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MM7150

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 I^2C
- 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:

- I^2C Controller
  - Supports I^2C 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

Temperature Ranges Available

- Industrial (-40°C to +85°C)
- Commercial (0°C to +70°C)

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.

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Table of Contents

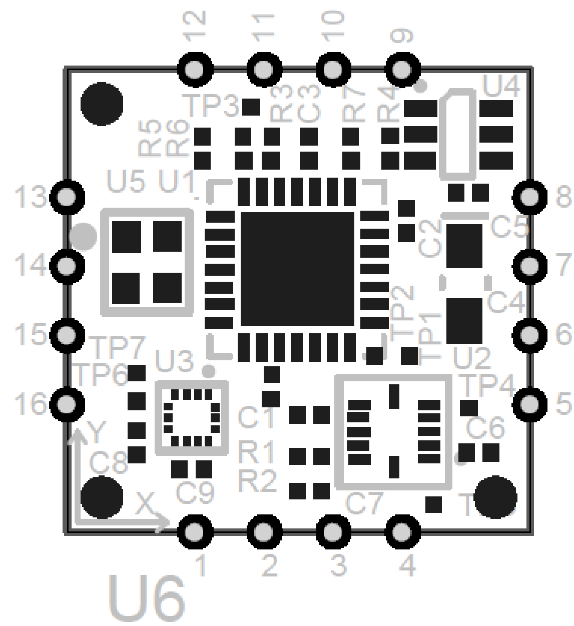
1.0 MM7150 PINOUT

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

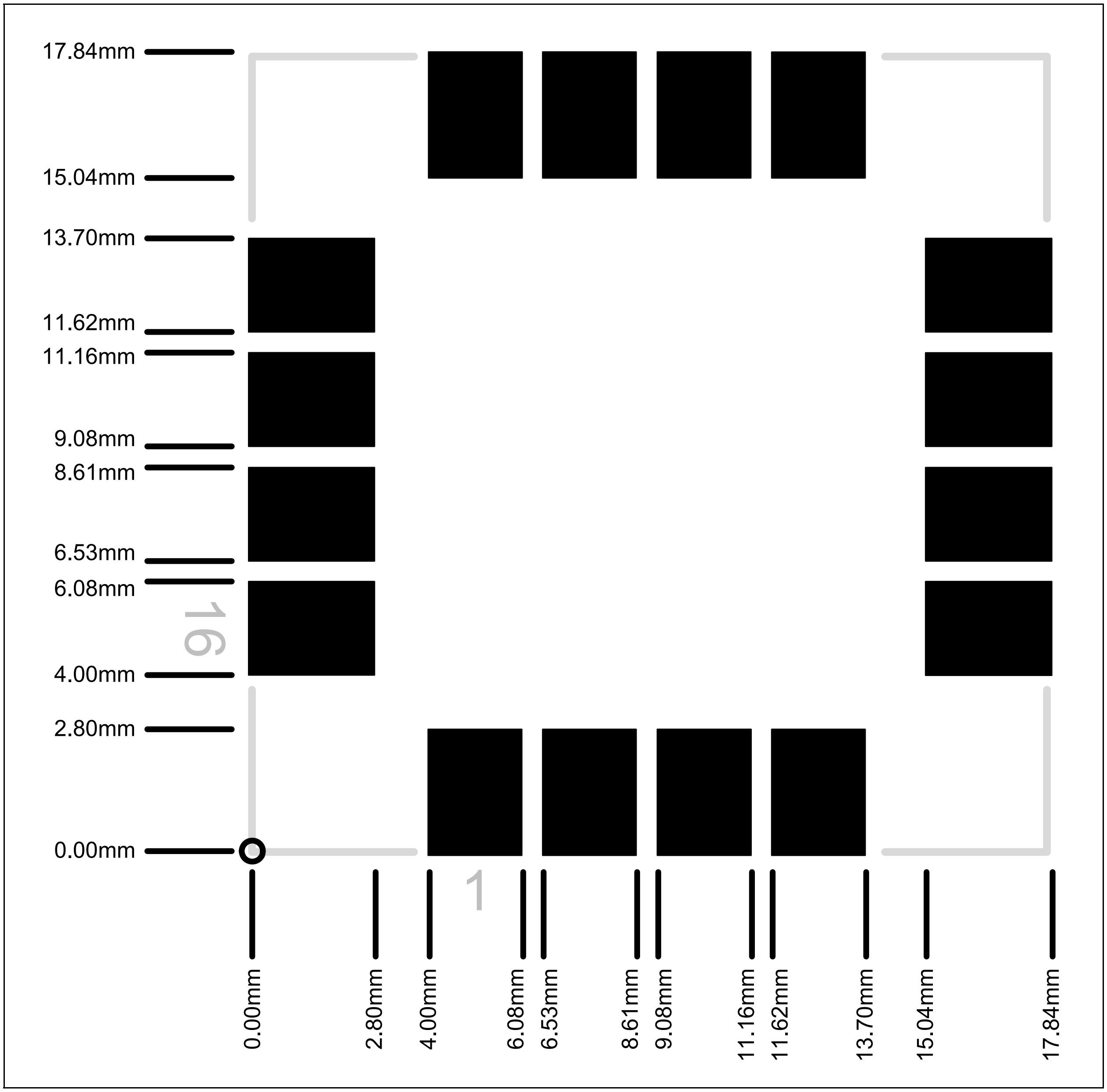
1.1 Assembly Drawing

The assembly drawing is shown in Figure 1-1.

FIGURE 1-1: ASSEMBLY DRAWING



1.2 Recommended Land Pattern



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^2C 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^2C 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^2C Controller Clock to Host Interface
16	HIDI2C_HOST_DAT	IOD	I^2C 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

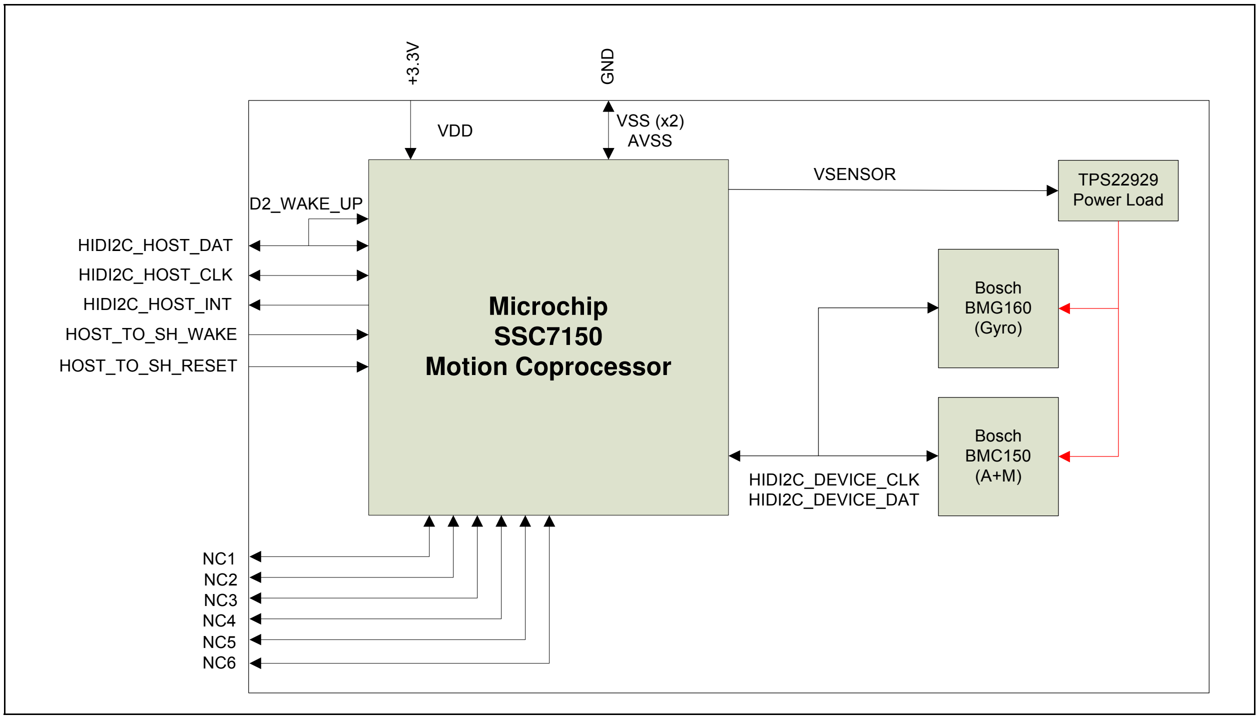
2.0 MM7150 MODULE

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 I^2C interface to the host, and supports HID over I^2C. 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.

3.0 MM7150 HID FUNCTIONS

The MM7150 responds to the standard HID protocol for sensors when used over I^2C, 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 (I^2C)

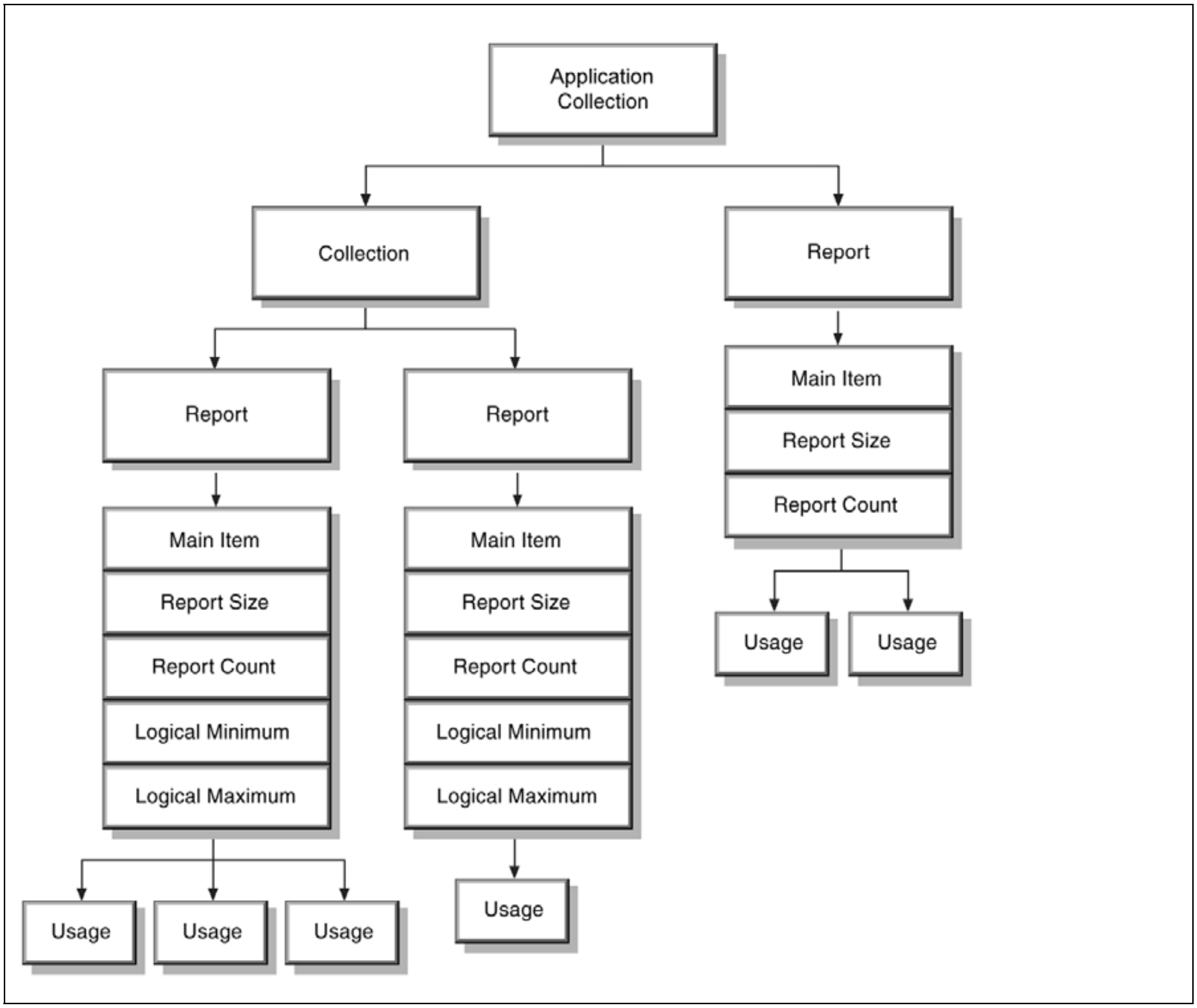
Field	Description	Size	Value
wHIDDescLength	Length of HID Descriptor	UINT 16	0x001E
bcdVersion	Version compliance. Compliant with Version 1.00	UINT 16	0x0100
wReportDescLength	Report Descriptor Length (3213 bytes)	UINT 16	0x0C8D
wReportDescRegister	Identifier to read Report Descriptor	UINT 16	0x0002
wInputRegister	Identifier to read Input Report	UINT 16	0x0003
wMaxInputLength	Input Report is 13 Bytes + 2 Bytes length field	UINT 16	0x000D
wOutputRegistert	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.

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
sHeadingCompensatedMag-neticNorthValue	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
sIncXValue	Inclinometer X axis values	INT 16
sIncYValue	Inclinometer Y axis value	INT 16
sIncZValue	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

4.0 MM7150 HOST INTERFACE

4.1 I^2C

The MM7150 can be connected to a host via the I^2C interface. The I^2C interface is compliant with the I^2C 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 I^2C 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.

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 I^2C Protocol Specification: Device Side”, version 1.00, 04/24/2012
4. NXP Corporation, “I^2C-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°

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 bias (Commercial temperature range).....0°C to +70°C

Ambient temperature under bias (Industrial temperature range).....-40°C to +85°C

Storage temperature.....-65°C to +150°C

Voltage on V_{DD} with respect to V_{SS}.....-0.3V to +4.0V

Voltage on any pin that is not 5V tolerant, with respect to V_{SS} **(Note 3)**.....-0.3V to (V_{DD} + 0.3V)

Voltage on any 5V tolerant pin with respect to V_{SS} when $V_{DD} \geq 2.3V$ **(Note 3)**.....-0.3V to +5.5V

Voltage on any 5V tolerant pin with respect to V_{SS} when V_{DD} < 2.3V **(Note 3)**.....-0.3V to +3.6V

Maximum current out of V_{SS} pin(s).....300 mA

Maximum current into V_{DD} 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) Commercial Operating temperature 0°C ≤ T_A ≤ +70°C Industrial Operating temperature -40°C ≤ T_A ≤ +85°C				
Param. No.	**Symbol**	**Characteristics**	**Min.**	**Typ.**	**Max.**	**Units**	**Conditions**
Operating Voltage							
DC10	V_{DD}	Supply Voltage **(Note 2)**	2.3	—	3.6	V	—
DC12	V_{DR}	RAM Data Retention Voltage **(Note 1)**	1.75	—	—	V	—
DC16	V_{POR}	**V_{DD} Start Voltage** to Ensure Internal Power-on Reset Signal	1.75	—	2.1	V	—
DC17	S_{VDD}	**V_{DD} Rise Rate** to Ensure Internal Power-on Reset Signal	0.00005	—	0.115	V/µs	—

Note 1: This is the limit to which V_{DD} can be lowered without losing RAM data.

2: Overall functional device operation at V_{BORMIN} < V_{DD} < V_{DDMIN} 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) Commercial Operating temperature 0°C ≤ T_A ≤ +70°C Industrial Operating temperature -40°C ≤ T_A ≤ +85°C	
Parameter No.	**Symbol**	**Typical**	**Max.**	**Units**	**Conditions**
Operating/Power-Down Current (Note 1, 2)					
DC20	I_{DD}		26.5	mA	—
DC30	I_{AVG}		13.65	mA	—
DC40	I_{IDLE}		2.5	mA	—
DC50	I_{PD}	70	150	µA	**0°C ≤ T_A ≤ +70°C**
DC50	I_{PD}	120	180	µA	**-40°C ≤ T_A ≤ +85°C**

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 (I_{DD}):
  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 (I_{PD}):
  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 I^2C host interface is used.
  Wakeup from power-down mode requires the HOST_TO_SH_WAKE pin if the I^2C host interface is used.

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

DC CHARACTERISTICS			Standard Operating Conditions: 2.3V to 3.6V (unless otherwise stated) Commercial Operating temperature 0°C ≤ TA ≤ +70°C Industrial Operating temperature -40°C ≤ TA ≤ +85°C				
Param. No.	**Symbol**	**Characteristics**	**Min.**	**Typical(1)**	**Max.**	**Units**	**Conditions**
	VIL	Input Low Voltage					
DI10		I/O Pins	VSS	—	0.2 VDD	V	
DI18		SDAx, SCLx	VSS	—	0.3 VDD	V	I²C disabled **(Note 4)**
DI19		SDAx, SCLx	VSS	—	0.8	V	I²C enabled **(Note 4)**
	VIH	Input High Voltage					
DI20		I/O Pins not 5V-tolerant(5)	0.65 VDD	—	VDD	V	**(Note 4,6)**
		I/O Pins 5V-tolerant(5)	0.65 VDD	—	5.5	V	
DI28		SDAx, SCLx	0.65 VDD	—	5.5	V	I²C disabled **(Note 4,6)**
DI29		SDAx, SCLx	2.1	—	5.5	V	I²C enabled, 2.3V ≤ VPIN ≤ 5.5 **(Note 4,6)**
	IIL	Input Leakage Current **(Note 3)**					
DI50		I/O Ports	—	—	±1	μA	VSS ≤ VPIN ≤ VDD, Pin at high-impedance
DI55		MCLR#(2)	—	—	±1	μA	VSS ≤ VPIN ≤ VDD

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 VIH 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 VIH 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) Commercial Operating temperature 0°C ≤ TA ≤ +70°C Industrial Operating temperature -40°C ≤ TA ≤ +85°C				
Param.	**Symbol**	**Characteristic**	**Min.**	**Typ.**	**Max.**	**Units**	**Conditions**
DO10	Vol	Output Low Voltage I/O Pins	—	—	0.4	V	IOL ≤ 10 mA, VDD = 3.3V
DO20	VOH	Output High Voltage I/O Pins	1.5(1)	—	—	V	IOH ≥ -14 mA, VDD = 3.3V
			2.0(1)	—	—		IOH ≥ -12 mA, VDD = 3.3V
			2.4	—	—		IOH ≥ -10 mA, VDD = 3.3V
			3.0(1)	—	—		IOH ≥ -7 mA, VDD = 3.3V

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) Commercial Operating temperature 0°C ≤ TA ≤ +70°C Industrial Operating temperature -40°C ≤ TA ≤ +85°C				
Param. No.	**Symbol**	**Characteristics**	**Min.(1)**	**Typical**	**Max.**	**Units**	**Conditions**
BO10	Vbor	BOR Event on VDD 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 VBORMIN < VDD < VDDMIN 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) Commercial Operating temperature 0°C ≤ TA ≤ +70°C Industrial Operating temperature -40°C ≤ TA ≤ +85°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.

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

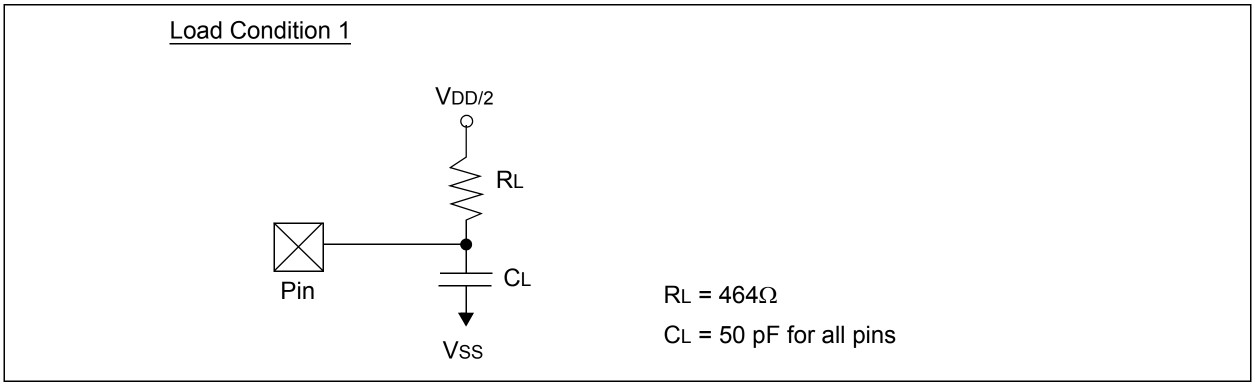
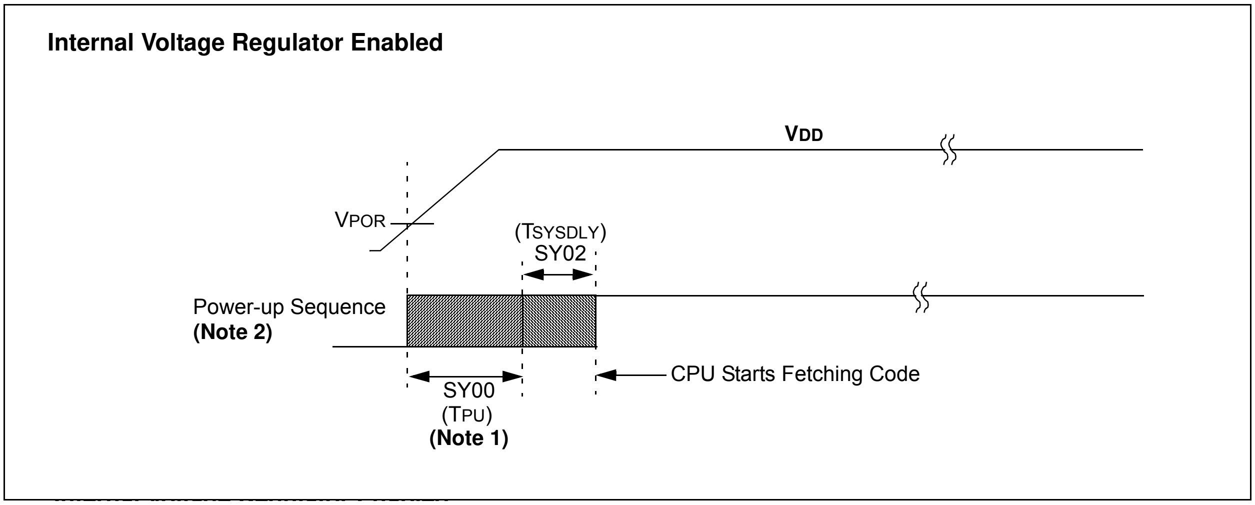


TABLE 8-7: CAPACITIVE LOADING REQUIREMENTS ON OUTPUT PINS

AC CHARACTERISTICS			Standard Operating Conditions: 2.3V to 3.6V (unless otherwise stated)				
Param. No.	Symbol	Characteristics	Min.	Typical(1)	Max.	Units	Conditions
DO56	C_{IO}	All I/O pins	—	—	50	pF	
DO58	C_B	SCLx, SDAx	—	—	400	pF	In I^2C™ 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

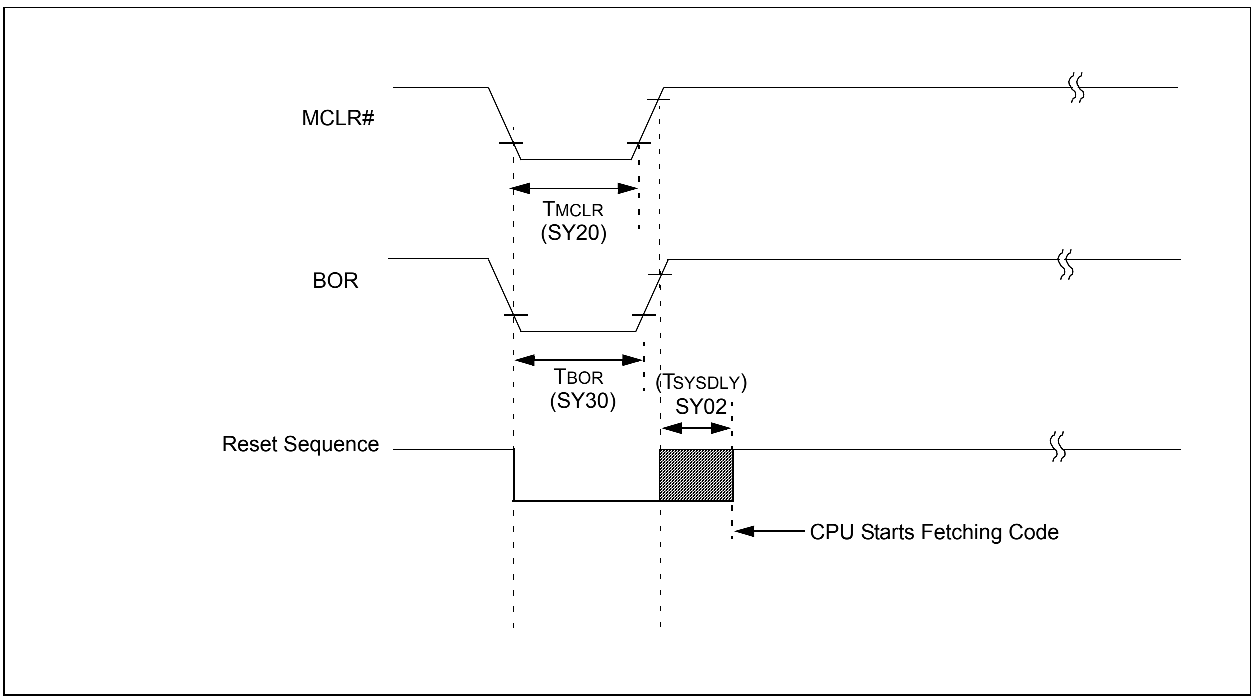
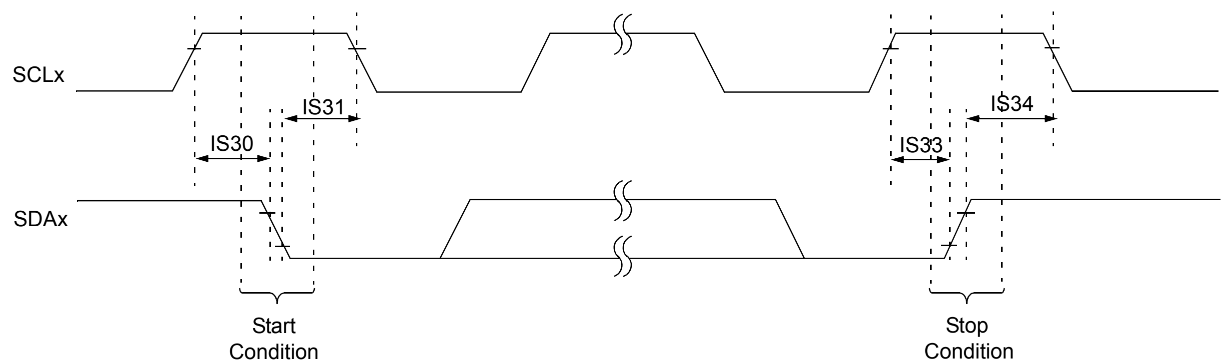


TABLE 8-8: RESETS TIMING

AC CHARACTERISTICS			Standard Operating Conditions: 2.3V to 3.6V (unless otherwise stated)				
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 µs + 8 SYSCLK cycles	—	—	—
SY20	Tmclr	MCLR# Pulse Width (low)	2	—	—	µs	—
SY30	TBOR	BOR Pulse Width (low)	—	1	—	µs	—

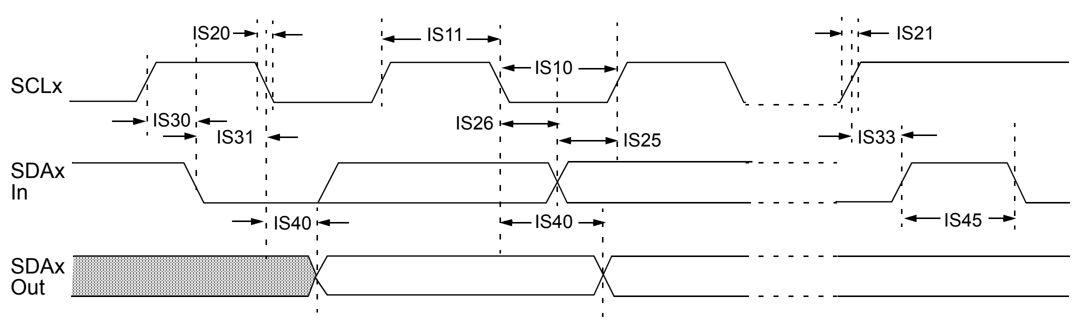
Note 1: These parameters are characterized, but not tested in manufacturing.
2: Data in “Typ” column is at 3.3V, 25°C unless otherwise stated. Characterized by design but not tested.
3: SYSCLK is 48MHz

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



Note: Refer to Figure 8-1 for load conditions.

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



Note: Refer to Figure 8-1 for load conditions.

TABLE 8-9: I^2Cx BUS DATA TIMING REQUIREMENTS (SLAVE MODE)

AC CHARACTERISTICS				Standard Operating Conditions: 2.3V to 3.6V (unless otherwise stated)			
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	—

APPENDIX A: REVISION HISTORY

TABLE A-1: REVISION HISTORY

Revision	Section/Figure/Entry	Correction
DS00001888B (01-26-16)	Industrial Temp Range	Added Industrial Temp Range to Data Sheet Updated IPD for Industrial Temp Range
DS00001888A (02-05-15)	Initial Release	

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