TCETC1, TCETD1 TouchChip® Fingerprint Modules

Rev. 2.1

Hardware User Guide

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Table of Contents

1 Features

- **Integrated Fingerprint Modules**
  - Integrated module with TCS1 sensor, TCD58H companion processor and active bezel
  - IP-65 rated between sensor and bezel. Will accommodate external gasket
  - Factory calibrated and tested
  - TCETC1, gold coating, PIV-071006 Certified (EIM)
  - TCETD1 with black SteelCoat™, EIM-Lite
  - Choice of metallic or black colored bezel
  - Compact 23 x 35 x 4.11 mm assembly

TCETC1
PIV

- **TouchChip® Sensors**
  - Array Size: 256 x 360 pixels
  - Image resolution: 508 DPI
  - Gray scale: 8-bit (256 levels)
  - 12.80mm x 18.0mm imaging area

- **Biometric Co-processor TCD58H**
  - Image capture, extract, match, and secure comm options
  - Non-volatile memory (NVM) storage for up to 100 templates
    - More than 100,000 erase/write cycles
    - More than 20 years data retention

TCETD1
SteelCoat

- **Power Consumption**
  - Sleep mode: 1350 uA @ 3.3 V
  - Fast Imaging mode: 105 mA @ 3.3 V
  - Wake-up time: <15 ms (Sleep to imaging)
  - Single supply voltage, two options: 3.0V to 3.6V or 4.5V to 5.5V

- **Environmental Specifications**
  - ESD tolerance: up to IEC 61000-4-2 Level 4
  - Operating temperature: -20° C to +70° C
  - Storage temperature: -40° C to +125° C
  - Storage/operating humidity: 5% to 85% RH w/o condensation

- **Applications**
  - Government and Mobile ID terminals
  - USB peripherals and POS terminals
  - Access Control and other embedded devices

- **Option “F”: Flex Cable Connector**
  - 12 position, 0.5mm pitch
  - Exposes USB, UART and SPI interfaces
  - Full speed USB signals (D+ / D-) also used for I/O select
  - 3.3V Vcc for direct to host integration

- **Option “G”: Customer Soldered USB Cable**
  - 5V Vcc only for USB compatibility
  - Requires solder-on USB cable (not included)

- **Option “I” or “N”: 5 position wire-to-board connector**
  - 5V Vcc only for USB compatibility
  - Matching connector/cable not included

2 TouchChip Serial Fingerprint Module

The TCETC1/D1 modules are ready-to-install fingerprint modules that integrate a TCS1 die with traditional or SteelCoat protective coatings together with the TCD58H companion chip, which in turn supports USB, UART and SPI interfaces to the host. This module enables equipment manufacturers to avoid the technical details associated with the assembly and calibration of this type of device, simplifying the integration process of adding a fingerprint reader into their products.

The TCETC1/D1 fingerprint reader modules have been assembled, calibrated, and tested by Crossmatch and are ready to install.

All modules include the bezel, an important active electrical and mechanical component. A gasket seals between the sensor and the bezel. The bezel must be kept electrically isolated from the device packaging.

The TCETC1xxxxx modules are PIV-071006 (PIV) certified. These are sometimes referred to as “EIM” or “FIPS-201” modules in older literature. For more PIV information please visit the FBI sites for biometric specifications and certifications:
https://www.fbibiospecs.cjis.gov/Home/BiometricSpecs
https://www.fbibiospecs.cjis.gov/Certifications/FAQ

3 Highlights

Maximum integration:
The TCETC1/D1 modules significantly reduce development time and costs, as they can easily be incorporated into embedded and USB applications. Crossmatch provides embedded firmware and image capture libraries needed to grab fingerprint images, enroll users, extract and match minutia based templates. The firmware comes pre-loaded in the module from the factory, while the libraries are distributed as a SDK. Contact Crossmatch to discuss support details for embedded environments.

Low overall height
The TCETC1/D1 module eases system integration by being only 4.11 mm high, including the bezel.

Flex cable connector
The standard flex cable connector (Option “F”) simplifies connection to system (host) boards by supporting off-the-shelf 12 position flex jumpers, industry standard active logic levels, and the most commonly available input voltage, 3.3 V nominal.

USB Cable solder pads
A standard USB cable may be added by the customer. Solder pads are standard while a voltage regulator is supplied as part of Option “G”.

USB Wire-to-Board Connector
5 Pin SURS wire type connector in tin (“I”) and gold flash (“N”) versions available in some markets.

4 Module Functionality

The TCETC1/D1 Module incorporates a fingerprint algorithm which performs all of the processes required for biometric functionality on a secure processor. This section describes the various processes that can be performed.

4.1 PerfectPrint® Image Optimization

The TCETC1/D1 Module incorporates the PerfectPrint™ algorithm to capture fingerprint images. The PerfectPrint firmware embedded in the Module includes image optimization functions that allow the sensor to capture the best-quality fingerprint image, according to environmental conditions and skin types.

4.1.1 Image Capture Modes

The TCETC1/D1 Module supports two image capture modes. These modes define the image capture characteristics of the TouchChip fingerprint sensor, in turn optimizing the balance between image quality, system cost, usability and grab speed for different market applications. An image gradient compensation method is used to optimize the TouchChip image quality for each imaging mode, providing TouchChip modules with a wide range of fingerprint image capture capabilities, and offering excellent reliability and usability for a broad range of users and environmental conditions. The image capture mode and gradient compensation information is programmed into the module once during manufacturing and remains constant for the life of the device.

4.1.1.1 Enhanced Image Mode (for PIV)

TCETC1 uses Enhanced Image Mode (EIM) which improves captured image quality over legacy standard mode by adding a conductive bezel around the sensor and modifying the calibration process to increase the signal-to-noise ratio (SNR) for the captured image. Improving the SNR increases the image contrast ratio. EIM makes use of extensive image post-processing by mapping a full byte per pixel correction image for gradient correction. EIM also improves dry finger performance and helps reject latent images. The TCS1C sensor is the first and only silicon fingerprint sensor to meet the FBI's PIV-071006 image quality criteria.

4.1.1.2 Light Version of Enhanced Image Mode (EIM-Lite)

TCETD1 uses EIM-Lite which supports the valuable bezel aided SNR improvements of full EIM minus the image post-processing. EIM-Lite also improves dry finger performance compared to older non-bezel based systems and helps reject latent images. This mode reduces some of the implementation overhead of the full Enhanced Imaging Mode, but still brings most of the image quality improvements.

4.2 Image Capture

The TCETC1/D1 firmware library supports several different modes for readout of the captured image from the module. This functionality includes the ability to change the DPI resolution (sub-sampling) and filtering/binarization. The three image modes supported are as follows:

- 508/508/8 (raw image data)
- 381/381/8 (sub-sampled on-the-fly in 3:4 ratio)
- 381/381/bin (sub-sampled on-the-fly in 3:4 ratio and filtered/binarized)

The following table shows the different captured image formats supported and the relative readout times. All times are in seconds, averaged from 10 grabs, measured on the host side.

Table 1: Image Readout Times

I/O	Image	TCETD1		TCETC1		
		LP[1]	HP[2]	LP	HP	unit
SPI	508/508/8	1.44	0.76	1.20	0.71	sec
	381/381/8	1.56	0.89	1.34	0.77	sec
	381/381/bin	1.63	0.96	1.40	0.83	sec
UART[3]	508/508/8	5.49	5.26	5.39	5.22	sec
	381/381/8	4.00	3.48	3.79	3.33	sec
	381/381/bin	1.97	1.44	1.75	1.31	sec
UART Secure Mode[4]	508/508/8	6.46	5.30	6.37	5.24	sec
	381/381/8	4.02	3.48	3.79	3.35	sec
	381/381/bin	1.98	1.46	1.75	1.31	sec
USB	508/508/8	1.0	0.62	0.85	0.52	sec
	381/381/8	1.11	0.73	0.95	0.62	sec
	381/381/bin	1.23	0.84	1.06	0.74	sec
USB Secure Mode	508/508/8	1.48	0.87	1.32	0.76	sec
	381/381/8	1.24	0.85	1.08	0.75	sec
	381/381/bin	1.24	0.86	1.08	0.75	sec

1. LP = Low Power, core running at 72MHz when sensor is enabled.
2. HP = High Power, core running at 144MHz when sensor is enabled.This is the default state.
3. UART running at 230.4MHz. Scale accordingly if using other transfer rates
4. Secure Channel mode

Note that all values measured while in “Wait” mode, meaning it waits for acceptable finger, while also enabling image stabilization, image segmentation and anti-latent detect. “No Wait” is faster but not the preferred solution. A quick study of the readout table reveals that the UART is not good at transferring raw images. For this reason it is suggested to limit UART usage to match on device applications.

4.3 PefectMatch® Fingerprint Template Extraction

PerfectMatch technology performs the fingerprint minutia-based extraction from live fingers. Two different TouchChip template formats are supported. The standard (aka “consolidated”) template is similar to those used in previous companion chips. The enhanced (aka “super”) template is a combination of multiple data inputs and averages 3 times larger in size. The increased template size enables improved biometric performance and usability compared to the standard template. The actual size of the template depends on the particular fingerprint. The maximum size of the template is limited to 428 bytes for standard and 2200 bytes for enhanced templates. Note that it will be very rare for an enhanced template to reach maximum size.

Support is offered for converting from/to TouchChip templates to/from some ANSI-378 or ISO 19794-2 formats templates. See the software guide(s) for details.

4.3.1 Fingerprint Template Enrollment

Following extraction, the PerfectMatch firmware allows a live fingerprint template to be:

- stored locally into the NVM of the module (enrolled to internal biometric database)
- transferred over to and managed by the host application
- used for various verification/matching operations while available in the LGT (Last Good Template) register of the module

The module supports the latest dynamic enrollment process. During dynamic enrollment multiple fingerprint images are grabbed and processed until the template meets the template quality criteria. The dynamic process permits a higher quality template combining the most important features extracted from the enrollment data. A minimum of five and a maximum of ten images are required to complete dynamic enrollment.

4.3.2 Fingerprint Template Matching

PerfectMatch firmware also performs the fingerprint match, it does this by comparing the live fingerprint template against a fingerprint template retrieved from memory. The enrollment template can be stored locally, on a server, or on another system component such as a smart card. The match algorithm supports different security settings, and the time required for the match algorithm will depend on both the security setting used, as well as the specific fingerprint being matched. Average template match time is shown in the following table.

Template Type	Typical Template Match Time
Standard	56.5 per Second
Enhanced	13.4 per Second

The matching feature can be used in a number of scenarios:

- 1:1 verification of live finger against a selected fingerprint template stored in the module's biometric database.
- 1:1 verification of live finger against a fingerprint template supplied to the module from outside.
- 1:1 matching of two fingerprint templates: One or both templates can be stored either on the module in the biometric database or can be supplied to the module from outside. This feature allows using the module as a biometric matcher.
- 1:few identification: Identification of a live finger against a given set of fingerprint templates. Templates against which identification is being performed can reside on the module or can be supplied from outside of the module for the sole purpose of this operation. The identification template set can also combine templates from both sources.
- 1:few identification: Identification of a live finger against all templates stored in the module's biometric database.

In case multiple operations against the live fingerprint template are needed, the live fingerprint template is stored in the module's session memory. This allows multiple uses of the live fingerprint template (e.g., for multiple 1:1 verification operations), instead of requiring the user to place the finger over the sensor repeatedly for each operation.

4.4 Biometric Database Functionality

The included NVM is used to store several types of information, including templates. Each template stored in the database is assigned a record number, called a slot number. Stored templates can be used for verification/matching operations or can be deleted. Data transfers to/from memory are encrypted.

The module is compatible with the following biometric database management features:

- Enroll a live finger to a biometric database (Add database record)
- Supply a template from outside of the module and store it in the database (Add database record)
- Delete a specified record from the database
- Delete all records from the database
- Read, store, modify or delete a data tag associated with the record
- List database (Lists all slot numbers and content of each record's data tag)

One or more data tags can be stored in the database record along with each enrollment template. Data tags can be used to store application-specific data of any type. A data tag can be edited, deleted, or modified within a database record at any time. Data tags can be either public (readable anytime) or private. Private data tags are readable only after the associated template is matched against a live finger, and they therefore allow user passwords or other credentials to be stored securely, with hardware-protected access.

The total number of templates that may be stored on a given device varies depending on the particular fingerprints as well as the amount of user data stored in the template memory space.

Table 2: Template Storage[1]

Module	Standard Template		Enhanced Template	
	Minimum	Average	Minimum	Average
All	100	100	36	51

1. Includes space for 254B of optional user data. Additional templates can be stored in lieu of this data.

4.5 Interface Bootstrap Options

The host interface is selected at the time that internal nRESET goes high by the states of the two USB logic signals. These logic levels must be strapped on the host side. Note that normal USB host behavior will pull both signals low until enumeration, so connecting active USB signals alone will result in choosing the USB option.

Table 3: Interface Bootstrap Logic

Selected Interface	USB_DP	USB_DN
USB	Low	Low
SPI	Low	High
UART	High	High

4.6 Active Bezel

The bezel is an important functional component of the module. The bezel performs four separate tasks: Finger Guide, Finger Detection, Image Enhancement and ESD Mitigation. In order to correctly perform the electrical tasks the bezel must not be conductively linked to any other voltage potential, signal or conductive surface.

- As a Finger Guide the bezel aids in correct finger placement.
- For Hardware Finger Detect the bezel is part of an electrical circuit that can detect the presence of a finger.
- The bezel is a critical component in Enhanced Image Modes, both full and -Lite versions. An electrical signal is passed through the bezel, into the skin, and detected by the sensor array. This signal has multiple purposes, including increasing the signal-to-noise ratio of the image.
- There is an ESD diode connected to the bezel that protects the sensitive underlying electronics. This protection works best when the module is properly connected to chassis ground or negative battery via the exposed ESD grounding pads on the bottom surface of the module.

4.7 Additional Features

TCETC1/D1 modules offer a number of useful additional features.

4.7.1 GUI Callbacks

All live fingerprint-scanning operations offer to the application the option to display a GUI feedback. The application can choose the level of callback communication, from simple (only requests to put/lift finger) to a full finger positioning feedback (e.g., advising user/application to move finger more to left, right etc.).

4.7.2 Finger Detection

The finger detection feature allows putting the module into a time-limited or infinite-wait cycle, including Standby, until a finger is detected on the bezel. Upon finger detection, the function reports back to the application, which can proceed with further action (e.g., verification). The module contains two internal frequency generators whose nominal frequencies are determined by external components. One generator connects to the bezel. The presence of a finger on the bezel effects the frequency of the generator. An internal comparison circuit detects when the bezel frequency reaches one-half the reference frequency, when this happens an interrupt flag will be set. Response to this flag is determined by the calling function.

4.7.3 Latent Print Detection

Latent and faint fingers are detected and rejected, with an error message being returned to the calling function.

4.7.4 On-Chip NVM Storage of Application-Specific Data

The module supports storage of limited application-specific data in the on-chip NVM. Two memory areas are available for this purpose:

- Application Memory Area: Accessible for read and write operations by all applications. The available memory size is limited to 256 bytes.
- OEM Memory Area: Accessible by OEM customers wishing to pre-load some OEM-specific data. The available memory size is limited to 256 bytes.

4.7.5 Functional States

The module supports two low-power states:

1. **DEEP SLEEP mode:**
   In this mode, the module is still powered but every part of the system is turned off. In this mode the power consumption used by the module is the minimum possible. The module can be awakened and go to active mode only via an external wake-up signal supplied by the host (WAKEUP line) or USB resume.
2. **STAND-BY mode:**
   In this mode, the module is still powered at a minimal amount sufficient to operate the finger detect function. In this mode, all circuit blocks are turned off with the exception of those needed

for the finger detect, and power consumption used by the module is very low. The module can be awakened and go to active mode via an external wake-up signal or by the hardware finger detect.

4.7.6 USB Power Management Support

The TouchChip USB driver supports the following:

- USB Power Management Capabilities Query. module is able to report to the USB host via the Standard Power Descriptors. These address power consumption, latency time, wake support, battery support and status notification.
- USB Power Management State Transition Commands. The USB host, via the standard SET_FEATURE command, controls the module power states. USB device power states are queried via the standard USB GET_STATUS command.

4.7.7 USB Selective Suspend

In Microsoft operating systems the USB core stack supports a feature known as “Selective Suspend.” This feature allows a device driver to turn off the USB device it controls when the device becomes idle, even while the system itself remains in a fully operational power state (S0). This feature is primarily intended to conserve battery power in notebook PCs. It should be recognized that user authentication devices connected to the USB port are used relatively infrequently during the operation of the notebook PC. The module implements this support to provide reasonable battery life for the user. Implementing this simple mechanism provides power reduction in three instances: for the USB controller, the USB device itself, and for the host CPU in the notebook PC.
Once suspended, the module can be awakened either by a USB resume signal from the host, or by remote wake-up request (finger detect).

4.7.8 LED Interface Support

The module has optional signal outputs which can be used to connect user interface LEDs. The number of available pins is dependent on the active hose interface. The LED behavior can be defined by the host application in order to facilitate the creation of a user interface in embedded applications. The APIs allow switching the LEDs on, off, or letting them blink at different rates and patterns. Refer to Crossmatch's application notes for more information regarding the LED interface.

4.7.9 Secure Communication Channel

The module supports encryption of the host communication channel. The encryption can use DES (56-bit) or AES with a key length of 128 or 256-bits. Some variations may require a government export license. The session key is based on a random number generated by the module and transferred to the host during the course of a 3-way challenge-response authentication. Secure communication can be initiated at any time during the session, and remains active until the session is terminated.

5 Host Interfaces

The main communication link between the TCETC1/D1 and any host system is via the USB, SPI or UART interfaces. All commands, status, and data are transmitted over a link based on one of these interfaces.

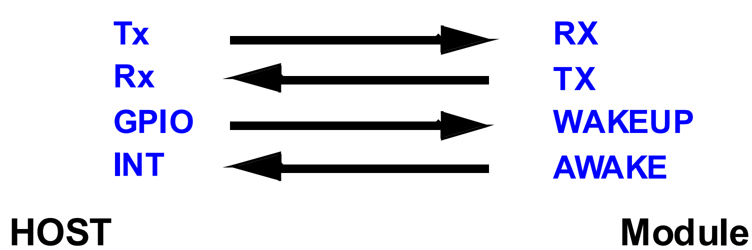
5.1 USB 2.0 Full Speed Bulk (12 Mbps)

The USB interface is fully compliant with USB 2.0 full speed (12 Mbps) specification. This interface is used for both command communication and image data transfer. The normal 1.5K ohm pull-up resistor from USB_DP to the USB Connect control is internally realized.

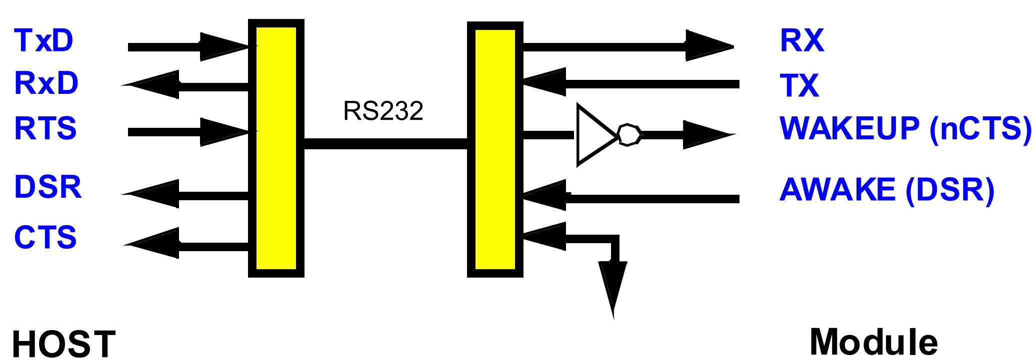
5.2 UART

The UART interface is a standard Universal Asynchronous Receive/Transmit interface compliant with the 16C550 UART specification. The UART interface is intended to be used as a primary command and communication interface, though it can also be used for image data transfer (depending on image transfer speed requirements). The UART interface supports speeds from 9600 bps to 230.4 kbps and supports modems signal DSR and CTS[1].

The figure below shows the actual connection of the TCETC1/D1 UART interface with a HOST UART when the HOST UART does not support any modem control signals.



In case the HOST UART supports modem control signals like RTS and DSR, it is possible to make use of such signals for advance wake-up functionality as described in the figure below.



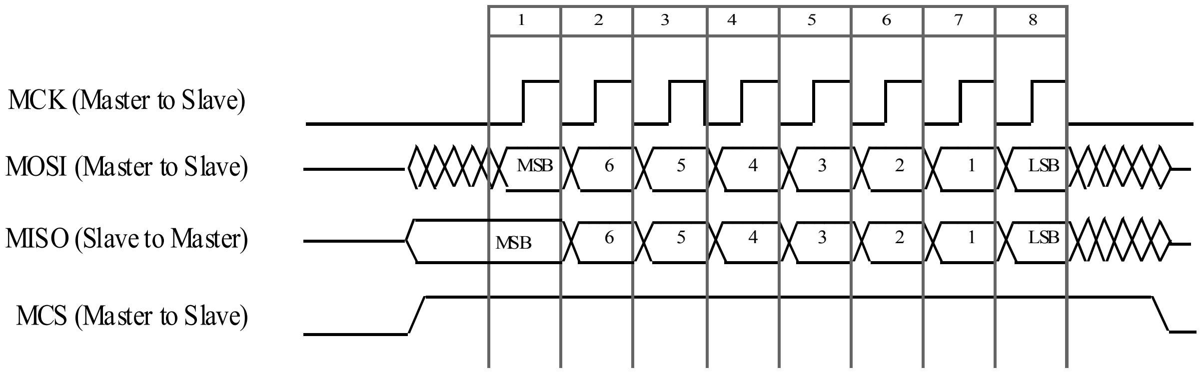
1. The support by the TCETC1/D1 of Host DSR and RTS signals is not completely standard: they are used for an advanced system wake-up implementation. Please note the inversion of the RTS/CTS signal.

5.3 SPI

The TCETC1/D1 incorporates an SPI interface that can be used to communicate to a host processor. This is a slave interface, i.e., the host acts as the SPI bus master. The range of supported clock speeds are up to 7.2 MHz.

The SPI block is configured in Slave mode, 8 bits per byte, 9 bytes per frame, CPOL = 0, CPHA = 0 (mode 0), chip select (MCS) active high. Note that active-high chip select polarity differs from typical Mode 0 implementations.

See “Flex Connector Options “F” and “Z”” on page 22 for pin assignment details of the SPI interface.

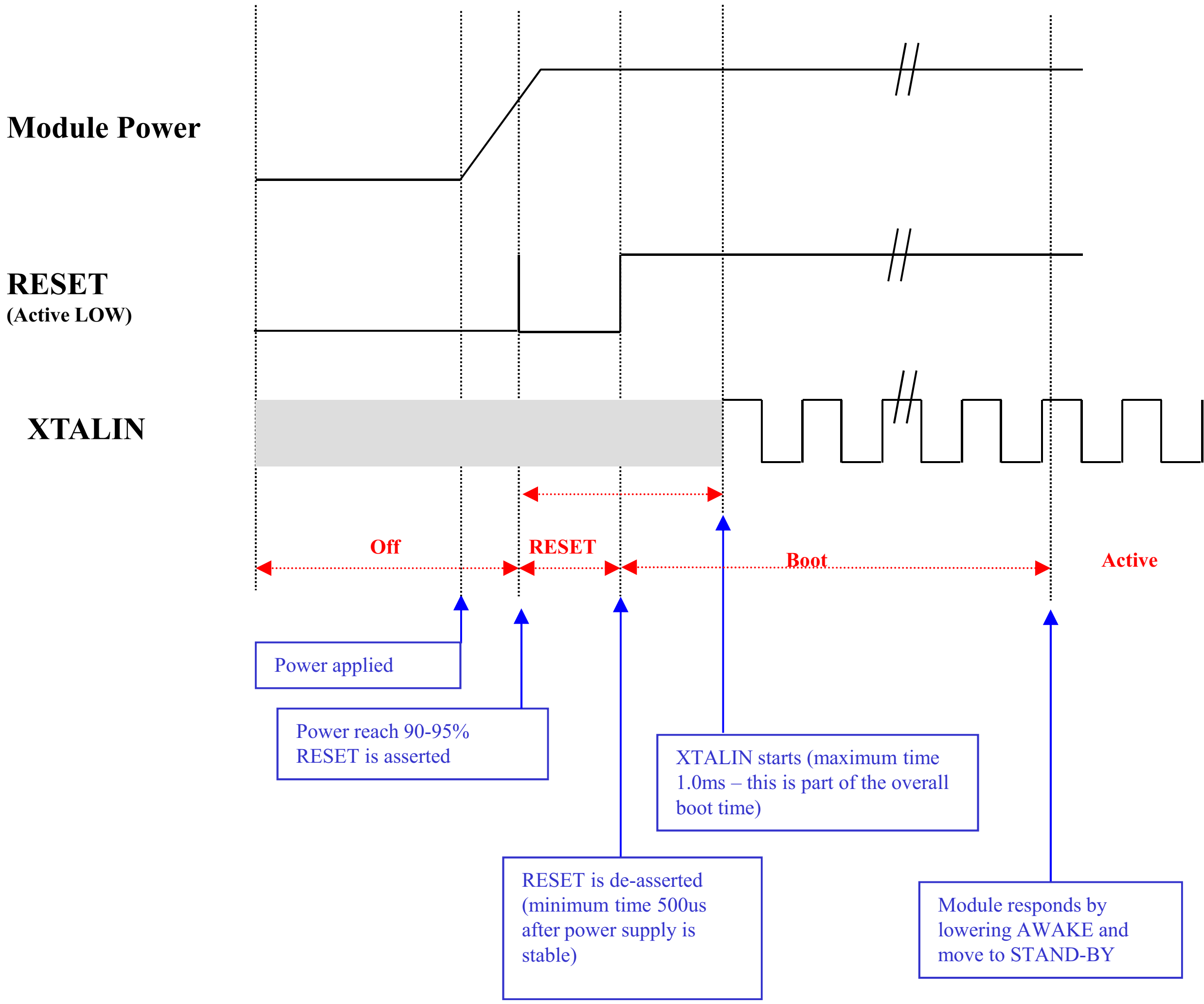


Note: MCS shown terminating after one byte for illustrative purposes only, actual transfers must maintain MCS in the active state for one frame of 9 bytes.

5.4 Signal Timing Diagrams

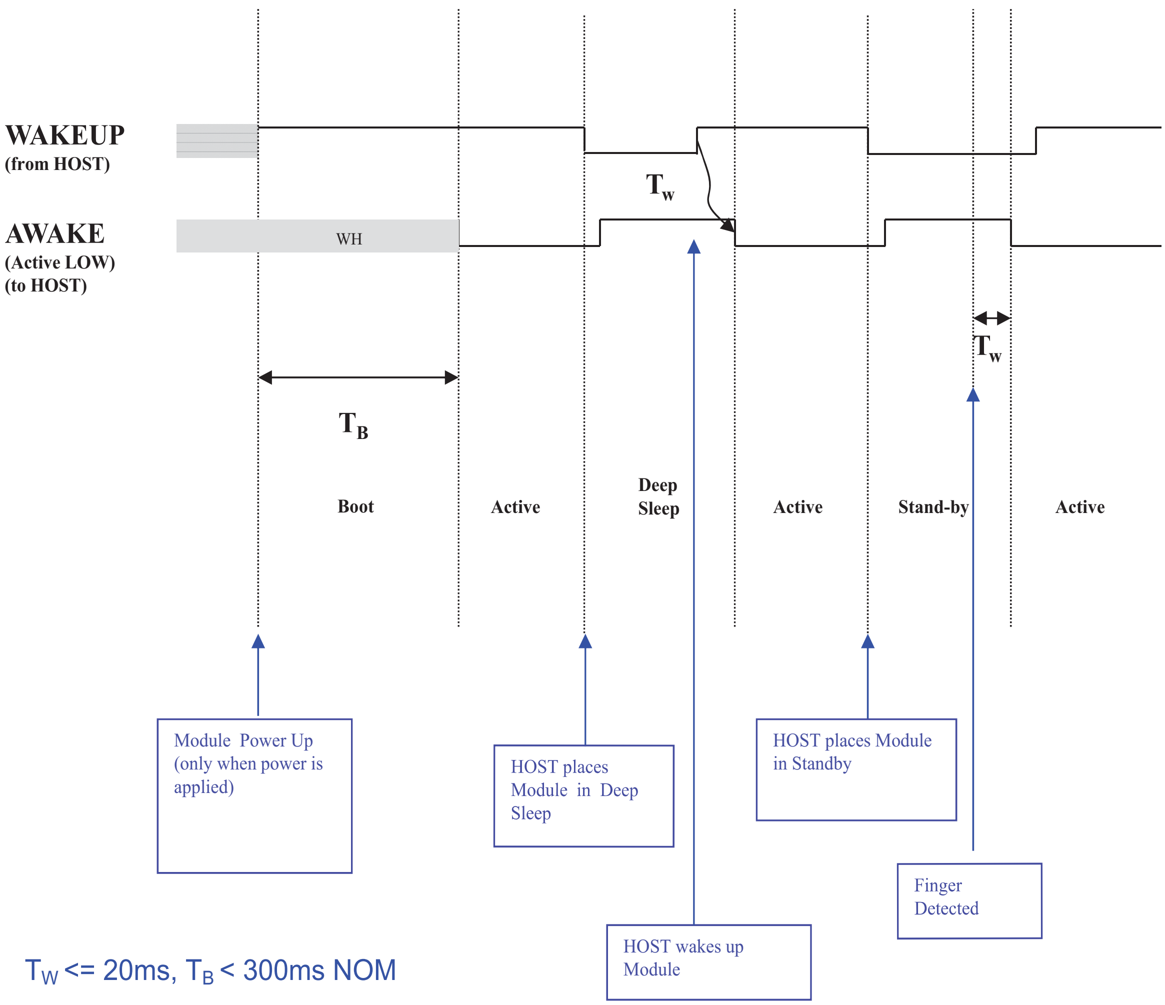
5.4.1 RESET Diagram

The module reset signal can be left floating as the module includes a RC circuit on this node. If the signal is externally controlled then the RC time must be factored into the total reset time. The internal RC values are 33K ohm and 1.0uF.



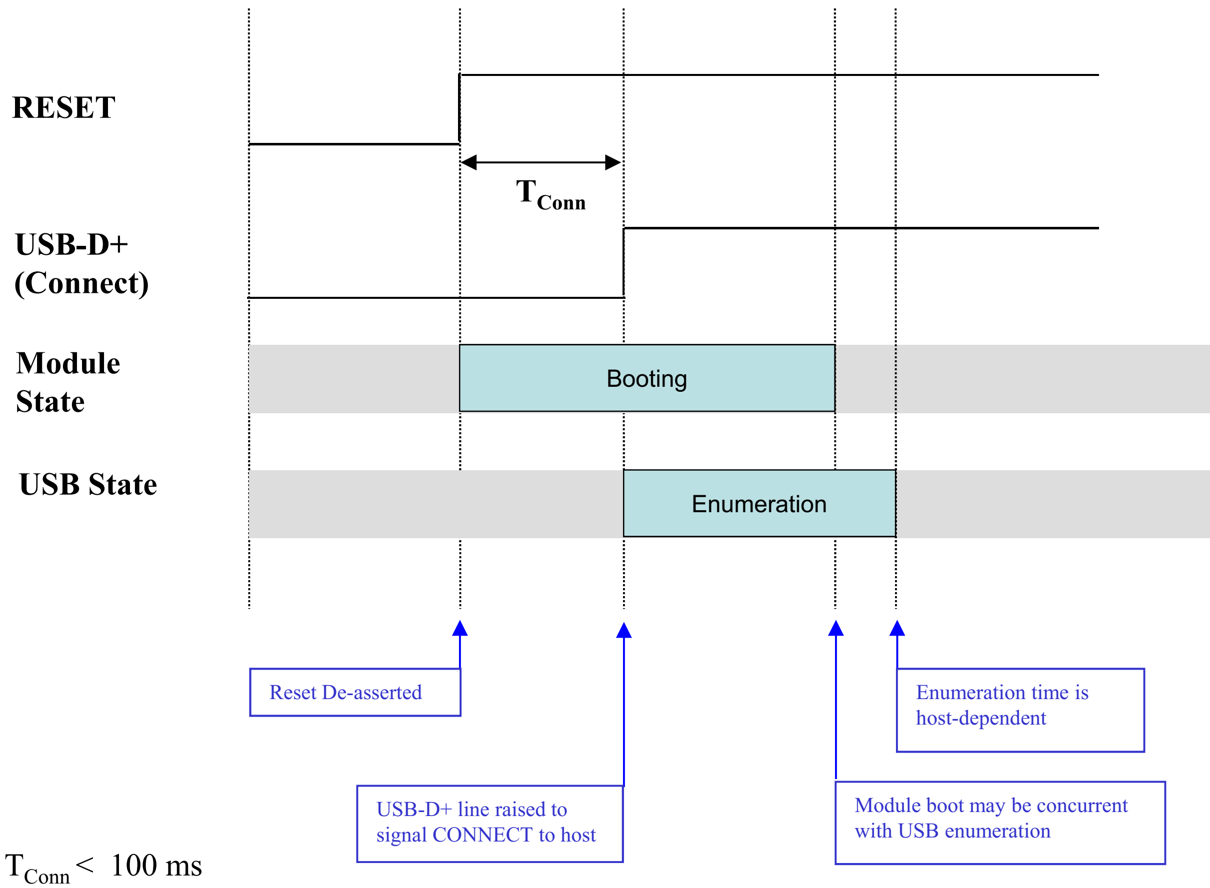
5.4.2 Functional State Diagram (Serial Modes)

The following timing diagram shows the typical signal transactions and timing between the different states supported by the TouchChip module in when the AWAKE is configured to be active LOW (default).



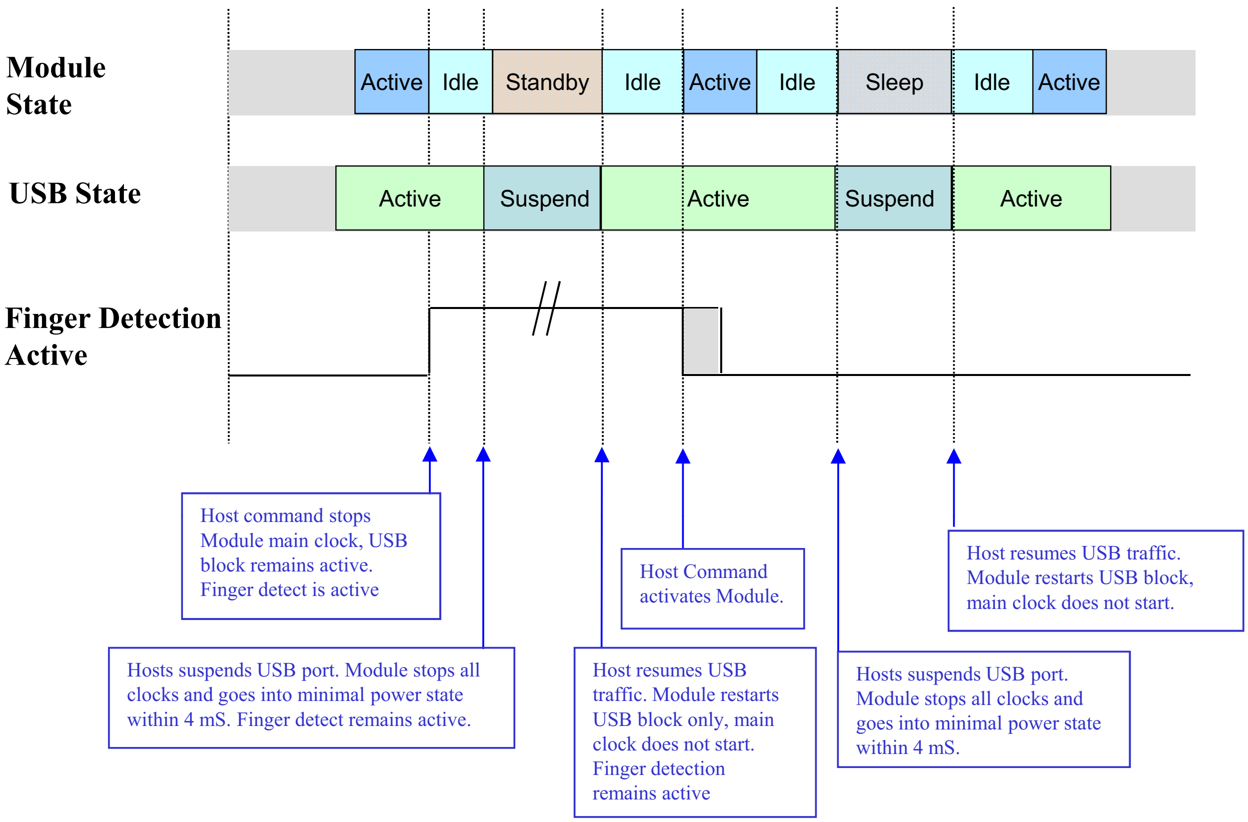
5.4.3 USB Enumeration

This diagram shows the USB enumeration sequence. In USB mode the USB D+ line will be raised within 100 milliseconds after the module reset signal deasserts. It is possible that the module boot sequence will still be in process at this time. The boot process can run concurrently with USB enumeration.



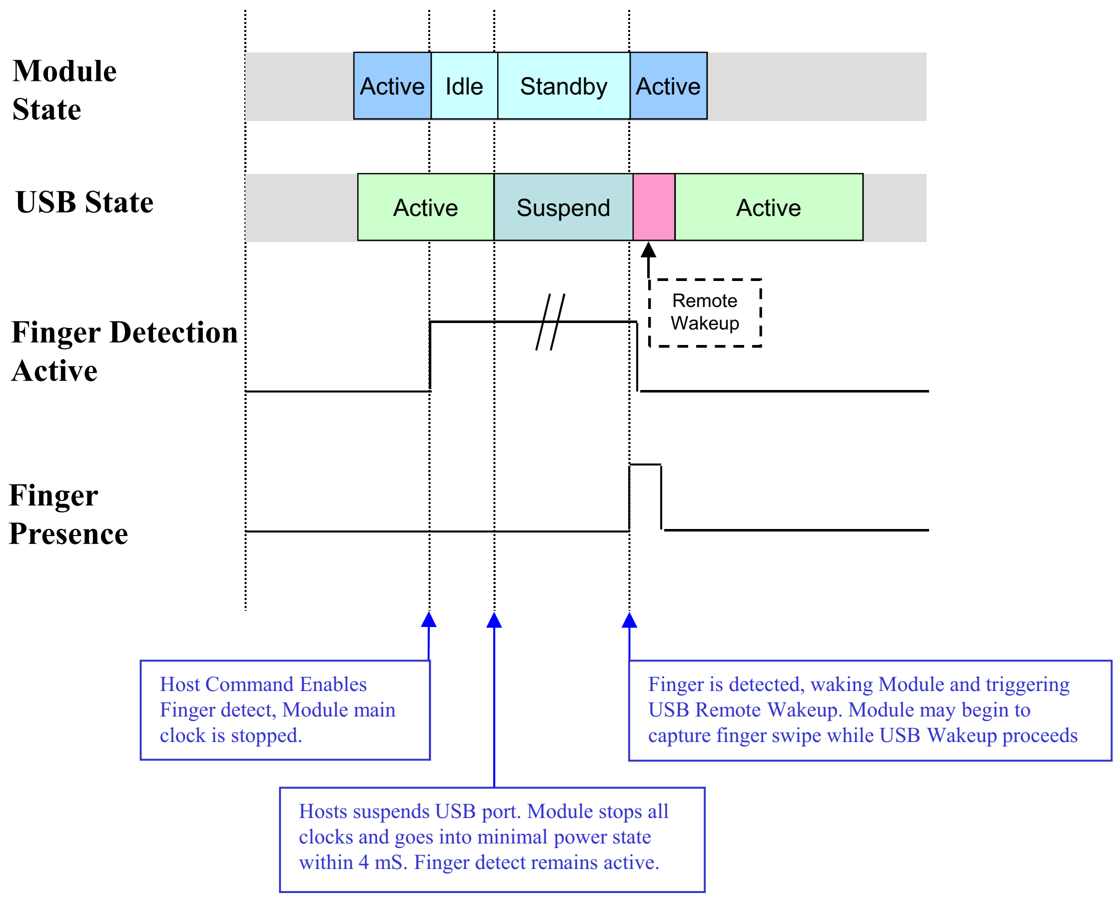
5.4.4 Idle, Standby, and Sleep States with USB

This diagram shows power-state transitions under USB operation. Idle state means that USB communication is active, even if the module is inactive. If USB communication is suspended, then the module will transition to “Standby” state if finger detection is active, or “Sleep” state if finger detection is inactive.



5.4.5 USB Remote Wake-up

This diagram shows USB remote wakeup operation. If finger detection is enabled, the module can initiate a Remote Wakeup over USB, bringing the host system out of a low power state in response to a finger placement. Note that the module can begin to capture fingerprint data even before the host is awake.



6 Electrical Specifications

6.1 Absolute Maximum Ratings

Symbol	Parameter	Min	Max	Unit
VDD	3.3V Supply voltage (Option “F”)	-0.5	4.2	V
VDD	5.0V Supply Voltage (other options)	-0.5	6.0	V
VIO	DC Voltage on any other pin (other than VDD)[1]	-0.5	VDD +0.5	V
TSTG	Storage temperature	-40	+125	°C
IK DC	Diode current		20	mA
IO DC	Output source sink current		20	mA
ICC/IGND	DC VCC or ground current		100	mA
VESD	PIN electrostatic discharge voltage[2]	-2000	+2000	V

1.Note that the sensor supply will be pumped to ~5V during operation.
2.JEDEC Std JESD22-A114-A (R=1.5 Kohm, C = 100 pF)

6.2 DC Electrical Characteristics

Symbol	Parameter	Min	Typ	Max	Unit	Condition
VDD	Internal 3.3 V Supply	3.0	3.3	3.6	V	
IDD	Sleep Active w/o image capture Active with image capture Active with fast image capture		1350 25 80 105	1485 27.5 88 115.5	uA mA mA mA	1
TOP	Operating temperature	-20		+70	°C	

1. Unless otherwise stated, typical data are based on TOP = 25 °C and VDD = 3.3 V, with 4-inch flex cable connecting to the host. Current used will increase by a 2-4 mA if a typical 6 foot USB cable must be driven.

6.3 Important Operating Conditions

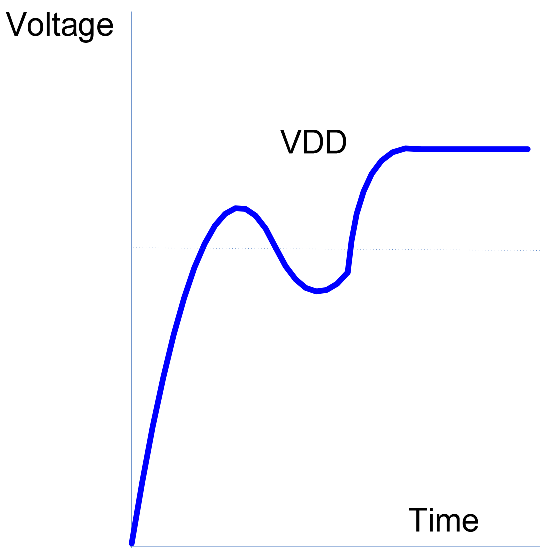
6.3.1 Power Supply Noise

The following table applies during image capture.

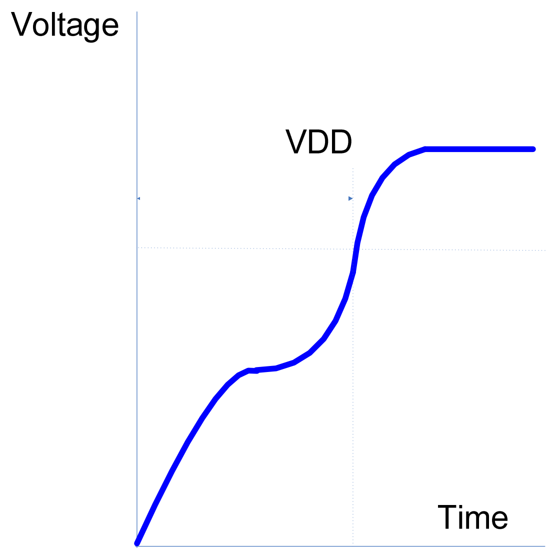
Pin Type	Parameter	Max	Unit
VDD	Digital voltage supply noise	100	mV p-p

6.3.2 Power Supply Rise Characteristics

Power supply rise must be monotonic as illustrated below.



Not Monotonic



Monotonic

6.3.3 Regulator Enable Delay

The module uses either an onboard regulator or an onboard power switch both of which incorporate a delay between the application of 5V (VDD_USB) and the enabling of the regulator output. This delay helps to ensure a stable input voltage prior to applying operating power to the module. The delay is 18mS nominal.

6.4 AC Characteristics

This section summarizes the AC characteristic of the device. The parameters in the AC characteristic tables that follow are derived from tests performed under the AC Measurement Conditions. The designer should check that the operating conditions in their circuit match the measurement conditions when relying on the quoted parameters.

Table 4: AC Measurement Conditions

Symbol	Parameter	Min	Norm	Max	Unit
C_L	Load capacitance		18		pF
T_{RISE}, T_{FALL}	Input rise and fall times	5	10	15	ns

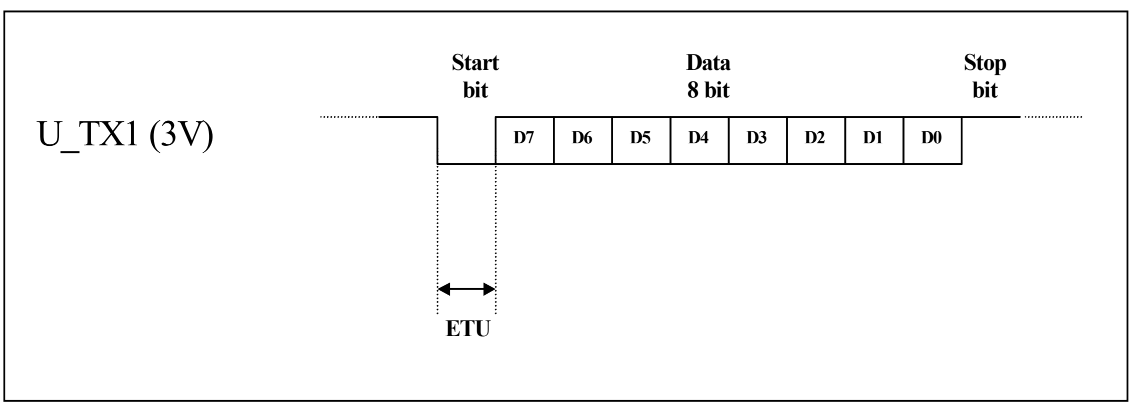
6.4.1 UART

Table 5: AC Characteristics - HOST UART CHANNEL: Protocol "8N1"

Time Name	Min	Nom	Max	Units	Conditions	Load
ETU[1]		8680 17360 26041 52083 104166		ns	115200 bps 57600 bps 38400 bps 19200 bps 9600 bps	20 pF
TX T_{RISE}		9.5		ns		20 pF
TX T_{FALL}		10.5		ns		20 pF
RX T_{RISE}			13			N/A
RX T_{FALL}			13			N/A

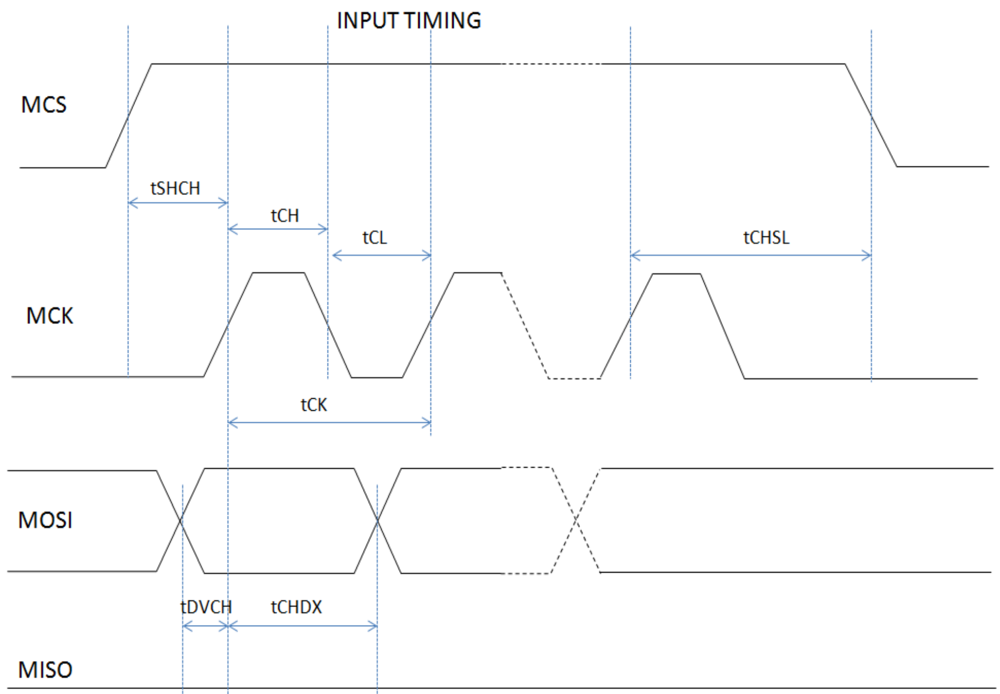
1. This timing tolerance depends on XTALIN tolerance

UART Transmission Sequence

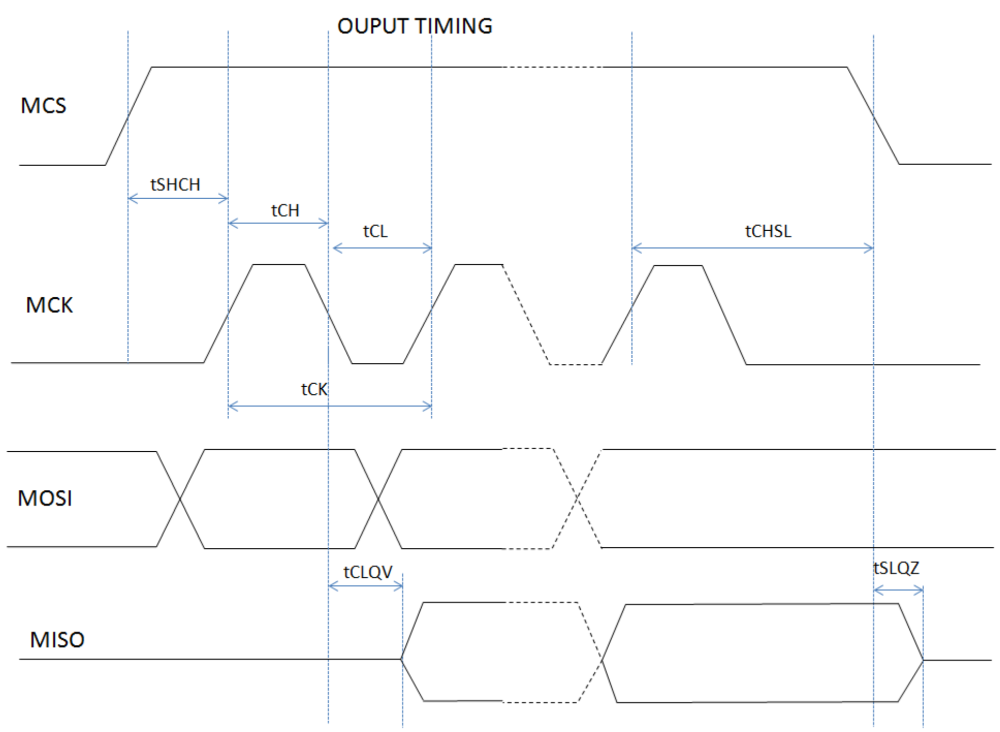


6.4.2 Serial Peripheral Interface (SPI)

6.4.2.1 SPI Input Timing Diagram



6.4.2.2 SPI Output Timing Diagram



6.4.3 SPI Timing Table

Table 6: SPI Timing

Symbol	Parameter	Min	Typ	Max	Unit
tSHCH	CS Active Setup Time	5			nS
tCH	Clock High Time	60			nS
tCL	Clock Low Time	60			nS
tCHSL	CS Deselect Time	10			nS
tCK	Clock Period	138.8			nS
tDVCH	Data IN Setup Time	7			nS
tCHDX	Data IN Hold Time	7			nS
tCLQV	Clock Low to Output Valid			50	nS@20pF
				45	nS@10pF
tSLQZ	Output Disable Time			10	nS

7 Environmental Robustness

7.1 TouchChip Lifetime

The TouchChip lifetime is expected to be at least 8.5 years, based on extrapolation of accelerated life test data.

7.2 Electrostatic Discharge

The TCETC1/D1 modules will withstand +/- 15KV air discharge to the image area and +/- 8KV bezel contact discharge, per the IEC61000-4-2 specification[2], provided the module is correctly connected to the chassis/battery ground via the ESD mounting points. Assumption is that all four corners are connected to earth ground, via the chassis, at a very low impedance level. Using EMI gaskets to complete this path has been shown to degrade ESD performance. See the mechanical mounting application note for examples of mounting/ESD hardware.

7.3 Scratch/Abrasion

The coatings on the surface of the TouchChip sensor provide protection from scratching and abrasion due to normal contact with fingertips and any incidental contact with fingernails. Applications requiring protection from direct contact of sharp metal objects with the sensor surface should provide such protection on the system (i.e., a sliding cover or some other means).

Table 7: Comparative Coating Performance

Test Performed	TCETC1	TCETD1
Pen Drop	8cm	60cm
Pen Scratch	4.5N	18N
Pencil Scratch	10N, 6H	20N, 6H
Touches	2 Million	4 Million

Crossmatch specifies the Visual/Mechanical Inspection (VMI) criterion used as a basis for the outgoing product. A copy of the Visual/Mechanical Inspection document can be provided to the customer on request. The VMI criterion may be used by customers as a basis for incoming inspection, or for inspection within the customers manufacturing process.

7.4 Chemical Contact

The coatings on the TouchChip sensor provides protection from exposure to a wide variety of chemical contaminants. Agents anticipated to come in contact with the sensor surface in normal use have been identified and tested. They do not cause damage or identifiable degradation in sensor performance or characteristics. A detailed list of the contaminants that have been tested is available upon request.

7.5 Ingress Protection

The bezel-to-sensor interface is gasket sealed. Units meet IP-65. In order for the whole system to meet ingress standards an additional gasket must be added between the module and the device package.

2. This value is achievable if the Testing Guidelines are observed. Guidelines are available upon request.

8 Mechanical Information

8.1 Dimensions

The module has an overall dimension of 23 x 35 x 4.11 mm.

8.2 Flex Connector Options “F” and “Z”

The LIF flex connector (J2) is Molex 51281-1294. Connector is 12 position, 0.5mm pitch, top and bottom contact, low insertion force. The “Z” module option uses the same pinout with a zero insertion force connector. Physical location of pin 1 is not defined by Molex, see package outline drawing for location. The customer supplied flex cable itself should not exceed 6 inches (15 cm) in length.

Module Connections			Host Side Connections[1]		
Number	Signal Name	Description	**USB**	**SPI**	**UART**
1	Ground	Ground	GND	GND	GND
2	Ground	Ground	GND	GND	GND
3	+3.3V	Power Input	Vcc	Vcc	Vcc
4	MOSI or RX	SPI: Master Out, Slave In Data[2] UART: Input Data	NC	MOSI	TX
5	MISO	Master In, Slave Out Data	NC	MISO	NC
6	MCK	SPI System Clock	NC	MCK	NC
7	AWAKE	Interrupt Output	NC	INT	AWAKE
8	MCS or WAKEUP	SPI: Slave Select UART: Interrupt Input	NC	MCS	WAKEUP
9	USBDP	USB Plus, Mode Select	USBDP	PD[3]	PU
10	USBDN	USB Minus, Mode Select	USBDN	PU	PU
11	TX	UART: Output Data	NC	NC	RX
12	nRESET	Reset	Opt.	Opt.	Opt.

1. NC = No Connect; Opt. = Optional; PD = Pull Down; PU = Pull Up
2. TCETC1/D1 is the Slave device.
3. See also “Interface Bootstrap Options” on page 6

8.3 USB Cable Connector Option "G"

Connector is composed of solder pads for attaching a standard USB cable. Standard USB input voltages are supported as the module incorporates a voltage regulator to generate the internally used 3.3V level. See the mechanical drawing for pin locations. These fingers are only included on the "G" option modules (TCETx1xGxxx). Some signals on the 12 position flex connector can be used simultaneously, such as for LED control, but using pin 3 on the flex connector as a power input is not supported as this will cause output of the 3.3V regulator to be back-biased on this variant.

Pad #	Signal Name
1	Signal Ground
2	USB Minus (USBDN)
3	5V Input (VDD_USB)
4	USB Plus (USBDP)
5	Shield (common with signal ground)

8.4 USB Wire-to-Board Connector Options “I” and “N”

Connector is 5 position plug type wire to board connector. Standard USB input voltages are supported as the module includes a voltage regulator to generate the internally used 3.3V level. See the mechanical drawing for pin locations. “I” is standard tin plated, “N” is gold flash plated, otherwise they are the same. Some signals on the 12 position flex connector can be used simultaneously, such as for LED control, but using pin 3 on the flex connector as a power input is not supported as this will cause the 3.3V regulator to be back-biased on these variants. An example of a potential matching connector is 05SUR-32S.

Pad #	Signal Name
1	5V input (VDD_USB)
2	USB Minus (USBDN)
3	USB Plus (USBDP)
4	Ground
5	Ground

8.5 Mounting and ESD Mitigation

There are exposed ESD pads on the board which must be routed to the chassis of the host device for optimal ESD performance. These locations are detailed on the mechanical drawing. The same pads can be used to press fit the module into the customer’s enclosure using a customer designed bracket. The bezel may NOT be connected to chassis, it is an active component and must be electrically isolated from voltage potentials. The four corner ESD pads should be connected via chassis all the way to earth ground with solid metal contacts, use of EMI gaskets at any point of this path have been shown to degrade ESD performance.

8.5.1 Optional Customer Supplied Gasket

If ingress protection is desired, or to electrically isolate the bezel from a conductive enclosure, a simple gasket can be added to the design. Crossmatch does not supply the gasket, the mechanical drawings can be used to extract the dimensions. A neoprene gasket of 40-50 durometer has been known to work in some designs.

8.5.2 Customer Supplied Mounting Bracket

A metal bracket is recommended to both mount the module and create the ESD ground path. Below are sample photos for reference only. Crossmatch does not supply either brackets or design drawings as these are unique to each design. Designs that place a conductive plane too close to the electronic circuits run the risk of routing ESD charges back into the circuitry, in such cases a insulating barrier may be required. The exact distance depends on multiple factors, but the distance suggested in the following photo is known to be good.

Photo below shows a bracket in contact with the module, also shown are a guide post and a conductive mounting screw.

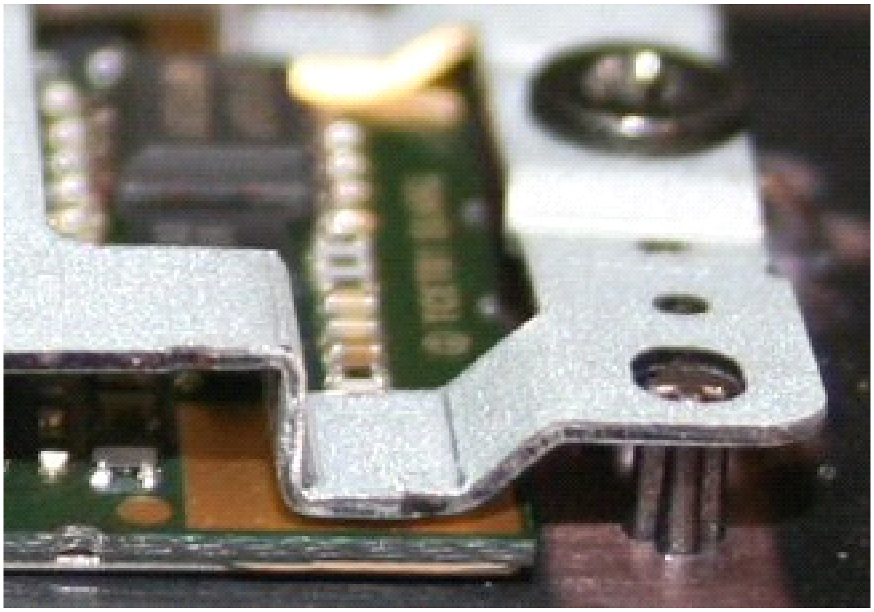
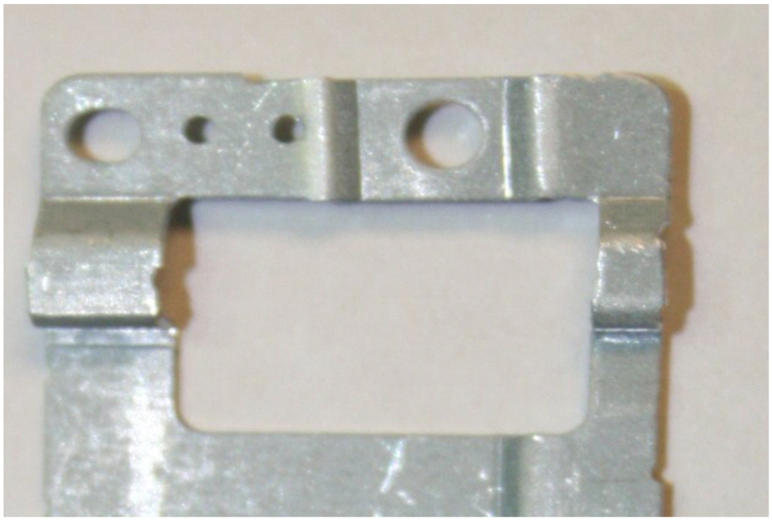


Photo below shows details on module contacting side of bracket.



9 Ordering Information

Product Code: TC E T x 1 x x 0x x

TouchChip

Embedded

Module Class

Image & Coating

C - PIV (EIM), Traditional (Gold) Coating
D - EIM-Lite, SteelCoat (Black) Coating

Sensor Size

1 - TCS1 die (18mm x 12.8mm size)

Bezel Coloration

F - Standard silver
P - PVD Coated Black

Host Interface Option

F - 12 Pos. LIF Flat Flex Connector, 3.3V input
G - USB cable solder pads, 5V input
I - 5 pin USB LIF Wire Connector w/ Tin Flash, 5V input
N - 5 pin USB LIF Wire Connector w/ Gold Flash, 5V input
Z - 12 Pos. ZIF Flat Flex Connector, 3.3V input

Firmware Option

02 - Embedded (USB, SPI, UART)

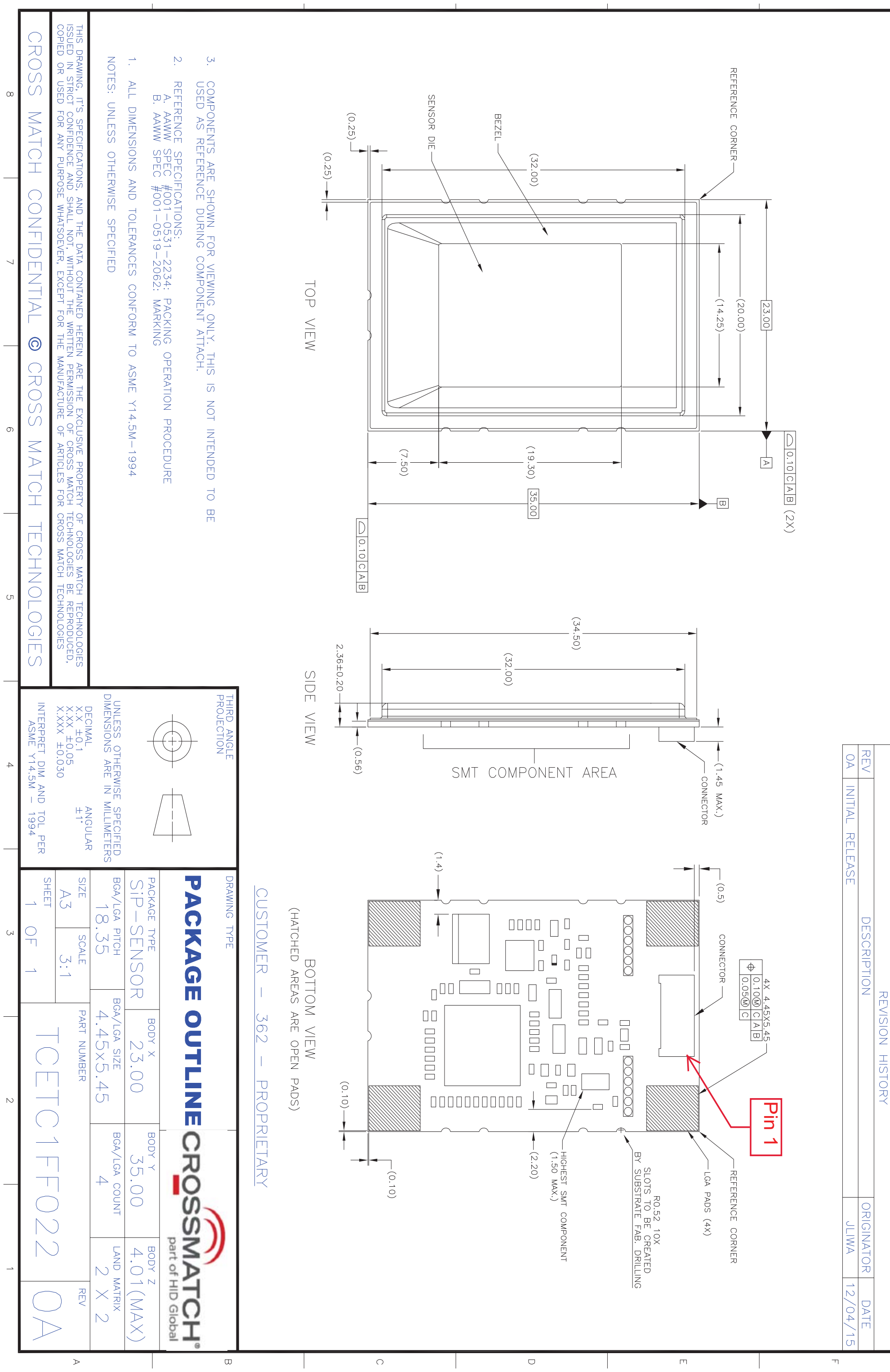
Packaging

2 - 36 Piece Tray
3 - 36 Piece Tray plus optional bar codes

Not all possible combinations of above are supported, check with your Sales person.

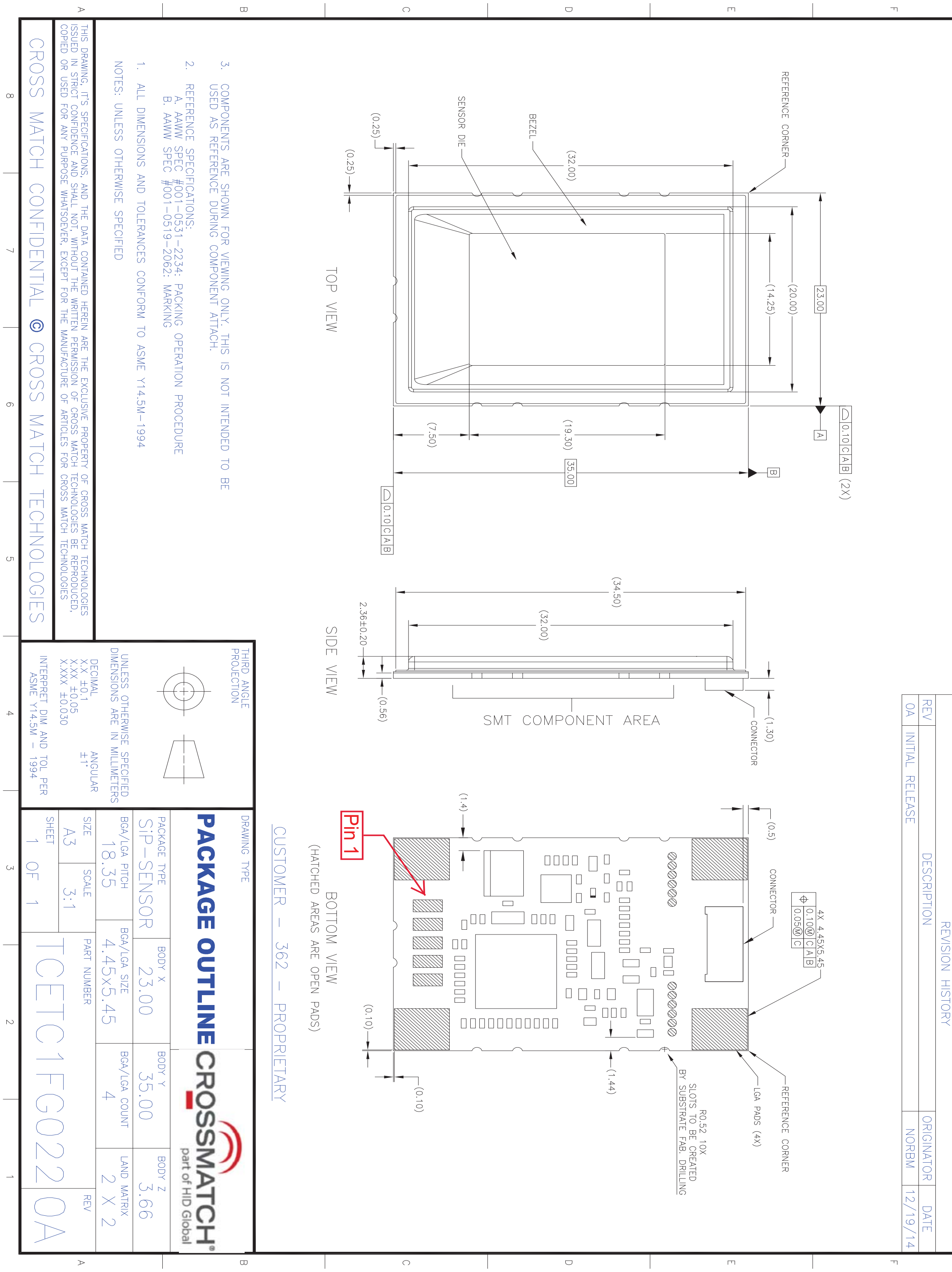
10 Mechanical Drawings[3]

10.1 TCETx1xF022



3. Included are a representative sample of product outline drawings

10.2 TCETx1xG022



10.3 TCETx1xI022 and TCETx1xN022