
Motion Module

Product Features

- High Performance 32-bit Embedded Controller
- Cost effective solution
- Small form factor ideal for embedded applications
- Low power; 13.25mA in active mode
- System in deep sleep consumes 70µA
- Host interface via I²C
- 3.3-Volt I/O
- Package
 - 17mm x 17mm, 16-pin module

Sensor Firmware

- Sensor fusion firmware features include:
 - Self-contained 9-axis sensor fusion
 - Sensor data pass-through
 - Fast in-use background calibration of all sensors and calibration monitor
 - Magnetic immunity: Enhanced magnetic distortion, detection and suppression
 - Gyroscope drift cancellation
 - Fully calibrated
- Easy to implement complete turnkey sensor fusion solution
- Sensor power management
- Sensors Supported
 - Bosch BMC150 Geomagnetic Sensor/Accelerometer
 - Bosch BMG160 Gyroscope

Hardware Features

The hardware features in the MM7150 module include the following:

- I²C Controller
 - Supports I²C bus speeds to 400kHz
 - Host Interface Supports Slave Operation
- Low Power Modes

Target Markets

- Internet of Things Applications
- Remote Controls, Gaming
- Fitness Monitoring
- Applications requiring data from an accelerometer, magnetometer and gyroscope

Description

The MM7150 Motion Module is a simple, cost-effective solution for integrating motion and positioning data into a wide range of applications. The module contains the SSC7150 motion coprocessor with integrated 9-axis sensor fusion as well as high performance MEMS technology including a 3-axis accelerometer, gyroscope and magnetometer. All components are integrated, calibrated and available on the module for PCB mounting.

TO OUR VALUED CUSTOMERS

It is our intention to provide our valued customers with the best documentation possible to ensure successful use of your Microchip products. To this end, we will continue to improve our publications to better suit your needs. Our publications will be refined and enhanced as new volumes and updates are introduced.

If you have any questions or comments regarding this publication, please contact the Marketing Communications Department via E-mail at docerrors@microchip.com. We welcome your feedback.

Most Current Data Sheet

To obtain the most up-to-date version of this data sheet, please register at our Worldwide Web site at:

<http://www.microchip.com>

You can determine the version of a data sheet by examining its literature number found on the bottom outside corner of any page. The last character of the literature number is the version number, (e.g., DS30000000A is version A of document DS30000000).

Errata

An errata sheet, describing minor operational differences from the data sheet and recommended workarounds, may exist for current devices. As device/documentation issues become known to us, we will publish an errata sheet. The errata will specify the revision of silicon and revision of document to which it applies.

To determine if an errata sheet exists for a particular device, please check with one of the following:

- Microchip's Worldwide Web site; <http://www.microchip.com>
- Your local Microchip sales office (see last page)

When contacting a sales office, please specify which device, revision of silicon and data sheet (include -literature number) you are using.

Customer Notification System

Register on our web site at www.microchip.com to receive the most current information on all of our products.

Table of Contents

1.0 MM7150 Pinout	4
2.0 MM7150 Module	7
3.0 MM7150 HID Functions	8
4.0 MM7150 Host Interface	12
5.0 MM7150 Firmware Update	13
6.0 MM7150 References	14
7.0 MM7150 Performance	15
8.0 Electrical Characteristics	16
Appendix A: Revision History	24
The Microchip Web Site	25
Customer Change Notification Service	25
Customer Support	25
Product Identification System	26

MM7150

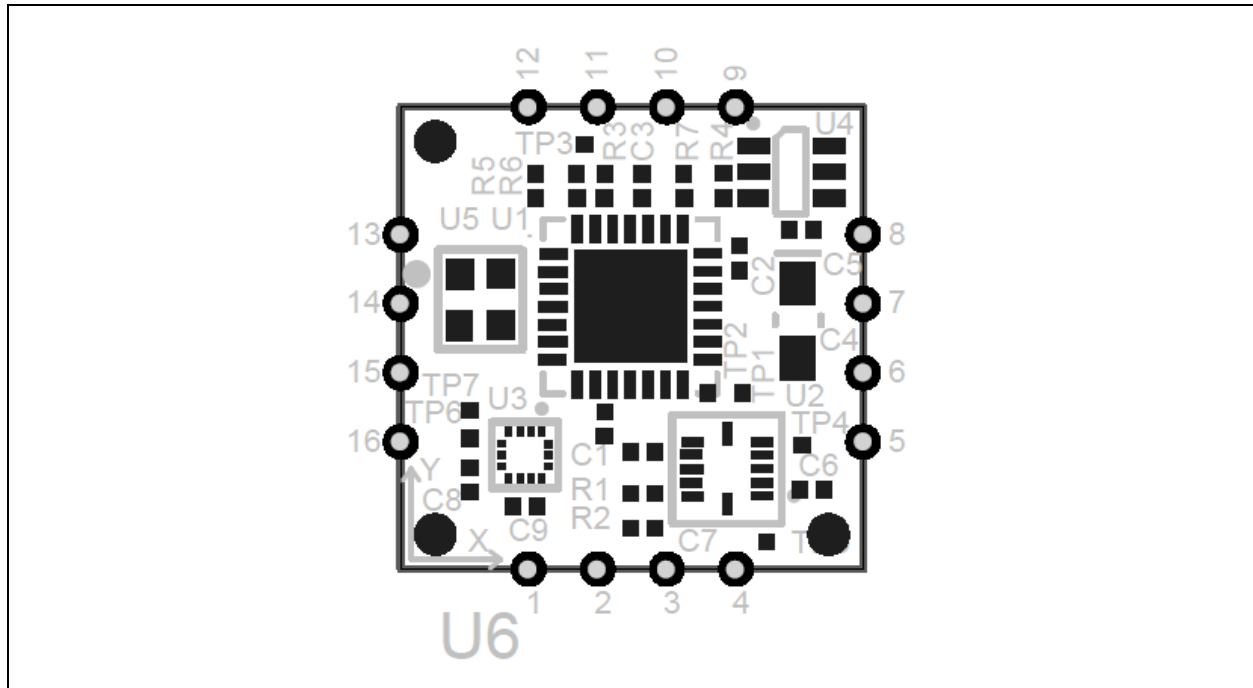
1.0 MM7150 PINOUT

The pinout of the MM7150 Motion Module is shown in the assembly drawing.

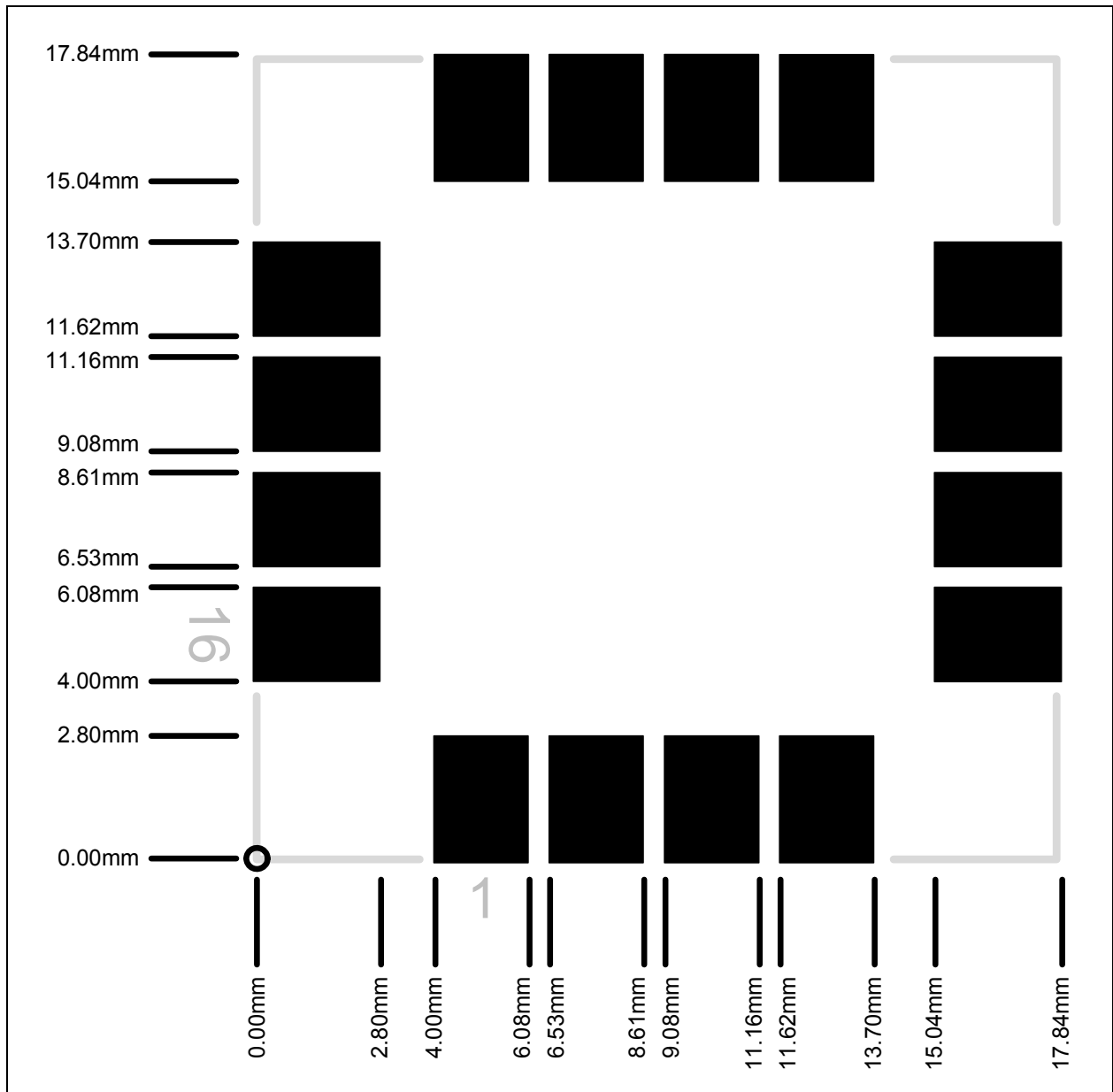
1.1 Assembly Drawing

The assembly drawing is shown in [Figure 1-1](#).

FIGURE 1-1: ASSEMBLY DRAWING



1.2 Recommended Land Pattern



MM7150

1.3 Pin Descriptions

The pin descriptions are provided in [Table 1-1](#).

TABLE 1-1: PIN DESCRIPTIONS

Pin Number	Name	Type	Description
1	HOST_TO_SH_WAKE	I	Used to wake Motion Module from a Sleep state. This signal must be driven high at least 11ms prior to sending any I ² C traffic to the Motion Module. Active high input. This pin should be connected to VDD through a 100KΩ resistor.
11	HOST_TO_SH_RESET	I	Reset input. Used to reset the host I ² C interface. This pin should be connected to VDD through a 100KΩ resistor.
4	HIDI2C_HOST_INT	O	Alert Interrupt signal from Motion Module to Host. Used to tell Host data from Motion Module is ready to be sent out. Active low output.
15	HIDI2C_HOST_CLK	IOD	I ² C Controller Clock to Host Interface
16	HIDI2C_HOST_DAT	IOD	I ² C Controller Data to Host Interface
10	NC1	-	This pin should be left unconnected
2	NC2	-	This pin should be left unconnected
9	NC3	-	This pin should be left unconnected
12	NC4	-	This pin should be left unconnected
13	NC5	-	This pin should be left unconnected
14	NC6	-	This pin should be left unconnected
3	NC7	-	This pin should be left unconnected
5	NC8	-	This pin should be left unconnected
6	NC9	-	This pin should be left unconnected
7	VDD	PWR	VDD supply
8	VSS	GND	VDD associated ground

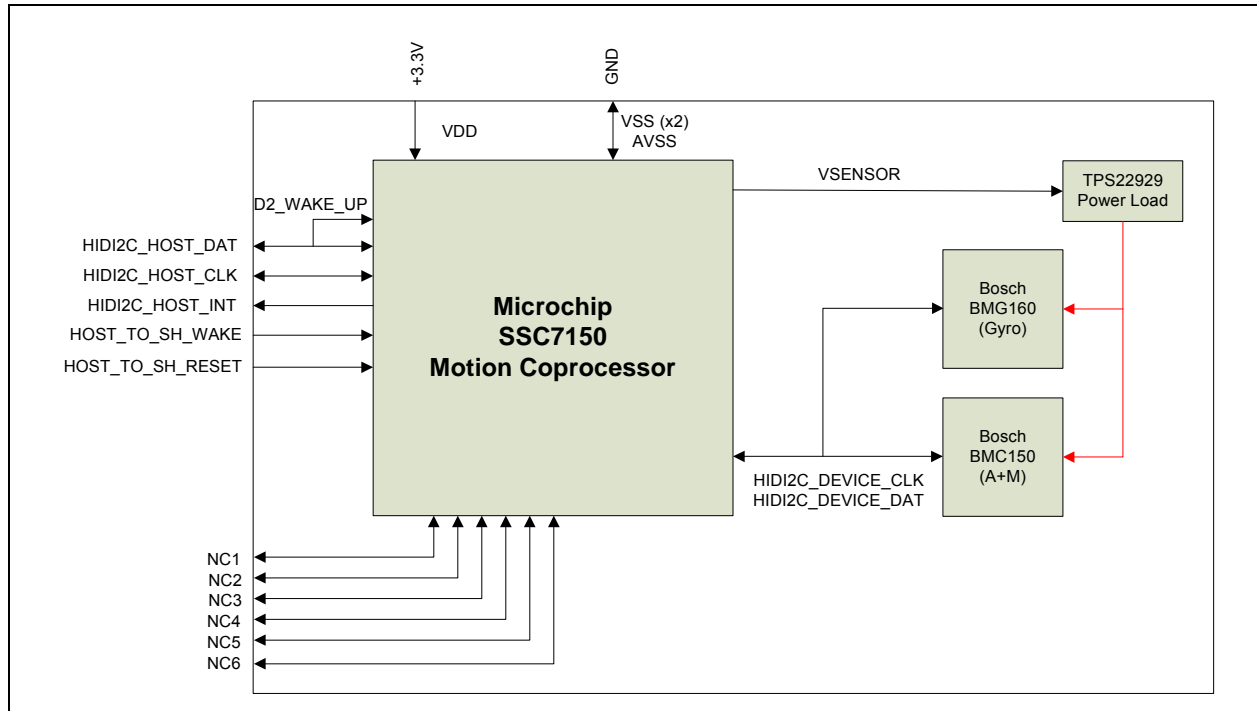
2.0 MM7150 MODULE

The MM7150 Motion Module provides 9-axis sensor fusion that includes a 3-axis accelerometer, a 3-axis gyroscope and a 3-axis magnetometer. The module has an I²C interface to the host, and supports HID over I²C. The module includes the Bosch BMC150 Geomagnetic Sensor/Accelerometer and Bosch BMG160 Gyroscope.

2.1 Module Block Diagram

The block diagram of the module is shown in Figure 2-1.

FIGURE 2-1: MM7150 MODULE BLOCK DIAGRAM



2.2 Module Features

The MM7150 Motion Module provides self-contained 9-axis sensor fusion. It supports fast in-use background calibration of all sensors and calibration monitor. Magnetic immunity features provide enhanced magnetic distortion detection and suppression. The module also provides gyroscope drift cancellation.

2.3 Calibration Requirements

User calibration is not required. The MM7150 Motion Module supports fast in-use background calibration of all sensors and calibration monitor.

2.4 Other Information

To obtain the most recent and complete documentation for this module, including:

- User's Guide
- Board Description
- Board Schematics
- Source Code
- Application Examples
- Links to Web Seminars

Please refer to the web site: www.microchip.com/motion.

MM7150

3.0 MM7150 HID FUNCTIONS

The MM7150 responds to the standard HID protocol for sensors when used over I²C, defined in References [1] and [2]. The hierarchy of descriptors used in the HID protocol is as follows:

The following sections described the descriptors required for communicating with the MM7150:

3.1 HID Descriptor

TABLE 3-1: HID DESCRIPTOR FORMAT (I²C)

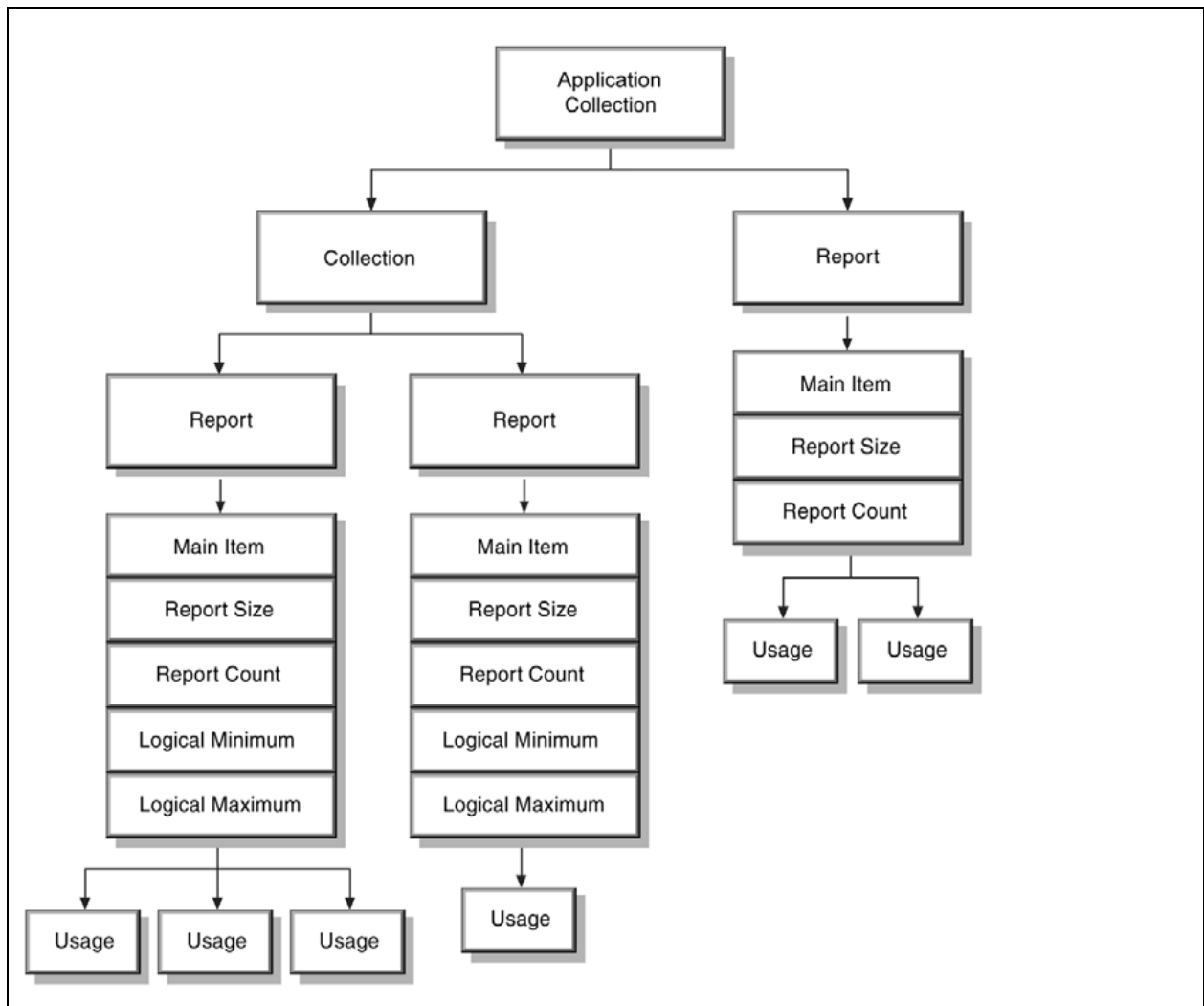
Field	Description	Size	Value
wHIDDescLength	Length of HID Descriptor	UINT 16	0x001E
bcdVersion	Version compliance. Compliant with Version 1.00	UINT 16	0x0100
wReportDescLength	Report Descriptor Length (3213 bytes)	UINT 16	0x0C8D
wReportDescRegister	Identifier to read Report Descriptor	UINT 16	0x0002
wInputRegister	Identifier to read Input Report	UINT 16	0x0003
wMaxInputLength	Input Report is 13 Bytes + 2 Bytes length field	UINT 16	0x000D
wOutputRegister	Identifier to read Output Report	UINT 16	0x0000
wMaxOutputLength	No Output Report	UINT 16	0x0000
wCommandRegister	Identifier for Command Register	UINT 16	0x0005
wDataRegister	Identifier for Data Register	UINT 16	0x0006
wVendorID	Vendor ID	UINT 16	0x04D8
wProductID	Product ID	UINT 16	0x0F01
wVersionID	Version	UINT 16	0x7150
RESERVED	Reserved	UINT 32	0x0

3.2 Report Descriptors

Report descriptors are composed of pieces of information. Each piece of information is called an Item.

The HID class driver contains a parser used to analyze items found in the Report descriptor. The parser extracts information from the descriptor in a linear fashion.

The parser collects the state of each known item as it walks through the descriptor, and stores them in an item state table. The item state table contains the state of individual items. From the parser's point of view, a HID class device looks like the following.



The Report descriptor is unlike other descriptors in that it is not simply a table of values. The length and content of a Report descriptor vary depending on the number of data fields required for the device's report or reports. The Report descriptor is made up of items that provide information about the device.

The HID report for each sensor has two sections **Feature Report** and **Input Report**. The feature report for all the sensors is same. The following sections describe the Feature Report and all Input Reports returned by the Motion Module.

MM7150

3.2.1 FEATURE REPORT

TABLE 3-2: FEATURE REPORT FORMAT

Field	Description	Size
ucReportID	Report ID	UINT 8
ucConnectionType	Connection Type	UINT 8
ucReportingState	Reporting State	UINT 8
ucPowerState	Power On State	UINT 8
ucSensorState	Sensor State	UINT 8
ulReportInterval	Reporting Interval	UINT 16
usAccuracy	Accuracy	UINT 16
usResolution	Resolution	UINT 16
usChangeSensitivity	Change Sensitivity	UINT 16
sMaximum	Maximum range	INT 16
sMinimum	Minimum range	INT 16
minimumReportInterval	Minimum report interval supported	UINT16
sensorDesc[6]	Sensor description, initialized "MCHPSF"	INT16

3.2.2 3D ACCELEROMETER INPUT REPORT

TABLE 3-3: 3D ACCELEROMETER REPORT FORMAT

Field	Description	Size
ucReportID	Report ID	UINT 8
ucSensorState	Sensor State	UINT 8
ucEventType	Event Type	UINT 8
sAccelXValue	Accelerometer X axis value	INT 16
sAccelYValue	Accelerometer Y axis value	INT 16
sAccelZValue	Accelerometer Z axis value	INT 16
ucShakeDetectState	Shake event detection	UINT 8

3.2.3 COMPASS INPUT REPORT

TABLE 3-4: COMPASS REPORT FORMAT

Field	Description	Size
ucReportID	Report ID	UINT 8
ucSensorState	Sensor State	UINT 8
ucEventType	Event Type	UINT 8
sHeadingCompensatedMagneticNorthValue	Magnetic north value	INT 16
sFluxXValue	Magnetic field strength, X axis value	INT16
sFluxYValue	Magnetic field strength, Y axis value	INT16
sFluxZValue	Magnetic field strength, Z axis value	INT16

3.2.4 3D GYROSCOPE INPUT REPORT

TABLE 3-5: 3D GYROSCOPE REPORT FORMAT

Field	Description	Size
ucReportID	Report ID	UINT 8
ucSensorState	Sensor State	UINT 8
ucEventType	Event Type	UINT 8
sGyroXValue	Gyroscope X axis value	INT 16
sGyroYValue	Gyroscope Y axis value	INT 16
sGyroZValue	Gyroscope Z axis value	INT 16
ucShakeDetectState	Shake event detection	UINT 8

3.2.5 INCLINOMETER INPUT REPORT

TABLE 3-6: INCLINOMETER REPORT FORMAT

Field	Description	Size
ucReportID	Report ID	UINT 8
ucSensorState	Sensor State	UINT 8
ucEventType	Event Type	UINT 8
slncXValue	Inclinometer X axis values	INT 16
slncYValue	Inclinometer Y axis value	INT 16
slncZValue	Inclinometer Z axis value	INT 16

3.2.6 ORIENTATION INPUT REPORT

TABLE 3-7: ORIENTATION REPORT FORMAT

Field	Description	Size
ucReportID	Report ID	UINT 8
ucSensorState	Sensor State	UINT 8
ucEventType	Event Type	UINT 8
sOriXValue	Orientation X axis value	INT 16
sOriYValue	Orientation Y axis value	INT 16
sOriZValue	Orientation Z axis value	INT 16
sOriWValue	Orientation W axis value	INT 16

MM7150

4.0 MM7150 HOST INTERFACE

4.1 I²C

The MM7150 can be connected to a host via the I²C interface. The I²C interface is compliant with the I²C standard described in [4], at speeds up to 400KHz. Above the transport layer, the protocol used by the MM7150 is the same HID protocol used when communicating over USB. The mapping of HID over I²C is defined in Reference [3]. The protocol and the interface, taken together, are compliant with Windows 8/8.1 certification.

5.0 MM7150 FIRMWARE UPDATE

The firmware in the MM7150 Module may be updated at run time. See Reference [\[5.\]](#) for details.

MM7150

6.0 MM7150 REFERENCES

1. USB-Sig, "Device Class Definition for Human Interface Devices (HID). Firmware Specification", Version 1.11, 6/27/01
2. USB-Sig, "HID Usage Table Sensor Page", Request HUTRR39, <http://www.usb.org/developers/hid-page/HUTRR39b.pdf>
3. Microsoft Corporation, "HID Over I²C Protocol Specification: Device Side", version 1.00, 04/24/2012
4. NXP Corporation, "I²C-bus Specification and User Manual", Rev. 6, 04/04/2014
5. Microchip Technology Inc., "MM7150 Motion Module User's Guide", 2014

7.0 MM7150 PERFORMANCE

TABLE 7-1: PERFORMANCE PARAMETERS

Parameter	Typical
Accelerometer	
Range	±2G
Resolution	0.98mG
Accuracy	±40mG
Magnetometer	
Range	X,Y: ±1300µT Z: ±2500µT
Resolution	0.3µT
Heading Accuracy	±3°
Compass	
Range	0° to 360°
Resolution	1°
Accuracy	±10°
Gyroscope	
Range	±2000°/s
Resolution	0.061°/s
Accuracy	±5°/s
Inclinometer	
Range: Pitch	-180° to +180°
Range: Roll	-90° to +90°
Range: Yaw	0° to +360°
Resolution	1°
Accuracy	±5°
Orientation - Quaternion	
Range	±1.0
Resolution	0.001
Accuracy	±5°

MM7150

8.0 ELECTRICAL CHARACTERISTICS

This section provides an overview of the MM7150 electrical characteristics. Additional information will be provided in future revisions of this document as it becomes available.

Absolute maximum ratings for the MM7150 devices are listed below. Exposure to these maximum rating conditions for extended periods may affect device reliability. Functional operation of the device at these or any other conditions, above the parameters indicated in the operation listings of this specification, is not implied.

Absolute Maximum Ratings

(See Note 1)

Ambient temperature under bias0°C to +70°C
Storage temperature	-65°C to +150°C
Voltage on VDD with respect to VSS	-0.3V to +4.0V
Voltage on any pin that is not 5V tolerant, with respect to VSS (Note 3)	-0.3V to (VDD + 0.3V)
Voltage on any 5V tolerant pin with respect to VSS when VDD ≥ 2.3V (Note 3)	-0.3V to +5.5V
Voltage on any 5V tolerant pin with respect to VSS when VDD < 2.3V (Note 3)	-0.3V to +3.6V
Maximum current out of VSS pin(s)	300 mA
Maximum current into VDD pin(s) (Note 2)	300 mA
Maximum output current sunk by any I/O pin	15 mA
Maximum output current sourced by any I/O pin	15 mA
Maximum current sunk by all ports	200 mA
Maximum current sourced by all ports (Note 2)	200 mA

Note 1: Stresses above those listed under “**Absolute Maximum Ratings**” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions, above those indicated in the operation listings of this specification, is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

2: Maximum allowable current is a function of device maximum power dissipation (see [Table 8-2](#)).

3: See the “[Pin List](#)” section for the 5V tolerant pins.

8.1 DC Characteristics

TABLE 8-1: DC TEMPERATURE AND VOLTAGE SPECIFICATIONS

DC CHARACTERISTICS			Standard Operating Conditions: 2.3V to 3.6V (unless otherwise stated) Operating temperature $-40^{\circ}\text{C} \leq T_A \leq +70^{\circ}\text{C}$				
Param. No.	Symbol	Characteristics	Min.	Typ.	Max.	Units	Conditions
Operating Voltage							
DC10	VDD	Supply Voltage (Note 2)	2.3	—	3.6	V	—
DC12	VDR	RAM Data Retention Voltage (Note 1)	1.75	—	—	V	—
DC16	VPOR	VDD Start Voltage to Ensure Internal Power-on Reset Signal	1.75	—	2.1	V	—
DC17	SVDD	VDD Rise Rate to Ensure Internal Power-on Reset Signal	0.00005	—	0.115	V/ μs	—

Note 1: This is the limit to which VDD can be lowered without losing RAM data.

2: Overall functional device operation at $V_{BORMIN} < VDD < VDDMIN$ is tested, but not characterized. Refer to parameter BO10 in [Table 8-5](#) for BOR values.

TABLE 8-2: DC CHARACTERISTICS: OPERATING/POWER-DOWN CURRENT

DC CHARACTERISTICS				Standard Operating Conditions: 2.3V to 3.6V (unless otherwise stated) Operating temperature $0^{\circ}\text{C} \leq T_A \leq +70^{\circ}\text{C}$		
Parameter No.	Symbol	Typical	Max.	Units	Conditions	
Operating/Power-Down Current (Note 1, 2)						
DC20	IDD		26.5	mA	—	
DC30	I _{AVG}		13.65	mA	—	
DC40	I _{IDLE}		2.5	mA	—	
DC50	IPD	70	150	μA	—	

Note 1: A device's supply current is mainly a function of the operating voltage and frequency, as well as temperature.

2: The current measurements are as follows:

- Operating current (IDD):
This is the peak active current value.
- Average current (I_{AVG}):
This value represents an average current measurement of active and low power mode time intervals during operation measured over 1 second period.
- Idle current (I_{IDLE}):
This is the average idle current value when no sensor is actively providing environmental changes (and the device is not in power-down mode).
- Power-Down current (IPD):
This value is the current measured in power-down mode. This is the sleep state entered when the Host issues the SET_POWER (Sleep) Command if the I²C host interface is used.
Wakeup from power-down mode requires the HOST_TO_SH_WAKE pin if the I²C host interface is used.

MM7150

TABLE 8-3: DC CHARACTERISTICS: I/O PIN INPUT SPECIFICATIONS

DC CHARACTERISTICS			Standard Operating Conditions: 2.3V to 3.6V (unless otherwise stated) Operating temperature $-40^{\circ}\text{C} \leq T_A \leq +70^{\circ}\text{C}$				
Param. No.	Symbol	Characteristics	Min.	Typical ⁽¹⁾	Max.	Units	Conditions
DI10	V _{IL}	Input Low Voltage					
DI18		I/O Pins	V _{SS}	—	0.2 V _{DD}	V	I ² C disabled (Note 4)
		SDAx, SCLx	V _{SS}	—	0.3 V _{DD}	V	
DI19		SDAx, SCLx	V _{SS}	—	0.8	V	
DI20	V _{IH}	Input High Voltage					
		I/O Pins not 5V-tolerant ⁽⁵⁾	0.65 V _{DD}	—	V _{DD}	V	I ² C disabled (Note 4,6)
		I/O Pins 5V-tolerant ⁽⁵⁾	0.65 V _{DD}	—	5.5	V	
DI28		SDAx, SCLx	0.65 V _{DD}	—	5.5	V	
DI29		SDAx, SCLx	2.1	—	5.5	V	I ² C enabled, 2.3V ≤ V _{PIN} ≤ 5.5 (Note 4,6)
	I _{IL}	Input Leakage Current (Note 3)					
DI50		I/O Ports	—	—	±1	μA	V _{SS} ≤ V _{PIN} ≤ V _{DD} , Pin at high-impedance
DI55		MCLR# ⁽²⁾	—	—	±1	μA	V _{SS} ≤ V _{PIN} ≤ V _{DD}

Note 1: Data in “Typical” column is at 3.3V, 25°C unless otherwise stated. Parameters are for design guidance only and are not tested.

- 2:** The leakage current on the MCLR# pin is strongly dependent on the applied voltage level. The specified levels represent normal operating conditions. Higher leakage current may be measured at different input voltages.
- 3:** Negative current is defined as current sourced by the pin.
- 4:** This parameter is characterized, but not tested in manufacturing.
- 5:** See the “[Pin List](#)” section for the 5V-tolerant pins.
- 6:** The V_{IH} specifications are only in relation to externally applied inputs, and not with respect to the user-selectable internal pull-ups. External open drain input signals utilizing the internal pull-ups of the device are ensured to be recognized only as a logic “high” internally to the device. For External “input” logic inputs that require a pull-up source, to ensure the minimum V_{IH} of those components, it is recommended to use an external pull-up resistor rather than the internal pull-ups of the device.

TABLE 8-4: DC CHARACTERISTICS: I/O PIN OUTPUT SPECIFICATIONS

DC CHARACTERISTICS			Standard Operating Conditions: 2.3V to 3.6V (unless otherwise stated) Operating temperature $-40^{\circ}\text{C} \leq T_A \leq +70^{\circ}\text{C}$				
Param.	Symbol	Characteristic	Min.	Typ.	Max.	Units	Conditions
DO10	Vol	Output Low Voltage I/O Pins	—	—	0.4	V	$I_{OL} \leq 10 \text{ mA}$, $V_{DD} = 3.3\text{V}$
DO20	VOH	Output High Voltage I/O Pins	1.5 ⁽¹⁾	—	—	V	$I_{OH} \geq -14 \text{ mA}$, $V_{DD} = 3.3\text{V}$
			2.0 ⁽¹⁾	—	—		$I_{OH} \geq -12 \text{ mA}$, $V_{DD} = 3.3\text{V}$
			2.4	—	—		$I_{OH} \geq -10 \text{ mA}$, $V_{DD} = 3.3\text{V}$
			3.0 ⁽¹⁾	—	—		$I_{OH} \geq -7 \text{ mA}$, $V_{DD} = 3.3\text{V}$

Note 1: Parameters are characterized, but not tested.

TABLE 8-5: ELECTRICAL CHARACTERISTICS: BROWN-OUT RESET (BOR)

DC CHARACTERISTICS			Standard Operating Conditions: 2.3V to 3.6V (unless otherwise stated) Operating temperature $-40^{\circ}\text{C} \leq T_A \leq +70^{\circ}\text{C}$				
Param. No.	Symbol	Characteristics	Min. ⁽¹⁾	Typical	Max.	Units	Conditions
BO10	Vbor	BOR Event on V_{DD} transition high-to-low ⁽²⁾	2.0	—	2.3	V	—

Note 1: Parameters are for design guidance only and are not tested in manufacturing.

2: Overall functional device operation at $V_{BORMIN} < V_{DD} < V_{DDMIN}$ is tested, but not characterized.

TABLE 8-6: INTERNAL VOLTAGE REGULATOR SPECIFICATIONS

DC CHARACTERISTICS			Standard Operating Conditions: 2.3V to 3.6V (unless otherwise stated) Operating temperature $-40^{\circ}\text{C} \leq T_A \leq +70^{\circ}\text{C}$				
Param. No.	Symbol	Characteristics	Min.	Typical	Max.	Units	Comments
D321	Cefc	External Filter Capacitor Value	8	10	—	μF	Capacitor must be low series resistance (1 ohm). Typical voltage on the VCAP pin is 1.8V.

MM7150

8.2 AC Characteristics and Timing Parameters

The information contained in this section defines MM7150 AC characteristics and timing parameters.

FIGURE 8-1: LOAD CONDITIONS FOR DEVICE TIMING SPECIFICATIONS

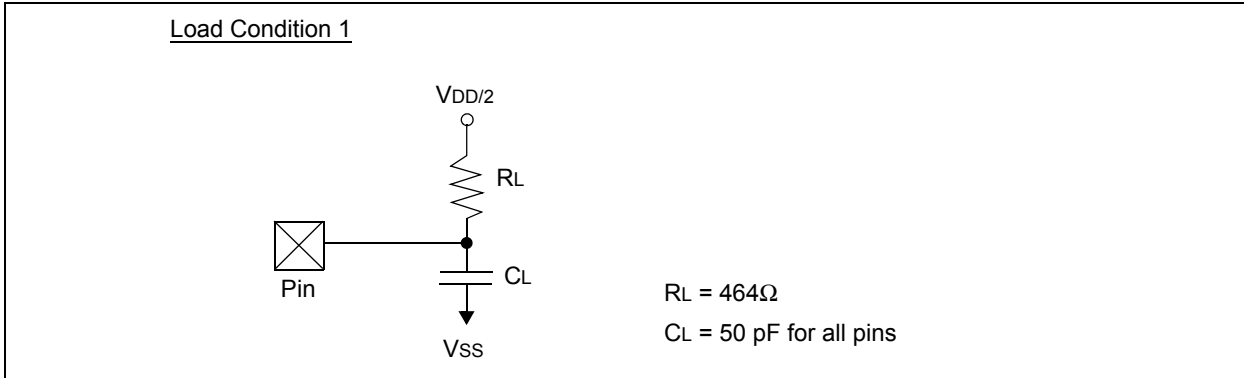
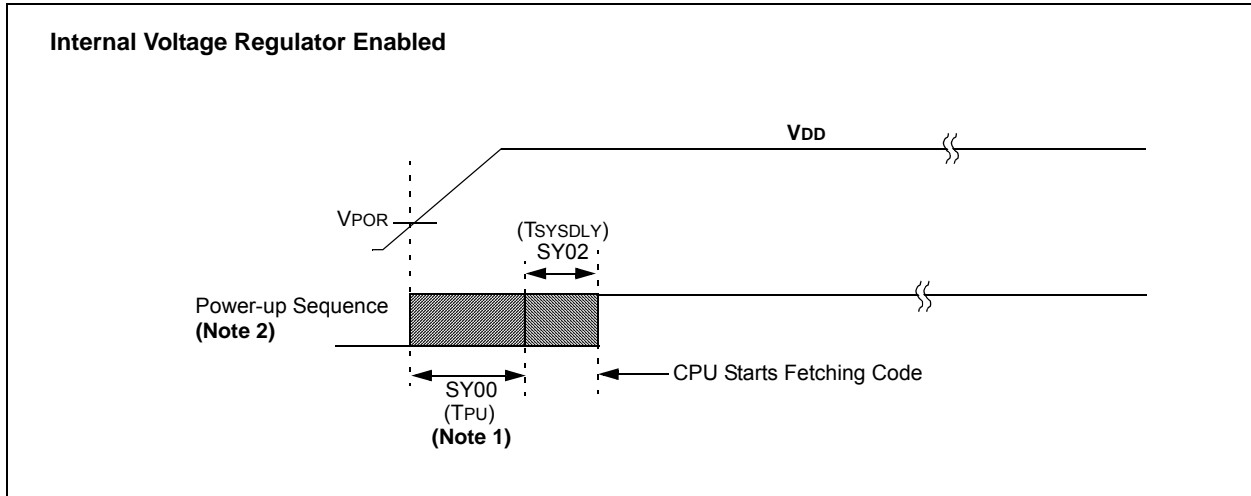


TABLE 8-7: CAPACITIVE LOADING REQUIREMENTS ON OUTPUT PINS

AC CHARACTERISTICS			Standard Operating Conditions: 2.3V to 3.6V (unless otherwise stated) Operating temperature $-40^{\circ}\text{C} \leq T_A \leq +70^{\circ}\text{C}$				
Param. No.	Symbol	Characteristics	Min.	Typical ⁽¹⁾	Max.	Units	Conditions
DO56	CIO	All I/O pins	—	—	50	pF	
DO58	CB	SCLx, SDAx	—	—	400	pF	In I ² C™ mode

Note 1: Data in "Typical" column is at 3.3V, 25°C unless otherwise stated. Parameters are for design guidance only and are not tested.

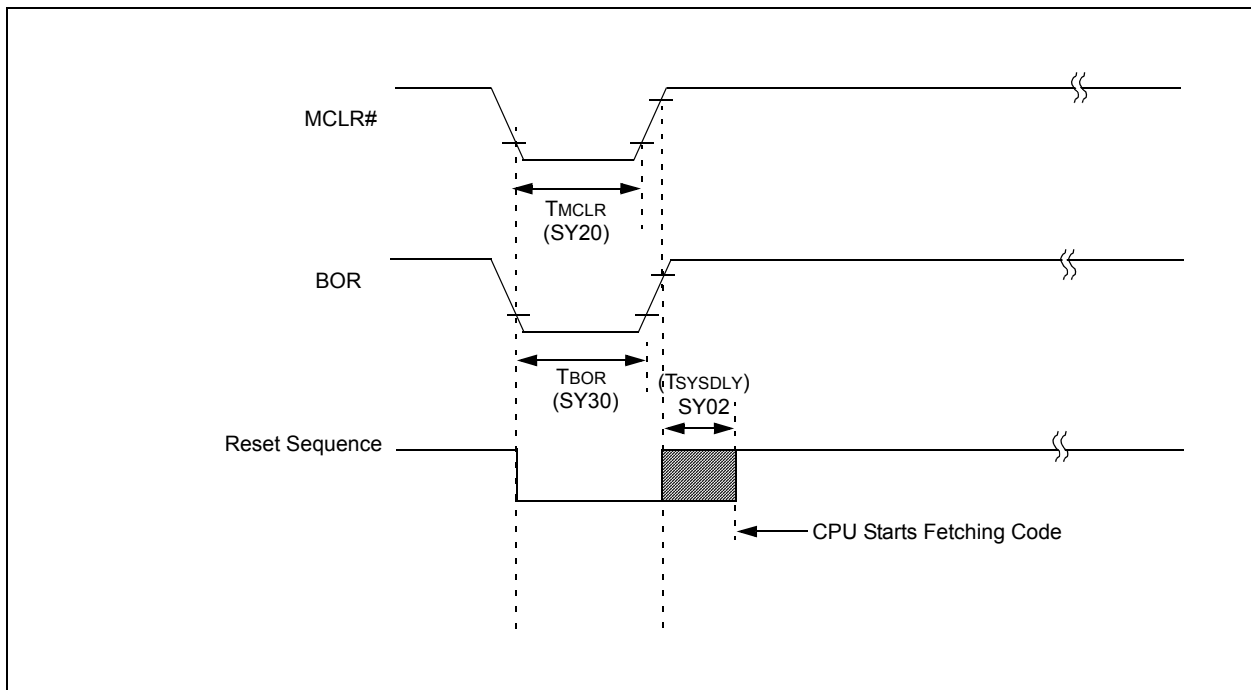
FIGURE 8-2: POWER-ON RESET TIMING CHARACTERISTICS



Note 1: The power-up period will be extended if the power-up sequence completes before the device exits from BOR ($V_{DD} < V_{DDMIN}$).

2: Includes interval voltage regulator stabilization delay.

FIGURE 8-3: EXTERNAL RESET TIMING CHARACTERISTICS



MM7150

TABLE 8-8: RESETS TIMING

AC CHARACTERISTICS			Standard Operating Conditions: 2.3V to 3.6V (unless otherwise stated) Operating temperature $-40^{\circ}\text{C} \leq T_A \leq +70^{\circ}\text{C}$				
Param. No.	Symbol	Characteristics ⁽¹⁾	Min.	Typical ⁽²⁾	Max.	Units	Conditions
SY00	TPU	Power-up Period Internal Voltage Regulator Enabled	—	400	600	μs	—
SY02	Tsysdly	System Delay Period: Time Required to Reload Device Configuration Fuses plus SYSCLK ⁽³⁾ Delay before First instruction is Fetched.	—	$1 \mu\text{s} +$ 8 SYSCLK cycles	—	—	—
SY20	Tmclr	MCLR# Pulse Width (low)	2	—	—	μs	—
SY30	TBOR	BOR Pulse Width (low)	—	1	—	μs	—

Note 1: These parameters are characterized, but not tested in manufacturing.

Note 2: Data in “Typ” column is at 3.3V, 25°C unless otherwise stated. Characterized by design but not tested.

Note 3: SYSCLK is 48MHz

FIGURE 8-4: I²Cx BUS START/STOP BITS TIMING CHARACTERISTICS (SLAVE MODE)

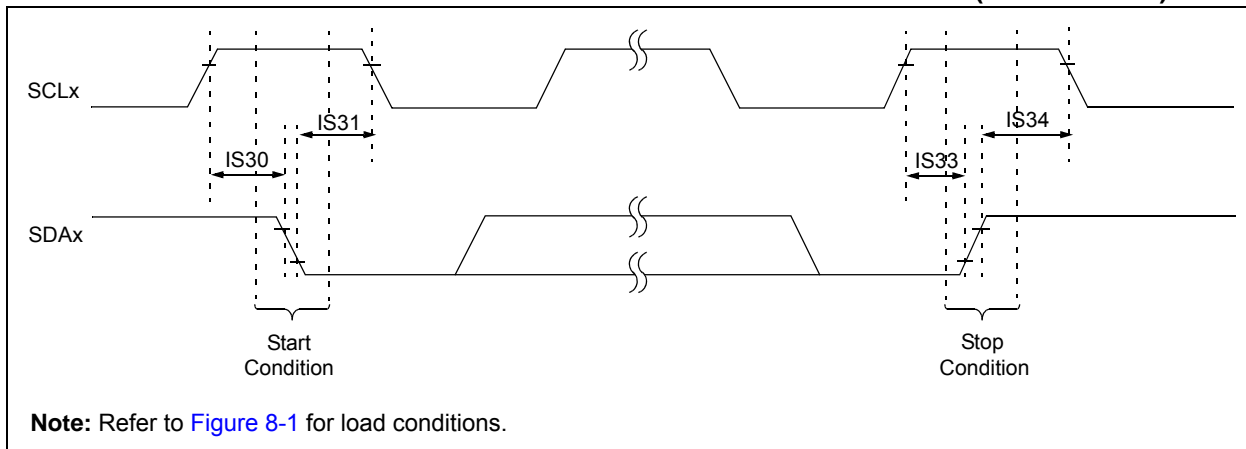


FIGURE 8-5: I²Cx BUS DATA TIMING CHARACTERISTICS (SLAVE MODE)

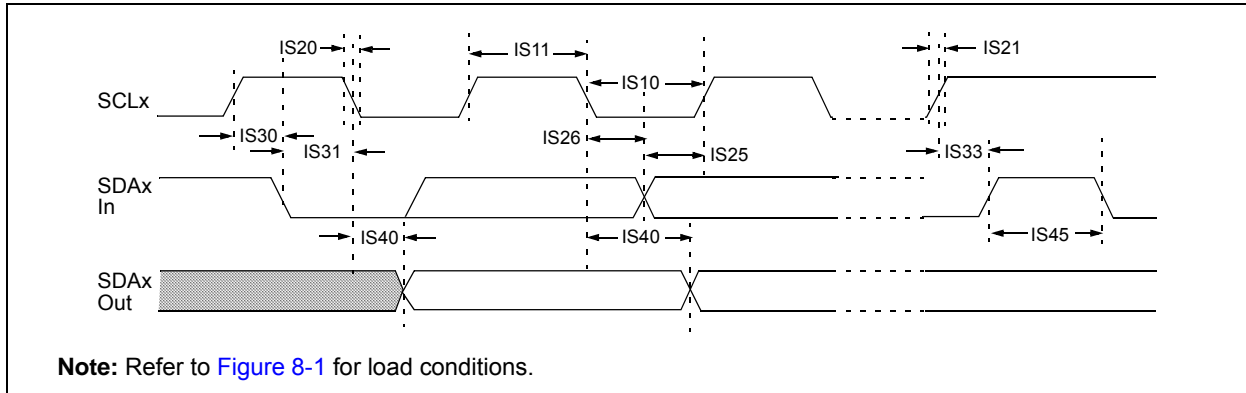


TABLE 8-9: I²Cx BUS DATA TIMING REQUIREMENTS (SLAVE MODE)

AC CHARACTERISTICS				Standard Operating Conditions: 2.3V to 3.6V (unless otherwise stated) Operating temperature -40°C ≤ TA ≤ +70°C			
Param. No.	Symbol	Characteristics		Min.	Max.	Units	Conditions
IS10	TLO:SCL	Clock Low Time	100 kHz mode	4.7	—	μs	—
			400 kHz mode	1.3	—	μs	—
IS11	THI:SCL	Clock High Time	100 kHz mode	4.0	—	μs	—
			400 kHz mode	0.6	—	μs	—
IS20	TF:SCL	SDAx and SCLx Fall Time	100 kHz mode	—	300	ns	CB is specified to be from 10 to 400 pF
			400 kHz mode	20 + 0.1 CB	300	ns	
IS21	TR:SCL	SDAx and SCLx Rise Time	100 kHz mode	—	1000	ns	CB is specified to be from 10 to 400 pF
			400 kHz mode	20 + 0.1 CB	300	ns	
IS25	TSU:DAT	Data Input Setup Time	100 kHz mode	250	—	ns	—
			400 kHz mode	100	—	ns	
IS26	THD:DAT	Data Input Hold Time	100 kHz mode	0	—	ns	—
			400 kHz mode	0	0.9	μs	
IS30	TSU:STA	Start Condition Setup Time	100 kHz mode	4700	—	ns	Only relevant for Repeated Start condition
			400 kHz mode	600	—	ns	
IS31	THD:STA	Start Condition Hold Time	100 kHz mode	4000	—	ns	After this period, the first clock pulse is generated
			400 kHz mode	600	—	ns	
IS33	TSU:STO	Stop Condition Setup Time	100 kHz mode	4000	—	ns	—
			400 kHz mode	600	—	ns	
IS34	THD:STO	Stop Condition Hold Time	100 kHz mode	4000	—	ns	—
			400 kHz mode	600	—	ns	
IS40	TAA:SCL	Output Valid from Clock	100 kHz mode	0	3500	ns	—
			400 kHz mode	0	1000	ns	
IS45	TBF:SDA	Bus Free Time	100 kHz mode	4.7	—	μs	The amount of time the bus must be free before a new transmission can start
			400 kHz mode	1.3	—	μs	
IS50	CB	Bus Capacitive Loading		—	400	pF	—

MM7150

APPENDIX A: REVISION HISTORY

TABLE A-1: REVISION HISTORY

Revision	Section/Figure/Entry	Correction
DS00001888A (02-05-15)	Initial Release	

THE MICROCHIP WEB SITE

Microchip provides online support via our WWW site at www.microchip.com. This web site is used as a means to make files and information easily available to customers. Accessible by using your favorite Internet browser, the web site contains the following information:

- **Product Support** – Data sheets and errata, application notes and sample programs, design resources, user's guides and hardware support documents, latest software releases and archived software
- **General Technical Support** – Frequently Asked Questions (FAQ), technical support requests, online discussion groups, Microchip consultant program member listing
- **Business of Microchip** – Product selector and ordering guides, latest Microchip press releases, listing of seminars and events, listings of Microchip sales offices, distributors and factory representatives

CUSTOMER CHANGE NOTIFICATION SERVICE

Microchip's customer notification service helps keep customers current on Microchip products. Subscribers will receive e-mail notification whenever there are changes, updates, revisions or errata related to a specified product family or development tool of interest.

To register, access the Microchip web site at www.microchip.com. Under "Support", click on "Customer Change Notification" and follow the registration instructions.

CUSTOMER SUPPORT

Users of Microchip products can receive assistance through several channels:

- Distributor or Representative
- Local Sales Office
- Field Application Engineer (FAE)
- Technical Support

Customers should contact their distributor, representative or field application engineer (FAE) for support. Local sales offices are also available to help customers. A listing of sales offices and locations is included in the back of this document.

Technical support is available through the web site at: <http://microchip.com/support>

MM7150

PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, refer to the factory or the listed sales office.

<u>PART NO.</u> ⁽¹⁾ Device Series	-	<u>XXX</u> Sensor Fusion Firmware
Device:		MM7150 ⁽¹⁾
Sensor Fusion Firmware:	AA0 =	Bosch 9-axis Sensor Fusion

Example:
a) MM7150-AA0, Bosch 9-axis sensor fusion.

Note 1: These products meet the halogen maximum concentration values per IEC61249-2-21.
All package options are lead-free and RoHS compliant. For RoHS compliance and environmental information, please visit <http://www.microchip.com/pagehandler/en-us/aboutus/ehs.html>.

Note the following details of the code protection feature on Microchip devices:

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as “unbreakable.”

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

Information contained in this publication regarding device applications and the like is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications. MICROCHIP MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL, STATUTORY OR OTHERWISE, RELATED TO THE INFORMATION, INCLUDING BUT NOT LIMITED TO ITS CONDITION, QUALITY, PERFORMANCE, MERCHANTABILITY OR FITNESS FOR PURPOSE. Microchip disclaims all liability arising from this information and its use. Use of Microchip devices in life support and/or safety applications is entirely at the buyer's risk, and the buyer agrees to defend, indemnify and hold harmless Microchip from any and all damages, claims, suits, or expenses resulting from such use. No licenses are conveyed, implicitly or otherwise, under any Microchip intellectual property rights.

Trademarks

The Microchip name and logo, the Microchip logo, dsPIC, FlashFlex, flexPWR, JukeBlox, KEELOQ, KEELOQ logo, Kleer, LANCheck, MediaLB, MOST, MOST logo, MPLAB, OptoLyzer, PIC, PICSTART, PIC³² logo, RightTouch, SpyNIC, SST, SST Logo, SuperFlash and UNI/O are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

The Embedded Control Solutions Company and mTouch are registered trademarks of Microchip Technology Incorporated in the U.S.A.

Analog-for-the-Digital Age, BodyCom, chipKIT, chipKIT logo, CodeGuard, dsPICDEM, dsPICDEM.net, ECAN, In-Circuit Serial Programming, ICSP, Inter-Chip Connectivity, KleerNet, KleerNet logo, MiWi, MPASM, MPF, MPLAB Certified logo, MPLIB, MPLINK, MultiTRAK, NetDetach, Omniscient Code Generation, PICDEM, PICDEM.net, PICKit, PICTail, RightTouch logo, REAL ICE, SQI, Serial Quad I/O, Total Endurance, TSHARC, USBCheck, VariSense, ViewSpan, WiperLock, Wireless DNA, and ZENA are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

SQTP is a service mark of Microchip Technology Incorporated in the U.S.A.

Silicon Storage Technology is a registered trademark of Microchip Technology Inc. in other countries.

GestIC is a registered trademarks of Microchip Technology Germany II GmbH & Co. KG, a subsidiary of Microchip Technology Inc., in other countries.

All other trademarks mentioned herein are property of their respective companies.

© 2015, Microchip Technology Incorporated, Printed in the U.S.A., All Rights Reserved.

ISBN: 9781632770479

QUALITY MANAGEMENT SYSTEM
CERTIFIED BY DNV
== ISO/TS 16949 ==

Microchip received ISO/TS-16949:2009 certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona; Gresham, Oregon and design centers in California and India. The Company's quality system processes and procedures are for its PIC[®] MCUs and dsPIC[®] DSCs, KEELOQ[®] code hopping devices, Serial EEPROMs, microperipherals, nonvolatile memory and analog products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001:2000 certified.



MICROCHIP

Worldwide Sales and Service

AMERICAS

Corporate Office
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-792-7200
Fax: 480-792-7277
Technical Support:
<http://www.microchip.com/support>

Web Address:
www.microchip.com

Atlanta
Duluth, GA
Tel: 678-957-9614
Fax: 678-957-1455

Austin, TX
Tel: 512-257-3370

Boston
Westborough, MA
Tel: 774-760-0087
Fax: 774-760-0088

Chicago
Itasca, IL
Tel: 630-285-0071
Fax: 630-285-0075

Cleveland
Independence, OH
Tel: 216-447-0464
Fax: 216-447-0643

Dallas
Addison, TX
Tel: 972-818-7423
Fax: 972-818-2924

Detroit
Novi, MI
Tel: 248-848-4000

Houston, TX
Tel: 281-894-5983

Indianapolis
Noblesville, IN
Tel: 317-773-8323
Fax: 317-773-5453

Los Angeles
Mission Viejo, CA
Tel: 949-462-9523
Fax: 949-462-9608

New York, NY
Tel: 631-435-6000

San Jose, CA
Tel: 408-735-9110

Canada - Toronto
Tel: 905-673-0699
Fax: 905-673-6509

ASIA/PACIFIC

Asia Pacific Office
Suites 3707-14, 37th Floor
Tower 6, The Gateway
Harbour City, Kowloon
Hong Kong
Tel: 852-2943-5100
Fax: 852-2401-3431

Australia - Sydney
Tel: 61-2-9868-6733
Fax: 61-2-9868-6755

China - Beijing
Tel: 86-10-8569-7000
Fax: 86-10-8528-2104

China - Chengdu
Tel: 86-28-8665-5511
Fax: 86-28-8665-7889

China - Chongqing
Tel: 86-23-8980-9588
Fax: 86-23-8980-9500

China - Dongguan
Tel: 86-769-8702-9880

China - Hangzhou
Tel: 86-571-8792-8115
Fax: 86-571-8792-8116

China - Hong Kong SAR
Tel: 852-2943-5100
Fax: 852-2401-3431

China - Nanjing
Tel: 86-25-8473-2460
Fax: 86-25-8473-2470

China - Qingdao
Tel: 86-532-8502-7355
Fax: 86-532-8502-7205

China - Shanghai
Tel: 86-21-5407-5533
Fax: 86-21-5407-5066

China - Shenyang
Tel: 86-24-2334-2829
Fax: 86-24-2334-2393

China - Shenzhen
Tel: 86-755-8864-2200
Fax: 86-755-8203-1760

China - Wuhan
Tel: 86-27-5980-5300
Fax: 86-27-5980-5118

China - Xian
Tel: 86-29-8833-7252
Fax: 86-29-8833-7256

ASIA/PACIFIC

China - Xiamen
Tel: 86-592-2388138
Fax: 86-592-2388130

China - Zhuhai
Tel: 86-756-3210040
Fax: 86-756-3210049

India - Bangalore
Tel: 91-80-3090-4444
Fax: 91-80-3090-4123

India - New Delhi
Tel: 91-11-4160-8631
Fax: 91-11-4160-8632

India - Pune
Tel: 91-20-3019-1500

Japan - Osaka
Tel: 81-6-6152-7160
Fax: 81-6-6152-9310

Japan - Tokyo
Tel: 81-3-6880-3770
Fax: 81-3-6880-3771

Korea - Daegu
Tel: 82-53-744-4301
Fax: 82-53-744-4302

Korea - Seoul
Tel: 82-2-554-7200
Fax: 82-2-558-5932 or
82-2-558-5934

Malaysia - Kuala Lumpur
Tel: 60-3-6201-9857
Fax: 60-3-6201-9859

Malaysia - Penang
Tel: 60-4-227-8870
Fax: 60-4-227-4068

Philippines - Manila
Tel: 63-2-634-9065
Fax: 63-2-634-9069

Singapore
Tel: 65-6334-8870
Fax: 65-6334-8850

Taiwan - Hsin Chu
Tel: 886-3-5778-366
Fax: 886-3-5770-955

Taiwan - Kaohsiung
Tel: 886-7-213-7828

Taiwan - Taipei
Tel: 886-2-2508-8600
Fax: 886-2-2508-0102

Thailand - Bangkok
Tel: 66-2-694-1351
Fax: 66-2-694-1350

EUROPE

Austria - Wels
Tel: 43-7242-2244-39
Fax: 43-7242-2244-393

Denmark - Copenhagen
Tel: 45-4450-2828
Fax: 45-4485-2829

France - Paris
Tel: 33-1-69-53-63-20
Fax: 33-1-69-30-90-79

Germany - Dusseldorf
Tel: 49-2129-3766400

Germany - Munich
Tel: 49-89-627-144-0
Fax: 49-89-627-144-44

Germany - Pforzheim
Tel: 49-7231-424750

Italy - Milan
Tel: 39-0331-742611
Fax: 39-0331-466781

Italy - Venice
Tel: 39-049-7625286

Netherlands - Drunen
Tel: 31-416-690399
Fax: 31-416-690340

Poland - Warsaw
Tel: 48-22-3325737

Spain - Madrid
Tel: 34-91-708-08-90
Fax: 34-91-708-08-91

Sweden - Stockholm
Tel: 46-8-5090-4654

UK - Wokingham
Tel: 44-118-921-5800
Fax: 44-118-921-5820

01/27/15

X-ON Electronics

Largest Supplier of Electrical and Electronic Components

Click to view similar products for [Multiple Function Sensor Modules](#) category:

Click to view products by [Microchip](#) manufacturer:

Other Similar products are found below :

[AD5T](#) [MM7150-AB1](#) [SIBA5-JRAB-DKL](#) [2314277-1](#) [2314277-2](#) [2314291-1](#) [ZMW-SENSOR-1](#) [2316851-1](#) [1-2314277-2](#) [2316852-1](#)
[2331211-3](#) [2316852-2](#) [2316851-2](#) [1-2314277-1](#) [CS-95HSS-A](#) [CS-205HSS-A](#) [CS-20SHSS-A](#) [CS-125HSS-A](#) [CS-205SSS-A](#) [CS-125SSS-A](#)
[CS-95SSS-A](#) [eATVS-4](#) [eATVS-8](#) [tvLYT](#) [NGM_1](#) [SKU-7000](#) [DFR0759](#) [SG-Link-200](#) [V-Link-200](#) [MNS2-9-IN-VM-005](#) [MNS2-9-W2-VD-](#)
[DC](#) [MNS2-9-W2-VM-005](#) [NGM-1](#) [2JCIE-BU01](#) [K6PM-THMD-EIP](#) [K6PM-THS3232](#) [WYZBEE-SENS-101](#) [OB1203SD-C4V](#) [101020932](#)
[101990693](#) [SIBA5-JRAB](#) [SIBA5-JREB](#) [SIBA5-JREB-DKL](#) [SIBA-JRA](#) [SIBA-JRAB](#) [SIBA-JRE](#) [SIBA-JREB](#) [SEK SCC30-DB](#) [Sample](#)
[ESYS11X](#) [ESYS11X+LOPY915](#)