FINGERPRINTS

Product Specification

FPC-BM

Biometric Module

Revision C

Contents

1 Overview

The FPC-BM module is a biometric fingerprint system, including a robust fingerprint sensor solution and on-board template storage. The biometric module can be used standalone, ready to use out-of-the-box at delivery, or connected to a host CPU over UART or SPI. Simple serial commands are used to enroll and verify.

Application examples

- Access control systems
- Time & Attendance
- Locks, safes
- POS terminals

1.1 General Description

The FPC-BM can be used in conjunction with either an FPC1020AM touch fingerprint sensor, or an FPC1011F3 area fingerprint sensor, depending on which is deemed most suitable for the intended application. Each FPC sensor has a protective coating which helps to protect the biometric module against ESD, scratches, impact and everyday wear-and-tear. All FPC sensors feature 3D pixel sensing technology that can read virtually any finger; dry or wet.

The FPC-BM includes the following features:

- Embedded / stand-alone fingerprint identification system
- Compact sensor module package
- Protective sensor coating: scratch and ESD resistant
- One-to-one verification mode
    - Matching against 1 multi-template
- Identify (Few) verification mode
    - 50 multi-templates
- On-board template storage
    - Max. 50 multi-templates
- Straightforward serial command interface
- Finger detect & FPC OneTouch™ wake-up functionality (with FPC1020AM)
- EU RoHS compliant
- Easy to integrate and minimize time-to-market

The FPC-BM can be integrated into virtually any application and controlled by a host sending basic commands for enrolment and verification via the serial interface. Fingerprint templates are automatically created and stored in the internal flash memory. Templates used for verification can also be imported from an external storage source, including a central database, smartcard, or portable flash memory.

1.2 Technical Features – Biometric Module

An overview of the technical features of the FPC-BM biometric module is shown in Table 1.

Parameter		Description	Value	Unit
Processor board dimension		(W x L x H)	40.2 x 20.2 x 2.65	mm
Supply voltage		Regulated	3.3	V
		Unregulated	5	V
Current consumption (3.3 V)	Active capture mode	Full Speed	<70	mA
		Half Speed	25	
	Idle mode (default)	Typical	10	mA
	Sleep mode	Finger detection active (FPC1020)	35	µA
	Deep Sleep mode	Finger detection not active	3.3	µA
ESD*		IEC61000-4-2, level X, air discharge	> ± 30	kV

**With proper integration as recommended in this specification. See section 11.10.3.*

Table 1: Technical features overview

1.3 Technical Features – Fingerprint Sensors

An overview of the fingerprint sensors which are compatible with the FPC-BM is shown in Table 2.

		
SENSOR / FEATURE	FPC1020AM-CM03 FPC1020AM-CM04 (IP67)	FPC1011F3
Sensor matrix	192 x 192 pixels	152 x 200 pixels
Number of pixels	36 864 pixels	30 400 pixels
Active sensing area	9.6 x 9.6 mm	10.6 x 14.0 mm
Spatial resolution	508 DPI	363 DPI
Pixel resolution	256 8-bit grayscale levels	
Durability	10 million finger placements	
Scratch resistance	Pencil hardness: 4H	
Resistance to household substances	Water, carbonated soft drinks, coffee, oil, petrol, soap, artificial sweat, orange juice	
RoHS / ACPEIP	EU RoHS 2 / China RoHS	

Table 2: Overview of the FPC1020AM and FPC1011F3 sensors.

See section 10.2 for information on the mechanical properties of the sensors in Table 2.

2 Functional Description

The FPC-BM biometric module is a versatile stand-alone fingerprint verification system which consists of two main components: an FPC fingerprint sensor and a processor board.

The FPC-BM processor board acquires the fingerprint image from the fingerprint sensor. The flash memory on the FPC-BM is pre-loaded with firmware from FPC and is used for all biometric operations and template storage.

2.1 Operating Modes

FPC-BM can be run in Standalone Mode, or Host Mode when connected to a host over UART or SPI.

The illustration in Figure 1 shows a system overview of the FPC-BM.

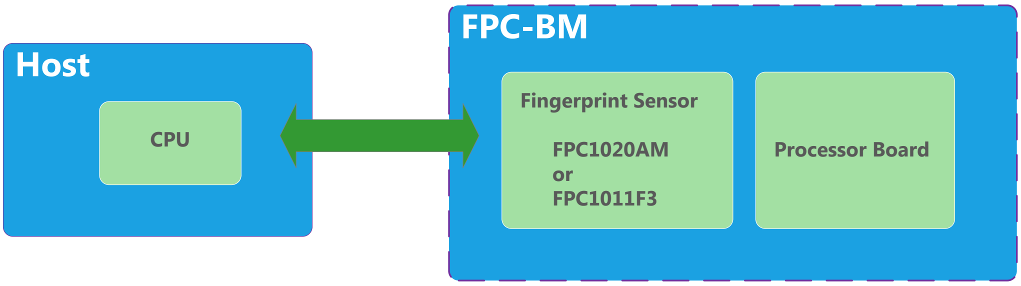

Figure 1: FPC-BM system overview

2.1.1 Standalone Mode

FPC-BM is ready to use out-of-the-box at delivery as a standalone biometric module where Standalone mode is activated by default. See section 7.31 for more information on how to toggle standalone mode.

Host Commands

In standalone mode, when a finger is present, the FPC-BM does not respond to commands from the host.

Unsupported Commands

The Capture Image command is not supported in Standalone mode. Standalone mode must be turned off to use this command. For more information on image capture, see section 7.17.1.

2.1.2 Host Mode

The FPC-BM can be used as a slave towards a host. In Host Mode, a host - selected and provided by the customer - executes the main application which interfaces with the FPC-BM biometric module. Requirements on the host processor associated with the module communication are extremely low; therefore, the host processor can be selected entirely to suit the primary application.

Command Interface

The interface between the host and the processor board is based on a simple-to-use serial UART or a 20 MHz SPI command interface. There is no direct interaction between the host processor and the fingerprint sensor in host mode.

Enroll Pin Deactivated

In Host Mode, the FPC-BM is run as a slave and the Enroll pin is deactivated.

2.2 Fingerprint Sensors

The FPC fingerprint sensors (FPC1020AM and FPC1011F3) which are compatible with the FPC-BM are based on capacitive technology and utilize a reflective measurement method. This method requires a galvanic contact point outside the sensor chip – this is achieved by means of a conductive bezel integrated into the sensor package.

To obtain good quality images, it is important that the sensor is correctly mounted in an enclosure. See section 10 for more information on mechanical properties.

2.2.1 Absolute Maximum Ratings

Exposure to absolute maximum rating conditions for extended periods may affect device reliability. Stress beyond the values outline in this section may cause permanent damage to the fingerprints sensors. Operation of the device in conditions beyond those indicated as normal operation in this specification is not implied or supported.

FPC1020AM

The values listed in Table 3 indicate the absolute maximum ratings for the FPC1020AM sensor.

Parameter	Absolute maximum value	Unit
VDD	-0.5 to +2.5	V
VDDIO	-0.5 to +4.8	V
VDDA	-0.5 to +2.5	V
Operating temperature	- 20 to + 60	˚C
Storage temperature	- 45 to + 85	˚C

Table 3: Absolute maximum ratings FPC1020AM

FPC1011F3

The values listed in Table 4 indicate the absolute maximum ratings for the FPC1011F3 sensor.

Parameter	Absolute maximum value	Unit
VDD	-0.5 to +7.0	V
VDDIO	-0.5 to VDD + 0.5	V
Operating temperature	- 20 to + 60	˚C
Storage temperature	- 45 to + 85	˚C

Table 4: Absolute maximum ratings FPC1011F3

2.3 Performance Characteristics

This section describes the performance characteristics for the sensors that are compatible with the FPC-BM. The FPC-BM has three operation levels which directly affect performance characteristics:

- High Convenience (Default)
- Normal
- High Security

The level that is selected determines the level of convenience and security - FRR and FAR – in any given implementation. The FRR and FAR values for the one-to-one verification mode is shown in Table 5.

25+ users

For applications that handle more than 25 users it is recommended to use the Normal or High Security level.

Parameter	Condition	1 User	Unit
FRR (False-rejection-rate)	High Convenience (Default)	2,5	%
	Normal	3	%
	High Security	4	%
FAR (False-acceptance-rate)	High Convenience (Default)	0.01	%
	Normal	0.002	%
	High Security	0.001	%

Table 5: Performance characteristics – FRR / FAR

2.4 Verification Times

Typical processing times for the biometric verification process in both full- and half-speed configuration modes are shown is Table 6.

Process	Full Speed			Half speed			Unit
	Min	Typical	Max	Min	Typical	Max	
Verification 1:1	-	400	-	-	800	-	ms
Identify (Few) 1:50	400	500	600	800	900	1000	ms

Table 6 : Biometric processing times

2.5 Template Updates and Limitations

A maximum limit of 70,000 user updates can be performed throughout the lifecycle of the FPC-BM. Each of the 7 data sectors is capable of 10k erases per sector (assuming optimal flash usage spread possible through algorithm use). Each multi-template for can be updated a maximum of 20 times (per enrolled finger).

For example, over a 3-year period, this equates to a maximum of approximately 1165 user changes or updates per year. [*70k / 20 = 3500 user changes. 3500 / 3 years ~= 1165 user changes / year.*]

2.6 State Machine Diagrams

This section contains state machine diagrams for both Standalone and Hosted mode.

2.6.1 Standalone Mode

A state machine diagram for FPC-BM with Standalone mode activated is illustrated in Figure 2.

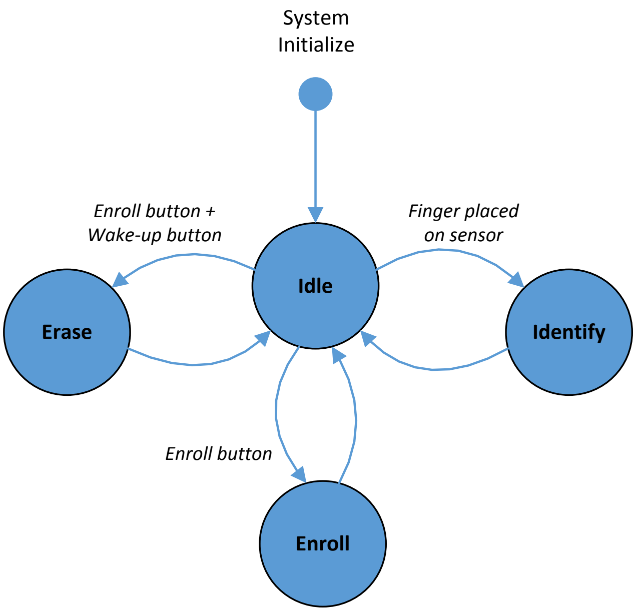

Figure 2: State machine diagram Standalone mode

2.6.2 Host Mode

A state machine diagram for FPC-BM in Host mode is illustrated in Figure 3.

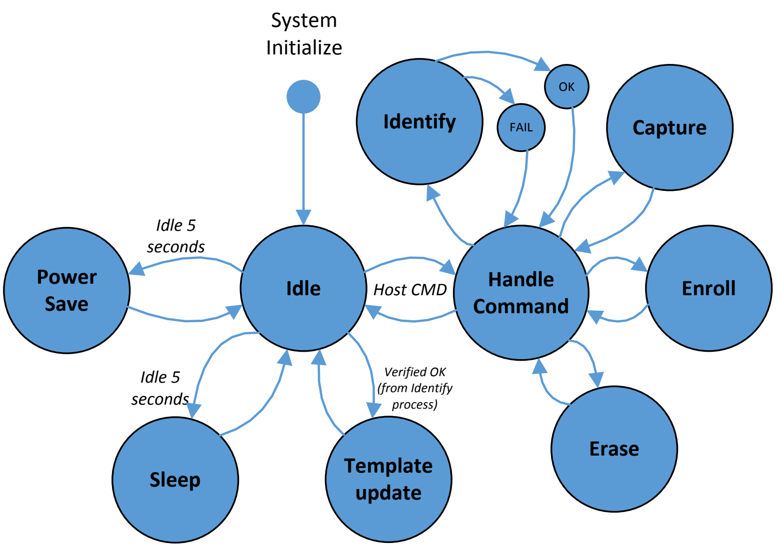

Figure 3: State machine diagram Host mode

3 Signal List

This section gives an overview of the signals sent between the FPC-BM and a host.

3.1 Sensor Signals

This section gives an overview of the signals sent between the FPC-BM and the sensor.

Name	ID	Signal Type (relative to FPC-BM)	Min. voltage [V]	Max. voltage [V]	Max. current [mA]	Max. frequency [MHz]
GND	GND	Output	0	0	24	DC
Reset (active low)	RST	Output	GND	3V3	~ 0	~ 0
SPI clock	SCLK	Output	GND	3V3	~ 0	8
SPI MOSI	MOSI	Output	GND	3V3	~ 0	SCLK
SPI chip select	SCS	Output	GND	3V3	~ 0	~ 0
SPI MISO	MISO	Input	GND	3V3	~ 0	SCLK
Interrupt*	INT	Input	GND	3V3	~ 0	~ 0
VDD (1.8 V)	1V8	Output	1.64	1.96	7	DC
Sensor reset (active low)	RST_N	Output	GND	3V3	~ 0	~ 0
Sensor SPI clock	SPICLK	Output	GND	3V3	~ 0	~ 0
Sensor SPI MOSI	MOSI	Output	GND	3V3	~ 0	SCLK
Sensor SPI C.S.	CS_N	Output	GND	3V3	~ 0	~ 0
Sensor SPI MISO	MISO	Input	GND	3V3	~ 0	SCLK
Sensor interrupt	INT	Input	GND	3V3	~ 0	~ 0
ESD FPC1011F3	ESD_DRAIN	Input	ESD_GND	n/a	n/a	n/a

**not applicable for FPC-BM1011*

Table 7: Sensor signals

3.2 Host Signals

This section gives an overview of the signals sent between the FPC-BM and a host.

Name	ID	Signal Type (relative to FPC-BM)	Min. voltage [V]	Max. voltage [V]	Design current [mA]	Max. frequency [MHz]
VDD (unreg.)	5V_IN	Input	4.18	6.00	135	DC
VDD (3.3 V in)	3V3_IN	Input	3.01	3.59	135	DC
VDD (3.3 V Out)	3V3_OUT	Output	3.01	3.59	135	DC
GND	GND	Input	0	0	135	DC
TX	TXD_UART	Output	GND	3V3	~ 0	0.1152
RX	RXD_UART	Input	GND	3V3	~ 0	0.1152
SPI clock host	SPICLK_HOST	Input	GND	3V3	~ 0	20
SPI MOSI host	MOSI_HOST	Input	GND	3V3	~ 0	SCLK
SPI chip select host	CS_N_HOST	Input	GND	3V3	~ 0	~ 0
SPI MISO host	MISO_HOST	Output	GND	3V3	~ 0	SCLK
Verified OK	Verified OK	Output	GND	3V3	8	~ 0
Reset FTDI	Reset FTDI	Output	GND	3V3	~ 0	~ 0
BOOT0 SET	BOOT0 SET	Input	GND	3V3	8	~ 0
Switch #1	SWITCH1_WAKE_UP	Input	GND	3V3	~ 0	~ 0
Switch #2	SWITCH2_ENROLL	Input	GND	3V3	~ 0	~ 0
Switch #3	SWiTCH3_RESET	Input	GND	3V3	~ 0	~ 0

Table 8: Host signals

Switches

The host system is responsible for handling any ESD events that may happen via the external switches.

3.3 LED Indicators

An LED indicates the current state of the FPC-BM. An overview of the LED behavior including color and LED state (solid or blinking) during biometric procedures is shown in Table 9.

Function	State	Color	LED State
Power On	-	Blue	Solid
Identify (Few)	Wait for Finger	Yellow	Blinking
	Processing captured image	Yellow	Solid
	Identify (Few) Successful	Green	Solid
	Identify (Few) Failed	Red	Solid
Enroll	Wait for Finger	Yellow	Blinking
	Processing captured image	Yellow	Solid
	Enroll Successful	Green	Solid
	Enroll Failed	Red	Solid
Delete All templates in FLASH	Processing	Red	Blinking
	Done	Green	Solid
Error	See section 3.3.1	Red	Blinking

Table 9: LED indicator status

3.3.1 Troubleshooting

Known errors including possible causes and potential workarounds are described in Table 10.

Error Type	Color	LED State	Possible Cause	Workaround
HW failure	Red	Blinking	Voltage too low during boot up	Ensure adequate supply voltage
			Sensor not connected at startup	Connect sensor
			Broken sensor	Replace sensor

Table 10: HW troubleshooting

4 Electrical Characteristics

The electrical characteristics of the FPC-BM are described in this chapter. All signals except the power supply rails and ground are 3.3 V or unregulated 5 V.

4.1 Supply Voltage

FPC-BM has two supply modes: 3.3 V (regulated, see section 4.1.1) and 5 V (unregulated, see section 4.1.2). Supply voltages for the FPC-BM are shown in Table 11.

Symbol	Parameter	Minimum	Typical	Maximum	Unit
VDD	Core supply, regulated input 3.3 V	3.01	3.3	3.59	V
VDD	Unregulated, input 5 V	4.18	5	6	V

Table 11: FPC -BM Supply Voltages

See section 11.4 for more information on power supply settings.

4.1.1 3.3 V Supply Mode (Regulated)

In the 3.3 V regulated power supply mode the supply voltage is connected directly to MCU and sensor.

The supply voltage shall be connected to 3V3_IN at contact J4-3 on the FPC-BM. No supply voltage shall be connected to the 5V_IN at contact J4- 1.

See Figure 17 for an overview of the pin layout.

Ripple and Noise Level

Ripple and noise level must be ≤ 20 mVpp with 20 MHz bandwidth. The rise and fall time of the host power interface must be slower than 20 µs/V at power-up and power-down to ensure MCU integrity.

4.1.2 5 V Supply Mode (Unregulated)

In the 5 V unregulated supply mode, the supply voltage is regulated down to 3V3 through a linear regulator before connection to MCU and sensor.

A power supply of 5 V shall be connected to *5V_IN* at contact J4-1 on the FPC-BM. In 5 V supply mode, the regulated *3V3_OUT* must be bridged to *3V3_IN,* as shown in Figure 19.

No other connection to the *3V3_IN* other than the bridge from *3V3_OUT* shall be connected.

Ripple and Noise Level

Ripple and noise level must be ≤ 80 mVpp with 20 MHz bandwidth.

4.2 Supply Current

Supply current for the FPC-BM is shown in Table 12. It should be noted that the FPC1011F3 sensor does not go into idle mode.

SYMBOL	PARAMETER	CONDITION	Minimum	Typical	Maximum	UNIT
IDD	Supply current	Idle*	-	10	-	mA
		Active full speed	-	70	-	mA
		Active half speed	-	25	-	mA
		Sleep	-	30	-	µA
		Deep Sleep	-	3.3	-	µA

**not applicable for the FPC-BM1011*

Table 12: Supply Current

4.3 Maximum Current Consumption and Power Dissipation

Current consumption and power dissipation for FPC-BM components is shown in Table 13. This does not include the power dissipation of the linear regulators.

Source	Typical voltage	Max. current	Duty cycle	Average power dissipation
FPC1020AM Sensor	1.8 V	5.6 mA	50 %	5 mW
	3.3 V	0.5 mA	50 %	1 mW
FPC1011F3 Sensor	3.3 V	24 mA	50 %	40 mW
Microcontroller	3.3 V	51 mA	50 %	84 mW
LED	3.3 V	10 mA	50 %	17 mW

Table 13: Maximum Current and power consumption

4.4 Digital Inputs

Digital inputs for the FPC-BM are shown in Table 14.

SYMBOL	PARAMETER	Minimum	Typical	Maximum	UNIT
V_{IL}	Logic '0' voltage	0	-	0.8	V
V_{IH}	Logic '1' voltage	0.7 V_{DD}	-	V_{DD}+0.3	V
I_{IL}	Logic '0' current (V_I = GND)	-	-	±10	µA
I_{IH}	Logic '1' current (V_I = V_{DD})	-	-	±10	µA

Table 14: Digital Inputs

4.5 Digital Outputs

Digital outputs for the FPC-BM are shown in Table 15.

SYMBOL	PARAMETER	Minimum	Typical	Maximum	UNIT
V_{OL}	Logic '0' output voltage	-	-	0.45	V
V_{OH}	Logic '1' output voltage	0.85 V_{DD}	-	-	V

Table 15: Digital Outputs

5 Software Command Interface

To communicate with the sensor module, a serial command interface is used between a host processor and the processor board. This interface is designed to be easy to use and performs the basic biometric functions needed in a fingerprint authentication system.

5.1 UART Serial Interface Settings

The software settings for the serial protocol using UART are outlined in Table 16.

Parameter	Value
Communication speed	Range from 9600 to 115200 baud. Factory default baud rate set to 9600 baud.
Format	8 data bits, odd parity, one stop bit.
Bit order	Least significant bit first

Table 16: UART interface settings

5.2 SPI Interface Settings

The software settings for using SPI commands are outlined in Table 17.

Parameter	Value
Communication speed	Guaranteed maximum speed: 20 MHz. For details, see SPI timing requirements, in section 5.5.
SPI Mode	Mode 3, Clock Polarity High and Clock Phase Rising
Chip Select	Active Low

Table 17: SPI interface settings

5.3 Command Send Structure

The structure of commands sent from a host are shown in Table 18 and described in this section:

0	1	2	3	4	5
STX	IDX-LSB	IDX-MSB	COMMAND	PAYLOAD-LSB	PAYLOAD-MSB

Table 18: Structure of commands sent from the host

STX
Start byte: 0x02.

IDX-LSB:

Index value, least significant byte.

If no specific value is used for a command setting, the IDX-LSB must be set to zero.

IDX-MSB:

Index value, most significant byte.

If no specific value is used for a command setting, the IDX-MSB must be set to zero.

COMMAND:

Command byte.

PAYLOAD-LSB:

If any additional data is sent, the payload is a counter of how many bytes that will be sent (not including the CRC-code), otherwise zero.

PAYLOAD-MSB:

Payload most significant byte, if no data, set to zero.

5.3.1 Additional Payload Data

If PAYLOAD != 0, then additional data should follow in the stream outline in Table 19.

6	…	n	n+1	n+2	n+3	n+4
DATA	DATA-…	DATA-n	CRC-LSB	CRC-BYTE2	CRC-BYTE3	CRC-MSB

Table 19: Command Send - Additional Payload Data

The CRC size (4 bytes) is not included in the payload counter. Its value is calculated from all the data bytes, and is used for checking if an error occurred during the transmission. The default for IDX-LSB and IDX-MSB is 0x00, if nothing else is stated.

A new command cannot be sent before a response has been received from the previous command. An exception is when using the API_CANCEL command. See section 7.12 for more information on the cancel command.

5.4 Response structure

The structure of the response from the FPC-BM is given in Table 20:

0	1	2	3
STX	RESULT	PAYLOAD-LSB	PAYLOAD-MSB

Table 20: Structure of response from the FPC-BM

STX: Start byte: 0x02

RESULT: Result byte

PAYLOAD-LSB: If any additional data is sent, the payload is a counter of how many bytes that will be sent (not including the CRC-code), otherwise zero.

PAYLOAD-MSB: Payload most significant byte, if no data, set to zero. If PAYLOAD != 0, then additional data should follow in the stream according to Table 21.

4	…	n	n+1	n+2	n+3	n+4
DATA-1	DATA-…	DATA-n	CRC-LSB	CRC-BYTE2	CRC-BYTE3	CRC-MSB

Table 21: Response Structure Additional Data

The CRC size (4 bytes) is not included in the payload counter. Its value is calculated from all the data bytes, and is used for checking if an error occurred during the transmission.

5.5 SPI Timing Requirements

The SPI interface of the FPC-BM is a slave interface, implying that the host (the master) determines when data is sent to and from the FPC-BM. Since the host cannot know when the FPC-BM has completed processing a given command, a polling process is implemented by the host when trying to read the response for a given command request.

The required implementation of the Request/Response process is as follows:

1. Let the host send the 6 command bytes
2. Wait a minimum of 20 ms for possible payload and CRC
3. Let the host send a byte with value *0x52* to the slave. The host asks the FPC-BM if it is ready to send the response back to the host.
4. Wait a minimum of 20 ms
5. Check that the received byte is *0x02*. If not, the slave is not ready, and requires more time to complete processing the command. Alternatively, the FPC-BM returns *0x52* to indicate that it is busy.
6. Repeat steps 4-6 until a *0x02* byte is received as response.
7. The *0x02* value is the first byte in the regular response consisting of 4 bytes (plus a possible payload and CRC).

The SPI data transfer speed is up to 20 MHz for all single -byte transmission.

UART Interface

The requirements outlined in this section do not apply for the UART interface, where the host is aware that the received response is the correct response.

6 Command Tables

This section gives an overview of the available commands that can be used with the FPC-BM.

6.1 Biometric Commands

This section describes the biometric commands for the FPC-BM.

Command	HEX	Description
API_CAPTURE_IMAGE	0x80	Capture image from sensor (before enroll).
API_CAPTURE_AND_ENROL_RAM	0x81	Enroll into RAM (includes Capture Image)
API_CAPTURE_AND_VERIFY_RAM	0x82	Verify against RAM (includes Capture Image)
API_CAPTURE_AND_VERIFY_FLASH	0x83	Verify against single FLASH slot (includes Capture Image) Set slot number (0 – 49) in IDX
API_CAPTURE_AND_IDENTIFY_FLASH	0x84	Identify (Few) against all FLASH slots (includes Capture Image)
API_ENROL_RAM	0x85	Enroll into RAM
API_VERIFY_RAM	0x86	Verify against RAM
API_VERIFY_FLASH	0x87	Verify against single FLASH slot. Set slot number (0 – 49) in IDX
API_IDENTIFY_FLASH	0x88	Identify (Few) against all FLASH slots
API_CAPTURE_IMAGE_FINGERPRESENT	0x89	Capture Image from sensor (once a finger is present)
API_ENROL_FLASH	0x92	Enroll into FLASH memory
API_CAPTURE_AND_ENROL_FLASH	0x93	Enroll into FLASH memory (includes Capture Image)

Table 22: Biometric Commands

6.2 Image transfer

This section describes the image transfer commands for the FPC-BM.

Command	HEX	Description
API_UPLOAD_IMAGE	0x90	Upload image from RAM to Host
API_DOWNLOAD_IMAGE	0x91	Download image to RAM to Host

Table 23: Image transfer commands

6.3 Template Handling

This section describes the template handling commands for the FPC-BM.

Command	HEX	Descriptions
API_UPLOAD_TEMPLATE	0xA0	Upload template from RAM to host
API_DOWNLOAD_TEMPLATE	0xA1	Download template to RAM to host
API_COPY_TEMPLATE_RAM_TO_FLASH	0xA2	Copy template from RAM to permanent FLASH storage Set slot number (0 to 49) in IDX
API_UPLOAD_TEMPLATE_FROM_FLASH	0xA3	Upload template from single FLASH slot to host. Set slot number (0 to 49) in IDX
API_DELETE_TEMPLATE_RAM	0xA4	Erase template from RAM
API_DELETE_SLOT_IN_FLASH	0xA5	Delete single slot in FLASH Set slot number (0 to 49) in IDX
API_DELETE_ALL_IN_FLASH	0xA6	Delete all FLASH slots
API_DOWNLOAD_TEMPLATE_TO_FLASH	0xA7	Download a template from host to FLASH

Table 24: Template handling commands

6.4 Algorithm Settings

This section describes the algorithm settings commands for the FPC-BM.

Command	HEX	Description
API_SECURITY_LEVEL_RAM	0xB0	Set security level, setting saved in RAM IDX-LSB: 0x04 = high convenience 0x05 = standard 0x06 = high security
API_SECURITY_LEVEL_STATIC	0xB1	Set security level, setting saved in non-volatile (static) memory.
API_GET_SECURITY_LEVEL	0xB2	Returns the current security level, value sent as payload data.
API_GET_DYNAMIC_UPDATE	0xB3	Returns the current dynamic update setting.
API_SET_DYNAMIC_UPDATE	0xB4	Sets the dynamic update IDX-LSB: 0x00 = Off 0x01 = On

Table 25: Commands for algorithm settings

6.5 Firmware Commands

This section describes the firmware commands for the FPC-BM.

Command	HEX	Description
API_FIRMWARE_VERSION	0xC0	Retrieve the version string for this device

Table 26: Firmware commands

6.6 Communication Commands

This section describes the communication commands for the FPC-BM.

Command	HEX	Description
API_SET_BAUD_RATE_RAM	0xD0	Set baud rate, setting saved in RAM. See section 7.28.
API_SET_BAUD_RATE_STATIC	0xD1	Set baud rate, setting saved in non-volatile static Flash memory. See section 7.29
API_TEST_HARDWARE	0xD2	Test hardware components

Table 27: Communication commands

6.7 Power Commands

This section describes the commands for power settings for the FPC-BM.

Command	HEX	Description
API_ENTER_SLEEP_MODE	0xE1	Enter sleep mode (wake up by activating proper pin)
API_GET_POWER_SAVE_MODE	0xE5	Get current power save mode, value sent as payload data: IDX-MSB: 0x00 = Frequency 0x01 = LED 0x02 = Sleep Mode 0x03 = Sensor wake up (detection frequency)
API_POWER_SAVE_MODE_RAM	0xE2	Set power save mode, setting saved in RAM IDX-MSB: 0x00 = Frequency 0x01 = LED 0x02 = Sleep Mode 0x03 = Sensor wake up (detection frequency) IDX-LSB (frequency): 0x00 = Half 0x01 = Full IDX-LSB (LED): 0x00 = On 0x01 = Mode 0x02 = Off IDX-LSB (sleep mode): 0x00 = Run

		0x01 = Standby 0x02 = Sleep 0x03 Deep Sleep IDX-LSB (sensor wake up): 0x00 = Min (always active) … up to 0xFF = 2000 ms (each step = 7.8 ms)
API_POWER_SAVE_MODE_STATIC	0xE3	Set power save mode, setting saved in non-volatile (static) memory IDX-MSB: 0x00 = Frequency 0x01 = LED 0x02 = Sleep Mode 0x03 = Sensor wake up (detection frequency) IDX-LSB (frequency): 0x00 = Half 0x01 = Full IDX-LSB (LED): 0x00 = On 0x01 = Mode 0x02 = Off IDX-LSB (sleep mode): 0x00 = Run 0x01 = Standby 0x02 = Sleep 0x03 Deep Sleep IDX-LSB (sensor wake up): 0x00 = Min (always active) … up to 0xFF = 2000 ms (each step = 7.8 ms)

Table 28: Power commands

6.8 Miscellaneous Commands

This section describes other miscellaneous commands for the FPC-BM.

Command	HEX	Description
API_CANCEL	0xE0	Cancel ongoing command, only valid for the following commands: API_CAPTURE_AND_ENROL_RAM, API_CAPTURE_AND_VERIFY_RAM, API_CAPTURE_AND_VERIFY_AGAINST_FLASH, API_CAPTURE_AND_IDENTIFY_AGAINST_FLASH
API_ADVANCED_SETTINGS	0xE8	Managing advanced settings, see section 7.36
API_STAND_ALONE	0xEF	Toggle stand-alone functionality IDX-LSB: 0x00 = Off 0x01 = On

Table 29: Miscellaneous commands

6.9 Response Bytes

This section describes the possible response bytes from the FPC-BM to the host.

Command	HEX
API_FAILURE	0x00
API_SUCCESS	0x01
API_NO_FINGER_PRESENT	0x02
API_FINGER_PRESENT	0x03
API_VERIFICATION_OK	0x04
API_VERIFICATION_FAIL	0x05
API_ENROL_OK	0x06
API_ENROL_FAIL	0x07
API_HW_TEST_OK	0x08
API_HW_TEST_FAIL	0x09
API_CRC_FAIL	0x0A
API_PAYLOAD_TOO_LONG	0x0B
API_PAYLOAD_TOO_SHORT	0x0C
API_UNKNOWN_COMMAND	0x0D
API_NO_TEMPLATE_PRESENT	0x0E
API_IDENTIFY_OK	0x0F

API_IDENTIFY_FAIL	0x10
API_INVALID_SLOT_NR	0x11
API_CANCEL_SUCCESS	0x12
API_APPL_CRC_FAIL	0x14
API_SYS_CRC_FAILED	0x16
API_LOW_VOLTAGE	0x17
API_NO_SENSOR	0x18
API_BROKEN_SENSOR	0x19

Table 30: Response Bytes

6.10 No sensor: API_NO_SENSOR

The response API_NO_SENSOR is sent for the following commands if there is no active sensor present in the system during runtime.

- API_TEST_HARDWARE
- API_CAPTURE_IMAGE
- API_CAPTURE_AND_VERIFY_RAM
- API_CAPTURE_IMAGE_FINGERPRESENT
- API_CAPTURE_AND_VERIFY_FLASH
- API_CAPTURE_AND_IDENTIFY_FLASH
- API_CAPTURE_AND_ENROL_FLASH

Startup

It should be noted that if there is no sensor present at system startup, the boot sequence will end and the red LED lamp will blink until the system is powered down or until a sensor is connected. The response API_NO_SENSOR is not sent in this case.

6.11 Broken sensor: API_BROKEN_SENSOR

The response API_BROKEN_SENSOR is sent for the following commands if an improper or corrupted response is received from the sensor:

- API_TEST_HARDWARE
- API_CAPTURE_IMAGE
- API_CAPTURE_AND_VERIFY_RAM
- API_CAPTURE_IMAGE_FINGERPRESENT
- API_CAPTURE_AND_VERIFY_FLASH
- API_CAPTURE_AND_IDENTIFY_FLASH
- API_CAPTURE_AND_ENROL_FLASH

Startup

It should be noted that if an improper or corrupted response is received from a connected sensor at system startup, the boot sequence will end and the red LED lamp will blink until the system is powered down, or until a functioning sensor is connected to the system. The response API_BROKEN_SENSOR is not sent in this case.

7 Command Descriptions

This chapter describes the individual commands of the main application, along with their parameters, and responses.

7.1 Capture image: API_CAPTURE_IMAGE

An image is captured from the fingerprint sensor. The fingerprint image is placed in RAM and can be uploaded by the command API_UPLOAD_IMAGE. Calculation is done on the image to determine if a finger is present or not present on the sensor. No payload is sent with this command.

Response command

- API_NO_FINGER_PRESENT = No finger present on sensor
- API_FINGER_PRESENT = Finger present on sensor
- API_BROKEN_SENSOR = Improper or corrupted response from sensor

No payload is received with the response from this command.

7.1.1 Standalone Mode

Capture Image is not supported in Standalone mode. To use the API_CAPTURE_IMAGE command, the API_STAND_ALONE setting must be turned off (command sequence: *0x02 0x00 0x00 0xEF 0x00 0x00*).

See section 7.31 for more information on API_STAND_ALONE.

7.2 Capture and Enroll (RAM): API_CAPTURE_AND_ENROL_RAM

An image is captured from the fingerprint sensor and enrolment of the image is performed. See Table 31 for the number of finger placements required during enroll.

Sensor	Number of finger placements during enroll
FPC1011	1
FPC1020	8

Table 31: Finger placements during enrolment

Images are captured in a loop from the sensor until a finger is present. The command waits for "finger present" before it starts enrolment. No payload is sent with this command.

The command returns with response when the enrolment is complete or if the enrolment fails for any reason. After enrolment, the template is stored in RAM and can be uploaded or moved to FLASH storage.

Response command

- API_ENROL_OK = Enrolment successful
- API_ENROL_FAIL = Enrolment failed
- API_CANCEL_SUCCESS = API_CANCEL successful, or timeout of 6 seconds per finger placement.

No payload is received with the response from this command.

Cancel operation

It is possible to cancel the current enroll operation by sending the command API_CANCEL. This cancels the enrolment and the device returns to its normal command loop.

See Section 7.12 for more information on the cancel command.

7.3 Capture and Verify (RAM): API_CAPTURE_AND_VERIFY_RAM

A template must be present in RAM before starting the verification, (use one of the following commands: API_DOWNLOAD_TEMPLATE, API_CAPTURE_ENROL_RAM). Thereafter the verification can be started. This command also captures an image from the fingerprint sensor. The command waits for "finger present" before it starts the verification. This means that images are captured in a loop from the sensor until a finger is present. The command returns with response when the verification is complete or if the verification fails for any reason. No payload is sent with this command.

Response command

- API_VERIFICATION_OK = Verification successful
- API_VERIFICATION_FAIL = Verification failed
- API_NO_TEMPLATE_PRESENT = No template present
- API_BROKEN_SENSOR = Improper or corrupted response from sensor
- API_CANCEL_SUCCESS = API_CANCEL successful, or timeout of 6 seconds per finger placement.

No payload is received with the response from this command. It is possible to cancel the current verification operation by sending the command API_CANCEL. This returns the device to its normal command loop.

See Section 7.12 for more information on the cancel command.

7.4 Capture and Identify (FLASH): API_CAPTURE_ AND _IDENTIFY_FLASH

Identification is made against all FLASH slots. This command first captures an image from the fingerprint sensor. The command waits for "finger present" before it starts the identification. This means that images are captured in a loop from the sensor until a finger is present. The command returns with response when the identification is complete or if the identification fails for any reason. No payload is sent with this command.

Response command

- API_ IDENTIFY _OK = Identification successful
- API_ IDENTIFY _FAIL = Identification fails
- API_BROKEN_SENSOR = Improper or corrupted response from sensor
- API_CANCEL_SUCCESS = API_CANCEL successful, or timeout of 6 seconds per finger placement.

In a successful identification, the slot index is received as payload in two bytes (LSB first) plus the 4 CRC bytes. Maximum number of templates during identification is 50.

It is possible to cancel the current identification operation by sending the API_CANCEL command. The device returns to its normal command loop. See Section 7.12 for more information on the cancel command.

7.5 Enroll (RAM): API_ENROL_RAM

A fingerprint image must be present in RAM before starting the enrolment, either by capturing an image from the fingerprint sensor using the API_CAPTURE_IMAGE command, or the API_DOWNLOAD_IMAGE. The command returns with response when the enrolment is complete or if the enrolment fails for any reason. After enrolment, the template is stored in RAM and can be uploaded or moved to FLASH storage. No payload is sent with this command.

Response command

- API_ENROL_OK = Enrolment successful
- API_ENROL_FAIL = Enrolment failed

No payload is received with the response from this command.

7.6 Verify (RAM): API_VERIFY_RAM

A template and a fingerprint image must both be present in RAM before verification starts; use the API_DOWNLOAD_TEMPLATE command, or the API_CAPTURE_ENROL_RAM command.

To process the image, use the API_DOWNLOAD_IMAGE command, or the API_CAPTURE_IMAGE command. The verification can be started after one of these commands has been sent.

The command returns with a response when the verification is complete or if the verification fails for any reason. No payload is sent with this command.

Response command

- API_VERIFICATION_OK = Verification successful
- API_VERIFICATION_FAIL = Verification failed
- API_NO_TEMPLATE_PRESENT = No template present

No payload is received with the response from this command.

7.7 Verify (FLASH): API_VERIFY_FLASH

A fingerprint image must be present in RAM before starting the verification, (use one of the following commands: API_DOWNLOAD_IMAGE, API_CAPTURE_IMAGE. The FLASH slot number must be given in the IDX bytes. The command returns with response when the verification is complete or if the verification fails for any reason. No payload is sent with this command.

Response command:

- API_VERIFICATION_OK = Verification successful
- API_VERIFICATION_FAIL = Verification failed
- API_NO_TEMPLATE_PRESENT = No template in given FLASH slot
- API_INVALID_SLOT_NR = Wrong slot number

No payload is received with the response from this command.

7.8 Identify (Few) (FLASH): API_IDENTIFY_FLASH

A fingerprint image must be present in RAM before starting the verification using either the API_DOWNLOAD_IMAGE or API_CAPTURE_IMAGE command.

Identification is performed against all FLASH slots. The command returns with response when the identification is complete or if the identification fails for any reason. No payload is sent with this command.

Response command

- API_ IDENTIFY _OK = Identification successful
- API_ IDENTIFY _FAIL = Identification failed
- API_NO_TEMPLATE_PRESENT = All FLASH slots are empty

During a successful identification, the slot index is received as payload in two bytes (LSB first), plus the 4 CRC bytes.

Maximum number of templates

The FPC-BM has integral support for a maximum of 50 templates.

7.9 Capture image (Finger present): API_CAPTURE_IMAGE_FINGERPRESENT

An image is captured from the fingerprint sensor once the system detects a finger on the sensor. The fingerprint image is placed in RAM and can be uploaded by the command API_UPLOAD_IMAGE. No payload is sent with this command. The system waits until a finger is detected, and can only be terminated with the API_CANCEL command.

Response command

- API_FINGER_PRESENT = Finger present on sensor
- API_CANCEL_SUCCESS = API_CANCEL successful, or timeout of 6 seconds
- API_BROKEN_SENSOR = Improper or corrupted response from sensor

No payload is received with the response from this command.

7.10 Enroll (FLASH): API_ENROL_FLASH

A fingerprint image must be present in RAM before starting the enrolment, either by capturing an image from the fingerprint sensor using the command API_CAPTURE_IMAGE or by using the Download Image Command, API_DOWNLOAD_IMAGE. The command returns with response when the enrolment is complete or if the enrolment fails for any reason.

After enrolment, the template is stored in FLASH and can be uploaded or moved to FLASH storage. The desired FLASH slot number must be given in the IDX bytes. No payload is sent with this command.

Response command

- API_ENROL_OK = Enrolment successful
- API_ENROL_FAIL = Enrolment failed
- API_INVALID_SLOT_NR = Incorrect FLASH slot number

No payload is received with the response from this command.

7.11 Capture Enroll (FLASH): API_CAPTURE_AND_ENROL_FLASH

This command first captures an image from the fingerprint sensor. The command waits for “finger present” before it starts the verification. This means that images are captured in a loop from the sensor until a finger is present. The command then returns with a response when the enrolment is complete or if the enrolment fails for any reason.

After enrolment, the template is stored in FLASH and can be uploaded or moved to FLASH storage. The desired FLASH slot number must be given in the IDX bytes. No payload is sent with this command.

Response command

- API_ENROL_OK = Enrolment successful
- API_ENROL_FAIL = Enrolment failed
- API_INVALID_SLOT_NR = Incorrect FLASH slot number
- API_BROKEN_SENSOR = Improper or corrupted response from sensor
- API_CANCEL_SUCCESS = API_CANCEL successful, or timeout of 6 seconds per finger placement.

No payload is received with the response from this command.

7.12 Cancel Current Command: API_CANCEL

It is possible to cancel the following ongoing commands:

- API_CAPTURE_IMAGE_FINGERPRESENT
- API_CAPTURE_AND_ENROL_RAM
- API_CAPTURE_AND_ENROL_FLASH
- API_CAPTURE_AND_VERIFY_RAM
- API_CAPTURE_AND_VERIFY_FLASH
- API_CAPTURE_AND_IDENTIFY_ FLASH

Important - When the cancel command is sent over SPI, only the following command byte shall be sent: 0xE0. The module will respond with API_CANCEL_SUCCESS and the return to normal command loop. No payload is sent with this command.

Response command

- API_ CANCEL_SUCCESS = Cancel successful
- API_ FAILURE = Cancel failed

No payload is received with the response from this command.

7.13 Upload Image: API_UPLOAD_IMAGE

By using this command, it is possible to upload the fingerprint image present in RAM. The response is the API_SUCCESS command followed by the image data. The first byte is the upper left pixel and then data follows row-wise (X-direction). Each pixel has a value of one byte (256 gray scales). There is no image header.

Response command

- API_ SUCCESS = Upload successful
- API_ FAILURE = Upload failed

7.14 Download Image: API_DOWNLOAD_IMAGE

By using this command, it is possible to download a fingerprint image to RAM. The first byte is the upper left pixel and then data follows row-wise (X-direction). Each pixel has value of one byte (256 gray scales).

Response command

- API_ SUCCESS = Download successful
- API_ FAILURE = Download failed

No payload is received with the response from this command.

7.15 Upload Template: API_UPLOAD_TEMPLATE

After a successful enrolment, a template is uploaded from RAM using the API_UPLOAD_TEMPLATE command. The response is the API_SUCCESS command followed by the template data. No payload is sent with this command.

Response command

- API_ SUCCESS = Upload successful
- API_ FAILURE = Upload failed

7.16 Download Template: API_DOWNLOAD_TEMPLATE

Before verification, a template is downloaded to RAM using the API_DOWNLOAD_TEMPLATE command.

Response command

- API_ SUCCESS = Download successful
- API_ FAILURE = Download failed

No payload is received with the response from this command.

7.17 Copy Template from RAM to FLASH: API_COPY_TEMPLATE_FROM_RAM_TO_FLASH

This command copies the template currently in RAM to FLASH. The FLASH slot number must be given in the IDX bytes. No payload is sent with this command.

Response command

- API_ SUCCESS = Template storage successful
- API_ FAILURE = Template storage failed
- API_INVALID_SLOT_NR = Wrong slot number

No payload is received with the response from this command.

7.18 Upload Template from FLASH: API_UPLOAD_TEMPLATE_FROM_FLASH

This command uploads the template from FLASH. The FLASH slot number must be given in the IDX bytes. No payload is sent with this command.

Response command

- API_ SUCCESS = Upload successful
- API_ FAILURE = Upload failed
- API_INVALID_SLOT_NR = Wrong slot number

7.19 Delete template in RAM: API_DELETE_TEMPLATE_RAM

This command deletes the template currently stored in RAM. No payload is sent with this command.

Response command

- API_ SUCCESS = Template removal successful
- API_ FAILURE = Template removal failed

No payload is received with the response from this command.

7.20 Delete Single Template in FLASH: API_DELETE_SLOT_IN_FLASH

By using the command Delete slot in FLASH one can choose which slot to delete (include slot number in index value of command). No payload is sent with this command.

Response command

- API_ SUCCESS = Template removal successful
- API_ FAILURE = Template removal failed
- API_INVALID_SLOT_NR = Wrong slot number

No payload is received with the response from this command.

7.21 Delete All Templates in FLASH: API_DELETE_ALL_IN_FLASH

It is possible to delete all templates in FLASH by issuing the command Delete all in FLASH. No payload is sent with this command.

Response command

- API_ SUCCESS = Template removal successful
- API_ FAILURE = Template removal failed

No payload is received with the response from this command.

7.22 Download Template to FLASH: API_DOWNLOAD_TEMPLATE_TO_FLASH

This command downloads a template from the host directly into the FLASH memory (and into RAM). The FLASH slot number must be given in the IDX bytes. The maximum size of the template is 15728 bytes.

Response command

- API_ SUCCESS = Download successful
- API_ FAILURE = Download failed
- API_INVALID_SLOT_NR = Wrong slot number

No payload is received with the response from this command.

7.23 Security Level (STATIC): API_SECURITY_LEVEL_STATIC

The security level to be used during verification and identification can be set by the Set Security Level command. The value of the security level should be set in the index value (IDX-LSB) of the command as seen in Table 32. The factory default security level is set to value 0x04. The value is stored in non-volatile memory and the setting is saved even after reset. The factory default value will be changed.

VALUE (IDXLSB)	SECURITY LEVEL
0x04	High convenience (factory default)
0x05	Standard
0x06	High security

Table 32: Security Level Settings

The security level is not stored together with the template. During enrolment, there is no effect when changing the security threshold. The created template will support all security settings. No payload is sent with this command.

Response command

- API_ SUCCESS = New security level set
- API_ FAILURE = Security level out of range

No payload is received with the response from this command.

7.24 Get Current Security Level: API_GET_SECURITY_LEVEL

The API_GET_SECURITY_LEVEL command returns the value of the current security level setting that the FPC-BM is using. No payload is sent with this command.

Response command

The response command is the API_SUCCESS command plus the security level string as payload.

- API_ SUCCESS = Command successful, followed by the security level string
- API_ FAILURE = Command fail

A payload + 4 CRC bytes is received if the request is successful. The payload value, which always is 1 byte corresponds to one of the security levels in Table 33.

VALUE	SECURITY LEVEL
0x04	High convenience (factory default)
0x05	Standard
0x06	High security

Table 33: Current security level values

7.25 Get Dynamic Update: API_GET_DYNAMIC_UPDATE

The API_GET_DYNAMIC_UPDATE command returns the value of the current dynamic update setting that the module FPC-BM is using. No payload is sent with this command.

Response command

- API_ SUCCESS = Request accepted, dynamic update setting string follows
- API_ FAILURE = Request failed

A payload + 4 CRC bytes will be received in a successful request. The payload value, which always is 1 byte corresponds to one of the update settings in Table 34.

VALUE (IDXLSB)	Dynamic update
0x00	Deactivated
0x01	Activated

Table 34: Dynamic update status

7.26 Set Dynamic Update: API_SET_DYNAMIC_UPDATE

To activate or deactivate dynamic update, issue the command API_SET_DYNAMIC_UPDATE. No payload is sent with this command.

VALUE (IDXLSB)	Dynamic update
0x00	Deactivate
0x01	Activate

Table 35: Dynamic update setting

Response command

- API_ SUCCESS = Request accepted, dynamic update activated or deactivated
- API_ FAILURE = Request failed

No payload is received with the response from this command.

7.27 Get Firmware Version: API_FIRMWARE_VERSION

The API_FIRMWARE_VERSION command returns the firmware version of the main application. No payload is sent with this command.

The response is the API_SUCCESS command followed by the firmware version string.

Response command

- API_ SUCCESS = Request successful, firmware version string follows as payload
- API_ FAILURE = Request failed

A payload + 4 CRC bytes will be received in a successful request. The size of this payload could vary with the version of the firmware.

7.28 Set Baud Rate (RAM): API_SET_BAUD_RATE RAM

It is possible to change the baud rate for the serial communication between host and FPC-BM. The default baud rate is 9600. The available baud rates are shown in Table 36.

VALUE (IDXLSB)	BAUD RATE
0x00	Currently active baud rate
0x10	9600 (factory default)
0x20	14400
0x30	19200
0x40	28800
0x50	38400
0x60	57600
0x70	76800
0x80	115200

Table 36: Baud Rate values for RAM

The new value is set in the IDX-LSB byte of the command. This new value is stored in RAM and is not saved after a reset. The value will return to the factory default after reset.

Index 0 is the recommended option to ensure that a non-compatible UART speed is not selected.

No payload is sent with this command.

Response command

- API_ SUCCESS = Baud rate change accepted
- API_ FAILURE = Baud rate out of range

No payload is received with the response from this command.

Once a baud rate change has been accepted, the next command must be sent with a new baud rate. However, the response command above is sent with the previous (old) baud rate.

7.29 Set Baud Rate (STATIC): API_SET_BAUD_RATE_STATIC

It is possible to change baud rate for the serial communication between host and FPC-BM. The default baud rate is 9600. The available baud rates are shown in Table 36.

The selected baud rate value is set in the IDX-LSB byte of the command. The value is stored in non-volatile memory and the setting is saved after reset.

Note that if the index 0 is used, the currently active baud rate will be stored. This is the recommended option, since it will ensure that a non-compatible UART speed not is permanently selected. No payload is sent with this command.

Response command:

- API_ SUCCESS = Baud rate change accepted
- API_ FAILURE = Baud rate out of range

No payload is received with the response from this command. Once a baud rate change has been accepted, the next command must be sent with a new baud rate. However, the response command above is sent with the previous (old) baud rate.

7.30 Test Hardware: API_TEST_HARDWARE

The API_TEST_HARDWARE command initiates a test of the FPC-BM hardware. No payload is sent with this command.

Response command

- API_HW_TEST_OK = Hardware check successful
- API_HW_TEST_FAIL = Hardware check failed, contact technical support
- API_BROKEN_SENSOR = Improper or corrupted response from sensor

No payload is received with the response from this command.

7.31 Set Standalone Mode: API_STAND_ALONE

Standalone mode is toggled by sending the API_STAND_ALONE command. See Table 37 for details. No payload is sent with this command. No payload is received with the response from this command.

VALUE (IDX-LSB)	STANDALONE MODE
0x00	Deactivate
0x01	Activate

Table 37: Standalone mode setting

When setting standalone mode, the save location can be set using IDX-MSB. See Table 38 for more information.

VALUE (IDX-MSB)	STANDALONE MODE- SAVE LOCATION
0x00	RAM
0x01	STATIC

Table 38: Standalone mode save location

Response command

- API_ SUCCESS = Request accepted, standalone mode activated or deactivated
- API_ FAILURE = Request failed

No payload is received with the response from this command.

7.32 Enter Sleep Mode: API_ENTER_SLEEP_MODE

To enter SLEEP MODE, issue the **API_ENTER_SLEEP_MODE** command. To wake up the device, a wakeup interrupt must occur. The wakeup interrupt is triggered by the following signal: SWITCH1_WAKEUP (active high).

Before the device enters SLEEP MODE it responds with one of the following:

Response command

- API_ SUCCESS = Request accepted, entering SLEEP MODE
- API_ FAILURE = Request failed

No payload is received with the response from this command.

7.33 Enter Power Save Mode: API_ENTER_POWER_SAVE_MODE_RAM

In POWER SAVE MODE the device reduces the clock frequency of the processor by half to lower power consumption. To enter POWER SAVE MODE, issue the **API_ENTER_POWER_SAVE_MODE_RAM** command. No payload is sent with this command.

Response command

- API_ SUCCESS = Request accepted, entering POWER SAVE MODE
- API_ FAILURE = Request failed

No payload is received with the response from this command.

7.34 Power Save Mode: (STATIC) API_POWER_SAVE_MODE_STATIC

In POWER SAVE MODE the module reduces the clock frequency of the processor by half to lower power consumption. The setting is stored in non-volatile memory and the setting is saved even after reset. This means that the factory default setting (value=1) will be changed. No payload is sent with this command.

Enter Power Save Mode

To enter POWER SAVE MODE, issue the command Power Save Mode with the value 0 in the IDX-LSB bytes, as shown in Table 39.

Exit Power Save Mode

To exit POWER SAVE MODE, issue the command Power Save Mode with the value 1 in the IDX-LSB byte, as shown in Table 39.

VALUE (IDX-LSB)	POWER SAVE MODE
0	Half Speed
1	Full Speed (factory default)

Table 39: Power save mode setting

Response command

- API_ SUCCESS = Request accepted, entering POWER SAVE MODE
- API_ FAILURE = Request failed

No payload is received with the response from this command.

7.35 Get current power save mode: API_GET_POWER_SAVE_MODE

This command returns the value of the current setting of power save mode. See Table 40 for details. The value is received as payload data. No payload is sent with this command.

VALUE (IDX-LSB)	POWER SAVE MODE
0	Half Speed
1	Full Speed (factory default)

Table 40: Current Power Save mode setting

Response command

- API_ SUCCESS = Command OK
- API_ FAILURE = Command fail

The received payload in a successful upload consists of 1 byte plus the 4 CRC bytes.

7.36 Manage Advance Settings: API_ADVANCED_SETTINGS

This command is used both to get current, and to set advanced current settings. The advanced settings presently supported include Supply Voltage Control, and disabling the UART host interface.

See Table 41 for command payload values.

7.36.1 Supply Voltage Control

The Supply Voltage Control monitors the supply voltage to ensure that it is at a proper level. The supply voltage threshold is > 2.93 V.

The Supply Voltage Control can be enabled temporarily (in RAM) or statically (in non-volatile Flash memory). If enabled in Flash memory, the setting will remain after a system reset.

Low supply voltage

If Supply Voltage Control is enabled and the supply voltage falls below the specified level, the system will respond to any command with the response code API_LOW_VOLTAGE.

Default setting

The default factory setting for Supply Voltage Control is *enabled*.

7.36.2 Disable UART

UART can be disabled using the API_ADVANCED_SETTINGS command. The setting can be stored in RAM or in the static Flash memory. The UART interface can only be disabled if the command is sent using an SPI host interface, otherwise the command will fail.

When issuing this command, the host is forced to set the values of both the advanced settings with the same payload byte.

7.36.3 Command with One Byte Payload

When the API_ADVANCED_SETTINGS command is sent with a one-byte payload, it is used to put the system in the desired mode, by turning on/off individual bits in the payload byte, as seen in Table 41.

Command Payload Value	Description
Bit 0 (LSB) = 0	Disable Supply Voltage Control
Bit 0 (LSB) = 1	Enable Supply Voltage Control
Bit 1 = 0	Do not store bit 0 setting statically
Bit 1 = 1	Store bit 0 setting statically
Bit 2 = 0	Enable both UART and SPI
Bit 2 = 1	Disable UART
Bit 3 = 0	Do not store bit 2 setting statically
Bit 3 = 1	Store bit 2 setting statically

Table 41: Command with one-byte payload

7.36.4 Command with No Payload

When the API_ADVANCED_SETTINGS command is sent with no payload, it will return a response including a payload of one byte, which represents the state that the system is currently as seen in Table 42.

Response Value Payload	Description
Bit 0 (LSB) = 0	Supply Voltage Control disabled
Bit 0 (LSB) = 1	Supply Voltage Control enabled
Bit 1	Not used
Bit 2 = 0	Both UART and SPI active
Bit 2 = 1	Only SPI active

Table 42: Command with no payload

Response command

- API_SCUCCESS = Command OK
- API_FAILURE = Command Fail

The CRC of 4 bytes are always added to the 1-byte payload. The index bytes of the command structure are not used with this command.

8 CRC Calculation

The CRC calculation can be implemented as a table of pre-computed effects to ensure efficiency. The CRC value is 32 bits long. The table is indexed by the byte to be encoded and thus the table contains 256 double words (256 x 32 bits).

The CRC algorithm implementation was initially developed by the University of California, Berkeley and its contributors, but has been changed and somewhat simplified to fit the embedded nature of FPC-BM. The algorithm uses the CCITT-32 CRC Polynomial.

The source code for the CRC implementation is available from FPC and can be compiled with limited impact in most environments.

9 Power Management

The FPC-BM uses an external crystal with a frequency of 25 MHz, and uses this clock to internally generate specific frequencies, depending on the current state of the system.

Two separate commands (API_POWER_SAVE_MODE_RAM, and API_POWER_SAVE_MODE_STATIC) allow the user to set the system in two different power management modes:

- Full Speed (Power Save Mode=disabled)
- Half Speed (Power Save Mode=enabled).

Full Speed Mode

In Full Speed Mode, the processor speed is 168 MHz

Half Speed Mode

In Half Speed Mode, the processor speed is 84 MHz

For more information on the API_POWER_SAVE_MODE_RAM command, see section 7.3.

For more information on the API_POWER_SAVE_MODE_STATIC command, see section 7.4.

10 Mechanical Properties

This chapter gives an overview of the mechanical properties for the FPC-BM biometric module processor card and compatible sensors.

- All measurements are in millimeters.
- Dimensional data is based on nominal values.

10.1 Part Drawings – Processor Card

The processor card for the FPC-BM is illustrated as schematic part drawings in this section.

10.1.1 Processor Card - Top View

A part drawing for the top view of the FPC-BM processor card is shown in Figure 4.

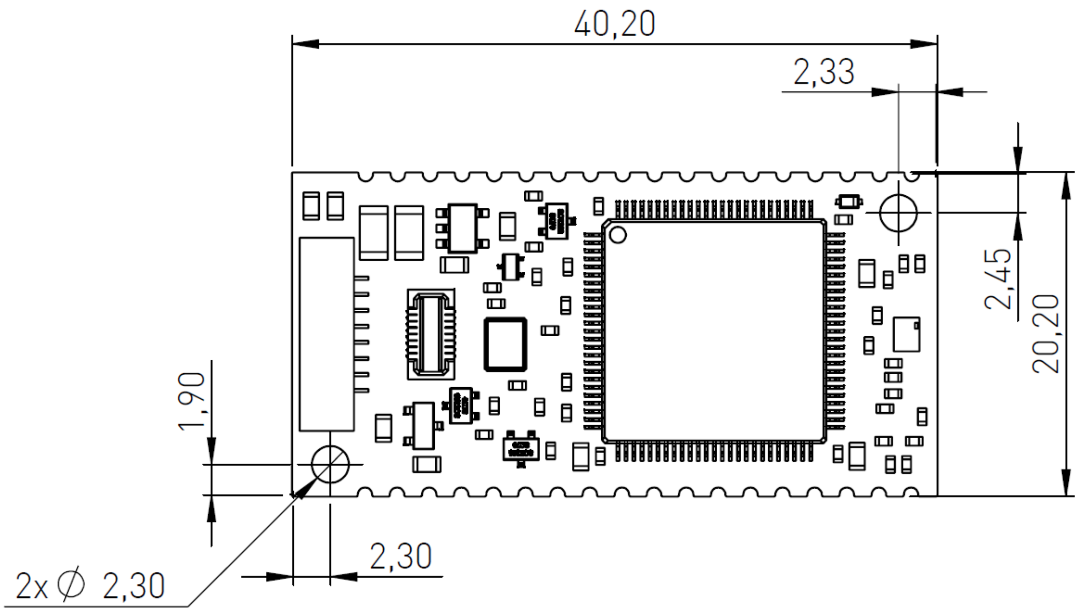

Figure 4: FPC-BM processor card - top view

10.1.2 Processor Card - Bottom View

A part drawing for the bottom view of the FPC-BM processor card is shown in Figure 5.

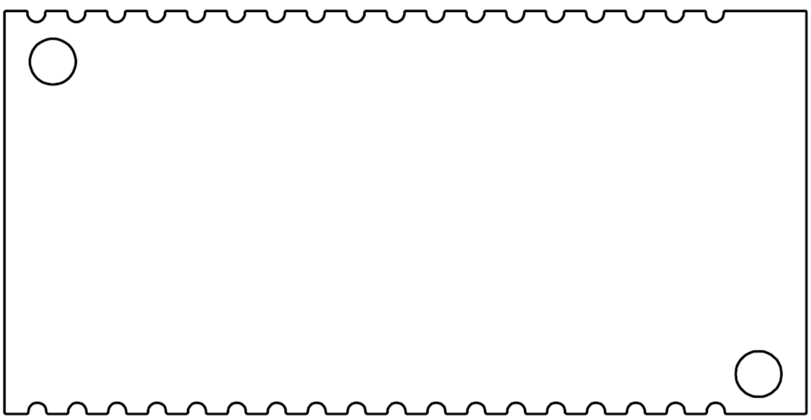

Figure 5: FPC-BM processor card - bottom view

10.1.3 Processor Card - Side View

A part drawing for the side view of the FPC-BM processor card is shown in Figure 6.

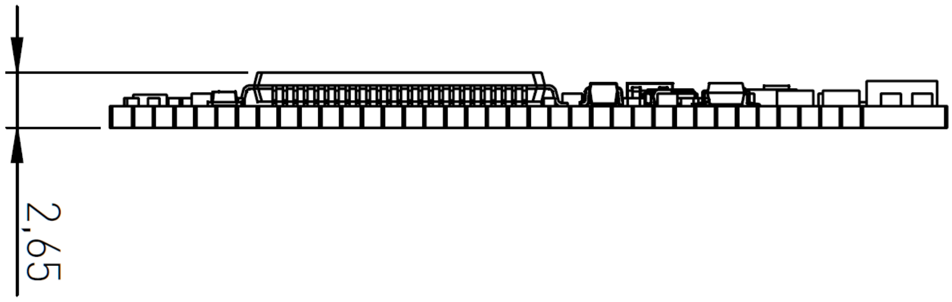

Figure 6: FPC-BM processor card – side view

10.1.4 Solder Pads

Physical properties of the solder pads including the solder mask on the PCB are described in this section.

Solder Mask Opening

The solder mask opening is 1.8 x 2.45 mm as illustrated in Figure 7.

Pad Size

The pad metal measures 1.6 x 2.25 mm with 0.1 mm around each side of the pad as shown in Figure 7.

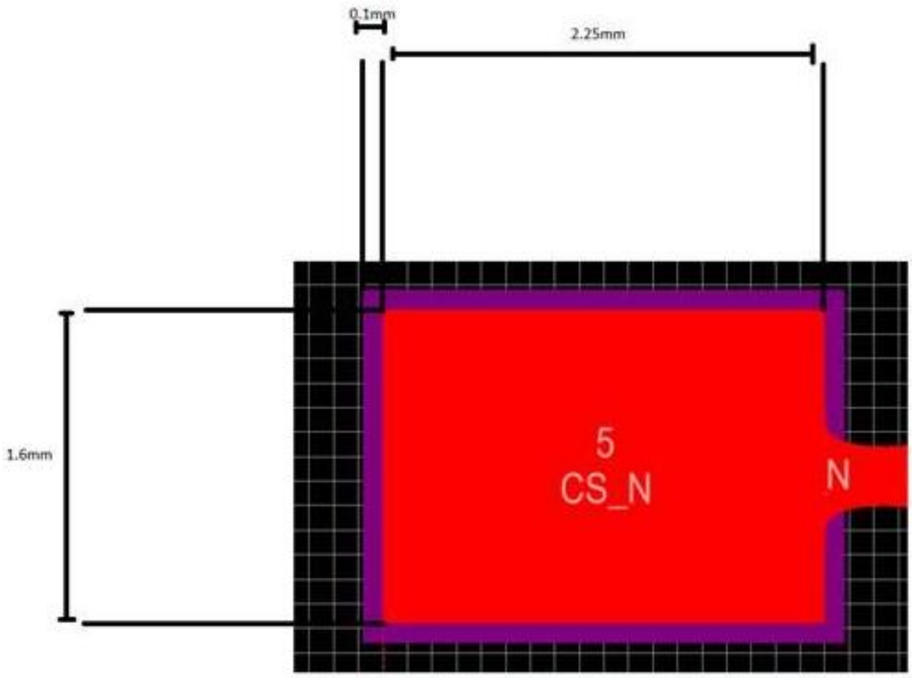

Figure 7: Solder Pad dimensions

Copper Layer Thickness

The thickness of the outer / top copper layer is 35 µm.

The thickness of the inner / bottom copper layer is 35 µm.

10.2 Part Drawings – Sensors

This section gives an overview of the mechanical properties of the sensors that are compatible with the FPC-BM.

10.2.1 Part Drawings - FPC1020AM CM03

The FPC1020AM CM03 configuration is illustrated as schematic part drawings in this section.

FPC1020AM CM03 - Top View

A part drawing for the top view of the FPC1020AM CM03 sensor is shown in Figure 8.

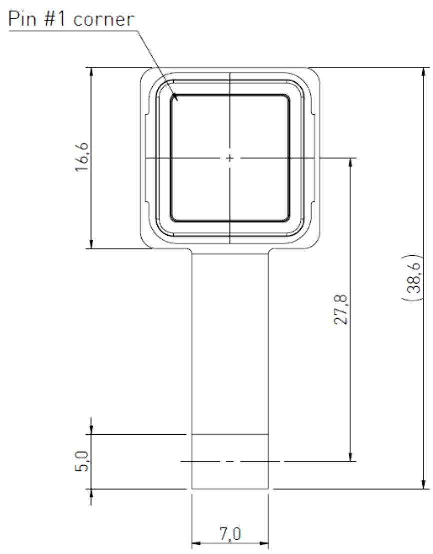

Figure 8: Part Drawing FPC1020AM CM03 – top view

FPC1020AM CM03 - Bottom View

A part drawing for the bottom view of the FPC1020AM CM03 sensor is shown in Figure 9.

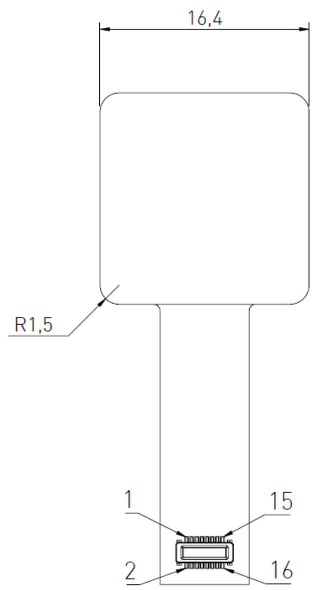

Figure 9: Part Drawing FPC1020AM CM03 – bottom view

FPC1020AM CM03 - Side View

A part drawing for the side view of the FPC1020AM CM03 sensor is shown in Figure 10.

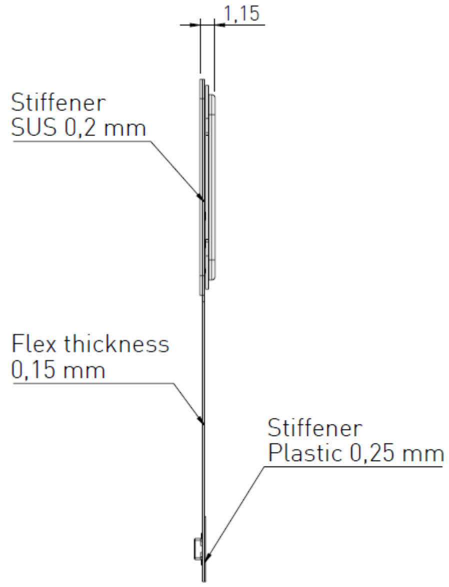

Figure 10: Part Drawing FPC1020AM CM03 – side view

10.2.2 Part Drawings – FPC1020AM CM04

The FPC1020AM CM04 configuration is illustrated as schematic part drawings in this section.

FPC1020AM CM04 - Top View

A part drawing for the top view of the FPC1020AM CM04 sensor is shown in Figure 11.

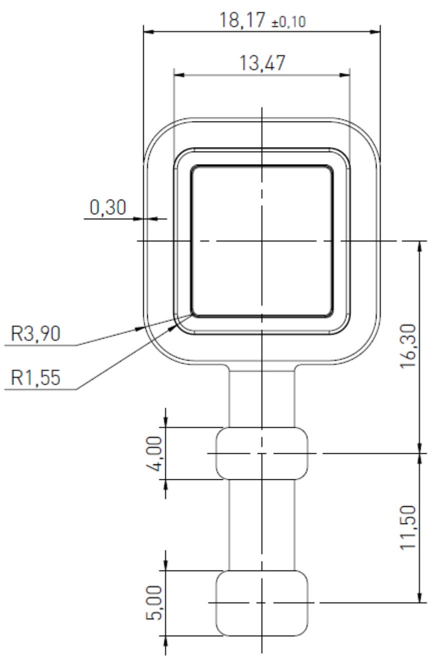

Figure 11: Part Drawing FPC1020AM CM04 – top view

FPC1020AM CM04 - Bottom View

A part drawing for the top view of the FPC1020AM CM04 sensor is shown in Figure 12.

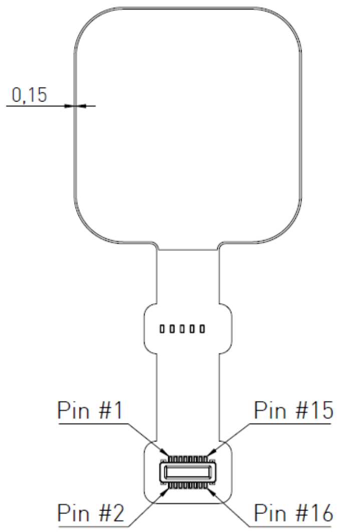

Figure 12: Part Drawing FPC1020AM CM04 – bottom view

FPC1020AM CM04 - Side View

A part drawing for the top view of the FPC1020AM CM04 sensor is shown in Figure 13.

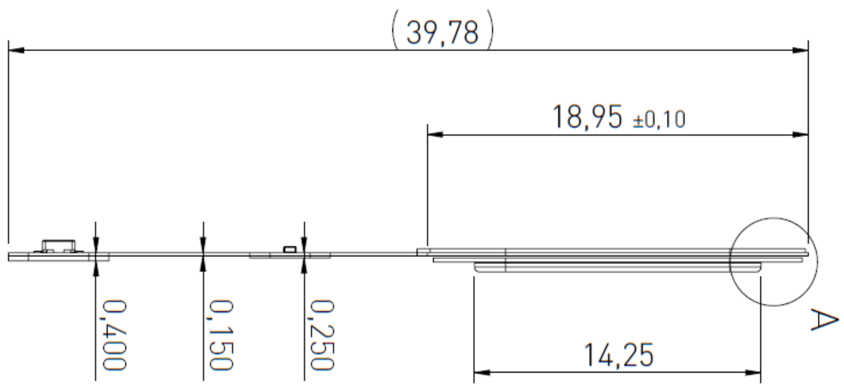

Figure 13: Part Drawing FPC1020AM CM04 – side view

10.2.3 Part Drawings – FPC1011F3

The FPC1011F3 sensor is illustrated as schematic part drawings in this section.

FPC1011F3 - Top View

A part drawing for the top view of the FPC1011F3 sensor is shown in Figure 14.

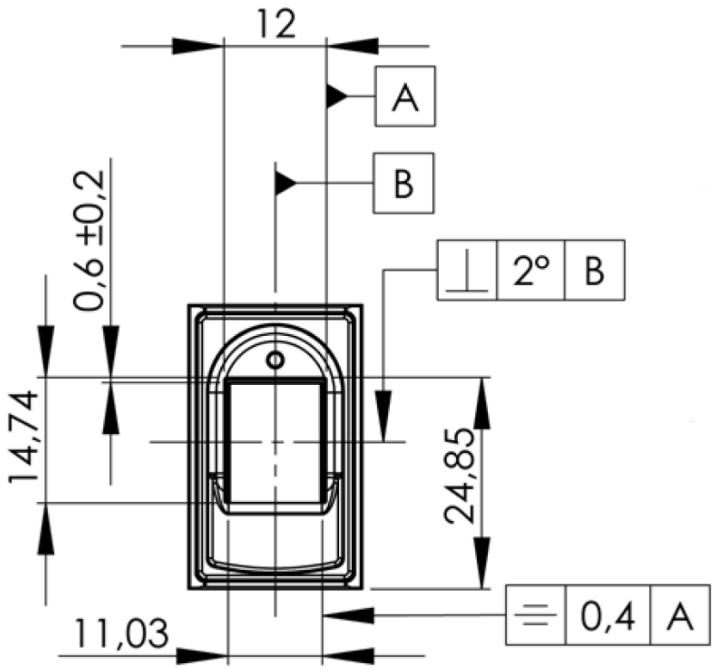

Figure 14: Part Drawing FPC1011F3 – top view

FPC1011F3 - Bottom View

A part drawing for the top view of the FPC1011F3 sensor is shown in Figure 15.

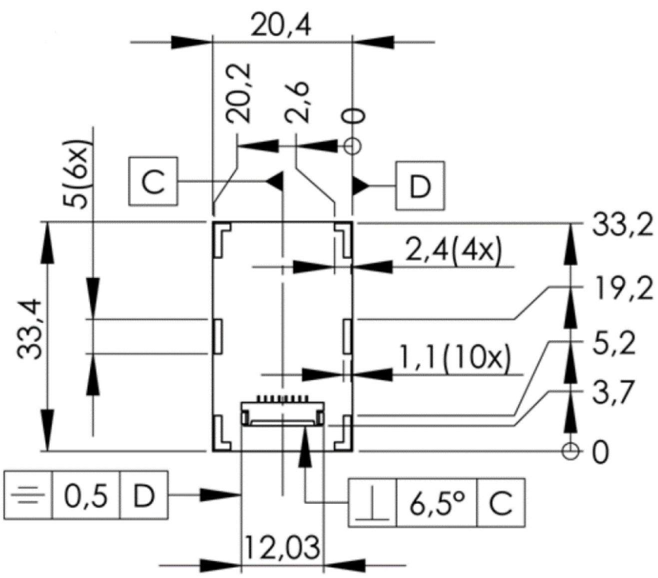

Figure 15: Part Drawing FPC1011F3 – bottom view

FPC1011F3 - Side View

A part drawing for the top view of the FPC1011F3 sensor is shown in Figure 16.

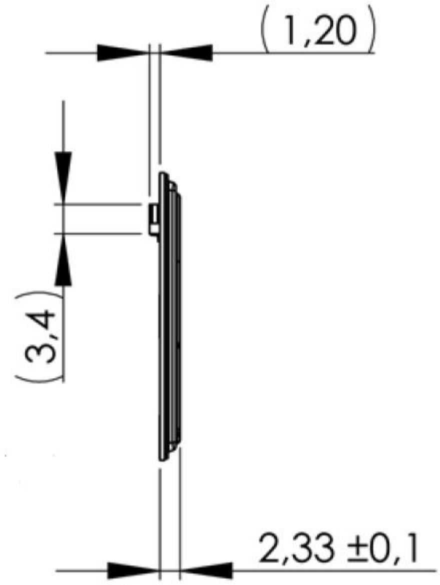

Figure 16: Part Drawing FPC1011F3 – side view

11 Integration and Configuration

This section contains recommendations for integrating the FPC-BM, including an overview of signaling, pin-pad and connector configuration.

11.1 Processor Card

The FPC-BM processor card is mounted using 36 side solder edge pads. There are 18 such side solder edge pads (castellations) on each long side of the PCB (contacts J4 and J5).

Each of the pads is configured to represent a signal as illustrated in Figure 17.

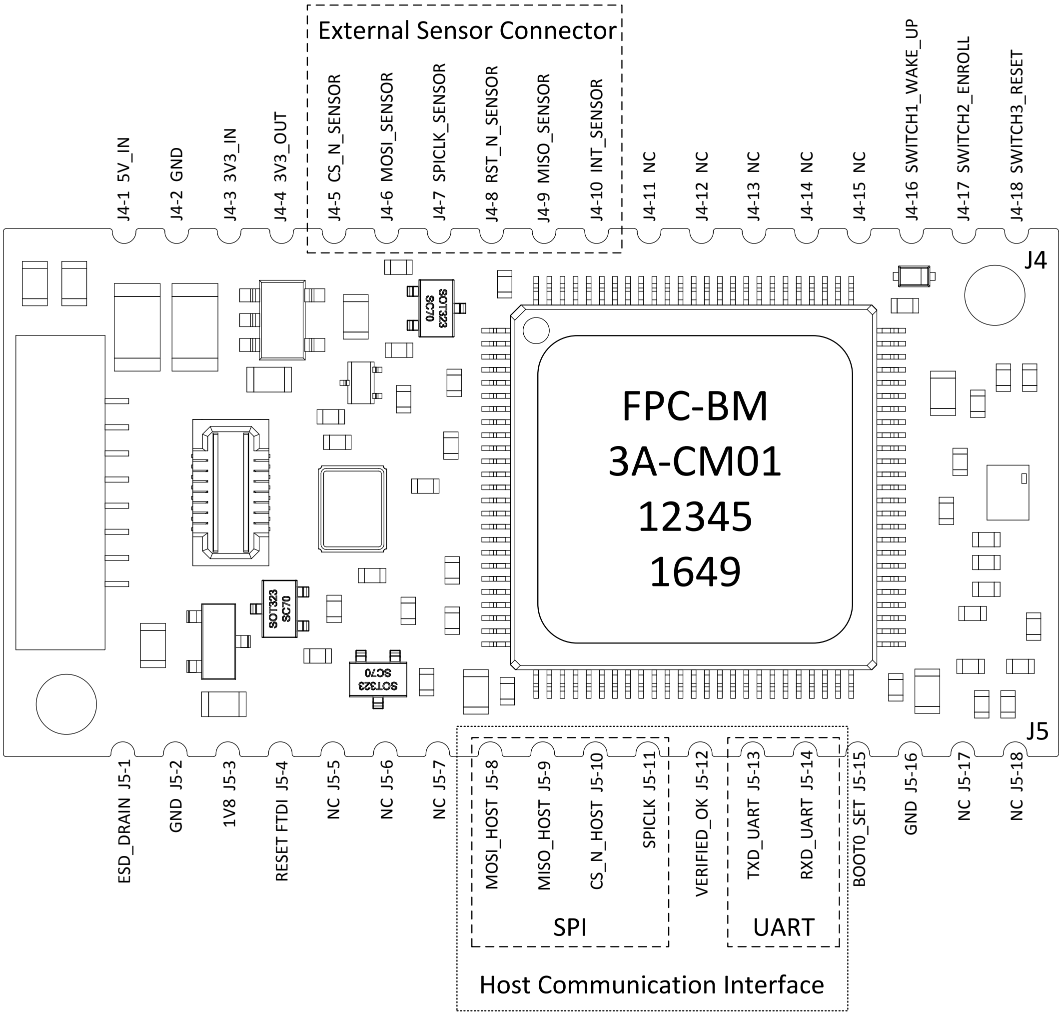

Figure 17: FPC-BM processor card overview

The illustration in Figure 17 is as seen from above.

11.2 Pin-pad Configuration

The pin-pad configuration as illustrated in Figure 17 is outlined in Table 43.

Pin number	Pad Name [contact J4]	Pad Name [contact J5]
1	5V_IN	ESD_DRAIN
2	GND	GND
3	3V3_IN	1V8
4	3V3_OUT	RESET_FTDI
5	CS_N_SENSOR	NC
6	MOSI_SENSOR	NC
7	SPICLK_SENSOR	NC
8	RST_N_SENSOR	MOSI_HOST
9	MISO_SENSOR	MISO_HOST
10	INT_SENSOR	CS_N_HOST
11	NC	SPICLK_HOST
12	NC	VERIFIED_OK
13	NC	TXD_UART
14	NC	RXD_UART
15	NC	BOOT0_SET
16	SWITCH1_WAKE_UP	GND
17	SWITCH2_ENROLL	NC
18	SWITCH3_RESET	NC

Table 43: Pin-pad configuration

11.3 Reference Design Schematic

An example reference design schematic for FPC-BM is shown in Figure 18.

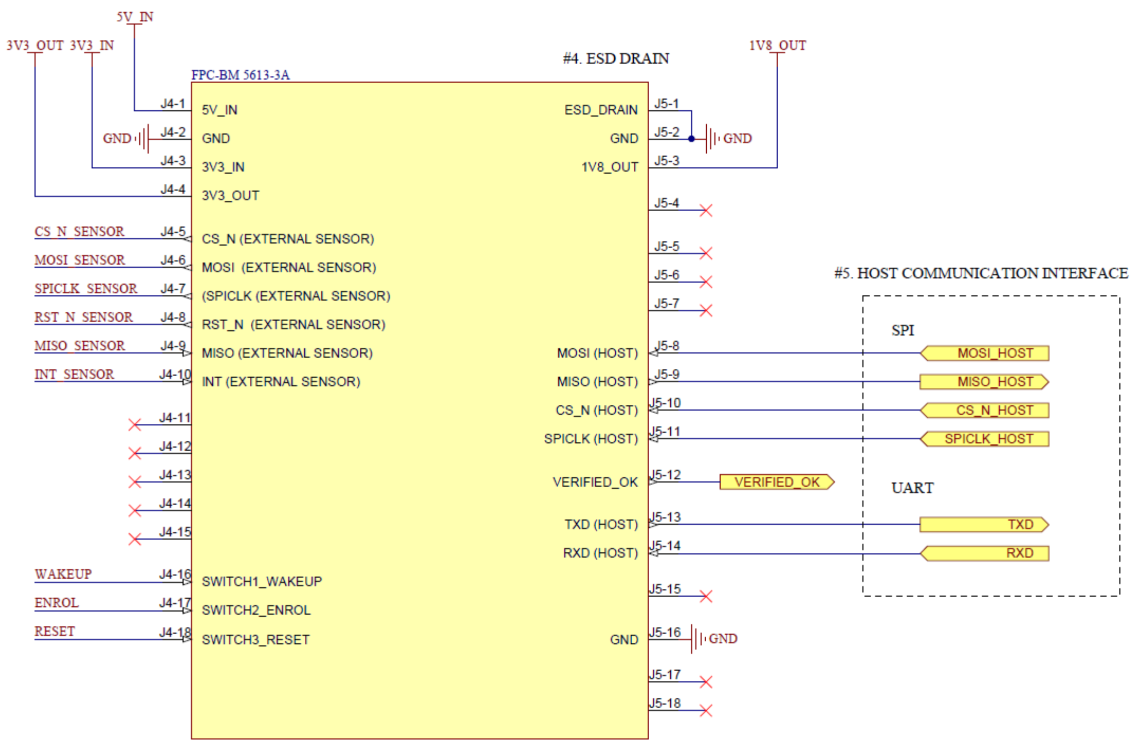

Figure 18: FPC-BM reference design, 5 V power supply

The schematic in Figure 18 shows the FPC-BM as seen from below. In the reference design presented in Figure 18, the FPC-BM is powered from a 5 V supply. See section 11.4 for more information on power supply settings.

11.4 Power Supply Settings

The FPC-BM can be supplied with power from either a 3.3 V or 5 V source.

See section 4.1 for more information on supply voltage.

11.4.1 3.3 V Power Supply

If the FPC-BM is powered from an external 3.3 V source connected to 3V3_IN (J4-3), then the following pins should be left unconnected: 5V_IN (J4-1) and 3V3_OUT (J4-4).

11.4.2 5 V Power Supply

When FPC-BM is powered from a 5 V power supply, it is required that 3V3_OUT (J4-4) and 3V3_IN (J4-3) are connected, as shown in Figure 19.

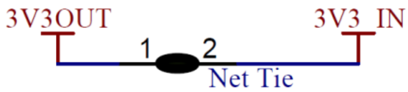

Figure 19: J4-4 and J4-3 connected for 5 V power supply.

11.5 Host Communication

Communication with a Host CPU is available over UART and SPI.

11.5.1 Unused Pins

If the UART and SPI host interfaces are not used, the unused pins shall be connected as follows:

UART

- TXD (J5-13)
- RXD (J5-14) pull-up to 3V3_IN(J4-3)

SPI

- CS_N (J5-10) pull-up to 3V3_IN(J4-3)
- SPICLK (J5-11)
- MOSI (J5-8)
- MISO(J5-9) Pull-down to GND

Recommended Resistor

The recommended resistor value is 680 kΩ.

11.6 External Sensor Connectors

An external sensor connector for an FPC1011F3 or FPC1020AM sensor can be implemented using the solder edge pads J4-5 through J4-10 on the FPC-BM processor card. See Figure 18 for reference.

SPI Interface

An SPI interface for external connectors can be connected in parallel to the existing connectors for the FPC1011F3 or FPC1020AM sensor which is mounted on FPC-BM processor card.

11.6.1 External Connector FPC1020AM

An example reference schematic of an external connector for an FPC1020AM is shown in Figure 20.

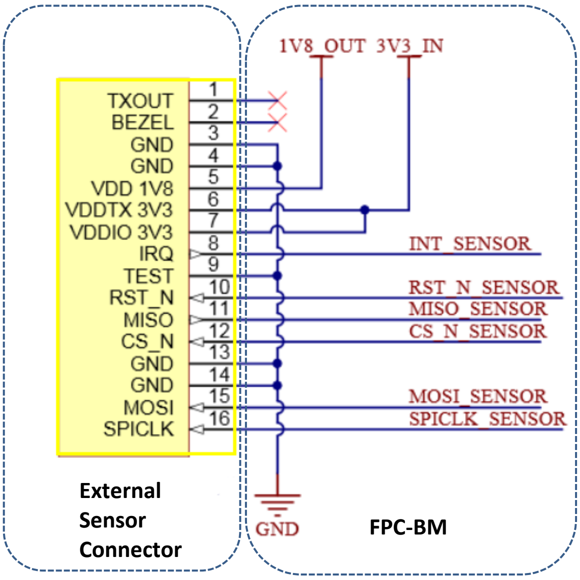

Figure 20: Reference schematic – external connector FPC1020AM

If an external connector for the FPC1020 sensor is not used, 1V8 (J5-3) shall be left unconnected.

11.6.2 External Connector FPC1011F3

An example reference schematic of an external connector for an FPC1011F3 is shown in Figure 21.

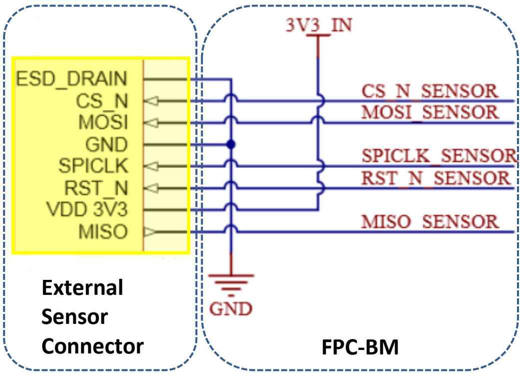

Figure 21: Reference schematic – external connector FPC1011F3

Sleep Mode FPC1011F3

The sleep-mode power consumption option is only supported if the FPC1011F3 is attached using the integrated connector on the FPC-BM processor card.

This option is not supported if an FPC1011F3 sensor is connected using the following pins: J4-3, J4-5, J4-6, J4-7, J4-8, GND

11.6.3 Decoupling Capacitors

Decoupling capacitors (C3) and (C4) shall be placed as close as possible to the external sensor connectors, as illustrated in Figure 22.

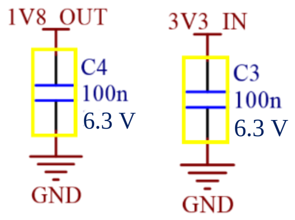

Figure 22: Decoupling Capacitors

See

Recommended Ratings

The recommended ratings for decoupling capacitors C3 and C4:

- 100 nF
- 6.3 V

11.7 Unconnected Pins

This section contains information on

11.7.1 No External Sensor Connector

If an external sensor connector is not used, the pins J4-5 through J4-10 shall be left unconnected.

11.7.2 Unused Pins

If the WAKEUP (J4-16), ENROL (J4-17) and RESET (J4-18) pins are not used, these pins shall be soldered to motherboard but are not connected (NC) to maintain mechanical integrity.

RESET and ENROLL Pins

RESET and ENROLL are active low (SIGNAL_N).

11.7.3 VERIFIED_OK pin

If VERIFIED_OK (J5-12) is not used, this pin shall be left unconnected.

11.8 ESD DRAIN

The connection between ESD_DRAIN (J5-1) and GND is optional.

11.8.1 FPC1011F3 ESD DRAIN

(J5-1) is connected to pin 8 on the FPC1011 connector mounted on FPC-BM.

11.9 Unused Pins

The following pins are not in use and shall be left unconnected (NC):

- J4-11
- J4-12
- J4-13
- J4-14
- J4-15
- J5-4
- J5-5
- J5-6
- J5-7
- J5-15
- J5-17
- J5-18

11.10 Sensor Integration

To maintain biometric performance, the FPC sensors connected to FPC-BM processor card should be mounted or integrated according to the guidelines outlined in this section.

11.10.1 Mechanical Support

The best way to ensure a solid mount is to apply a stable, non-conductive, support to the back side of the sensor module. This non-conductive support can be attached to the entire back side area.

Important! Mechanical force outside the maximum rating may cause permanent damage to the sensor.

11.10.2 Galvanic Contact – Sensor Modules

Due to the conductive bezel on the sensor module, a smooth transition to exterior mechanics can easily be obtained.

Important! Ensure galvanic isolation!

The sensor must be mounted in such way that electrical insulation to adjacent conductive surfaces is achieved. It is also recommended to avoid grounded surfaces nearby the bezel, as this may interfere with sensor operation.

11.10.3 ESD Protection

The FPC-BM has integrated ESD protection. ESD current is deflected across a protective coating on the sensor surface to the bezel surrounding the sensor. From the bezel, the discharged current is conducted via a Transient Voltage Suppressor (TVS) to the local ESD drain node ground pin (GND) on the PCB.

Power Supply Rails

The power supply rails do not need to be protected with an ESD device as they have bulk capacitors that will efficiently store any charge delivered by the ESD.

11.11 Moisture Sensitivity Level

The FPC-BM processor card and connected sensors are moisture-sensitive devices. All components should be handled in accordance with IPC/JEDEC guidelines to avoid damage from moisture absorption and exposure to solder reflow temperatures, which may cause reliability degradation and affect biometric performance.

The FPC-BM module is delivered with an MSL level 3 guarantee (168 hours) based on J-STD-20A. Once soldering has been performed and the FPC-BM module has been mounted, there is reduced risk of degradation from moisture absorption to the device throughout its lifecycle.

Solder Reflow Profile

The solder reflow curve as illustrated in Figure 23 is based on IPC/JEDEC J-STD-020D.

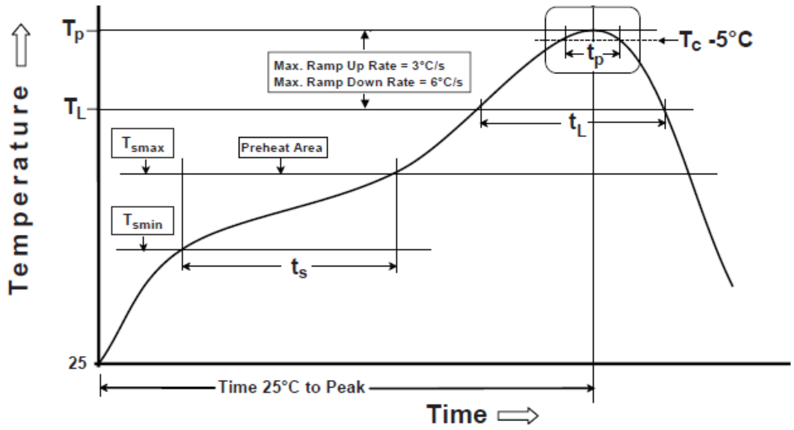

Figure 23: FPC-BM solder reflow curve.

11.11.1 China RoHS

Based on the information from our suppliers FPC-BM has an Environment Friendly Use Period (EFUP) of 50 years.

Part Name	Toxic and Harmful Substances					
	Pb	Hg	Cd	Cr (VI)	PBB	PBDE
Resistors	X*	O*	O*	O*	O*	O*

** O: All homogenous materials in the part are under the limits set out in standard GB/T 26572-2011.*
** X: In at least one homogenous material in the part the substance exceeds the limits set out in standard GB/T 26572-2011.*

Table 44: Toxic and harmful substances

12 Product Identification

To allow for visual recognition and traceability, the FPC-BM is delivered with device name, revision, and manufacturing date marked on the surface of the processor chip, as shown in Figure 24.

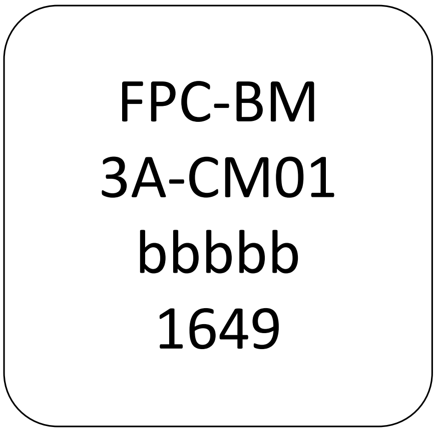

Figure 24: FPC-BM marking

The designation used for the labelling in Figure 24 is described in Table 45.

Row	Reference label	Name	Length (# of characters)	Example
1	nnn-nn	Device name	6	FPC-BM
2	rr-cccc	HW revision & configuration	7	3A-CM01
3	bbbbb	Batch number	5	12345
4	yyww	Manufacturing date (year and week)	4	1649

Table 45: Marking designation

13 Product Updates

An overview of the latest updates to the FPC-BM can be found in this section.

13.1 Product Configurations

An overview of the available product configurations for the FPC-BM is shown in Table 46.

Article Number	Description
FPC-BM-3C-CM01	FPC Biometric Module processor card, software version 2.0.0
FPC-BM-3B-CM01	FPC Biometric Module processor card, software version 1.0.4
FPC-BM1020-3C-CM02	FPC Biometric Module with FPC1020AM CM04 (IP67), software version 2.0.0
FPC-BM1020-3C-CM01	FPC Biometric Module with FPC1020AM CM03, software version 2.0.0
FPC-BM1020-3B-CM02	FPC Biometric Module with FPC1020AM CM04 (IP67), software version 1.0.4
FPC-BM1020-3B-CM01	FPC Biometric Module with FPC1020AM CM03, software version 1.0.4
FPC-BM1011-3C-CM01	FPC Biometric Module with FPC1011F3, software version 2.0.0
FPC-BM1011-3B-CM01	FPC Biometric Module with FPC1011F3, software version 1.0.4

Table 46: Product Configurations

13.1.1 Document History

The updates and changes between the previous versions of this specification are outlined in Table 47.

Revision	Changes
C	Signaling information updated; Integration, mechanical drawings, and reference design updated; State machine diagrams added.
B	Initiate Firmware and Firmware Update commands are removed. Performance Characteristics section is updated. Document filename is changed. RoHS and REACH information added.
A	New document. CS release FPC-BM.

Table 47: Document History