

If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

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FCC Warning:

The FCC requires that you be notified that any changes or modifications to this device not expressly approved by the manufacturer could void the user's authority to operate the equipment.

RF Radiation Exposure Statement:

This equipment complies with FCC RF radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with a minimum distance of 20 centimeters between the radiator and your body.

This Transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

Regulatory Module Integration Instructions

Only those antennas with same type and lesser gain filed under this FCC ID number can be used with this device.

The final system integrator must ensure there is no instruction provided in the user manual or customer documentation indicating how to install or remove the transmitter module.

Required end product labeling:

Any device incorporating this module must include an external, visible, permanent marking or label which states: "Contains FCC ID: SPYIM0002"

The final host / module combination may also need to be evaluated against the FCC Part 15B criteria for unintentional radiators in order to be properly authorized for operation as a Part 15 digital device.

If the final host / module combination is intended for use as a portable device (see classifications below) the host manufacturer is responsible for separate approvals for the SAR requirements from FCC Part 2.1093.

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Charpt 7. Appendix

7.1. Abbreviations

Abbreviation	Description
BGA	Ball Grid Array
BLR	Board Level Reliability
DCE	Data Communication Equipment
DTE	Data Terminal Equipment
ENIG	Electroless Nickel Immersion Gold
LGA	Land Grid Array
PCB	Printed Circuit Board
RF	Radio Frequency
SMD	Surface Mount Device
SMT	Surface Mount Technology
TC	Thermocouples
TP	Test Point
UART	Universal Asynchronous Receiver-Transmitter

7.2. Mounting Advice Sheet

To prevent mechanical damage, be careful not to force, bend or twist the module. Be sure it is soldered flat against the host device. The advice sheet on the follow shows a number of examples for the kind of bending that may lead to mechanical damage of the module (the module as part of an external application is integrated into a housing).

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	By pressing from above
	By mounting under pressure
	By putting object on top
	By putting objects below

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