Features

- Sensitive Layer Over a 0.35 mm CMOS Array
- Image Zone: 0.4 x 12.4 mm
- Image Array: 8 x 248 = 1984 Pixels
- Pixel Pitch: 50 mm x 50 mm = 500 dpi
- USB V2.0 Certified (Listed on USB Integrators List)
- Full-speed USB (12 Mbps), Isochronous
- Integrated USB Transceiver
- On-chip Voltage Regulator
- 12 MHz External Clock (XTAL Integrated in Production)
- On-chip PLL to Support 48 MHz Internal Clock
- Suspend/Normal Modes Supported
- Internal Power on Reset (POR)
- USB Driver Supported for Windows 98/Me/2000
- Die Size: 1.68 x 16.52 mm
- Operating Voltage Range: Bus Powered 5V
- Power Consumption: 75 mW at 5V, Full-speed, 25°C
- Chip-on-board (COB) Package, with Specific Protective Layer
- Operating Temperature Range: 0°C to +70°C: C Suffix
- Naturally Protected Against ESD: > 16 kV Air Discharge
- Resistant to Abrasion: > 1 Million Finger Sweeps

Applications

- Terminal Access (Notebooks, PCs, Access to Networks)
- Electronic Payment
- User Authentication Combined with Data Security and Encryption Software

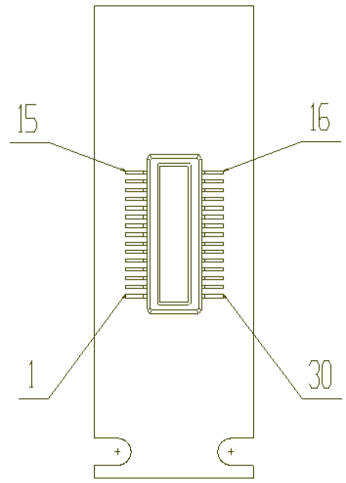
Thermal Fingerprint Sensor with 0.4 x 12.4 mm Sensing Area and USB Interface

AT77C103 FingerChip® Prototype Version

Preliminary

5371A–BIOM–12/03

Figure 1. Pad Connection Chip-on-board: AT77C103A-CB03C[1]



Note: This package is not the production package.

Table 1. Pad Connection Chip-on-board

Pad Number	Name	Pad Number	Name
15	TCK3	16	MODE0
14	LED	17	D+
13	OBS	18	D-
12	RSTN	19	VCC-D
11	TPP	20	VCC
10	GND-PLL	21	VCC-A
9	LFT	22	GND-A
8	VCC-PLL	23	AVIE
7	XOUT	24	AVIO
6	XIN	25	GND-D/GND-H
5	TIN4	26	MODE1
4	TEN2	27	NC
3	NC	28	FPL
2	NC	29	NC
1	NC	30	NC

Note: 1. Connector Ref: DF23C-30DP-0.5V

Table 2. Pin Description for Development Package

CB03	Symbol	Type	Description
20	VCC	P	5V power supply, from USB cable
21	VCC_A	C/P	Analog 3.3V regulator output, to be connected to capacitor
19	VCC_D	C/P	Digital 3.3V regulator output, to be connected to capacitor
8	VCC_PLL	C/P	PLL 3.3V supply: to be connected to VCC_D pin
22	GND_A	P	Analog ground
25	GND_D	P	Digital ground
10	GND_PLL	P	PLL ground
9	LFT	C	PLL external filter, referenced to GND_PLL
6	XIN	I	12 MHz crystal oscillator input
7	XOUT	O	Crystal oscillator output
28	FPL	P	Connect to GND_A
17	D+	I/O	USB transceiver D+ pin
18	D-	I/O	USB transceiver D- pin
11	TPP	P	Connect to VCC via limiting resistor (see “Temperature Management” on page 13)
14	LED	O	LED output; used to drive a LED indicating acquisition
23	AVIE	I/O	Not connected
24	AVIO	I/O	Not connected
12	RSTN	I	Connect to VCC_D
16	MODE0	I	Connect to GND_D
26	MODE1	I	
4	TEN2	I	
15	TCK3	I	
5	TIN4	I/O	
13	OBS	O	Not connected

Description

The AT77C103 is part of Atmel's FingerChip® monolithic fingerprint sensor family for which no optics, no prism and no light source are required.

The AT77C103 is a single-chip, high-performance, low-cost sensor based on the temperature's physical effects for fingerprint sensing. It has a linear shape, enabling capture of a fingerprint image by sweeping the finger across the sensing area. After capturing several images, Atmel proprietary software can be used to reconstruct a full 8-bit fingerprint image.

The AT77C103 has a small surface combined with CMOS technology and chip-on-board package assembly, which contribute to a low cost device.

The AT77C103 delivers a programmable number of images per second, while an integrated analog-to-digital converter delivers a digital signal with an on-chip USB interface. Thus, no additional chips are necessary to send the frames to a PC. Consequently, the AT77C103 is an easy device to include in any USB-supported system for identification or verification applications.

The AT77C103 is currently delivered in a testing package, enabling you to evaluate performances and anticipate your software development.

Table 3. Absolute Maximum Ratings

Parameter	Symbol	Comment	Value	Unit
Positive supply voltage	VCC		GND to 6.5V	V
Temperature stabilization power	TPP		GND to 6.5V	V
Front plane	FPL		GND to VCC	V
Digital input voltage			GND to VCC	V
Storage temperature	T_{stg}		-40 to +85	°C
Lead temperature (soldering 10 s)	T_{leads}	Do not solder DIL: socket mandatory	Forbidden	

*NOTICE: Absolute maximum ratings are limiting values only, to be applied individually, while other parameters are within specified operating conditions. Long exposure to maximum ratings may affect device reliability.

Table 4. Recommended Conditions of Use

Parameter	Symbol	Comments	Min	Typ	Max	Unit
Positive supply voltage	VCC		4.75V	5V	5.25V	V
Front plane	FPL	Must be grounded	GND			V
Digital input voltage	Mode0 Mode1 TEN2, TIN4,	Test pins Recommended to be grounded				V
	RSTN	Must be connected to VCC_D	VCC_D			V
	TCK3	Must be grounded	GND			V
Digital output voltage	LED	Not connected if not used	CMOS levels			V
Digital output voltage	OBS	Not connected				V
Digital load	CL				50	pF
Analog load		Not connected				
Operating temperature range	T_{amb}	Civil : "C" grade	0 to +70			°C
Maximum current on TPP	ITPP		0	50	100	mA

Table 5. Resistance

	Minimum Value	Standard method
ESD		
On pins. HBM (Human Body Model) CMOS I/O	2 kV	MIL-STD-883- method 3015.7
On die surface (Zapgun) Air discharge		NF EN 6100-4-2
Mechanical abrasion		
Number of cycles without lubricant Multiply by a factor of 20 for correlation with a real finger	200 000	MIL E 12397B
Chemical resistance		
Cleaning agent, acid, grease, alcohol, diluted acetone	4 hours	Internal method

Table 6. Test Levels

Explanation of Test Levels	
I	100% production tested at +25°C
II	100 % production tested at +25°C and sample tested at specified temperatures (AC testing done on sample)
III	Sample tested only
IV	Parameter is guaranteed by design and/or characterization testing
V	Parameter is a typical value only
VI	100 % production tested at temperature extremes
D	100 % probe tested on wafer at T_{amb} = +25°C

Table 7. Specifications

Parameter	Symbol	T_{amb}	Test Level	Min	Typ	Max	Unit
Resolution			IV		50		Micron
Size			IV		8 x 248		Pixel
Yield: number of bad pixels			I			15	Bad pixels
Equivalent resistance on TPP pin			I	23	30	47	Ohm

Table 8. Electrical Characteristics
Power supply = +5V; T_{amb} = 25°C; $F_{crystal}$ = 12 MHz (active mode)
Digital and analog outputs disconnected unless otherwise specified

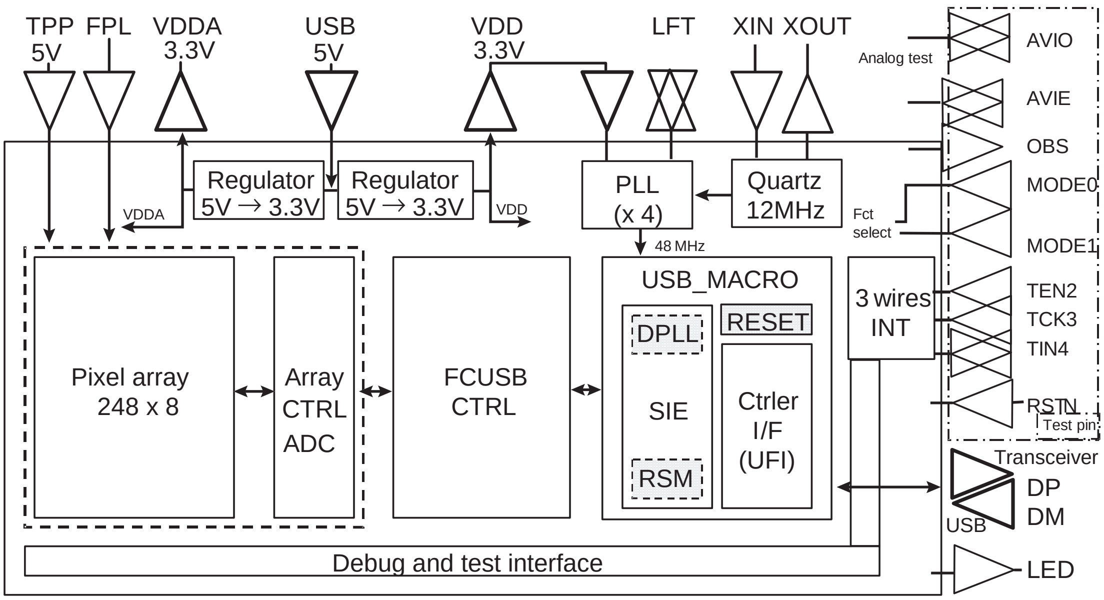
Parameter	Symbol	T_{amb}	Test Level	Min	Typ	Max	Unit
Power Requirements							
Positive supply voltage	VCC			4.75	5	5.25	V
Digital positive supply current on VCC pin	ICC		I		15		mA
Power dissipation on VCC	PCC		I		75		mW
Power dissipation on VCC in Suspend mode	PCCNAP		I			1.5	mW
Digital Inputs RSTN Signal							
Logic compatibility					CMOS		
Logic "0" voltage Logic "1" voltage Logic "0" current Logic "1"current	VIL VIH IIL IIH		I I I I	0.7 x VDD - 10		0.3 x VDD 10	V V mA mA
Digital Inputs/Outputs for D+ D-							
USB 2.0 compliant							
Digital Outputs LED signal: C_{load} 50 pF							
Logic compatibility					CMOS		
Logic "0" voltage Logic "1" voltage	VOL VOH		I I	VDd - 0.1		VSS + 0.1	V V
Output rise time (10% - 90% final value)	tr		IV		10		ns
Output rise time (10% - 90% final value)	tf		IV		5		ns
Crystal Characteristics							
XTAL integrated on production package							
XTAL frequency	FXTAL		I		12		MHz
Internal capacitance [xin - gnd]					10		pF
Internal capacitance [xout - gnd]					10		pF

Table 8. Electrical Characteristics (Continued)
Power supply = +5V; T_{amb} = 25°C; $F_{crystal}$ = 12 MHz (active mode)
Digital and analog outputs disconnected unless otherwise specified

Parameter	Symbol	T_{amb}	Test Level	Min	Typ	Max	Unit
Equivalent load capacitance [xin - xout]					5		pF
Series resistance (crystal)						40	Ohm
Shunt capacitance (crystal)						6	pF

Note: 1. With I_{OL} = 0.3 mA and I_{OH} = 0.3 mA

Figure 2. Block Diagram



The circuit is divided into three main sections:

- The sensor
- Data conversion elements
- The USB interface

The pixel's read frequency directly depends on the USB bus' data rate. The full-speed USB transfer is used for this chip. A 48 MHz clock is necessary for the clock recovery, synchronized with the data coming from the USB bus. The 48 MHz is achieved with a 12 MHz crystal oscillator and a PLL.

Functional Description

Analog Part

Sensor

Each pixel is a sensor in itself. The sensor detects a temperature difference between the beginning of the acquisition and the reading of the information. This period is the integration time, which begins with an internal reset of the pixel to a predefined initial state. Note that reset of the integration time is independent of reset of the digital section.

Electrical charges are then generated at a rate that depends on the temperature variation between the reset and the end of the integration time, as well as on the duration of the integration time, nominally 1 millisecond, as defined by the USB specification in full bandwidth mode (2 milliseconds in economy mode).

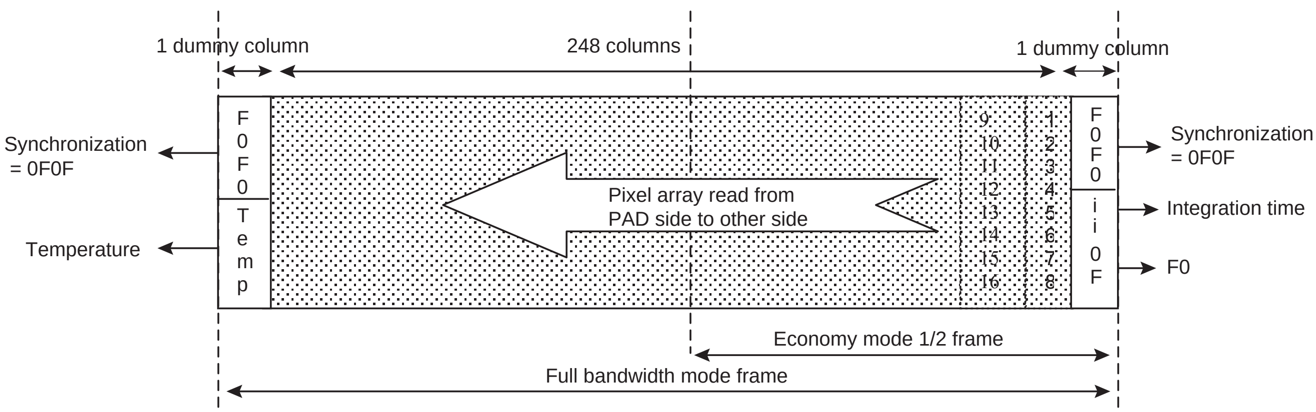
Analog-to-digital Converter

An analog-to-digital converter (ADC) is used to convert the analog signal coming from the pixel into digital data that can be used by a processor. Two 4-bit ADCs are used to output two pixels at a time on one byte.

Frame Description

A frame consists of 248 true columns and 2 dummy columns of 8 pixels and 4 bits each. A frame starts and ends with a dummy column.

Figure 3. Frame Description



For each byte, the four most significant bits correspond to the even pixel's converted value, and the four least significant bits to the odd pixel's converted value.

The first dummy column, at the beginning of the pixel array, is added to the sensor to act as a specific easy-to-detect pattern and used as a start-of-frame tag. This column also contains the measurement of the integration time duration with a 10 µs precision.

Code Hexadecimal	Integration Time µs
00	0
01	10 µs
02	20 µs
64	1 µs
C8	2 µs
FF	Overflow

First Column Dummy Bytes Description

	Even	Odd	
Dummy byte 1 DB1	0000	1111	} Synchronization
Dummy byte 2 DB2	0000	1111	
Dummy byte 3 DB3	i i i i	i i i i	→ Integration time
Dummy byte 4 DB4	1111	0000	

Even values are first sent during the phase of data serialization for the USB transfer. Therefore, the synchronization sequence is 0F0F (hexadecimal).

The last dummy column, at the end of the pixel array, also contains the synchronization sequence and the temperature measurement. The four bytes of the dummy column contain the fixed pattern 0F0F on the first two bytes, and temperature information on the last two bytes.

Last Column Dummy Bytes Description

	Even	Odd
Dummy byte 1 DB1	0000	1111
Dummy byte 2 DB2	0000	1111
Dummy byte 3 DB3	nnnn	r r r r
Dummy byte 4 DB4	pppp	t t t t

The sequence 0F0F can be used to check the frame synchronization.

Frame Reading

The pixel array is always read in the following order:

- The first byte after the four bytes of the dummy column - this byte contains the value of the two pixels physically located on the upper right corner of the array, when looking at the die with bond pads to the right.
- The following three bytes - these contain the value of the pixels physically located on the same vertical line, from top to bottom.
- The next line on the left

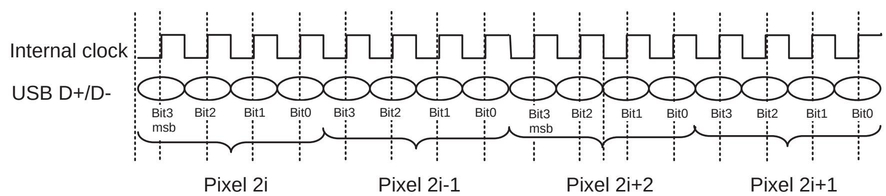
and so on, until the last line on the left is output.

Even values are first sent during the phase of data serialization for the USB transfer. The host PC receives data in the following order on the USB channel:

Table 9. Read Order of the Pixel Array

Byte Number	MSB							LSB	Note
1	0	0	0	0	1	1	1	1	1st column
2	0	0	0	0	1	1	1	1	1st column
3	DB2_Bit3	DB2_Bit2	DB2_Bit1	DB2_Bit0	DB1_Bit3	DB1_Bit2	DB1_Bit1	DB1_Bit0	1st column
4	DB4_Bit3	DB4_Bit2	DB4_Bit1	DB4_Bit0	DB3_Bit3	DB3_Bit2	DB3_Bit1	DB3_Bit0	1st column
5	Pix2_Bit3	Pix2_Bit2	Pix2_Bit1	Pix2_Bit0	Pix1_Bit3	Pix1_Bit2	Pix1_Bit1	Pix1_Bit0	
6	Pix4_Bit3	Pix4_Bit2	Pix4_Bit1	Pix4_Bit0	Pix3_Bit3	Pix3_Bit2	Pix3_Bit1	Pix3_Bit0	
…									
996	Last 2 pixels of the frame								
997	0	0	0	0	1	1	1	1	last column
998	0	0	0	0	1	1	1	1	last column
999	DB2_Bit3	DB2_Bit2	DB2_Bit1	DB2_Bit0	DB1_Bit3	DB1_Bit2	DB1_Bit1	DB1_Bit0	last column
1000	DB4_Bit3	DB4_Bit2	DB4_Bit1	DB4_Bit0	DB3_Bit3	DB3_Bit2	DB3_Bit1	DB3_Bit0	last column

Figure 4. Reading of Frame



Digital Part (Including USB Function)

USB Function

The AT77C103 functions with the isochronous transfer. This is the most suitable type of transfer because:

- It is made for devices that require a constant rate and can tolerate errors.
- Access to the USB is guaranteed as there are no interferences with other devices during the transfer

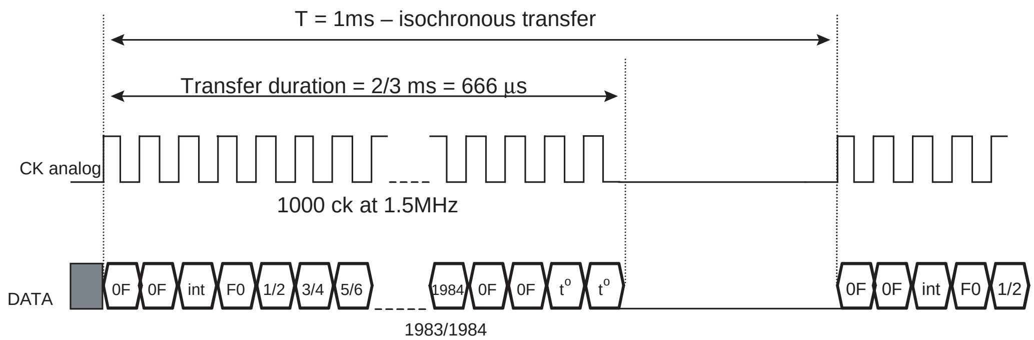
Two modes are available for the data transfer, with two different bandwidths:

- Full bandwidth (and default) mode that requires nearly all the isochronous bandwidth:
  - 1 frame/millisecond (ms) -> 8000 Mbps for a maximum of 8184 Mbps for the isochronous transfer.

- Economy mode that requires half the bandwidth. Half the pixel array is transferred per millisecond:
  – 1/2 frame/ms -> 4000 Mbps, including 1 dummy column plus 124 array columns for the first ms, and 124 array columns plus 1 dummy column for the second ms. The PC driver gathers the frame.

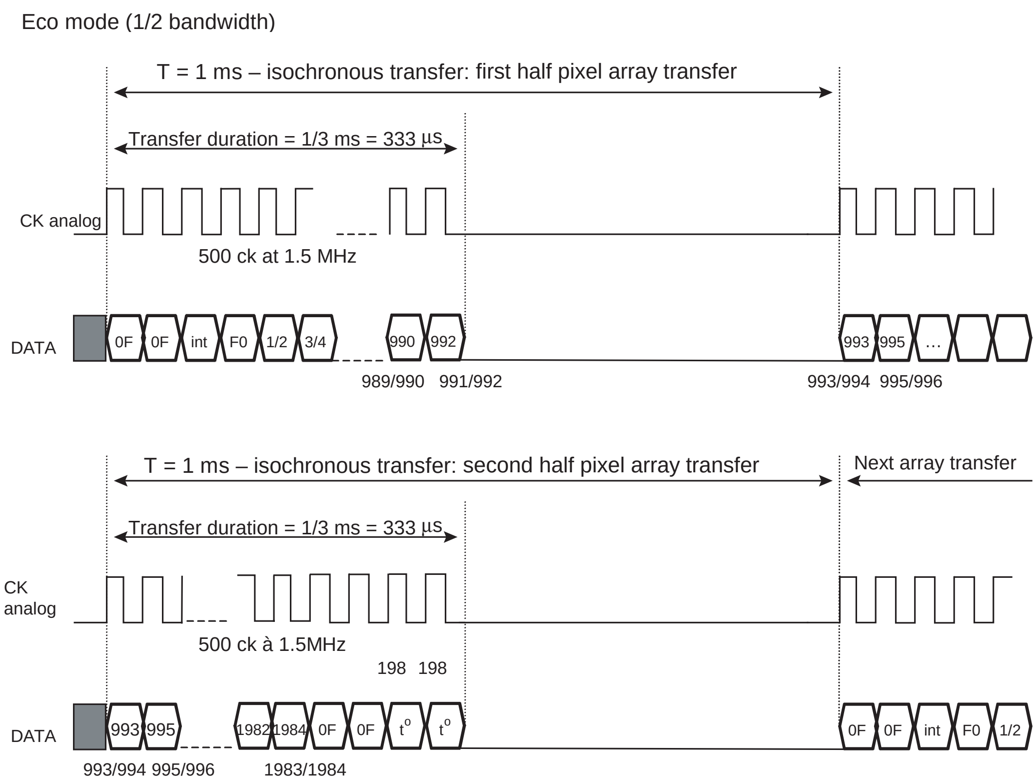
The full bandwidth mode is the recommended mode. One complete frame is transferred each millisecond, therefore the PC receives a frame of 4 x (248 +2) which equals 1000 bytes or 8000 Mbps.

Figure 5. Full Bandwidth Mode



In economy mode, half the frame is transferred each millisecond, therefore the PC needs two milliseconds to reconstruct the complete frame. The finger is swept at half the speed compared to full mode. This mode is only used when there is not enough bandwidth for full mode. On the USB bus, the data packet is 4 x (124 + 1), which equals 500 bytes or 4000 Mbps.

Figure 6. Economy Mode (Half Bandwidth)



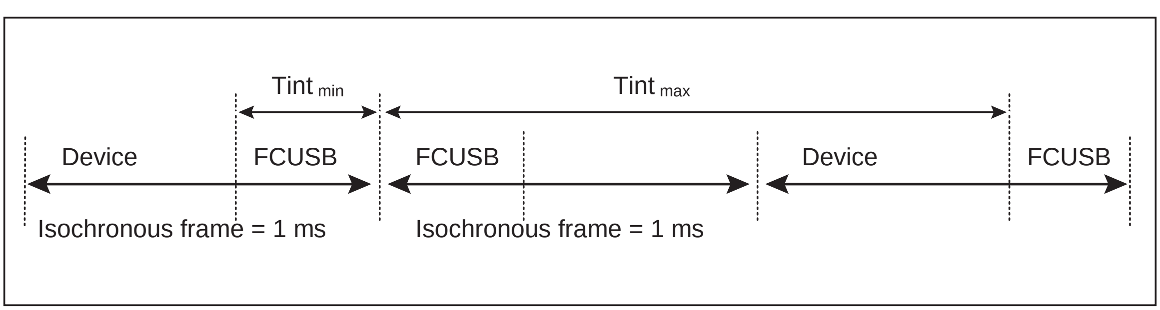
Integration Time

The frame integration time must be as regular as possible to obtain consistent fingerprint slices. This is handled by the USB interface in the full bandwidth mode, which asks for one full frame each millisecond according to the isochronous end-point specification.

In economy mode, while using only part of the bandwidth, this integration time regularity is not guaranteed. Another isochronous device could be used simultaneously with the FCUSB (AT77C103) so that the isochronous bandwidth is shared between the two devices (or more).

If the second device transfers its data before the FCUSB and the data packet is variable (as USB load speaker, for example), the integration time is not fixed to 1 millisecond. The worst scenario would be a device transferring data every two isochronous transfers (2 milliseconds), which would mean that the integration time could vary between T_{int} minimum = 0.333 ms to T_{int} maximum = 1.333 ms.

Figure 7.



Since the integration time cannot be guaranteed in economy mode, it is advisable to check the integration time in the software application to detect a possible problem and stop the device(s) during finger capture.

Temperature Management

Each of the FingerChip's pixels acts as a temperature sensor that detects temperature changes, generated by the difference in temperature between the finger and the chip. It is these changes that enable the capture of an image. Ideally, there should be a large temperature difference between the finger and the chip (for instance, when the chip temperature is very low or very high, although this is rather unusual). At worst, the finger temperature is exactly the same as the chip temperature, and therefore no image can be captured.

Two separate features are available:

1. An absolute temperature sensor: information is digitally transmitted in bytes DB3 and DB4 of the last dummy column. Data format and values are available once chip characterization is complete. The measurement precision is nearly 10°C (refer to Table 10 on page 13).
2. Temperature stabilization circuitry, powered by the TPP power pin and enabled through the end-point 0 control register.

The stabilization feedback is externally managed by the USB host and the client application can implement the application-appropriate algorithm.

TPP is the pin that delivers power and must be externally connected to the USB power supply (VCC_A) through a resistor to limit the maximum current. A value of TBD O limits the power below 50 mA.

Table 10.

Decimal	Binary	Temperature differential with code 8 in Kelvin
15	1111	12
14	1110	9
13	1101	7.5
12	1100	6
11	1011	4.5
10	1010	3
9	1001	1.5
8	1000	0
7	0111	-1.5
6	0110	-3
5	0101	-4.5
4	0100	-6
3	0011	-7.5
2	0010	-9
1	0001	-12
0	0000	-16.5

Power Management

- In functional mode and in a typical application, power consumption is nearly 15 mA.
- In power-down or suspended mode, power consumption can reach nearly 285 mA.

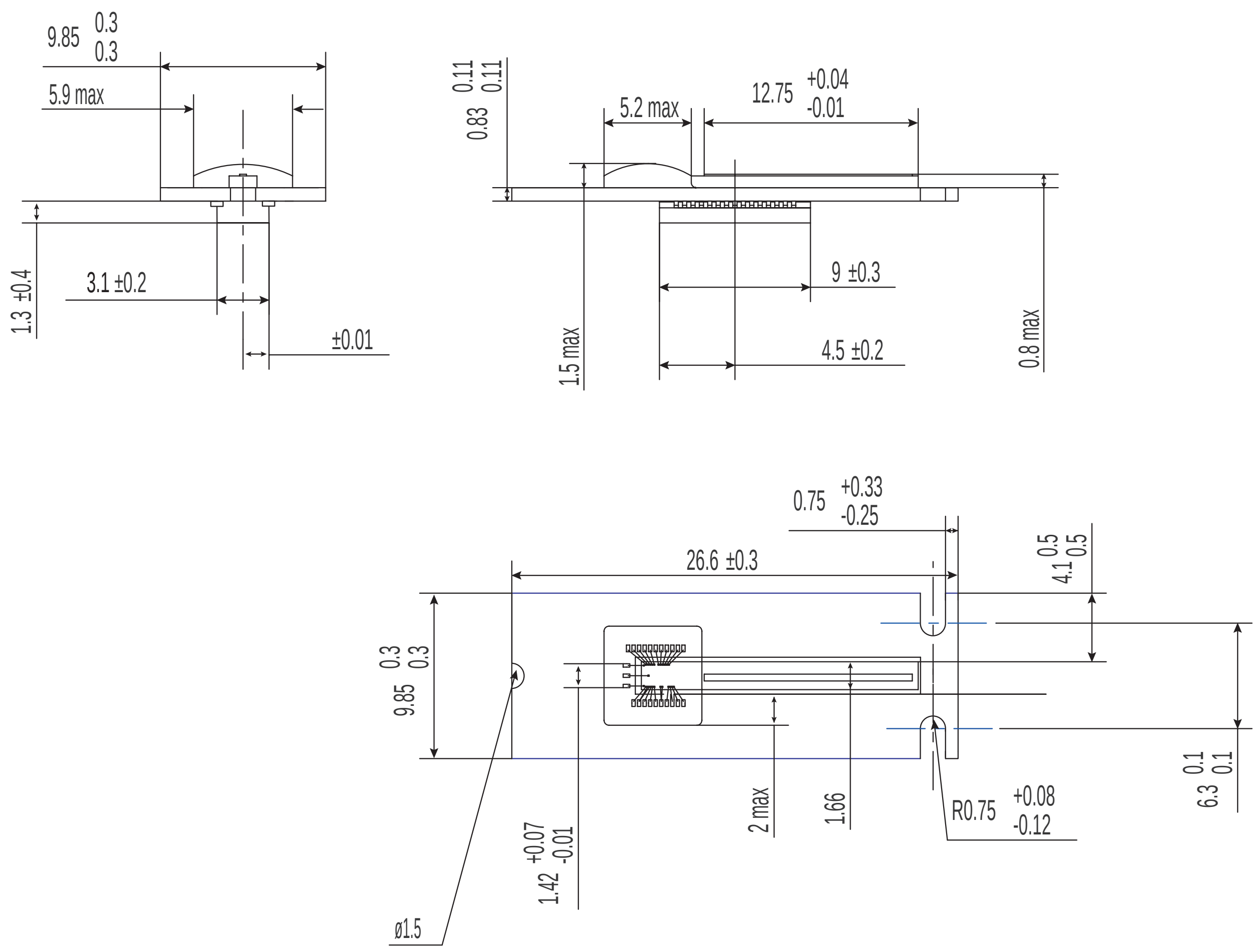
The USB interface switches to suspended mode after the USB bus has remained inactive for more than 3 milliseconds. Most of the circuits are then automatically switched off by the device to ensure that the chip does not fall to more than 0.3 mA (USB 2.0 compliance).

- With heating, power consumption can reach 50 mA, or 100 mA maximum in worst cases. This mode is selected with the CONTROL_HEAT command.

Packaging Material Data

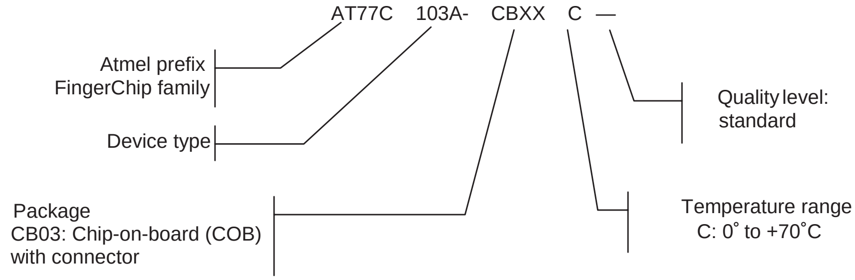
Only the development package is currently available. The production package, which shall include discrete components as well as XTAL, is not shown here.

Figure 8. Product Reference: AT77C103A-CB03C (all dimensions in mm)



Ordering Information

Package Device



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