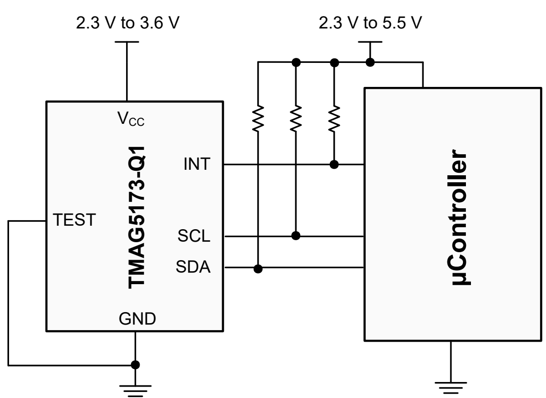
TMAG5173-Q1 具有 I²C 接口的高精度 3D 霍尔效应传感器

1 特性

- 符合面向汽车应用的 AEC-Q100 标准：
  - 温度等级 1：–40°C 至 125°C
- 高精度线性 3D 霍尔效应传感器，可优化位置检测速度和精度：
  - 角度测量误差：±1°（最大值）
  - 单轴转换率为 20kSPS
- 以功能安全合规型为目标：
  - 专为功能安全应用开发
  - 在发布量产版本时将会提供有助于使系统设计符合 ISO 26262 ASIL B 标准的文档
- 可配置的电源模式，包括：
  - 1.5μA 唤醒和睡眠模式电流
- X、Y 或 Z 轴上可选择的线性磁范围：
  - TMAG5173x1-Q1：±40mT，±80mT
  - TMAG5173x2-Q1：±133mT，±266mT
- 来自用户定义的磁性和温度阈值交叉的中断信号
- 具有增益和偏轴调节的集成角 CORDIC 计算
- 用于降低噪声的可配置均值滤波器
- 具有循环冗余校验 (CRC) 功能的 I²C 接口：
  - 最大 1MHz I²C 时钟速度
- 由 I²C 或专用 $\overline{\text{INT}}$ 引脚触发转换
- 多种磁体类型的集成温度补偿
- 内置温度传感器
- 2.3V 至 3.6V 电源电压范围

2 应用

- 转向柱控制
- 方向盘控制
- 换挡系统
- 电动自行车
- 传动器



应用方框图

3 说明

TMAG5173-Q1 是一款低功耗线性 3D 霍尔效应传感器，适用于各种汽车类应用。此器件在 X、Y 和 Z 轴集成三个独立的霍尔效应传感器。精密模拟信号链和集成的 12 位 ADC 使测量的模拟磁场值数字化。支持多个工作 V_{CC} 范围时，I²C 接口可确保使用低电压微控制器实现无缝的数据通信。该器件具有集成的温度传感器，可用于多种系统功能，例如给定磁场的热预算检查或温度补偿计算。

可以通过 I²C 接口来配置 TMAG5173-Q1，以实现磁轴和温度测量的任意组合。此外，该器件可以配置为各种电源选项（包括唤醒和睡眠模式），从而让设计人员能够根据其系统级需要优化系统功耗。多个传感器转换方案和 I²C 读取帧有助于优化吞吐量和准确性。专用的 $\overline{\text{INT}}$ 引脚可以在低功耗唤醒和睡眠模式期间充当系统中断，也可以被微控制器用来触发新的传感器转换。

集成角度计算引擎 (CORDIC) 为同轴和离轴角度测量拓扑提供完整的 360° 角度位置信息。使用用户选择的两个磁轴执行角度计算。该器件具有磁增益和偏轴校正功能，可减轻系统机械误差源的影响。

TMAG5173-Q1 具有四个不同的出厂编程 I²C 地址。通过修改用户可配置的 I²C 地址寄存器，该器件还支持其他 I²C 地址。每个可订购器件可配置为选择在系统校准期间适合磁体强度和元件放置的两个磁场范围之一。

该器件在 -40°C 至 +125°C 的宽环境温度范围内能够保持稳定一致的优异性能。

器件信息[(1)]

器件型号	封装	封装尺寸（标称值）
TMAG5173-Q1	DBV (6)	2.90mm × 1.60mm

(1) 如需了解所有可用封装，请参阅数据表末尾的封装选项附录。

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内容

4 Revision History

DATE	REVISION	NOTES
September 2022	*	Initial release.

5 Pin Configuration and Functions

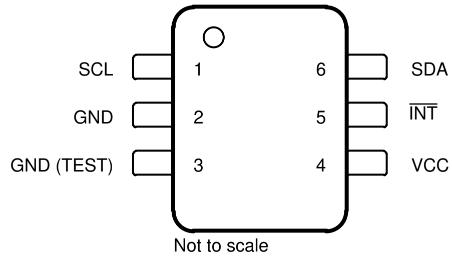

图 5-1. DBV Package, 6-Pin SOT-23 (Top View)

表 5-1. Pin Functions

PIN		TYPE	DESCRIPTION
NO.	NAME		
1	SCL	IO	Serial clock.
2	GND	GND	Ground
3	GND (TEST)	I	TI Test Pin. Connect to ground in application.
4	VCC	P	Supply voltage
5	$\overline{\text{INT}}$	IO	Interrupt input/ output. If not used and connected to ground, set MASK_INTB = 1b.
6	SDA	IO	Serial data.

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6 Specifications

6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)[(1)]

		MIN	MAX	UNIT
V_{CC}	Main supply voltage	–0.3	4	V
I_{OUT}	Output current, SDA, $\overline{INT}$	0	10	mA
V_{OUT}	Output voltage, SDA, $\overline{INT}$	–0.3	7	V
V_{IN}	Input voltage, SCL, SDA, , $\overline{INT}$	–0.3	7	V
B_{MAX}	Magnetic flux density		Unlimited	T
T_J	Junction temperature	–40	150	°C
T_{stg}	Storage temperature	–65	170	°C

(1) Operation outside the Absolute Maximum Ratings may cause permanent device damage. Absolute Maximum Ratings do not imply functional operation of the device at these or any other conditions beyond those listed under Recommended Operating Conditions. If used outside the Recommended Operating Conditions but within the Absolute Maximum Ratings, the device may not be fully functional, and this may affect device reliability, functionality, performance, and shorten the device lifetime.

6.2 ESD Ratings

				VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per AEC Q100-002[(1)]		±2000	V
		Charged device model (CDM), per AEC Q100-011	Corner pins (1, 6, 3, and 4)	±700	
			Other pins	±500	

(1) AEC Q100-002 indicates that HBM stressing shall be in accordance with the ANSI/ESDA/JEDEC JS-001 specification.

6.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)
over recommended V_{Vcc} range (unless otherwise noted)

		MIN	NOM	MAX	UNIT
V_{VCC}	Main supply voltage	2.3		3.6	V
V_{OUT}	Output voltage, SDA, $\overline{INT}$	0		5.5	V
I_{OUT}	Output current, SDA, $\overline{INT}$			2	mA
V_{IH}	Input HIGH voltage, SCL, SDA, $\overline{INT}$	0.7			V_{VCC}
V_{IL}	Input LOW voltage, SCL, SDA, $\overline{INT}$			0.3	V_{VCC}
T_A	Operating free air temperature	–40		125	C

6.4 Thermal Information

THERMAL METRIC[(1)]		TMAG5173-Q1	UNIT
		DBV (6-SOT23)	
		6 pins	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	162	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	81.6	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	50.1	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	30.7	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	49.8	°C/W

(1) For more information about traditional and new thermal metrics, see the Semiconductor and IC Package Thermal Metrics application report.

6.5 Electrical Characteristics

over operating free-air temperature range (unless otherwise noted)
over recommended V_{Vcc} range (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
SDA, $\overline{INT}$						
V_{OL}	Output LOW voltage, SDA, $\overline{INT}$ pin	I_{OUT} = 2 mA	0		0.4	V
I_{OZ}	Output leakage current, SDA, $\overline{INT}$ pin	Output disabled V_{OZ} = 5.5V			±100	nA
tFALL_$\overline{INT}$	$\overline{INT}$ output fall time	R_{PU} = 10 kΩ C_L = 20pF V_{PU} = 1.7 V to 5.5 V		6		ns
tINT ($\overline{INT}$)	$\overline{INT}$ Interrupt time duration during pulse mode	INT_MODE = 001b or 010b		10		µs
tINT (SCL)	SCL Interrupt time duration	INT_MODE = 011b or 100b		10		µs
DC POWER SECTION						
VCC_{UV}	Under voltage threshold at V_{CC}	Internal parameter (OTP option)	1.9	2.1	2.2	V
I_{ACTIVE}	Active mode current	X, Y, Z, or thermal sensor active conversion, LP_LN = 0b		2.4		mA
I_{ACTIVE}	Active mode current	X, Y, Z, or thermal sensor active conversion, LP_LN = 1b		3.0		mA
$I_{STANDBY}$	Stand-by mode current	Device in trigger mode, no conversion started		0.45		mA
I_{SLEEP}	Sleep mode current			8		nA
AVERAGE POWER DURING DUTY-CYCLE MODE						
$I_{CC\_DCM\_0p2\_1}$	W&S mode current consumption	Wake-up interval of 5000 ms Magnetic 1-channel conversion LP_LN = 0b V_{CC} = 3.3 V		1.5		µA
$I_{CC\_DCM\_0p2\_1}$	W&S mode current consumption	Wake-up interval of 5000 ms Magnetic 4-channel conversion LP_LN = 0b V_{CC} = 3.3 V		1.6		µA
$I_{CC\_DCM\_1000\_1}$	W&S mode current consumption	Wake-up interval of 1 ms Magnetic 1-channel conversion LP_LN = 0b V_{CC} = 3.3 V		110		µA
$I_{CC\_DCM\_1000\_4}$	W&S mode current consumption	Wake-up interval 1-ms, magnetic 4-ch conversion, LP_LN =0b, V_{CC} =3.3V		240		µA

6.6 Temperature Sensor

over operating free-air temperature range (unless otherwise noted)
over recommended V_{Vcc} range (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
T_{SENS_RANGE}	Temperature sensing range		–40		170	℃
T_{SENS}	Temperature Output[(1)]	T_A = 25°C		25		℃
T_{SENS_RES}	Temperature sensing resolution (in 16-bit format)			60.1		LSB/℃
T_{SENS_T0}	Reference temperature for T_{ADC_T0}			25		℃
T_{ADC_T0}	Temperature result in decimal value for T_{SENS_T0}			17508		
NRMS_T	RMS (1 Sigma) temperature noise	CONV_AVG = 101b		0.05		℃

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over operating free-air temperature range (unless otherwise noted)
over recommended V_{Vcc} range (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
NRMS_T	RMS (1 Sigma) temperature noise	CONV_AVG = 000b		0.3		℃

(1) The temperature data is collected with T_CH_EN =1h and at least one magnetic channel enabled

6.7 Magnetic Characteristics For A1

over operating free-air temperature range (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$B_{IN\_A1\_X\_Y}$	Linear magnetic range	x_y_RANGE = 0b		±40		mT
$B_{IN\_A1\_X\_Y}$		x_y_RANGE = 1b		±80		mT
$B_{IN\_A1\_Z}$		z_RANGE = 0b		±40		mT
$B_{IN\_A1\_Z}$		z_RANGE = 1b		±80		mT
$SENS_{40\_A1}$	Sensitivity, X, Y, or Z axis	±40 mT range		790		LSB/mT
$SENS_{80\_A1}$		±80 mT range		400		LSB/mT
$SENS_{ER\_PC\_25C\_A1}$	Sensitivity error, X, Y, Z axis	T_A = 25°C		±0.5%		
$SENS_{ER\_PC\_TEMP\_A1}$	Sensitivity drift from 25°C, X, Y, Z axis			±1.5%		
$SENS_{LER\_XY\_A1}$	Sensitivity Linearity Error, X, Y-axis	T_A = 25°C		±0.10%		
$SENS_{LER\_Z\_A1}$	Sensitivity Linearity Error, Z axis	T_A = 25°C		±0.10%		
$SENS_{MS\_XY\_A1}$	Sensitivity mismatch among X-Y axes	T_A = 25°C		±0.75%		
$SENS_{MS\_Z\_A1}$	Sensitivity mismatch among Y-Z, or X-Z axes	T_A = 25°C		±0.55%		
$SENS_{MS\_DR\_XY\_A1}$	Sensitivity mismatch drift from 25°C value; X-Y axes			±1.5%		
$SENS_{MS\_DR\_Z\_A1}$	Sensitivity mismatch drift from 25°C value; Y-Z, or X-Z axes			±1.5%		
$SENS_{LDR\_A1}$	Sensitivity Lifetime drift, X, Y, Z axis	T_A = 25°C		±1.0%		
B_{off_A1}	Offset	T_A = 25°C		±100		µT
$B_{off\_TC\_A1}$	Offset drift from 25°C value			±1.2		µT/°C
$B_{off\_DR\_A1}$	Offset Lifetime drift	T_A = 25°C		±100		µT
$N_{RMS\_XY\_00\_000\_A1}$	RMS (1 Sigma) magnetic noise (X or Y-axis) T_A = 25°C	LP_LN = 0b CONV_AVG = 000b		98		µT
$N_{RMS\_XY\_01\_000\_A1}$		LP_LN = 1b CONV_AVG = 000b		87		µT
$N_{RMS\_XY\_00\_101\_A1}$		LP_LN = 0b CONV_AVG = 101b		17.5		µT
$N_{RMS\_XY\_01\_101\_A1}$		LP_LN = 1b CONV_AVG = 101b		16		µT
$N_{RMS\_Z\_00\_000\_A1}$	RMS (1 Sigma) magnetic noise (Z axis) T_A = 25°C	LP_LN = 0b CONV_AVG = 000b		53		µT
$N_{RMS\_Z\_01\_000\_A1}$		LP_LN = 1b CONV_AVG = 000b		47		µT
$N_{RMS\_Z\_00\_101\_A1}$		LP_LN = 0b CONV_AVG = 101b		10		µT
$N_{RMS\_Z\_01\_101\_A1}$		LP_LN = 1b CONV_AVG = 101b		9		µT
$A_{ERR\_X\_Z\_101\_A1}$	X-Z Angle error in full 360 degree rotation T_A = 25°C	CONV_AVG = 101b		±0.5		Degree
$A_{ERR\_X\_Y\_101\_A1}$	X-Y Angle error in full 360 degree rotation T_A = 25°C	CONV_AVG = 101b		±0.25		Degree

over operating free-air temperature range (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$A_{DR\_X\_Z\_101\_A1}$	X-Z Angle temp drift from 25°C in full 360 degree rotation	CONV_AVG = 101b		±0.5		Degree
$A_{DR\_X\_Y\_101\_A1}$	X-Y Angle temp drift from 25°C in full 360 degree rotation	CONV_AVG = 101b		±0.25		Degree

6.8 Magnetic Characteristics For A2

over operating free-air temperature range (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$B_{IN\_A2\_X\_Y}$	Linear magnetic range	x_y_RANGE = 0b		±133		mT
$B_{IN\_A2\_X\_Y}$		x_y_RANGE = 1b		±266		mT
$B_{IN\_A2\_Z}$		z_RANGE = 0b		±133		mT
$B_{IN\_A2\_Z}$		z_RANGE = 1b		±266		mT
$SENS_{133\_A2}$	Sensitivity, X, Y, or Z axis	±133 mT range		246		LSB/mT
$SENS_{266\_A2}$		±266 mT range		123		LSB/mT
$SENS_{ER\_PC\_25C\_A2}$	Sensitivity error, X, Y, Z axis	T_A = 25°C		± 0.5%		
$SENS_{ER\_PC\_TEMP\_A2}$	Sensitivity drift from 25°C, X, Y, Z axis			±1.5%		
$SENS_{LER\_XY\_A2}$	Sensitivity Linearity Error, X, Y-axis	T_A = 25°C		±0.10%		
$SENS_{LER\_Z\_A2}$	Sensitivity Linearity Error, Z axis	T_A = 25°C		±0.10%		
$SENS_{MS\_XY\_A2}$	Sensitivity mismatch among X-Y axes	T_A = 25°C		±0.50%		
$SENS_{MS\_Z\_A2}$	Sensitivity mismatch among Y-Z, or X-Z axes	T_A = 25°C		±0.55%		
$SENS_{MS\_DR\_XY\_A2}$	Sensitivity mismatch drift from 25°C value; X-Y axes			±1.5%		
$SENS_{MS\_DR\_Z\_A2}$	Sensitivity mismatch drift from 25°C value; Y-Z, or X-Z axes			±1.5%		
$SENS_{LDR\_A2}$	Sensitivity Lifetime drift, X, Y, Z axis	T_A = 25°C		±1.0%		
B_{off_A2}	Offset	T_A = 25°C		±100		µT
$B_{off\_TC\_A2}$	Offset drift from 25°C value			±1.2		µT/°C
$B_{off\_DR\_A2}$	Offset Lifetime drift	T_A = 25°C		±100		µT
$N_{RMS\_XY\_00\_000\_A2}$	RMS (1 Sigma) magnetic noise (X or Y-axis)	LP_LN =0 b CONV_AVG = 000b		127		µT
$N_{RMS\_XY\_01\_000\_A2}$		LP_LN = 1b CONV_AVG = 000b		117		µT
$N_{RMS\_XY\_00\_010\_A2}$		LP_LN = 0b CONV_AVG = 101b		22		µT
$N_{RMS\_XY\_10\_010\_A2}$		LP_LN = 1b CONV_AVG = 101b		21		µT
$N_{RMS\_Z\_00\_000\_A2}$	RMS (1 Sigma) magnetic noise (Z axis)	LP_LN = 0b CONV_AVG = 000b		93		µT
$N_{RMS\_Z\_10\_000\_A2}$		LP_LN = 1b CONV_AVG = 000b		88		µT
$N_{RMS\_Z\_00\_101\_A2}$		LP_LN = 0b CONV_AVG = 101b		16		µT
$N_{RMS\_Z\_10\_101\_A2}$		LP_LN = 1b CONV_AVG = 101b		15.5		µT
$A_{ERR\_X\_Z\_101\_A2}$	X-Z Angle error in full 360 degree rotation T_A = 25°C	CONV_AVG = 101b		±0.5		Degree

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over operating free-air temperature range (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$A_{ERR\_X\_Y\_101\_A2}$	X-Y Angle error in full 360 degree rotation T_A = 25°C	CONV_AVG = 101b		±0.25		Degree
$A_{DR\_X\_Z\_101\_A2}$	X-Z Angle temp drift from 25°C in full 360 degree rotation	CONV_AVG = 101b		±0.5		Degree
$A_{DR\_X\_Y\_101\_A2}$	X-Y Angle temp drift from 25°C in full 360 degree rotation	CONV_AVG = 101b		±0.25		Degree

6.9 Magnetic Temp Compensation Characteristics

over operating free-air temperature range (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$TC_{\_00}$	Temperature compensation (X, Y, Z-axes)	TEMPCO = 00b		0		%/°C
$TC_{\_12}$		TEMPCO = 01b		0.12		%/°C
$TC_{\_03}$		TEMPCO = 10b		0.03		%/°C
$TC_{\_20}$		TEMPCO = 11b		0.2		%/°C

6.10 I2C Interface Timing

over operating free-air temperature range (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
I2C Interface Fast Mode Plus						
f_{I2C_fmp}	I2C clock (SCL) frequency	LOAD = 50 pF			1000	KHz
t_{whigh_fmp}	High time: SCL logic high time duration		350			ns
t_{wlo_wfmp}	Low time: SCL logic low time duration		500			ns
$t_{su\_cs\_fmp}$	SDA data setup time		50			ns
$t_{h\_cs\_fmp}$	SDA data hold time		120			ns
t_{icr_fmp}	SDA, SCL input rise time				120	ns
t_{icf_fmp}	SDA, SCL input fall time				55	ns
$t_{h\_ST\_fmp}$	Start condition hold time		0.1			µs
$t_{su\_SR\_fmp}$	Repeated start condition setup time		0.1			µs
$t_{su\_SP\_fmp}$	Stop condition setup time		0.1			µs
$t_{w\_SP\_SR\_fmp}$	Bus free time between stop and start condition		0.2			µs
I2C Interface Fast Mode						
f_{I2C}	I2C clock (SCL) frequency	LOAD = 50 pF			400	KHz
t_{whigh}	High time: SCL logic high time duration		600			ns
t_{wlow}	Low time: SCL logic low time duration		1300			ns
t_{su_cs}	SDA data setup time		100			ns
t_{h_cs}	SDA data hold time		0			ns
t_{icr}	SDA, SCL input rise time				300	ns
t_{icf}	SDA, SCL input fall time				300	ns
t_{h_ST}	Start condition hold time		0.3			µs
t_{su_SR}	Repeated start condition setup time		0.3			µs
t_{su_SP}	Stop condition setup time		0.3			µs
$t_{w\_SP\_SR}$	Bus free time between stop and start condition		0.6			µs

6.11 Power up Timing

over operating free-air temperature range (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$t_{start\_power\_up}$	Time to go to stand-by mode after V_{CC} supply voltage crossing V_{CC_MIN}			270		µs
t_{start_sleep}	Time to go to stand-by mode from sleep mode(1)			50		µs
$t_{start\_measure}$	Time to go into continuous measure mode from stand-by mode			70		µs
$t_{measure}$	Conversion time	CONV_AVG = 000b, OPERATING_MODE =10b, only one channel enabled		50		µs
$t_{measure}$	Conversion time	CONV_AVG = 101b, OPERATING_MODE =10b, only one channel enabled		825		µs
t_{go_sleep}	Time to go into sleep mode after SCL goes high			20		µs

(1) The device will recognize the I2C communication from a primary only during stand-by or continuous measure modes. While the device is in sleep mode, a valid secondary address will wake up the device but no acknowledge will be sent to the primary. Start up time need to be considered before addressing the device after wake up.

6.12 Typical Characteristics

at T_A = 25°C typical (unless otherwise noted)

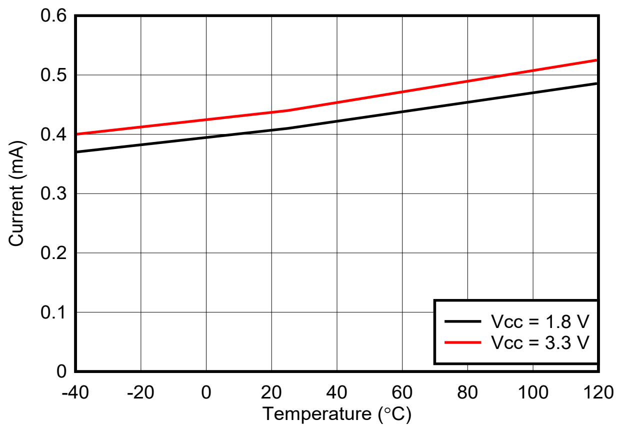


图 6-1. Standby Mode ICC vs Temperature

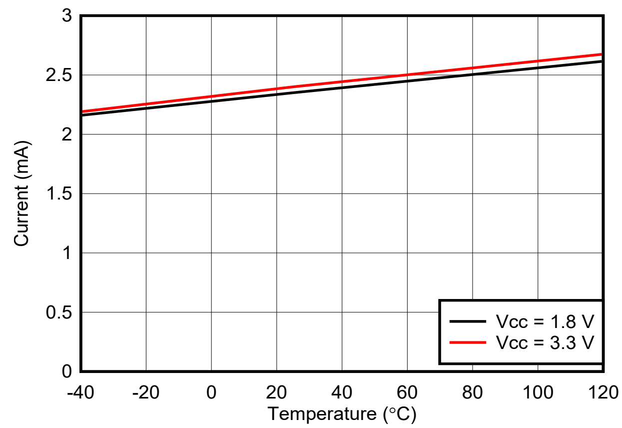


图 6-2. Active Mode ICC vs Temperature

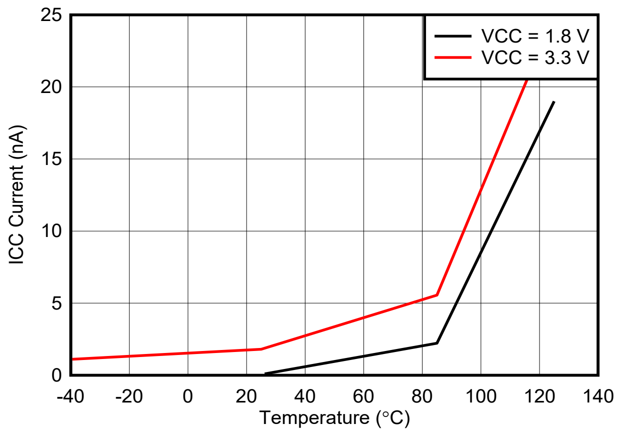


图 6-3. Sleep Mode ICC vs Temperature

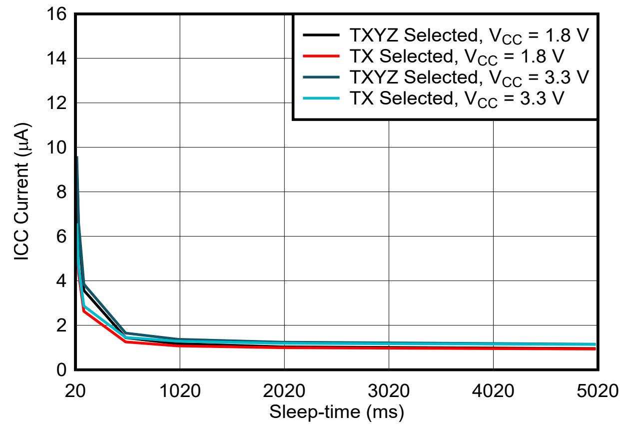


图 6-4. Average ICC vs W&S Mode Sleep Time

7 详细说明

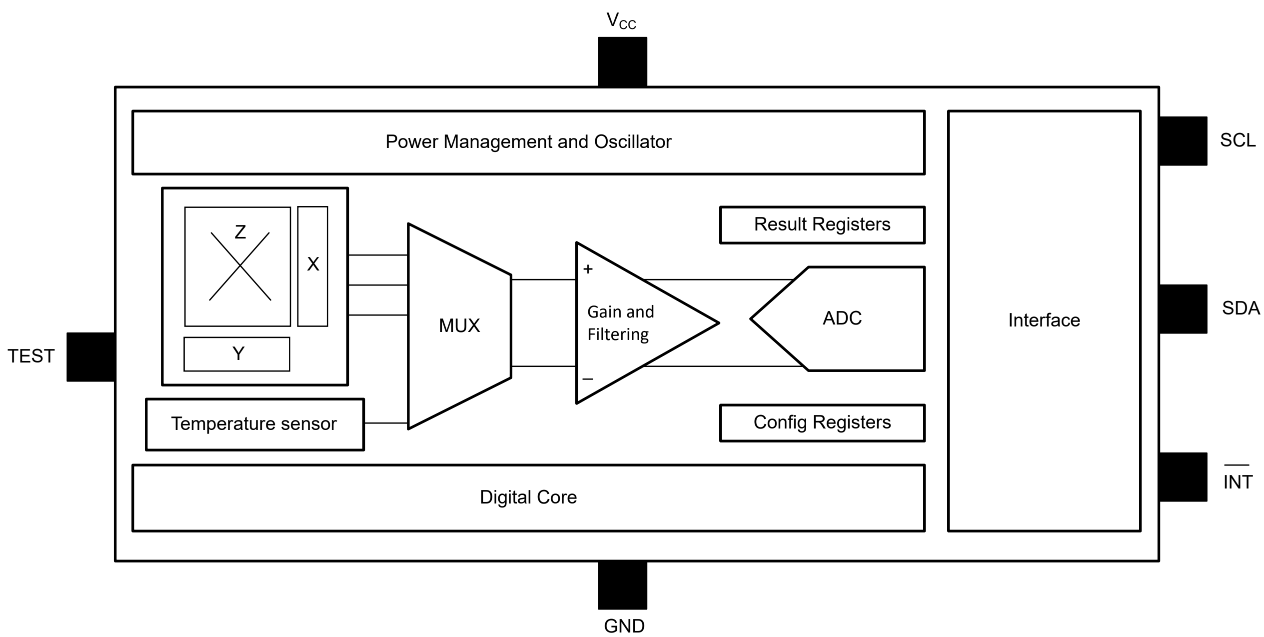
7.1 概述

TMAG5173-Q1 IC 基于德州仪器 (TI) 的霍尔效应技术和精密混合信号电路。输出信号（原始 X、Y、Z 磁数据和温度数据）可通过 I²C 接口访问。

该 IC 包含以下功能块和构建块：

- 电源管理和振荡器模块包含一个低功耗振荡器、偏置电路、欠压检测电路和一个快速振荡器。
- 传感和温度测量模块包含霍尔偏置、带多路复用器的霍尔传感器、噪声滤波器、积分器电路、温度传感器和 ADC。霍尔效应传感器数据和温度数据通过同一 ADC 进行多路复用。
- 接口模块包含 I²C 控制电路、ESD 保护电路和所有 I/O 电路。TMAG5173-Q1 支持多个 I²C 读取帧以及集成循环冗余校验 (CRC)。

7.2 功能方框图



7.3 Feature Description

7.3.1 磁通量方向

如图 7-1 所示，TMAG5173-Q1 将在靠近磁体北极时生成正 ADC 代码。同样，如果磁体南极从同一方向接近，TMAG5173-Q1 将生成负 ADC 代码。

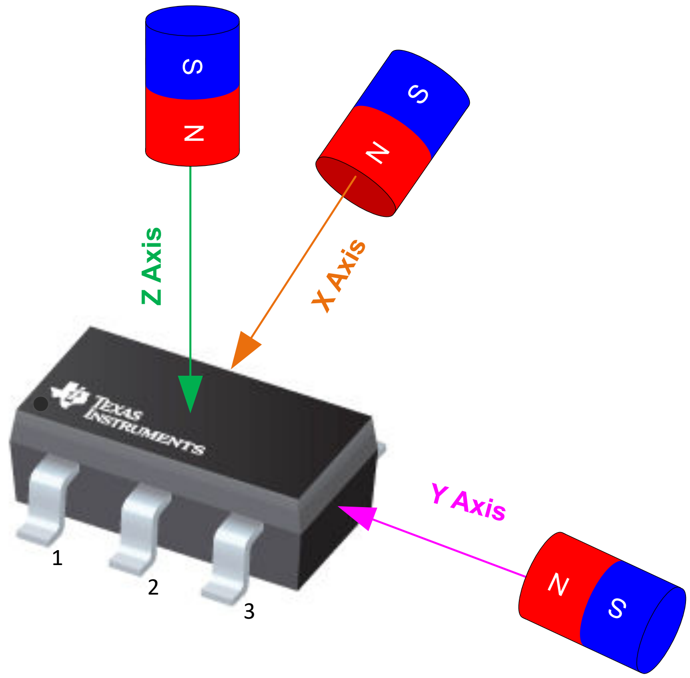


图 7-1. 灵敏度方向

7.3.2 Sensor Location

图 7-2 shows the location of X, Y, Z hall elements inside the TMAG5173-Q1.

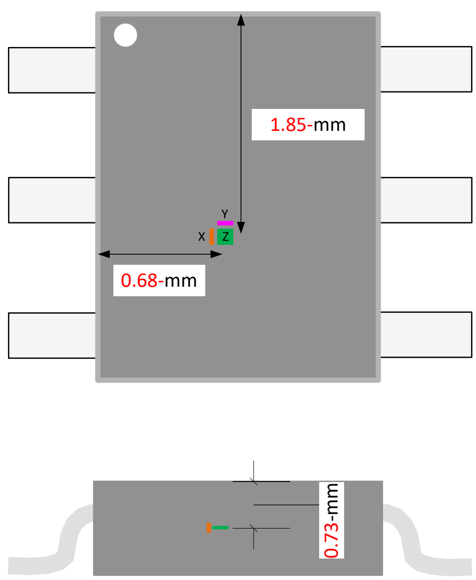


图 7-2. Location of X, Y, Z Hall Elements

7.3.3 Interrupt Function

The TMAG5173-Q1 supports flexible and configurable interrupt functions through either the $\overline{INT}$ or the SCL pin. 表 7-1 shows different conversion completion events where result registers and SET_COUNT bits update, and where they do not.

表 7-1. Result Register & SET_COUNT Update After Conversion Completion

INT_MODE	MODE DESCRIPTION	I²C BUS BUSY, NOT TALKING TO DEVICE		I²C BUS BUSY & TALKING TO DEVICE		I²C BUS NOT BUSY	
		RESULT UPDATE?	SET_COUNT UPDATE?	RESULT UPDATE?	SET_COUNT UPDATE?	RESULT UPDATE?	SET_COUNT UPDATE?
000b	No interrupt	Yes	Yes	No	No	Yes	Yes
001b	Interrupt through $\overline{INT}$	Yes	Yes	No	No	Yes	Yes
010b	Interrupt through $\overline{INT}$ except when I²C busy	Yes	Yes	No	No	Yes	Yes
011b	Interrupt through SCL	Yes	Yes	No	No	Yes	Yes
100b	Interrupt through SCL except when I²C busy	No	No	No	No	Yes	Yes

备注

TI does not recommend sharing the same I²C bus with multiple secondary devices when using the SCL pin for interrupt function. The SCL interrupt may corrupt transactions with other secondary devices if present in the same I²C bus.

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7.3.3.1 Interrupt Through SCL

图 7-3 shows an example for interrupt function through the SCL pin with the device programmed to wake-up and sleep mode for threshold cross at a predefined intervals. The wake-up intervals can be set through the SLEEPTIME bits. When the magnetic threshold cross is detected, the device asserts a fixed width interrupt signal through the SCL pin, and goes back to standby mode.

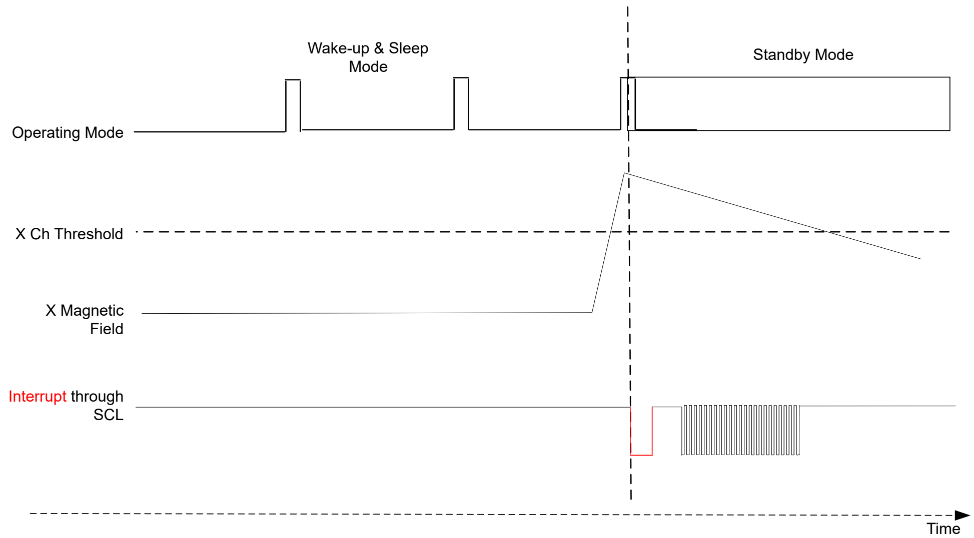

图 7-3. Interrupt Through SCL

7.3.3.2 Fixed Width Interrupt Through INT

图 7-4 shows an example for fixed-width interrupt function through the INT pin. The device is programmed to be in wake-up and sleep mode to detect a magnetic threshold. The INT_STATE register bit is set 1b. When the magnetic threshold cross is detected, the device asserts a fixed width interrupt signal through the INT pin, and goes back to standby mode.

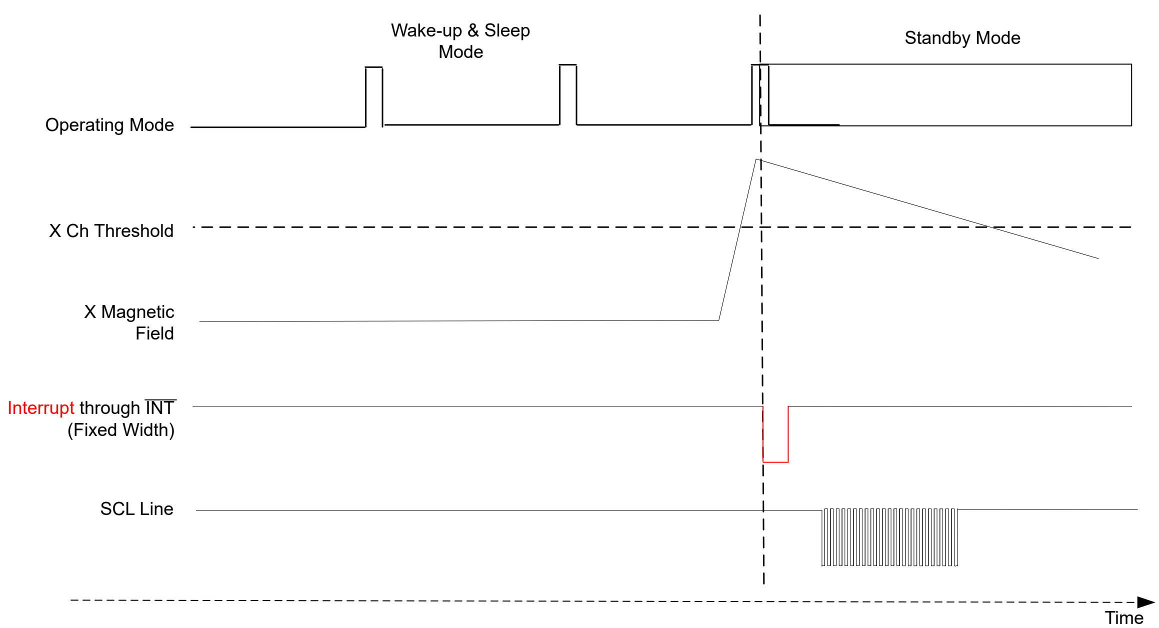

图 7-4. Fixed Width Interrupt Through INT

7.3.3.3 Latched Interrupt Through INT

图 7-5 shows an example for latched interrupt function through the INT pin. The device is programmed to be in wake-up and sleep mode to detect a magnetic threshold. The INT_STATE register bit is set 0b. When the magnetic threshold cross is detected, the device asserts a latched interrupt signal through the INT pin, and goes back to standby mode. The interrupt latch is cleared only after the device receives a valid address through the SCL line.

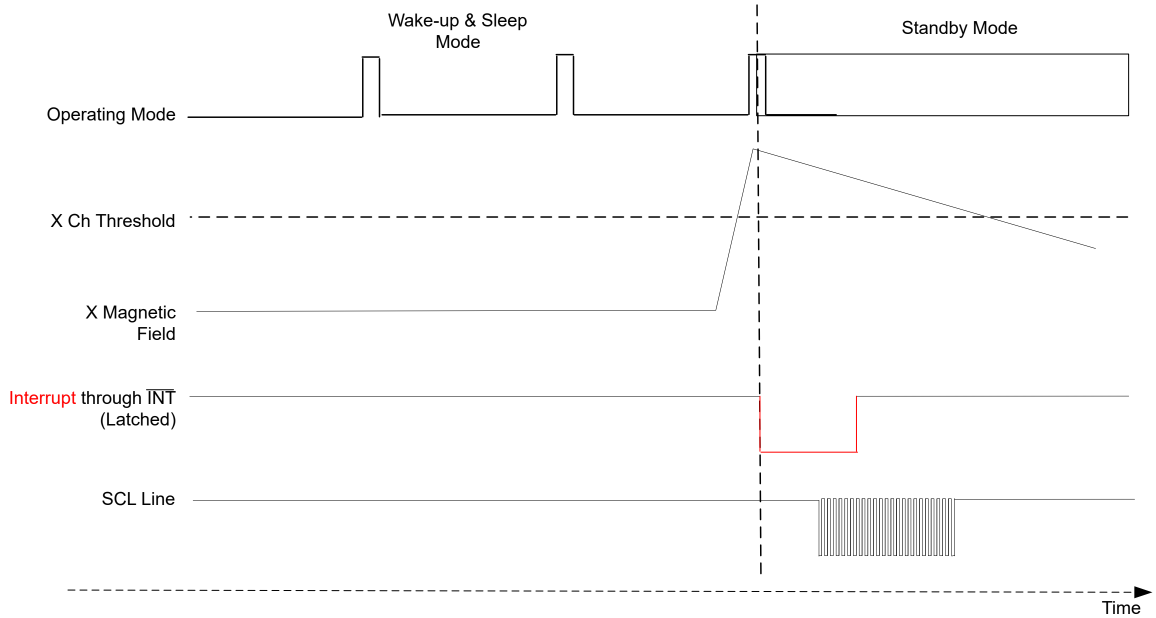

图 7-5. Latched Interrupt Through INT

7.3.4 Device I²C Address

表 7-2 shows the default factory programmed I²C addresses of the TMAG5173-Q1. The device needs to be addressed with the factory default I²C address after power up. If required, a primary can assign a new I²C address through the I2C_ADDRESS register bits after power up.

表 7-2. I²C Default Address

DEVICE VERSION	MAGNETIC RANGE	I²C ADDRESS (7 MSB BITS)	I²C WRITE ADDRESS (8-BIT)	I²C READ ADDRESS (8-BIT)
TMAG5173A1	±40 mT, ±80 mT	35h	6Ah	6Bh
TMAG5173B1		22h	44h	45h
TMAG5173C1		78h	F0h	F1h
TMAG5173D1		44h	88h	89h
TMAG5173A2	±133 mT, ±266 mT	35h	6Ah	6Bh
TMAG5173B2		22h	44h	45h
TMAG5173C2		78h	F0h	F1h
TMAG5173D2		44h	88h	89h

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7.3.5 Magnetic Range Selection

表 7-3 shows the magnetic range selection for the TMAG5173-Q1 device. The X, Y, and Z axes range can be selected with the X_Y_RANGE and Z_RANGE register bits.

表 7-3. Magnetic Range Selection

	RANGE REGISTER SETTING	TMAG5173A1	TMAG5173A2	COMMENT
X, Y Axis Field	X_Y_RANGE = 0b	±40 mT	±133 mT	
	X_Y_RANGE = 1b	±80 mT	±266 mT	Better SNR performance
Z Axis Field	Z_RANGE = 0b	±40 mT	±133 mT	
	Z_RANGE = 1b	±80 mT	±266 mT	Better SNR performance

7.3.6 Update Rate Settings

The TMAG5173-Q1 offers multiple update rates to offer design flexibility to system designers. The different update rates can be selected with the CONV_AVG register bits. 表 7-4 shows different update rate settings for the TMAG5173-Q1.

表 7-4. Update Rate Settings

OPERATING MODE	REGISTER SETTING	UPDATE RATE			COMMENT
		SINGLE AXIS	TWO AXES	THREE AXES	
X, Y, Z Axis	CONV_AVG = 000b	20.0 kSPS	13.3 kSPS	10.0 kSPS	Fastest update rate
X, Y, Z Axis	CONV_AVG = 001b	13.3 kSPS	8.0 kSPS	5.7 kSPS	
X, Y, Z Axis	CONV_AVG = 010b	8.0 kSPS	4.4 kSPS	3.1 kSPS	
X, Y, Z Axis	CONV_AVG = 011b	4.4 kSPS	2.4 kSPS	1.6 kSPS	
X, Y, Z Axis	CONV_AVG = 100b	2.4 kSPS	1.2 kSPS	0.8 kSPS	
X, Y, Z Axis	CONV_AVG = 101b	1.2 kSPS	0.6 kSPS	0.4 kSPS	Best SNR case

7.4 Device Functional Modes

The TMAG5173-Q1 supports multiple functional modes for wide array of applications as explained in 图 7-6. A specific functional mode is selected by setting the corresponding value in the OPERATING_MODE register bits. The device starts powering up after VCC supply crosses the minimum threshold as specified in the *Recommended Operating Conditions* (ROC) table.

7.4.1 Standby (Trigger) Mode

The TMAG5173-Q1 goes to stand-by mode after first-time power up. At this mode, the digital circuitry and oscillators are on and the device is ready to accept commands from the primary device. Based off the commands the device can start a sensor data conversion, go to power saving mode or the start data transfer through I^2C interface. A new conversion can be triggered through I^2C command or through $\overline{INT}$ pin. In this mode the device retains the immediate past conversion result data in the corresponding result registers. The time it takes for the device to go to standby mode from power up is denoted by $T_{start\_power\_up}$.

7.4.2 Sleep Mode

The TMAG5173-Q1 supports an ultra-low power sleep mode where it retains the critical user configuration settings. In this mode the device doesn't retain the conversion result data. A primary can wake up the device from sleep mode through I^2C communications or the $\overline{INT}$ pin. The time it takes for the device to go to standby mode from sleep mode is denoted by T_{start_sleep}.

7.4.3 Wake-up and Sleep (W&S) Mode

In this mode the TMAG5173-Q1 can be configured to go to sleep and wake up at a certain interval, and measure sensor data based off the SLEEPTIME register bits setting. The device can be set to generate an interrupt through the INT_CONFIG_1 register. Once the conversion is complete and the interrupt condition is met, the TMAG5173-Q1 will exit the W&S mode and go to the standby mode. The last measured data will be stored in the corresponding result registers before the device goes to the standby mode. If the interrupt condition isn't met, the device will continue to be in the W&S mode to wake up and measure data at the specified interval. A primary can wake up the TMAG5173-Q1 anytime during the W&S mode through I^2C bus or $\overline{INT}$ pin. The time it takes for the device to go to standby mode from W&S mode is denoted by T_{start_sleep}.

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7.4.4 Continuous Measure Mode

In this mode the TMAG5173-Q1 continuously measures the sensor data per SENSOR_CONFIG & DEVICE_CONFIG register settings. In this mode the result registers can be accessed through the I2C lines. The time it takes for the device to go from standby mode to continuous measure mode is denoted by $T_{start\_measure}$.

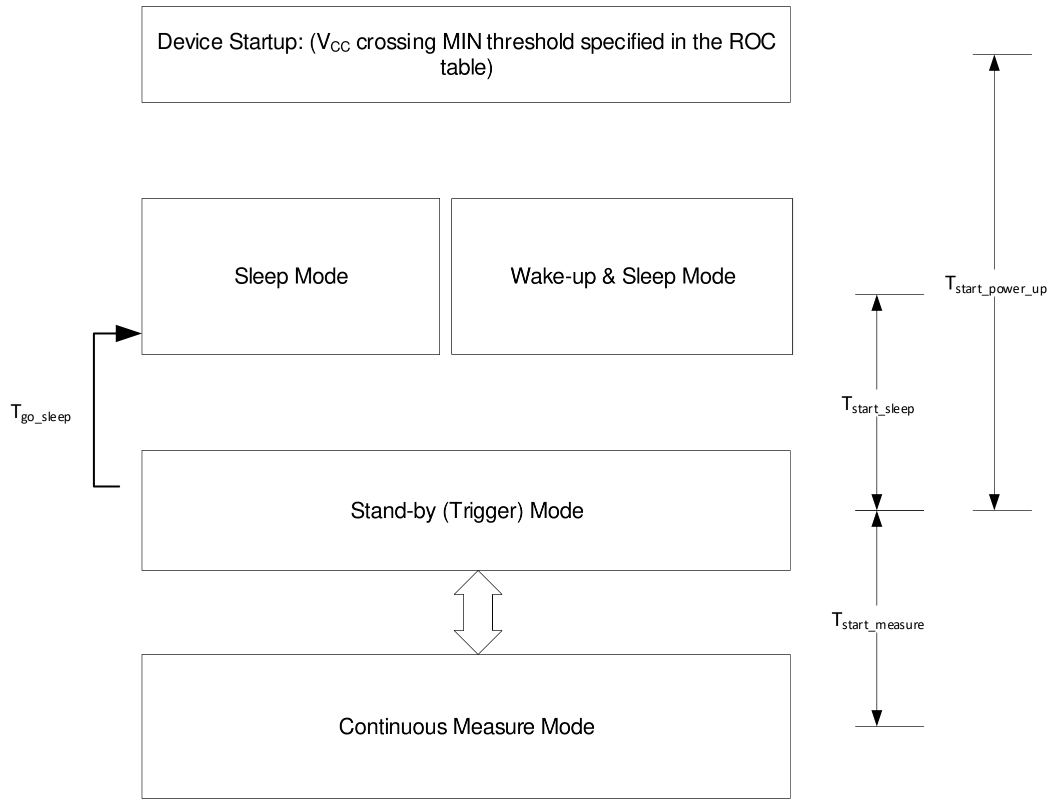

图 7-6. TMAG5173-Q1 Power-Up Sequence

表 7-5 shows different device operational modes of the TMAG5173-Q1.

表 7-5. Operating Modes

OPERATING MODE	DEVICE FUNCTION	ACCESS TO USER REGISTERS	RETAIN USER CONFIGURATION	COMMENT
Continuous Measure Mode	Continuously measuring x, y, z axis, or temperature data	Yes	Yes	
Standby Mode	Device is ready to accept I^{2}C commands and start active conversion	Yes	Yes	
Wake-up and Sleep Mode	Wakes up at a certain interval to measure the x, y, z axis, or temperature data	No	Yes	1, 5, 10, 15, 20, 30, 50, 100, 500, 1000, 2000, 5000, & 20000-ms intervals supported.
Sleep Mode	Device retains key configuration settings, but doesn't retain the measurement data	No	Yes	Sleep mode can be utilized by a primary device to implement other power saving intervals not supported by wake-up and sleep mode.

7.5 Programming

7.5.1 I^2C 接口

TMAG5173-Q1 提供了 I^2C 接口，这是一种两线制接口，用于连接各种低速器件，例如微控制器、模数转换器和数模转换器、I/O 接口和嵌入式系统中的其他类似外设。

7.5.1.1 SCL

The SCL is the clock line used to synchronize all data transfers over the I^2C bus.

7.5.1.2 SDA

SDA 是 I^2C 接口的双向数据线。

7.5.1.3 I^2C Read/Write

The TMAG5173-Q1 supports multiple I^2C read and write frames targeting different applications. I2C_RD and CRC_EN bits offers multiple read frames to optimize the read time, data resolution, and data integrity for a select application.

7.5.1.3.1 标准 I^2C 写入

图 7-7 显示了 TMAG5173-Q1 支持的标准 I^2C 二字节写入命令示例。起始字节包含 7 位辅助器件地址和 R/$\overline{W}$ 命令位“0”。第二个字节的 MSB 包含转换触发位。在该触发位写入“1”将在寄存器地址解码完成后开始新的转换。第二个字节的 7 个 LSB 位包含写入命令的起始寄存器地址。在两个命令字节之后，主器件开始发送要写入相应寄存器地址的数据。每个连续写入字节将发送辅助器件中连续寄存器地址对应的数据。

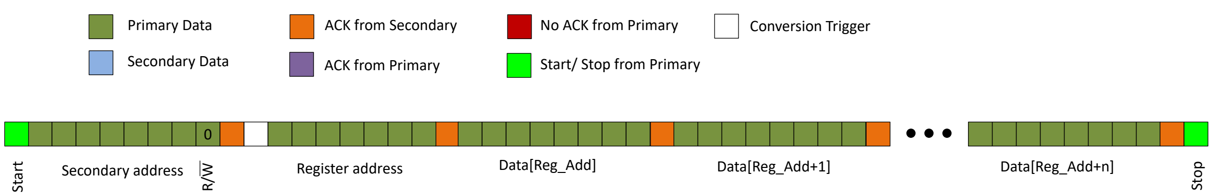

图 7-7. 标准 I^2C 写入

7.5.1.3.2 通用广播写入

图 7-8 显示了 TMAG5173-Q1 支持的通用广播 I^2C 写入命令示例。此命令对于同时配置 I^2C 总线上的多个 I^2C 器件非常有用。起始字节包含 8 位“0”。第二个字节的 MSB 包含转换触发位。在该触发位写入“1”将在寄存器地址解码完成后开始新的转换。第二个字节的 7 个 LSB 位包含写入命令的起始寄存器地址。在两个命令字节之后，主器件开始发送要写入 I^2C 总线上所有辅助器件所对应的寄存器地址的数据。每个连续写入字节将为辅助器件中的连续寄存器地址发送数据。

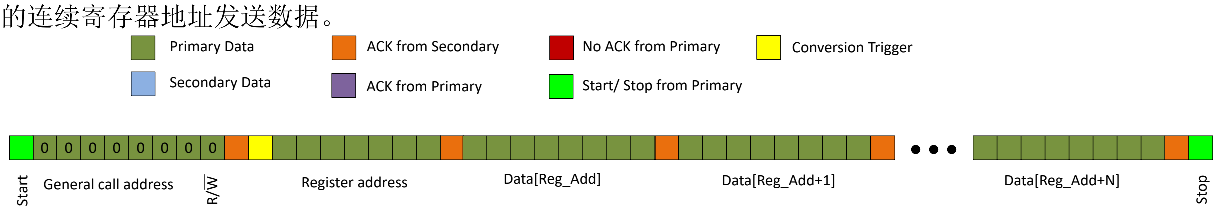

图 7-8. 通用广播 I^2C 写入

7.5.1.3.3 Standard 3-Byte I^{2}C Read

图 7-9 and 图 7-10 show examples of standard I^{2}C three byte read command supported by the TMAG5173-Q1. The starting byte contains 7-bit secondary device address and the R/$\overline{W}$ command bit '0'. The MSB of the second byte contains the conversion trigger command bit. Writing '1' at this trigger bit will start a new conversion after the register address decoding is completed. The 7 LSB bits of the second byte contains the starting register address for the write command. After receiving ACK signal from secondary, the primary send the secondary address once again with R/$\overline{W}$ command bit as '1'. The secondary starts to send the corresponding register data. It will send successive register data with each successive ACK from primary. If CRC is enabled, the secondary will send the fifth CRC byte based off the CRC calculation of immediate past 4 register bytes.

备注

In the standard 3-byte read command the TMAG5173-Q1 doesn't support CRC if the data length is more than 4 byte. Initiate successive read commands for larger data stream requiring CRC.

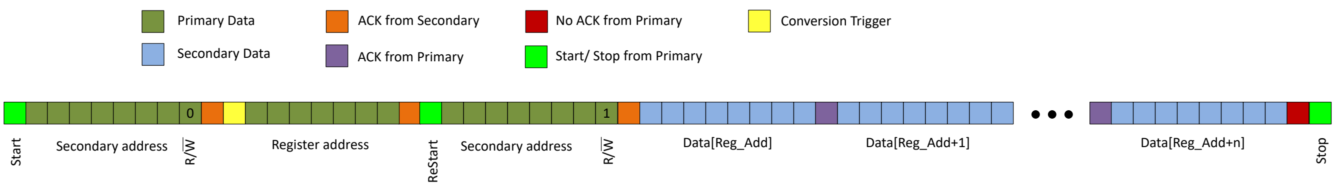

图 7-9. Standard 3-Byte I^{2}C Read With CRC Disabled, CRC_EN = 0b

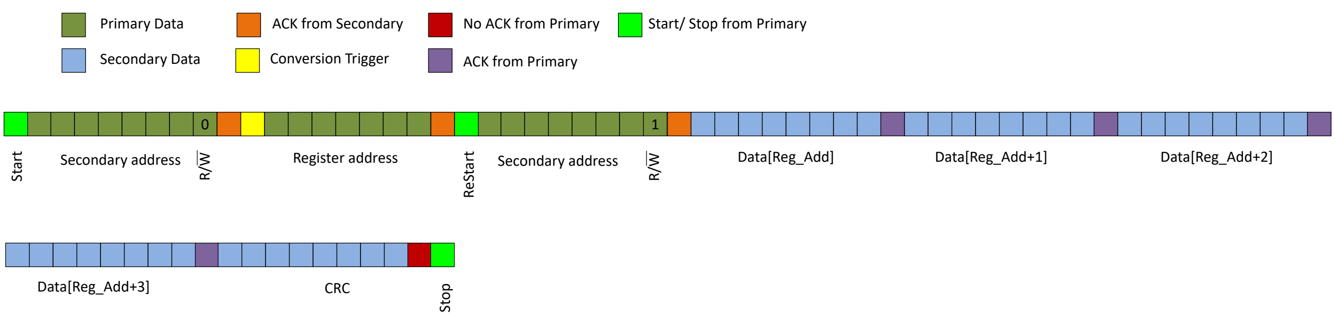

图 7-10. Standard 3-Byte I^{2}C Read With CRC Enabled, CRC_EN = 1b

7.5.1.3.4 1-Byte I2C Read Command for 16-Bit Data

图 7-11 and 图 7-12 show examples of 1-byte I^{2}C read command supported by the TMAG5173-Q1. Select I2C_RD =01b to enable this mode. The command byte contains 7-bit secondary device address and a '1' at the R/$\overline{W}$ bit. In this mode, per MAG_CH_EN and T_CH_EN bits setting, the device will send 16-bit data of the enabled channels and the CONV_STATUS register data byte. If CRC is enabled, the device will send an additional CRC byte based off the CRC calculation of the command byte and the data sent in the current packet. When multiple channels are enabled, the sent data follows the T, X, Y, and Z sequence in the successive data bytes.

图 7-11. 1-Byte I²C Read Command for 16-Bit Data With CRC Disabled, CRC_EN = 0b

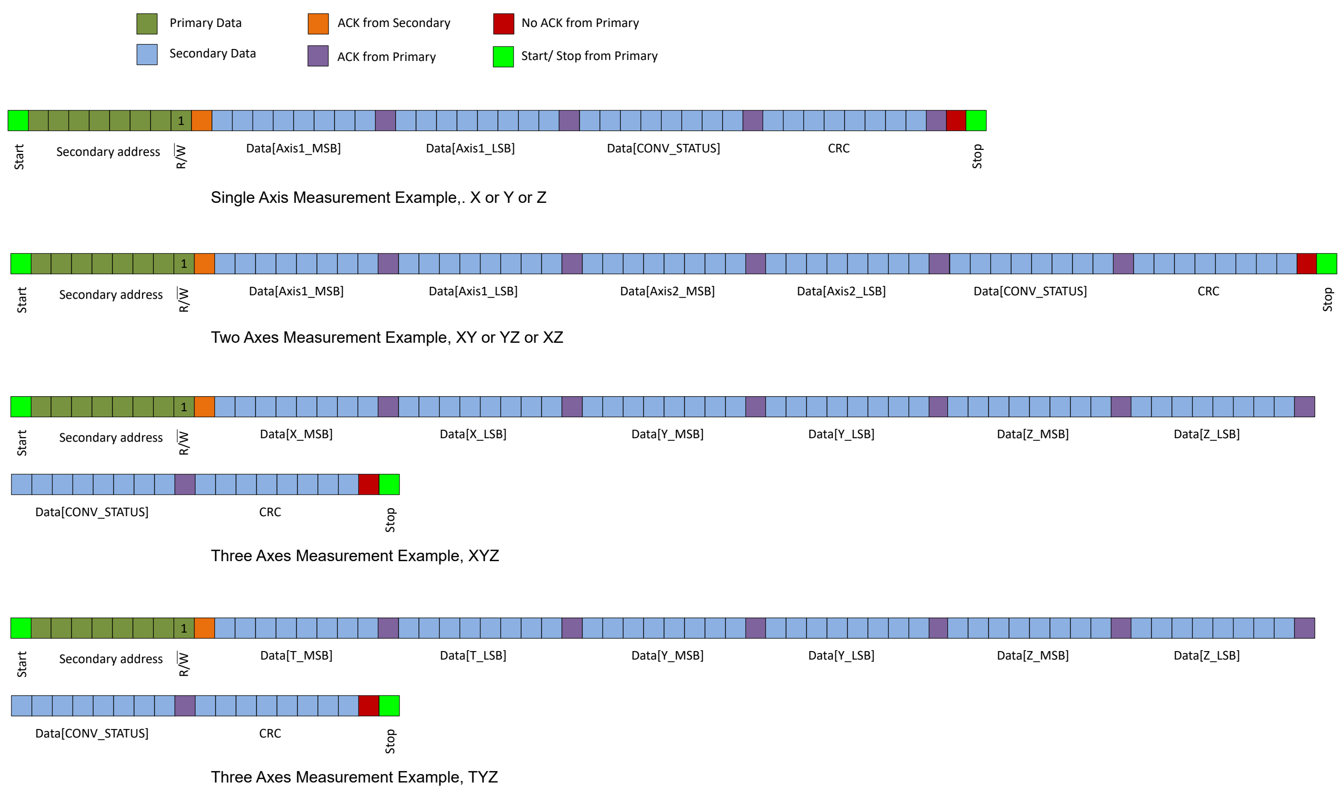

图 7-12. 1-Byte I²C Read Command for 16-Bit Data With CRC Enabled, CRC_EN = 1b

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备注

In the 1-byte read command for 16-bit data only up to 3 channels data can be sent when CRC is enabled. This restriction doesn't apply if CRC is disabled.

7.5.1.3.5 1-Byte I²C Read Command for 8-Bit Data

图 7-13 and 图 7-14 show examples of 1-byte I²C read command supported by the TMAG5173-Q1. Select I2C_RD =10b to enable this mode. The command byte contains 7-bit secondary device address and a '1' at the R/W̄ bit. In this mode, per MAG_CH_EN and T_CH_EN bits setting, the device will send 8-bit data of the enabled channels and the CONV_STATUS register data byte. If CRC is enabled, the device will send an additional CRC byte based off the CRC calculation of the command byte and the data sent in the current packet. When multiple channels are enabled, the sent data follows the T, X, Y, and Z sequence in the successive data bytes.

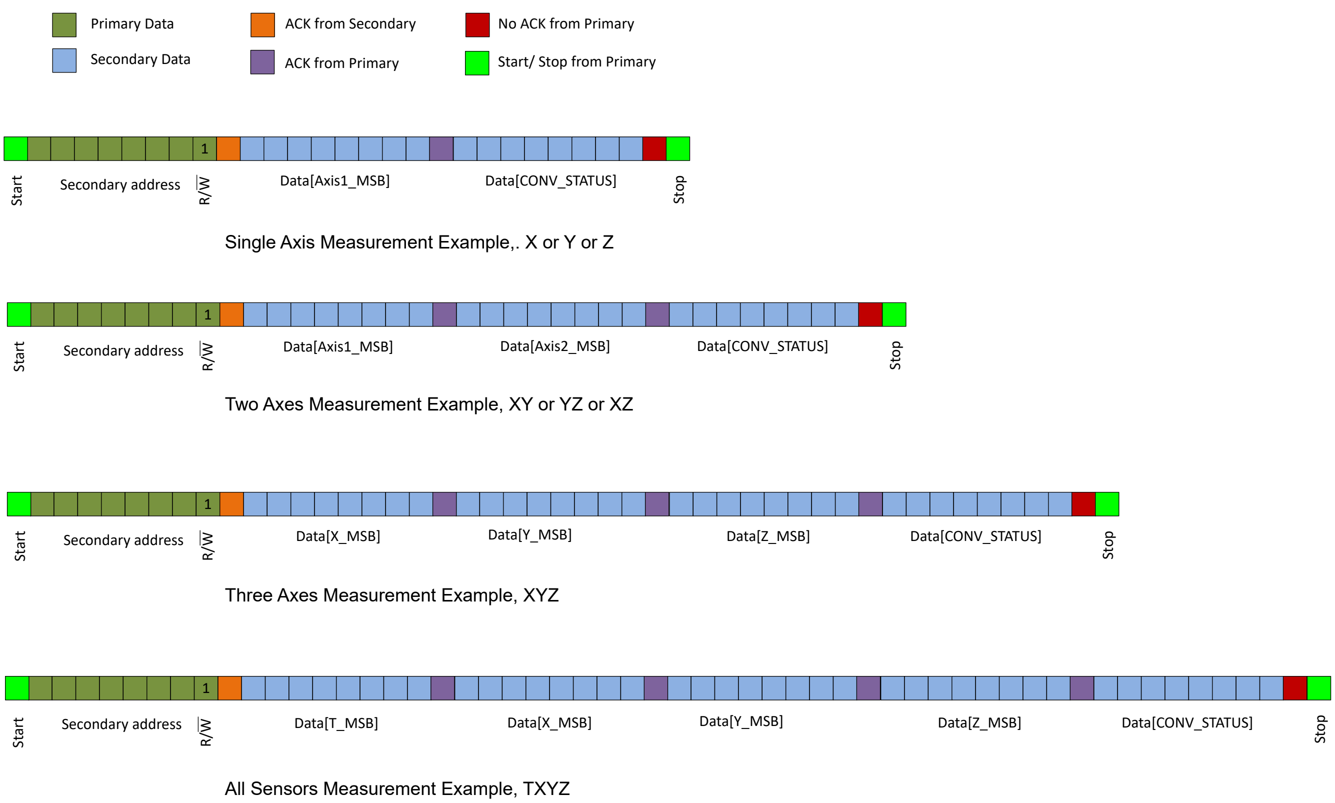

图 7-13. 1-Byte I²C Read Command for 8-Bit Data With CRC Disabled, CRC_EN = 0b

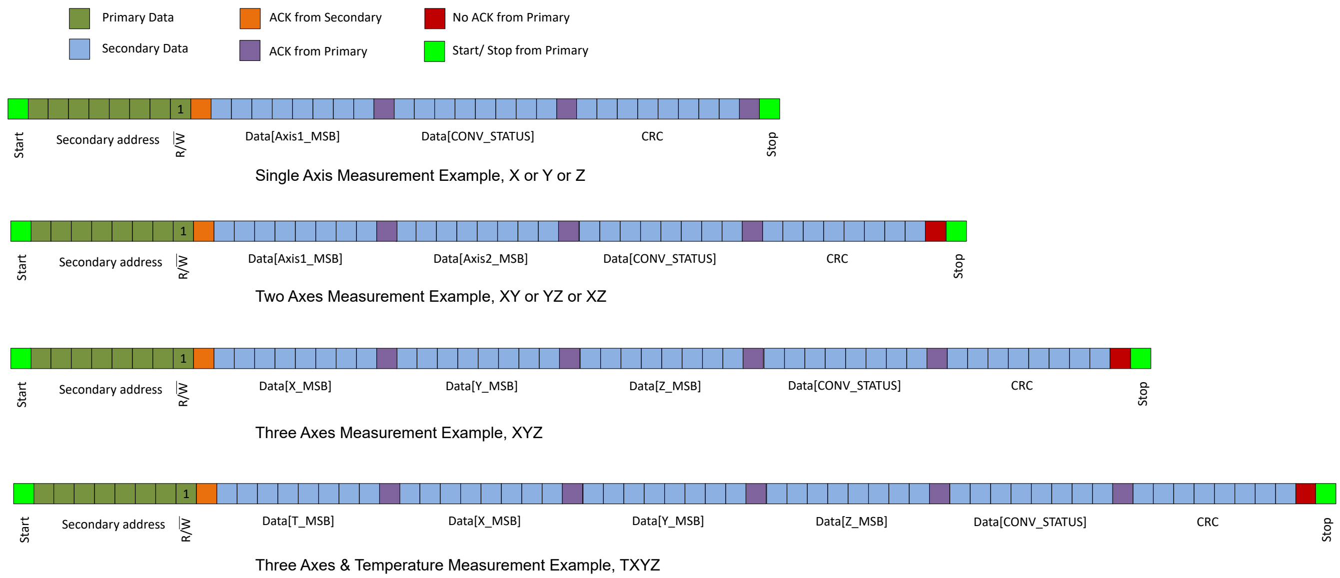

图 7-14. 1-Byte I²C Read Command for 8-Bit Data With CRC Enabled, CRC_EN = 1b

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备注

In the 1-byte read command for 8-bit data any combinations of channels can be sent without restrictions.

7.5.1.3.6 I²C Read CRC

The TMAG5173-Q1 supports optional CRC during I²C read. The CRC can be enabled through the CRC_EN register bit. The CRC is performed on a data string that is determined by the I²C read type. The CRC information is sent as a single byte after the data bytes. The code is generated by the polynomial $x^8 + x^2 + x + 1$. Initial CRC bits are FFh.

The following equations can be employed to calculate CRC:

d = Data Input, c = Initial CRC (FFh) (1)

newcrc[0] = d[7] ^ d[6] ^ d[0] ^ c[0] ^ c[6] ^ c[7] (2)

newcrc[1] = d[6] ^ d[1] ^ d[0] ^ c[0] ^ c[1] ^ c[6] (3)

newcrc[2] = d[6] ^ d[2] ^ d[1] ^ d[0] ^ c[0] ^ c[1] ^ c[2] ^ c[6] (4)

newcrc[3] = d[7] ^ d[3] ^ d[2] ^ d[1] ^ c[1] ^ c[2] ^ c[3] ^ c[7] (5)

newcrc[4] = d[4] ^ d[3] ^ d[2] ^ c[2] ^ c[3] ^ c[4] (6)

newcrc[5] = d[5] ^ d[4] ^ d[3] ^ c[3] ^ c[4] ^ c[5] (7)

newcrc[6] = d[6] ^ d[5] ^ d[4] ^ c[4] ^ c[5] ^ c[6] (8)

newcrc[7] = d[7] ^ d[6] ^ d[5] ^ c[5] ^ c[6] ^ c[7] (9)

The following examples show calculated CRC byte based off various input data:

I2C Data 00h : CRC = F3h

I2C Data FFh : CRC = 00h

I2C Data 80h : CRC = 7Ah

I2C Data 4Ch : CRC = 10h

I2C Data E0h : CRC = 5Dh

I2C Data 00000000h : CRC = D1h

I2C Data FFFFFFFFh : CRC = 0Fh

7.5.2 数据定义

7.5.2.1 磁传感器数据

X、Y 和 Z 磁传感器数据存储在 x_MSB_RESULT 和 x_LSB_RESULT 寄存器中。图 7-15 显示了每个传感器输出以 16 位二进制补码格式存储在两个 8 位寄存器中。数据可以结合 MSB 和 LSB 寄存器以 16 位格式检索，也可以通过 MSB 寄存器以 8 位格式检索。

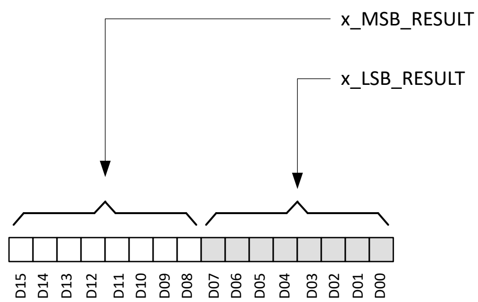

图 7-15. 磁传感器数据定义

对于 16 位数据，测量的磁场可以使用方程式 10 来计算，而对于 8 位数据，则可以使用方程式 11 来计算。

$$B = \frac{-\left(D_{15} \times 2^{15}\right) + \sum_{i=0}^{14} D_i \times 2^i}{2^{16}} \times 2\left|B_R\right| \quad (10)$$

其中

- B 表示磁场，单位为 mT。
- D_i 是图 7-15 中所示的数据位。
- B_R 是相应通道的磁场范围，以 mT 为单位。

$$B = \frac{-\left(D_{15} \times 2^{7}\right) + \sum_{i=0}^{6} D_{i+8} \times 2^i}{2^{8}} \times 2\left|B_R\right| \quad (11)$$

7.5.2.2 Temperature Sensor Data

The TMAG5173-Q1 will measure temperature from –40°C to 170°C. The temperature sensor data are stored in T_MSB_RESULT and T_LSB_RESULT registers. 图 7-16 shows the sensor output stored in a 16-bit 2's complement format in two 8-bit registers. The data can be retrieved as 16-bit format combining both MSB and LSB registers, or as 8-bit format through the MSB register.

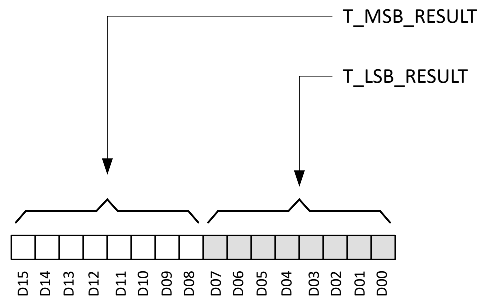

图 7-16. Temperature Sensor Data Definition

Use 方程式 12 to calculate the measured temperature in degree Celsius for 16-bit data, and use 方程式 13 to calculate the measured temperature for 8-bit data.

$$T = T_{SENS\_T0} + \frac{T_{ADC\_T} - T_{ADC\_T0}}{T_{ADC\_RES}} \tag{12}$$

$$T = T_{SENS\_T0} + \frac{256 \times \left(T_{ADC\_T} - \frac{T_{ADC\_T0}}{256}\right)}{T_{ADC\_RES}} \tag{13}$$

where

- T is the measured temperature in degree Celsius.
- T_{SENS_T0} as listed in the *Electrical Characteristics* table.
- T_{ADC_RES} is the change in ADC code per degree Celsius.
- T_{ADC_T0} as listed in the *Electrical Characteristics* table.
- T_{ADC_T} is the measured ADC code for temperature T.

7.5.2.3 Angle and Magnitude Data Definition

The TMAG5173-Q1 calculates the angle from a pair of magnetic axes based off the ANGLE_EN register bits setting. 图 7-17 shows the angle information stored in the ANGLE_RESULT_MSB and ANGLE_RESULT_LSB registers. Bits D04-D12 store angle integer value from 0 to 360 degree. Bits D00-D03 store fractional angle value. The 3-MSB bits are always populated as b000. Use 方程式 14 to calculate the angle value.

$$A = \sum_{i=4}^{12} D_i \times 2^{i-4} + \frac{\sum_{i=0}^{3} D_i \times 2^i}{16} \tag{14}$$

where

- A is the angle measured in degree.
- D_i is the data bit as shown in 图 7-17.

For example: a 354.50 degree is populated as 0001 0110 0010 1000b and a 17.25 degree is populated as 000 0001 0001 0100b.

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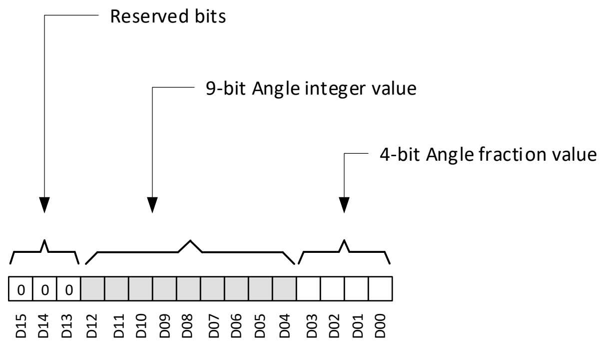

图 7-17. Angle Data Definition

During the angle calculation, use 方程式 15 to calculate the resultant vector magnitude.

$$M = \sqrt{MADC_{Ch1}{}^2 + MADC_{Ch2}{}^2} \quad (15)$$

where

- $MADC_{Ch1}$, $MADC_{Ch2}$ are the ADC codes of the two magnetic channels selected for the angle calculation.

图 7-18 shows the magnitude value stored in the MAGNITUDE_RESULT register. For on-axis angular measurement the magnitude value should remain constant across the full 360° measurement.

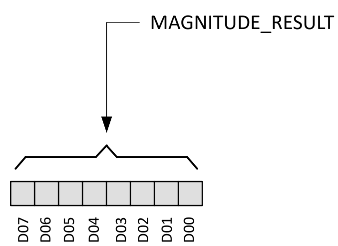

图 7-18. Magnitude Result Data Definition

7.5.2.4 Magnetic Sensor Offset Correction

The TMAG5173-Q1 enables offset correction for a pair of magnetic axes (see 图 7-19). The MAG_OFFSET_CONFIG_1 and MAG_OFFSET_CONFIG_2 registers store the offset values to be corrected in 2's complement data format. As an example, if the uncorrected waveform for a particular axis has a value that is +2 mT too high, the offset correction value of –2 mT should be entered in the corresponding offset correction register. The selection and order of the sensors are defined in the ANGLE_EN register bits setting. The default value of these offset correction registers are set as zero.

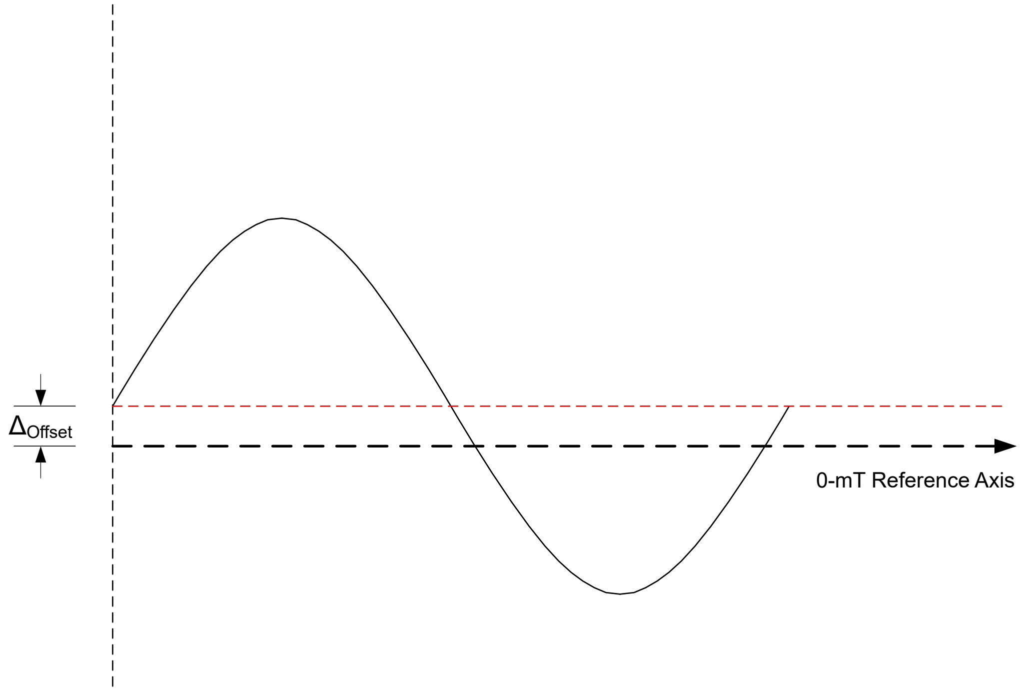

图 7-19. Magnetic Sensor Data Offset Correction

Use 方程式 16 to calculate the amount of offset for each axis. As an example, with a ±40 mT range, MAG_OFFSET_CONFIG_1 set at 1000 0000b, and MAG_OFFSET_CONFIG_2 set at 0001 0000b, the offset correction for the first axis is −2.5 mT and second axis is 0.312 mT.

$$\Delta_{Offset} = \frac{-\left(D_7 \times 2^7\right) + \sum_{i=0}^{6} D_i \times 2^i}{2^{12}} \times 2\left|B_R\right| \quad (16)$$

where

- Δ_{Offset} is the amount of offset correction to be applied in mT.
- D_i is the data bit in the MAG_OFFSET_CONFIG_1 or MAG_OFFSET_CONFIG_2 register.
- B_R is the magnetic range in mT for the corresponding channel.

Alternately, you can use 方程式 17 to calculate the values for MAG_OFFSET_CONFIG_1 or MAG_OFFSET_CONFIG_2 for a target offset correction.

$$\mathrm{MAG\_OFFSET} = \frac{2^{12} \times \Delta_{Offset}}{2\left|B_R\right|} \quad (17)$$

where

- MAG_OFFSET is the decimal value to be entered in the MAG_OFFSET_CONFIG_1 or MAG_OFFSET_CONFIG_2 register.
- Δ_{Offset} is the amount of offset correction to be applied in mT.
- B_R is the magnetic range in mT for the corresponding channel.

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7.6 TMAG5173 Registers

表 7-6 lists the memory-mapped registers for the TMAG5173 registers. All register offset addresses not listed in 表 7-6 should be considered as reserved locations and the register contents should not be modified.

表 7-6. TMAG5173 Registers

Offset	Acronym	Register Name	Section
0h	DEVICE_CONFIG_1	Configure Device Operation Modes	DEVICE_CONFIG_1 Register (Offset = 0h) [Reset = 00h]
1h	DEVICE_CONFIG_2	Configure Device Operation Modes	DEVICE_CONFIG_2 Register (Offset = 1h) [Reset = 00h]
2h	SENSOR_CONFIG_1	Sensor Device Operation Modes	SENSOR_CONFIG_1 Register (Offset = 2h) [Reset = 00h]
3h	SENSOR_CONFIG_2	Sensor Device Operation Modes	SENSOR_CONFIG_2 Register (Offset = 3h) [Reset = 00h]
4h	X_THR_CONFIG	X Threshold Configuration	X_THR_CONFIG Register (Offset = 4h) [Reset = 00h]
5h	Y_THR_CONFIG	Y Threshold Configuration	Y_THR_CONFIG Register (Offset = 5h) [Reset = 00h]
6h	Z_THR_CONFIG	Z Threshold Configuration	Z_THR_CONFIG Register (Offset = 6h) [Reset = 00h]
7h	T_CONFIG	Temp Sensor Configuration	T_CONFIG Register (Offset = 7h) [Reset = 00h]
8h	INT_CONFIG_1	Configure Device Operation Modes	INT_CONFIG_1 Register (Offset = 8h) [Reset = 00h]
9h	MAG_GAIN_CONFIG	Configure Device Operation Modes	MAG_GAIN_CONFIG Register (Offset = 9h) [Reset = 00h]
Ah	MAG_OFFSET_CONFIG_1	Configure Device Operation Modes	MAG_OFFSET_CONFIG_1 Register (Offset = Ah) [Reset = 00h]
Bh	MAG_OFFSET_CONFIG_2	Configure Device Operation Modes	MAG_OFFSET_CONFIG_2 Register (Offset = Bh) [Reset = 00h]
Ch	I2C_ADDRESS	I2C Address Register	I2C_ADDRESS Register (Offset = Ch) [Reset = 6Ah]
Dh	DEVICE_ID	ID for the device die	DEVICE_ID Register (Offset = Dh) [Reset = 05h]
Eh	MANUFACTURER_ID_LSB	Manufacturer ID lower byte	MANUFACTURER_ID_LSB Register (Offset = Eh) [Reset = 49h]
Fh	MANUFACTURER_ID_MSB	Manufacturer ID upper byte	MANUFACTURER_ID_MSB Register (Offset = Fh) [Reset = 54h]
10h	T_MSB_RESULT	Conversion Result Register	T_MSB_RESULT Register (Offset = 10h) [Reset = 00h]
11h	T_LSB_RESULT	Conversion Result Register	T_LSB_RESULT Register (Offset = 11h) [Reset = 00h]
12h	X_MSB_RESULT	Conversion Result Register	X_MSB_RESULT Register (Offset = 12h) [Reset = 00h]
13h	X_LSB_RESULT	Conversion Result Register	X_LSB_RESULT Register (Offset = 13h) [Reset = 00h]
14h	Y_MSB_RESULT	Conversion Result Register	Y_MSB_RESULT Register (Offset = 14h) [Reset = 00h]
15h	Y_LSB_RESULT	Conversion Result Register	Y_LSB_RESULT Register (Offset = 15h) [Reset = 00h]
16h	Z_MSB_RESULT	Conversion Result Register	Z_MSB_RESULT Register (Offset = 16h) [Reset = 00h]
17h	Z_LSB_RESULT	Conversion Result Register	Z_LSB_RESULT Register (Offset = 17h) [Reset = 00h]

表 7-6. TMAG5173 Registers (continued)

Offset	Acronym	Register Name	Section
18h	CONV_STATUS	Conversion Status Register	CONV_STATUS Register (Offset = 18h) [Reset = 10h]
19h	ANGLE_RESULT_MSB	Conversion Result Register	ANGLE_RESULT_MSB Register (Offset = 19h) [Reset = 00h]
1Ah	ANGLE_RESULT_LSB	Conversion Result Register	ANGLE_RESULT_LSB Register (Offset = 1Ah) [Reset = 00h]
1Bh	MAGNITUDE_RESULT	Conversion Result Register	MAGNITUDE_RESULT Register (Offset = 1Bh) [Reset = 00h]
1Ch	DEVICE_STATUS	Device_Diag Status Register	DEVICE_STATUS Register (Offset = 1Ch) [Reset = 10h]

Complex bit access types are encoded to fit into small table cells. 表 7-7 shows the codes that are used for access types in this section.

表 7-7. TMAG5173 Access Type Codes

Access Type	Code	Description
Read Type		
R	R	Read
Write Type		
W	W	Write
W1CP	W 1C P	Write 1 to clear Requires privileged access
Reset or Default Value		
-n		Value after reset or the default value

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7.6.1 DEVICE_CONFIG_1 Register (Offset = 0h) [Reset = 00h]

DEVICE_CONFIG_1 is shown in 表 7-8.

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表 7-8. DEVICE_CONFIG_1 Register Field Descriptions

Bit	Field	Type	Reset	Description
7	CRC_EN	R/W	0h	Enables I2C CRC byte to be sent 0h = CRC disabled 1h = CRC enabled
6-5	MAG_TEMPCO	R/W	0h	Temperature coefficient of the magnet 0h = 0% (No temperature compensation) 1h = 0.12%/ deg C (NdBFe) 2h = 0.03%/ deg C (SmCo) 3h = 0.2%/deg C (Ceramic)
4-2	CONV_AVG	R/W	0h	Enables additional sampling of the sensor data to reduce the noise effect (or to increase resolution) 0h = 1x average, 10.0-kSPS (3-axes) or 20-kSPS (1 axis) 1h = 2x average, 5.7-kSPS (3-axes) or 13.3-kSPS (1 axis) 2h = 4x average, 3.1-kSPS (3-axes) or 8.0-kSPS (1 axis) 3h = 8x average, 1.6-kSPS (3-axes) or 4.4-kSPS (1 axis) 4h = 16x average, 0.8-kSPS (3-axes) or 2.4-kSPS (1 axis) 5h = 32x average, 0.4-kSPS (3-axes) or 1.2-kSPS (1 axis)
1-0	I2C_RD	R/W	0h	Defines the I2C read mode 0h = Standard I2C 3-byte read command 1h = 1-byte I2C read command for 16bit sensor data and conversion status 2h = 1-byte I2C read command for 8 bit sensor MSB data and conversion status 3h = Reserved

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7.6.2 DEVICE_CONFIG_2 Register (Offset = 1h) [Reset = 00h]

DEVICE_CONFIG_2 is shown in 表 7-9.

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表 7-9. DEVICE_CONFIG_2 Register Field Descriptions

Bit	Field	Type	Reset	Description
7-5	THR_HYST	R/W	0h	Select thresholds for the interrupt function. Example, for 40-mT range with THR_HYST = 010b, the hysteresis value = $((40/(2^{11}))*8$ =0.156mT 0h = Takes the 2's complement value of each x_THR_CONFIG register to create a magnetic threshold of the corresponding axis 1h = Takes the 7 LSB bits of the x_THR_CONFIG register to create two opposite magnetic thresholds (one north, and another south) of equal magnitude. 2h = 8 LSB of threshold based off full scale magnetic range at 12 bit resolution 3h = 16 LSB of threshold based off full scale magnetic range at 12 bit resolution 4h = 32 LSB of threshold based off full scale magnetic range at 12 bit resolution 5h = 64 LSB of threshold based off full scale magnetic range at 12 bit resolution 6h = 128 LSB of threshold based off full scale magnetic range at 12 bit resolution 7h = 256 LSB of threshold based off full scale magnetic range at 12 bit resolution
4	LP_LN	R/W	0h	Selects the modes between low active current or low-noise modes 0h = Low active current mode 1h = Low noise mode
3	I2C_GLITCH_FILTER	R/W	0h	I2C glitch filter 0h = Glitch filter on 1h = Glitch filter off
2	TRIGGER_MODE	R/W	0h	Selects a condition which initiates a single conversion based off already configured registers. A running conversion completes before executing a trigger. Redundant triggers are ignored. TRIGGER_MODE is available only during the mode explicitly mentioned in OPERATING_MODE. 0h = Conversion Start at I2C Command Bits, DEFAULT 1h = Conversion starts through trigger signal at $\overline{\text{INT}}$ pin
1-0	OPERATING_MODE	R/W	0h	Selects Operating Mode and updates value based on operating mode if device transitions from Wake-up and sleep mode to Standby mode. 0h = Stand-by mode (starts new conversion at trigger event) 1h = Sleep mode 2h = Continuous measure mode 3h = Wake-up and sleep mode (W&S mode)

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7.6.3 SENSOR_CONFIG_1 Register (Offset = 2h) [Reset = 00h]

SENSOR_CONFIG_1 is shown in 表 7-10.

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表 7-10. SENSOR_CONFIG_1 Register Field Descriptions

Bit	Field	Type	Reset	Description
7-4	MAG_CH_EN	R/W	0h	Enables data acquisition of the magnetic axis channel(s) 0h = All magnetic channels of off, DEFAULT 1h = X channel enabled 2h = Y channel enabled 3h = X, Y channel enabled 4h = Z channel enabled 5h = Z, X channel enabled 6h = Y, Z channel enabled 7h = X, Y, Z channel enabled 8h = XYX channel enabled 9h = YXY channel enabled Ah = YZY channel enabled Bh = XZX channel enabled Ch = X,Y,Z with positive diagnostic offset Dh = X,Y,Z with negative diagnostic offset Eh = Hall resistance check + ADC check Fh = Hall offset check +ADC check
3-0	SLEEPTIME	R/W	0h	Selects the time spent in low power mode between conversions when OPERATING_MODE =11b 0h = 1ms 1h = 5ms 2h = 10ms 3h = 15ms 4h = 20ms 5h = 30ms 6h = 50ms 7h = 100ms 8h = 500ms 9h = 1000ms Ah = 2000ms Bh = 5000ms Ch = 20000ms

7.6.4 SENSOR_CONFIG_2 Register (Offset = 3h) [Reset = 00h]

SENSOR_CONFIG_2 is shown in 表 7-11.

Return to the Summary Table.

表 7-11. SENSOR_CONFIG_2 Register Field Descriptions

Bit	Field	Type	Reset	Description
7	RESERVED	R	0h	Reserved
6	THRX_COUNT	R/W	0h	Number of threshold crossings before the interrupt is asserted 0h = 1 threshold crossing 1h = 4 threshold crossing
5	MAG_THR_DIR	R/W	0h	Selects the direction of threshold check. This bit is ignored when THR_HYST > 001b 0h = sets interrupt for field above the threshold 1h = sets interrupt for field below the threshold
4	MAG_GAIN_CH	R/W	0h	Selects the axis for magnitude gain correction value entered in MAG_GAIN_CONFIG register 0h = 1st channel is selected for gain adjustment 1h = 2nd channel is selected for gain adjustment
3-2	ANGLE_EN	R/W	0h	Enables angle calculation, magnetic gain, and offset corrections between two selected magnetic channels 0h = No angle calculation, magnitude gain, and offset correction enabled 1h = X 1st, Y 2nd 2h = Y 1st, Z 2nd 3h = X 1st, Z 2nd
1	X_Y_RANGE	R/W	0h	Select the X and Y axes magnetic range from 2 different options. 0h = ±40mT (TMAG5173A1) or ±133mT (TMAG5173A2), DEFAULT 1h = ±80mT (TMAG5173A1) or ±266mT (TMAG5173A2)
0	Z_RANGE	R/W	0h	Select the Z axis magnetic range from 2 different options. 0h = ±40mT (TMAG5173A1) or ±133mT (TMAG5173A2), DEFAULT 1h = ±80mT (TMAG5173A1) or ±266mT (TMAG5173A2)

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7.6.5 X_THR_CONFIG Register (Offset = 4h) [Reset = 00h]

X_THR_CONFIG is shown in 表 7-12.

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表 7-12. X_THR_CONFIG Register Field Descriptions

Bit	Field	Type	Reset	Description
7-0	X_THR_CONFIG	R/W	0h	8-bit, 2's complement X axis threshold code for limit check. The range of possible threshold entrees can be +/-128. The threshold value in mT is calculated for A1 as (40(1+X_Y_RANGE)/128)*X_THR_CONFIG, for A2 as (133(1+X_Y_RANGE)/128)*X_THR_CONFIG. Default 0h means no threshold comparison.

7.6.6 Y_THR_CONFIG Register (Offset = 5h) [Reset = 00h]

Y_THR_CONFIG is shown in 表 7-13.

Return to the Summary Table.

表 7-13. Y_THR_CONFIG Register Field Descriptions

Bit	Field	Type	Reset	Description
7-0	Y_THR_CONFIG	R/W	0h	8-bit, 2's complement Y axis threshold code for limit check. The range of possible threshold entrees can be +/-128. The threshold value in mT is calculated for A1 as (40(1+X_Y_RANGE)/128)*X_THR_CONFIG, for A2 as (133(1+X_Y_RANGE)/128)*X_THR_CONFIG. Default 0h means no threshold comparison.

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7.6.7 Z_THR_CONFIG Register (Offset = 6h) [Reset = 00h]

Z_THR_CONFIG is shown in 表 7-14.

Return to the Summary Table.

表 7-14. Z_THR_CONFIG Register Field Descriptions

Bit	Field	Type	Reset	Description
7-0	Z_THR_CONFIG	R/W	0h	8-bit, 2's complement Z axis threshold code for limit check. The range of possible threshold entrees can be +/-128. The threshold value in mT is calculated for A1 as (40(1+Z_RANGE)/128)*Z_THR_CONFIG, for A2 as (133(1+Z_RANGE)/128)*Z_THR_CONFIG. Default 0h means no threshold comparison.

7.6.8 T_CONFIG Register (Offset = 7h) [Reset = 00h]

T_CONFIG is shown in 表 7-15.

Return to the Summary Table.

表 7-15. T_CONFIG Register Field Descriptions

Bit	Field	Type	Reset	Description
7-1	T_THR_CONFIG	R/W	0h	Temperature threshold code entered by user. The valid temperature threshold ranges are -41C to 170C with the threshold codes for -41C = 1Ah, and 170C = 34h. Resolution is 8 degree C/ LSB. Default 0h means no threshold comparison.
0	T_CH_EN	R/W	0h	Enables data acquisition of the temperature channel 0h = Temp channel disabled. The T_MSB_RESULT and T_LSB_RESULT data are invalid 1h = Temp channel enabled

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7.6.9 INT_CONFIG_1 Register (Offset = 8h) [Reset = 00h]

INT_CONFIG_1 is shown in 表 7-16.

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表 7-16. INT_CONFIG_1 Register Field Descriptions

Bit	Field	Type	Reset	Description
7	RSLT_INT	R/W	0h	Enable interrupt response on conversion complete. 0h = Interrupt is not asserted when the configured set of conversions are complete 1h = Interrupt is asserted when the configured set of conversions are complete
6	THRSLD_INT	R/W	0h	Enable interrupt response on a predefined threshold cross. 0h = Interrupt is not asserted when a threshold is crossed 1h = Interrupt is asserted when a threshold is crossed
5	INT_STATE	R/W	0h	$\overline{INT}$ interrupt latched or pulsed. 0h = $\overline{INT}$ interrupt latched until clear by a primary addressing the device 1h = $\overline{INT}$ interrupt pulse for 10us
4-2	INT_MODE	R/W	0h	Interrupt mode select. 0h = No interrupt 1h = Interrupt through $\overline{INT}$ 2h = Interrupt through $\overline{INT}$ except when I2C bus is busy. 3h = Interrupt through SCL 4h = Interrupt through SCL except when I2C bus is busy. 5h = Unipolar Switch Mode (Only one B-Field Conversion Support, Selects the first Magnetic field in X, Y, Z order if multiple thresholds are enabled). This mode overrides any interrupt function (INT trigger is also disabled), and only implements a Hall switch function based off the x_THRX_CONFIG and THR_HYST settings. Select THR_HYST >001b for this mode. 6h = Omnipolar Switch Mode (Only one B-Field Conversion Support, Selects the first Magnetic field in X, Y, Z order if multiple thresholds are enabled). This mode overrides any interrupt function (INT trigger is also disabled), and only implements a Hall switch function based off the x_THRX_CONFIG and THR_HYST settings. Select THR_HYST >001b for this mode. 7h = Not valid- defaults to 000b mode
1	RESERVED	R	0h	Reserved
0	MASK_INTB	R/W	0h	Mask $\overline{INT}$ pin when $\overline{INT}$ connected to GND 0h = $\overline{INT}$ pin is enabled 1h = $\overline{INT}$ pin is disabled (for wake-up and trigger functions)

7.6.10 MAG_GAIN_CONFIG Register (Offset = 9h) [Reset = 00h]

MAG_GAIN_CONFIG is shown in 表 7-17.

Return to the Summary Table.

表 7-17. MAG_GAIN_CONFIG Register Field Descriptions

Bit	Field	Type	Reset	Description
7-0	GAIN_VALUE	R/W	0h	8-bit gain value determined by a primary to adjust a Hall axis gain. The particular axis is selected based off the settings of MAG_GAIN_CH and ANGLE_EN register bits. The binary 8-bit input is interpreted as a fractional value in between 0 and 1 based off the formula, 'user entered value in decimal/256'. Gain value of 0 is interpreted by the device as 1.

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7.6.11 MAG_OFFSET_CONFIG_1 Register (Offset = Ah) [Reset = 00h]

MAG_OFFSET_CONFIG_1 is shown in 表 7-18.

Return to the Summary Table.

表 7-18. MAG_OFFSET_CONFIG_1 Register Field Descriptions

Bit	Field	Type	Reset	Description
7-0	OFFSET_VALUE_1ST	R/W	0h	8-bit, 2's complement offset value determined by a primary to adjust first axis offset value. The range of possible offset valid entrees can be +/-128. The offset value is calculated by multiplying bit resolution with the entered value.

7.6.12 MAG_OFFSET_CONFIG_2 Register (Offset = Bh) [Reset = 00h]

MAG_OFFSET_CONFIG_2 is shown in 表 7-19.

Return to the Summary Table.

表 7-19. MAG_OFFSET_CONFIG_2 Register Field Descriptions

Bit	Field	Type	Reset	Description
7-0	OFFSET_VALUE_2ND	R/W	0h	8-bit, 2's complement offset value determined by a primary to adjust second axis offset value. The range of possible offset valid entrees can be +/-128. The offset value is calculated by multiplying bit resolution with the entered value.

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7.6.13 I2C_ADDRESS Register (Offset = Ch) [Reset = 6Ah]

I2C_ADDRESS is shown in 表 7-20.

Return to the Summary Table.

表 7-20. I2C_ADDRESS Register Field Descriptions

Bit	Field	Type	Reset	Description
7-1	I2C_ADDRESS	R/W	35h	7-bit default factory I2C address is loaded from OTP during first power up. Change these bits to a new setting if a new I2C address is required (at each power cycle these bits need to be written again to avoid going back to default factory address).
0	I2C_ADDRESS_UPDATE_EN	R/W	0h	Enable a new user defined I2C address. 0h = Disable update of I2C address 1h = Enable update of I2C address with bits (7:1)

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7.6.14 DEVICE_ID Register (Offset = Dh) [Reset = 05h]

DEVICE_ID is shown in 表 7-21.

Return to the Summary Table.

表 7-21. DEVICE_ID Register Field Descriptions

Bit	Field	Type	Reset	Description
7-2	RESERVED	R	1h	Reserved
1-0	VER	R	1h	Device version indicator. Reset value of DEVICE_ID depends on the orderable part number. 0h = ±40-mT and ±80-mT range 1h = ±40-mT and ±80-mT range 2h = ±133-mT and ±266-mT range 3h = Reserved

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7.6.15 MANUFACTURER_ID_LSB Register (Offset = Eh) [Reset = 49h]

MANUFACTURER_ID_LSB is shown in 表 7-22.

Return to the Summary Table.

表 7-22. MANUFACTURER_ID_LSB Register Field Descriptions

Bit	Field	Type	Reset	Description
7-0	MANUFACTURER_ID_[7:0]	R	49h	8-bit unique manufacturer ID

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7.6.16 MANUFACTURER_ID_MSB Register (Offset = Fh) [Reset = 54h]

MANUFACTURER_ID_MSB is shown in 表 7-23.

Return to the Summary Table.

表 7-23. MANUFACTURER_ID_MSB Register Field Descriptions

Bit	Field	Type	Reset	Description
7-0	MANUFACTURER_ID_[15:8]	R	54h	8-bit unique manufacturer ID

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7.6.17 T_MSB_RESULT Register (Offset = 10h) [Reset = 00h]

T_MSB_RESULT is shown in 表 7-24.

Return to the Summary Table.

表 7-24. T_MSB_RESULT Register Field Descriptions

Bit	Field	Type	Reset	Description
7-0	T_CH_RESULT [15:8]	R	0h	T-channel data conversion results, MSB 8 bits.

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7.6.18 T_LSB_RESULT Register (Offset = 11h) [Reset = 00h]

T_LSB_RESULT is shown in 表 7-25.

Return to the Summary Table.

表 7-25. T_LSB_RESULT Register Field Descriptions

Bit	Field	Type	Reset	Description
7-0	T_CH_RESULT [7:0]	R	0h	T-channel data conversion results, LSB 8 bits.

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7.6.19 X_MSB_RESULT Register (Offset = 12h) [Reset = 00h]

X_MSB_RESULT is shown in 表 7-26.

Return to the Summary Table.

表 7-26. X_MSB_RESULT Register Field Descriptions

Bit	Field	Type	Reset	Description
7-0	X_CH_RESULT [15:8]	R	0h	X-channel data conversion results, MSB 8 bits.

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7.6.20 X_LSB_RESULT Register (Offset = 13h) [Reset = 00h]

X_LSB_RESULT is shown in 表 7-27.

Return to the Summary Table.

表 7-27. X_LSB_RESULT Register Field Descriptions

Bit	Field	Type	Reset	Description
7-0	X_CH_RESULT [7:0]	R	0h	X-channel data conversion results, LSB 8 bits.

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7.6.21 Y_MSB_RESULT Register (Offset = 14h) [Reset = 00h]

Y_MSB_RESULT is shown in 表 7-28.

Return to the Summary Table.

表 7-28. Y_MSB_RESULT Register Field Descriptions

Bit	Field	Type	Reset	Description
7-0	Y_CH_RESULT [15:8]	R	0h	Y-channel data conversion results, MSB 8 bits.

7.6.22 Y_LSB_RESULT Register (Offset = 15h) [Reset = 00h]

Y_LSB_RESULT is shown in 表 7-29.

Return to the Summary Table.

表 7-29. Y_LSB_RESULT Register Field Descriptions

Bit	Field	Type	Reset	Description
7-0	Y_CH_RESULT [7:0]	R	0h	Y-channel data conversion results, LSB 8 bits.

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7.6.23 Z_MSB_RESULT Register (Offset = 16h) [Reset = 00h]

Z_MSB_RESULT is shown in 表 7-30.

Return to the Summary Table.

表 7-30. Z_MSB_RESULT Register Field Descriptions

Bit	Field	Type	Reset	Description
7-0	Z_CH_RESULT [15:8]	R	0h	Z-channel data conversion results, MSB 8 bits.

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7.6.24 Z_LSB_RESULT Register (Offset = 17h) [Reset = 00h]

Z_LSB_RESULT is shown in 表 7-31.

Return to the Summary Table.

表 7-31. Z_LSB_RESULT Register Field Descriptions

Bit	Field	Type	Reset	Description
7-0	Z_CH_RESULT [7:0]	R	0h	Z-channel data conversion results, LSB 8 bits.

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7.6.25 CONV_STATUS Register (Offset = 18h) [Reset = 10h]

CONV_STATUS is shown in 表 7-32.

Return to the Summary Table.

表 7-32. CONV_STATUS Register Field Descriptions

Bit	Field	Type	Reset	Description
7-5	SET_COUNT	R	0h	Rolling Count of Conversion Data Sets
4	POR	R/W1CP	1h	Device powered up, or experienced power-on-reset. Bit is clear when host writes back '1'. 0h = No POR 1h = POR occurred
3-2	RESERVED	R	0h	Reserved
1	DIAG_STATUS	R	0h	Detect any internal diagnostics fail which include VCC UV, internal memory CRC error, $\overline{INT}$ pin error and internal clock error. Ignore this bit status if VCC < 2.3V. 0h = No diag fail 1h = Diag fail detected
0	RESULT_STATUS	R	0h	Conversion data buffer is ready to be read. 0h = Conversion data not complete 1h = Conversion data complete

7.6.26 ANGLE_RESULT_MSB Register (Offset = 19h) [Reset = 00h]

ANGLE_RESULT_MSB is shown in 表 7-33.

Return to the Summary Table.

表 7-33. ANGLE_RESULT_MSB Register Field Descriptions

Bit	Field	Type	Reset	Description
7-0	ANGLE_RESULT_MSB	R	0h	Angle measurement result in degree. The data is displayed from 0 to 360 degree in 13 LSB bits after combining the ANGLE_RESULT_MSB and _LSB bits. The 4 LSB bits allocated for fraction of an angle in the format (xxxx/16).

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7.6.27 ANGLE_RESULT_LSB Register (Offset = 1Ah) [Reset = 00h]

ANGLE_RESULT_LSB is shown in 表 7-34.

Return to the Summary Table.

表 7-34. ANGLE_RESULT_LSB Register Field Descriptions

Bit	Field	Type	Reset	Description
7-0	ANGLE_RESULT_LSB	R	0h	Angle measurement result in degree. The data is displayed from 0 to 360 degree in 13 LSB bits after combining the ANGLE_RESULT_MSB and _LSB bits. The 4 LSB bits allocated for fraction of an angle in the format (xxxx/16).

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7.6.28 MAGNITUDE_RESULT Register (Offset = 1Bh) [Reset = 00h]

MAGNITUDE_RESULT is shown in 表 7-35.

Return to the Summary Table.

表 7-35. MAGNITUDE_RESULT Register Field Descriptions

Bit	Field	Type	Reset	Description
7-0	MAGNITUDE_RESULT	R	0h	Resultant vector magnitude (during angle measurement) result. This value should be constant during 360 degree measurements

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7.6.29 DEVICE_STATUS Register (Offset = 1Ch) [Reset = 10h]

DEVICE_STATUS is shown in 表 7-36.

Return to the Summary Table.

表 7-36. DEVICE_STATUS Register Field Descriptions

Bit	Field	Type	Reset	Description
7-5	RESERVED	R	0h	Reserved
4	INTB_RB	R	1h	Indicates the level that the device is reading back from $\overline{INT}$ pin. The reset value of DEVICE_STATUS depends on the status of the $\overline{INT}$ pin at power-up. 0h = $\overline{INT}$ pin driven low 1h = $\overline{INT}$ pin status high
3	OSC_ER	R/W1CP	0h	Indicates if Oscillator error is detected. Bit is clear when host writes back '1'. 0h = No Oscillator error detected 1h = Oscillator error detected
2	INT_ER	R/W1CP	0h	Indicates if $\overline{INT}$ pin error is detected. Bit is clear when host writes back '1'. 0h = No $\overline{INT}$ error detected 1h = $\overline{INT}$ error detected
1	OTP_CRC_ER	R/W1CP	0h	Indicates if OTP CRC error is detected. Bit is clear when host writes back '1'. 0h = No OTP CRC error detected 1h = OTP CRC error detected
0	VCC_UV_ER	R/W1CP	0h	Indicates if VCC undervoltage was detected. Bit is clear when host writes back '1'. Ignore this bit status if VCC < 2.3V. 0h = No VCC UV detected 1h = VCC UV detected

8 Application and Implementation

备注

以下应用部分中的信息不属于 TI 器件规格的范围，TI 不担保其准确性和完整性。TI 的客 户应负责确定器件是否适用于其应用。客户应验证并测试其设计，以确保系统功能。

8.1 Application Information

8.1.1 Select the Sensitivity Option

Select the highest TMAG5173-Q1 sensitivity option that can measure the required range of magnetic flux density so that the ADC input range is maximized.

Larger-sized magnets and farther sensing distances can generally enable better positional accuracy than very small magnets at close distances, because magnetic flux density increases exponentially with the proximity to a magnet. TI created an online tool to help with simple magnet calculations under the TMAG5173-Q1 product folder on ti.com.

8.1.2 Temperature Compensation for Magnets

The TMAG5173-Q1 temperature compensation is designed to directly compensate the average temperature drift of several magnets as specified in the MAG_TEMPCO register bits. The residual induction (B_r) of a magnet typically reduces by 0.12%/°C for NdFeB, and 0.20%/°C for ferrite magnets as the temperature increases. Set the MAG_TEMPCO bit to default 00b if the device temperature compensation is not needed.

8.1.3 Sensor Conversion

Multiple conversion schemes can be adopted based off the MAG_CH_EN and CONV_AVG register bits settings.

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8.1.3.1 Continuous Conversion

The TMAG5173-Q1 can be set in continuous conversion mode when OPERATING_MODE is set to 10b. 图 8-1 shows a few examples of continuous conversion. The input magnetic field is processed in two steps. In the first step, the device spins the Hall sensor elements and integrates the sampled data. In the second step, the ADC block converts the analog signal into digital bits and stores in the corresponding result register. While the ADC starts processing the first magnetic sample, the spin block can start processing another magnetic sample. In this mode, the temperature data is taken at the beginning of each new conversion. This temperature data is used to compensate for the magnetic thermal drift.

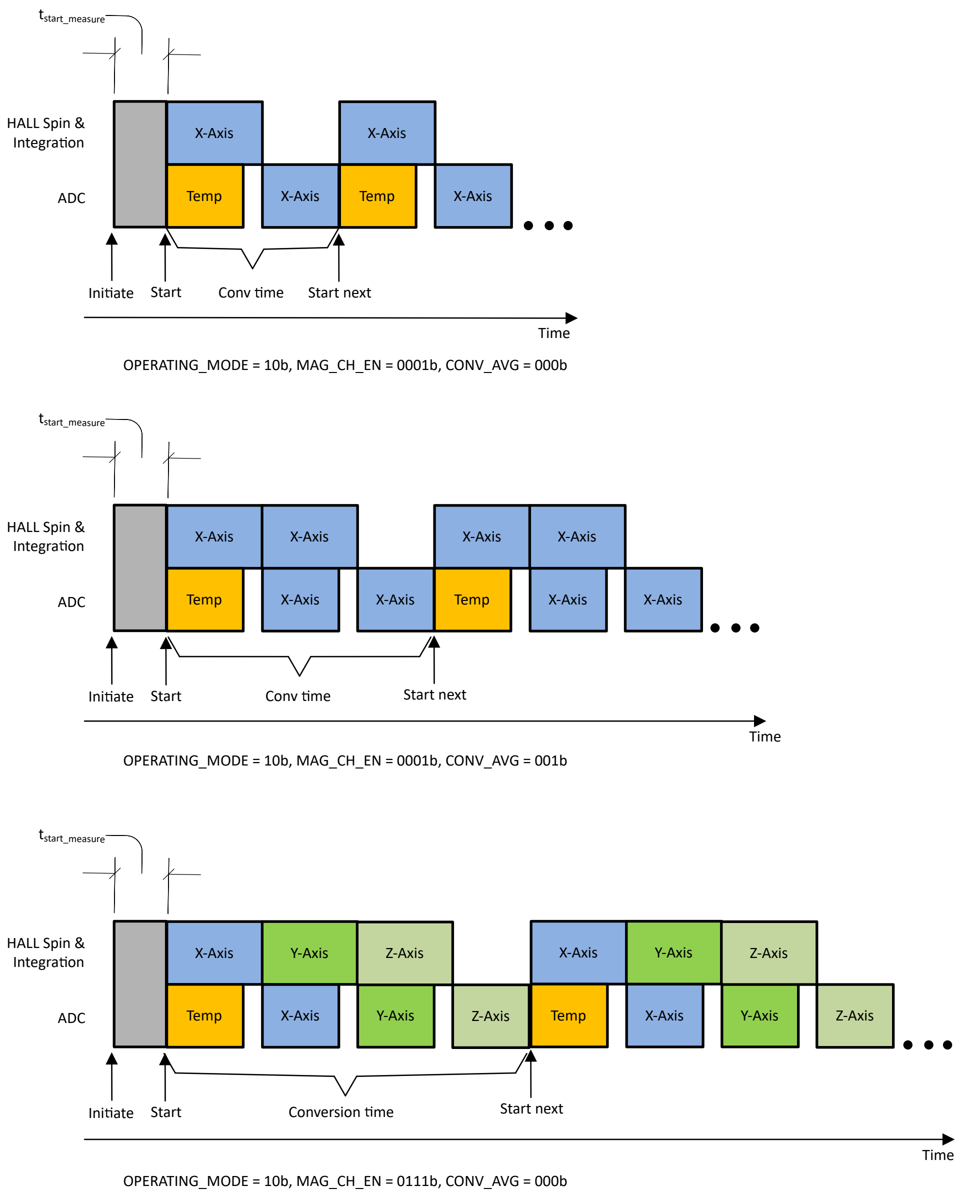

图 8-1. Continuous Conversion Examples

8.1.3.2 Trigger Conversion

The TMAG5173-Q1 supports trigger conversion with OPERATING_MODE set to 00b. The trigger event can be initiated through I²C command or $\overline{INT}$ signal. 图 8-2 shows an example of trigger conversion with temperature, X, Y, and Z sensors activated.

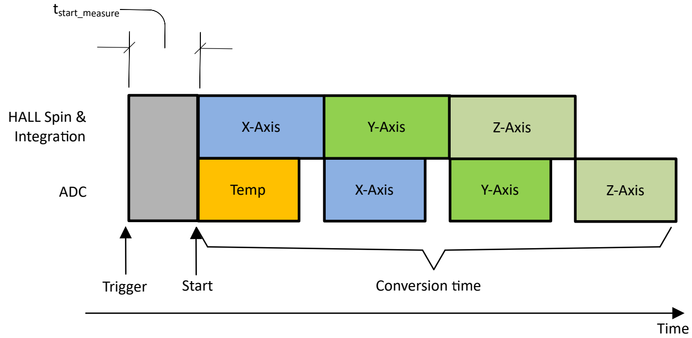

图 8-2. Trigger Conversion for Temperature, X, Y, & Z Sensors

8.1.3.3 Pseudo-Simultaneous Sampling

In absolute angle measurement, application sensor data from multiple axes are required to calculate an accurate angle. The magnetic field data collected at different times through the same signal chain introduces error in angle calculation. The TMAG5173-Q1 offers pseudo-simultaneous sampling data collection modes to eliminate this error. 图 8-3 shows an example where MAG_CH_EN is set at 1011b to collect XZX data. 方程式 18 shows that the time stamps for the X and Z sensor data are the same.

$$t_Z = \frac{t_{X1} + t_{X2}}{2} \tag{18}$$

where

- t_{X1}, t_Z, t_{X2} are time stamps for X, Z, X sensor data completion as defined in 图 8-3.

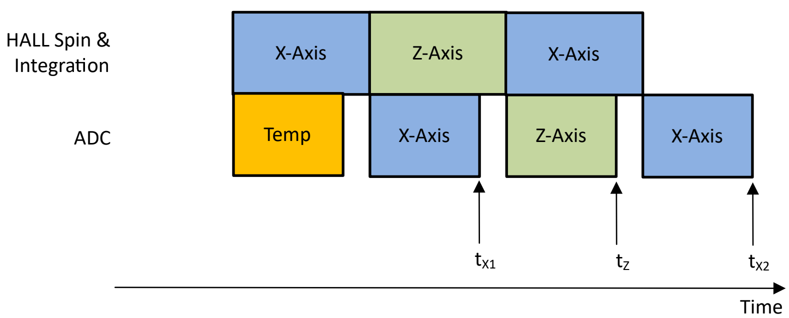

图 8-3. XZX Magnetic Field Conversion

The vertical X, Y sensors of the TMAG5173-Q1 exhibit more noise than the horizontal Z sensor. The pseudo-simultaneous sampling can be used to equalize the noise floor when two set of vertical sensor data are collected against one set of horizontal sensor data, as in examples of XZX or YZY modes.

8.1.4 Magnetic Limit Check

The TMAG5173-Q1 enables magnetic limit checks for single or multiple axes at the same time. 图 8-4 to 图 8-7 show examples of magnetic limit cross detection events while the field going above, below, exiting a magnetic band, and entering a magnetic band. The device will keep generating interrupt with each new conversion if the magnetic fields remain in the shaded regions in the figures. The MAG_THR_DIR and THR_HYST register bits help select different limit cross modes.

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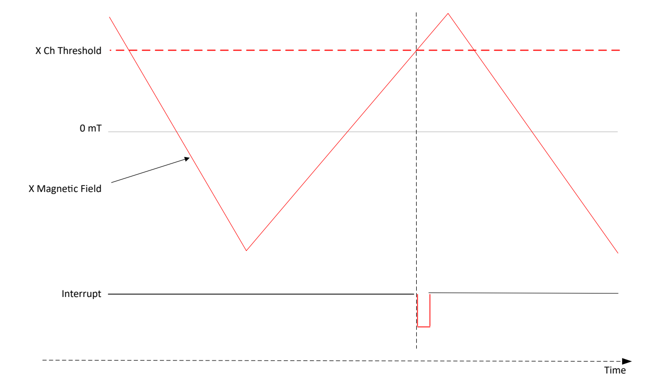

图 8-4. Magnetic Upper Limit Cross Check With MAG_THR_DIR =0b, THR_HYST = 000b

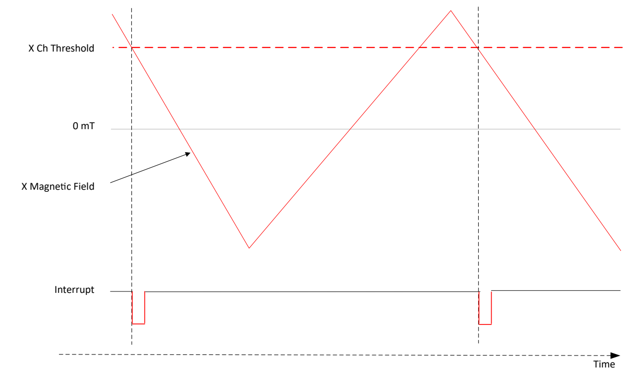

图 8-5. Magnetic Lower Limit Cross Check With MAG_THR_DIR =1b, THR_HYST = 000b

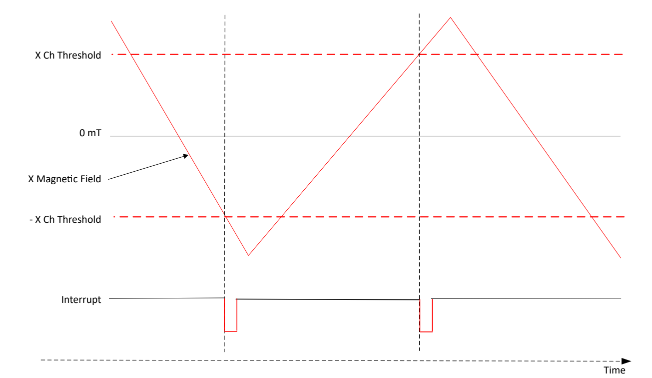

图 8-6. Magnetic Field Going Out of Band Check With MAG_THR_DIR =0b, THR_HYST = 001b

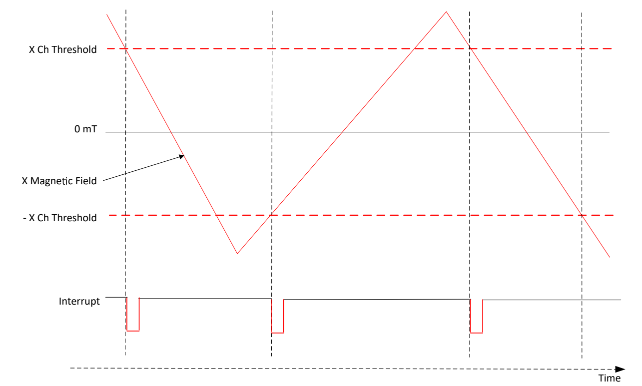

图 8-7. Magnetic Field Entering a Band Check With MAG_THR_DIR =1b, THR_HYST = 001b

8.1.5 Error Calculation During Linear Measurement

The TMAG5173-Q1 offers independent configurations to perform linear position measurements in X, Y, and Z axes. To calculate the expected error during linear measurement, the contributions from each of the individual error sources must be understood. The relevant error sources include sensitivity error, offset, noise, cross axis sensitivity, hysteresis, nonlinearity, drift across temperature, drift across life time, and so forth. For a 3-axis Hall solution like the TMAG5173-Q1, the cross-axis sensitivity and hysteresis error sources are insignificant. Use 方程式 19 to estimate the linear measurement error calculation at room temperature.

$$Error_{LM\_25C} = \frac{\sqrt{(B \times SENS_{ER})^2 + B_{off}^2 + N_{RMS\_25}^2}}{B} \times 100\% \tag{19}$$

where

- $Error_{LM\_25C}$ is total error in % during linear measurement at 25°C.
- B is input magnetic field.
- $SENS_{ER}$ is sensitivity error in decimal number at 25°C. As an example, enter 0.05 for sensitivity error of 5%.
- B_{off} is offset error at 25°C.
- N_{RMS_25} is RMS noise at 25°C.

In many applications, system level calibration at room temperature can nullify the offset and sensitivity errors at 25°C. The noise errors can be reduced by internally averaging by up to 32x on the device in addition to the averaging that could be done in the microcontroller. Use 方程式 20 to estimate the linear measurement error across temperature after calibration at room temperature.

$$Error_{LM\_Temp} = \frac{\sqrt{(B \times SENS_{DR})^2 + B_{off\_DR}^2 + N_{RMS\_Temp}^2}}{B} \times 100\% \quad (20)$$

where

- $Error_{LM\_Temp}$ is total error in % during linear measurement across temperature after room temperature calibration.
- B is input magnetic field.
- $SENS_{DR}$ is sensitivity drift in decimal number from value at 25°C. As an example, enter 0.05 for sensitivity drift of 5%.
- B_{off_DR} is offset drift from value at 25°C.
- N_{RMS_Temp} is RMS noise across temperature.

If room temperature calibration is not performed, sensitivity and offset errors at room temperature must also account for total error calculation across temperature (see 方程式 21).

$$Error_{LM\_Temp\_NCal} = \frac{\sqrt{(B \times SENS_{ER})^2 + (B \times SENS_{DR})^2 + B_{off}^2 + B_{off\_DR}^2 + N_{RMS\_Temp}^2}}{B} \times 100\% \quad (21)$$

where

- $Error_{LM\_Temp\_NCal}$ is total error in % during linear measurement across temperature without room temperature calibration.

备注

In this section, error sources such as system mechanical vibration, magnet temperature gradient, earth magnetic field, nonlinearity, lifetime drift, and so forth, are not considered. The user must take these additional error sources into account while calculating overall system error budgets.

8.1.6 Error Calculation During Angular Measurement

The TMAG5173-Q1 offers on-chip CORDIC to measure angle data from any of the two magnetic axes. The linear magnetic axis data can be used to calculate the angle using an external CORDIC as well. To calculate the expected error during angular measurement, the contributions from each individual error source must be understood. The relevant error sources include sensitivity error, offset, noise, axis-axis mismatch, nonlinearity, drift across temperature, drift across life time, and so forth. Use the Angle Error Calculation Tool to estimate the total error during angular measurement.

8.2 Typical Applications

Magnetic 3D sensors are very popular due to contactless and reliable measurements, especially in applications requiring long-term measurements in rugged environments. The TMAG5173-Q1 offers design flexibility in wide range of industrial and personal electronics applications. In this section three common application examples are discussed in details.

8.2.1 I^2C Address Expansion

The TMAG5173-Q1 is offered in four different factory-programmed I^2C addresses. The device also supports additional I^2C addresses through the configuration of the I2C_ADDRESS register. There are 7 bits to select 128 different addresses. Take system limitations like bus loading, maximum clock frequency, available GPIOs from a microcontroller, and so forth, in account before selecting maximum number of sensors in a single I^2C bus.

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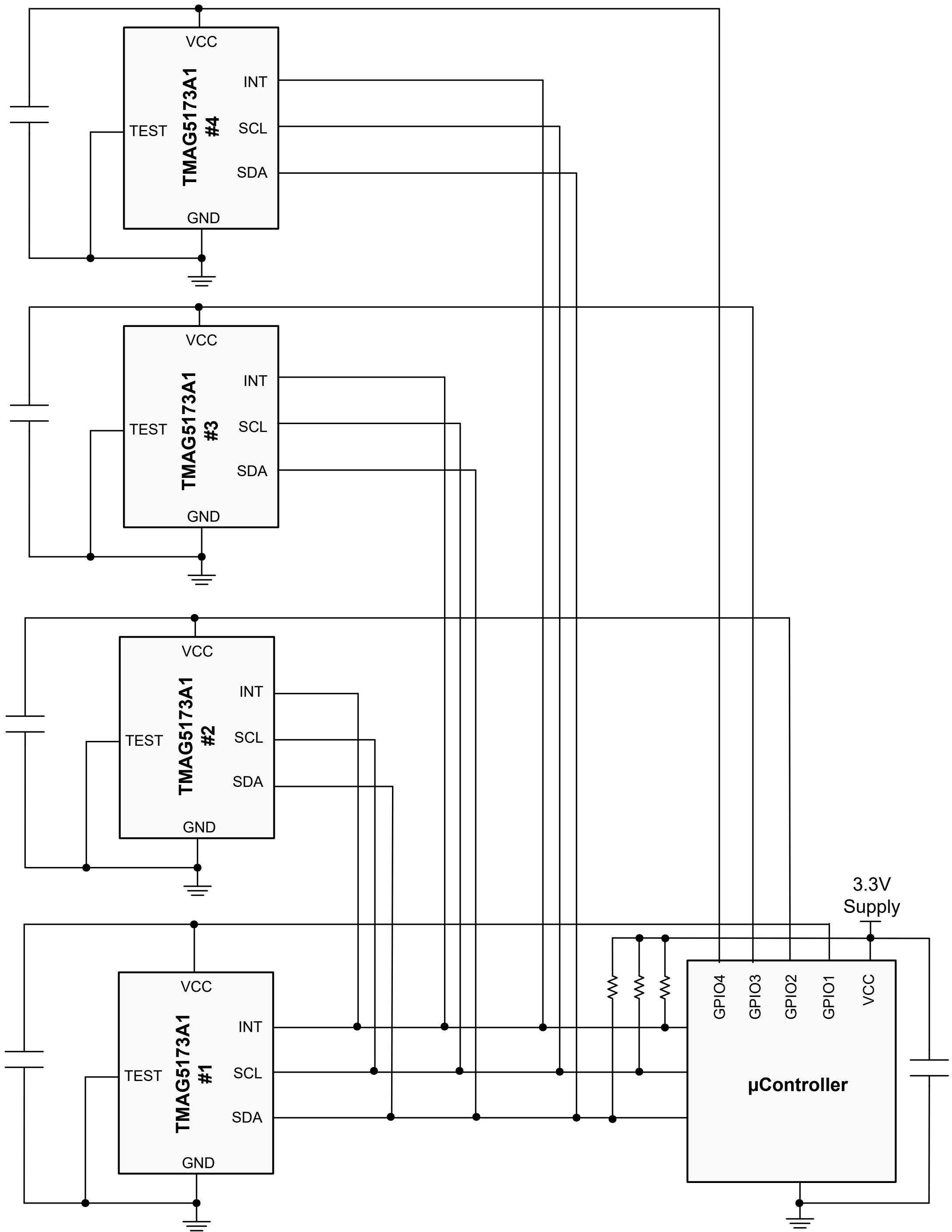

图 8-8. TMAG5173-Q1 Application Diagram for I^{2}C Address Expansion

8.2.1.1 Design Requirements

Use the parameters listed in 表 8-2 for this design example.

表 8-1. Design Parameters

PARAMETERS	DESIGN TARGET
Device orderable	TMAG5173A1-Q1
VCC	3.3 V

表 8-1. Design Parameters (continued)

PARAMETERS	DESIGN TARGET
# of Devices in same bus	4 (same method can be used to expand the number of sensors in the I^2C bus)
Design objective	Optimize the # GPIO and component count
Current supply per sensor	5-mA, supplied by a microcontroller GPIO

8.2.1.2 Detailed Design Procedure

Select GPIO with current supply capability of 5 mA. 图 8-8 shows that the SCL, SDA lines and $\overline{INT}$ pin can be shared. However, the function of the $\overline{INT}$ pin must be analyzed when shared by multiple sensors. As an example, if the sensors are configured to generate interrupt through the $\overline{INT}$ pin, the microcontroller needs to read all the sensors to determine which specific one sending the interrupt. Take the following steps sequentially to assign new I^2C addresses to the four TMAG5173-Q1 shown in 图 8-9:

- Turn on the GPIO#1 and wait until $t_{start\_power\_up}$ time is elapsed.
- Address the device#1 with factory programmed address. Write to the I2C_ADDRESS register to assign a new address.
- Turn on the GPIO#2 and wait until $t_{start\_power\_up}$ time is elapsed.
- Address the device#2 with factory programmed address. Write to the I2C_ADDRESS register to assign a new unique address.
- Turn on the GPIO#3 and wait until $t_{start\_power\_up}$ time is elapsed.
- Address the device#3 with factory programmed address. Write to the I2C_ADDRESS register to assign a new unique address.
- Turn on the GPIO#4 and wait until $t_{start\_power\_up}$ time is elapsed.
- Address the device#4 with factory programmed address. Write to the I2C_ADDRESS register to assign a new unique address.

Repeat the above steps if there is a power outage or power-up reset condition.

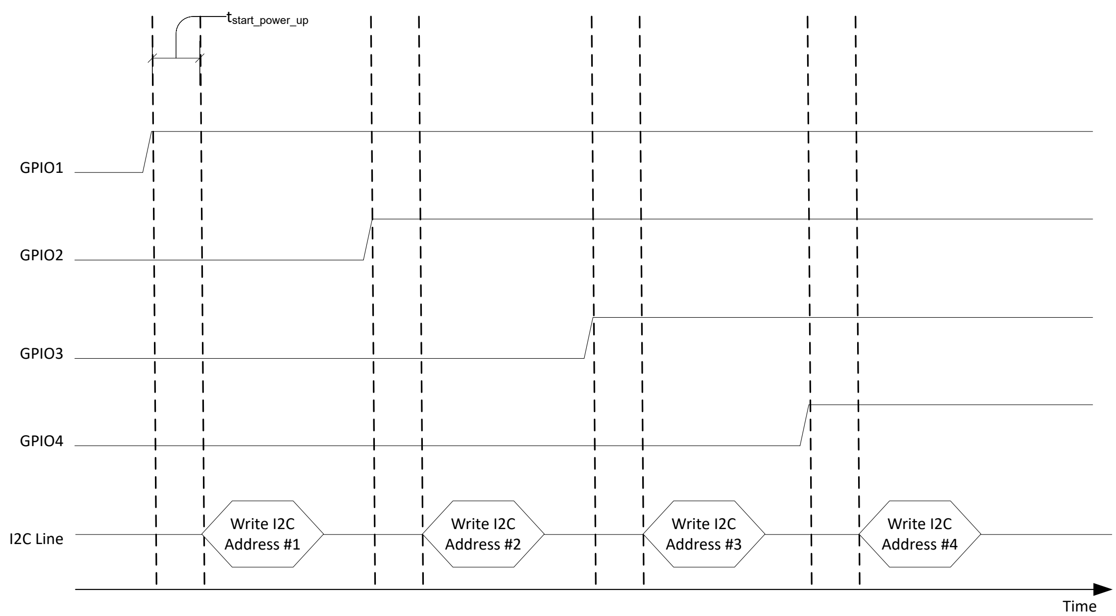

图 8-9. Power-Up Timing and I^2C Address Allocation for the Four Sensors

8.2.2 Angle Measurement

Magnetic angle sensors are very popular due to contactless and reliable measurements, especially in applications requiring long-term measurements in rugged environments. The TMAG5173-Q1 offers an on-chip

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angle calculator providing angular measurement based off any two of the magnetic axes. The two axes of interest can be selected in the ANGLE_EN register bits. The device offers angle output in complete 360 degree scale. Take several error sources into account for angle calculation, including sensitivity error, offset error, linearity error, noise, mechanical vibration, temperature drift, and so forth.

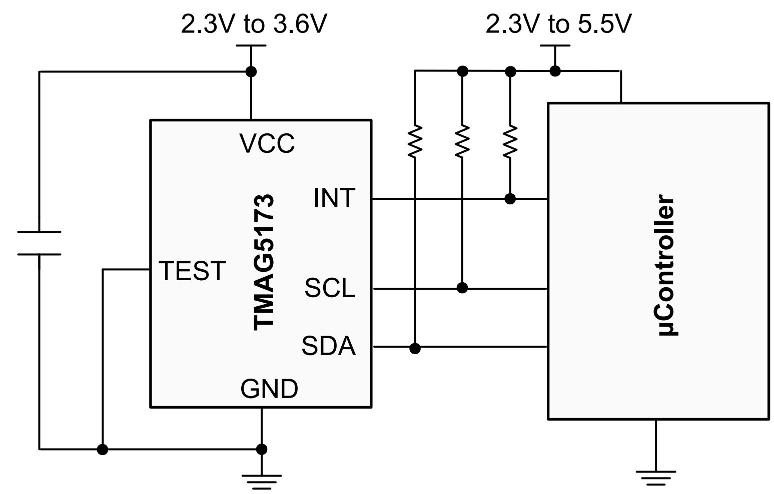

图 8-10. TMAG5173-Q1 Application Diagram for Angle Measurement

8.2.2.1 Design Requirements

Use the parameters listed in 表 8-2 for this design example.

表 8-2. Design Parameters

DESIGN PARAMETERS	ON-AXIS MEASUREMENT	OFF-AXIS MEASUREMENT
Device	TMAG5173A1-Q1	TMAG5173A1-Q1
VCC	3.3 V	3.3 V
Device Position	Directly under the magnet	At the adjacent side of the magnet
Magnet	Cylinder: 4.7625-mm diameter, 12.7-mm thick, neodymium N52, Br = 1480	Cylinder: 4.7625-mm diameter, 12.7-mm thick, neodymium N52, Br = 1480
Magnetic Range Selection	Select the same range for both axes based off the highest possible magnetic field seen by the sensor	Select the same range for both axes based off the highest possible magnetic field seen by the sensor
RPM	<600	<600
Desired Accuracy	<2° for 360° rotation	<2° for 360° rotation

8.2.2.2 Detailed Design Procedure

For accurate angle measurement, the two axes amplitudes must be normalized by selecting the proper gain adjustment value in the MAG_GAIN_CONFIG register. The gain adjustment value is a fractional decimal number between 0 and 1. The following steps must be followed to calculate this fractional value:

- Set the device at 32x average mode and rotate the shaft full 360 degree.
- Record the two axes sensor ADC codes for the full 360 degree rotation.
- A normalized plot for the full 360 degree rotations are represented in 图 8-12 or 图 8-13.
- Measure the maximum peak-peak ADC code delta for each axis, A_X and A_Y.
- If $A_X > A_Y$, set the MAG_GAIN_CH register bit to 0b. Calculate the gain adjustment value for X axis: $G_X = \frac{A_Y}{A_X}$
- If $A_X < A_Y$, set the MAG_GAIN_CH register bit to 1b. Calculate the gain adjustment value for Y axis: $G_Y = \frac{1}{G_X}$
- The target binary gain setting at the GAIN VALUE register bits are calculated from the equation, G_X or G_Y = $GAIN\_VALUE_{decimal}$/ 256.

Example 1: If $A_X = A_Y = 60,000$, the GAIN_VALUE register bits are set at default 0000 0000b.

Example 2: If A_X= 60,000, A_Y = 45,000, the G_X = 45,000/60,000 =0.75. Set MAG_GAIN_CH to 0b and GAIN_VALUE to 1100 0000b.

Example 3: If A_X= 45,000, A_Y = 60,000, the G_X = (60,000/45,000) =1.33. Since G_X >1, the gain adjustment needs to be applied to Y axis with G_Y =1/G_X. Set MAG_GAIN_CH to 1b and GAIN_VALUE to 1100 0000b.

8.2.2.2.1 Gain Adjustment for Angle Measurement

Common measurement topology include angular position measurements in on-axis or off-axis angular measurements shown in 图 8-11. Select the on-axis measurement topology whenever possible as this offers the best optimization of magnetic field and the device measurement ranges. The TMAG5173-Q1 offers on-chip gain adjustment option to account for mechanical position misalignments.

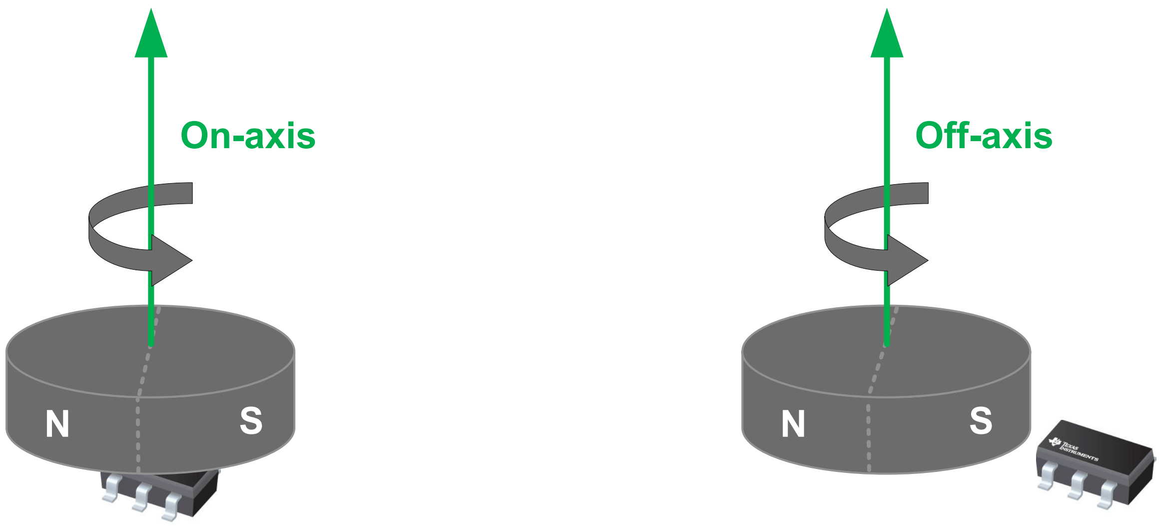

图 8-11. On-Axis vs Off-Axis Angle Measurements

8.2.2.3 Application Curves

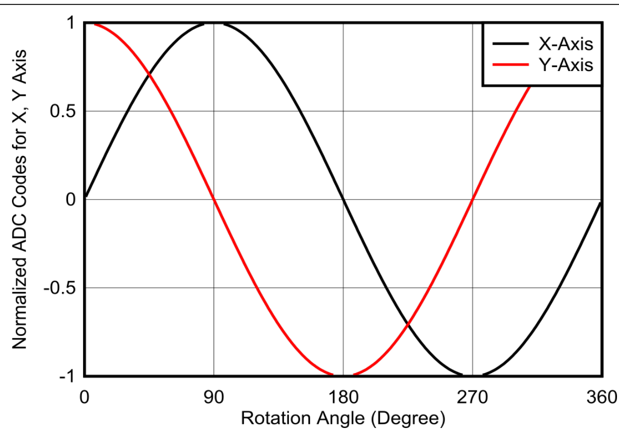

图 8-12. X and Y Sensor Data for Full 360 Degree Rotation for On-Axis Measurement

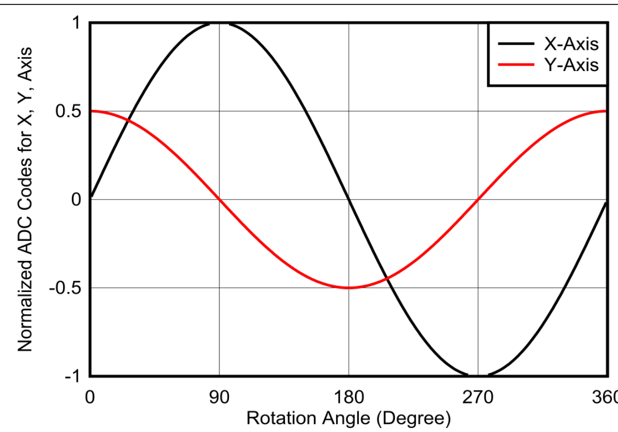

图 8-13. X and Y Sensor Data for Full 360 Degree Rotation for Off-Axis Measurement

8.3 What to Do and What Not to Do

The TMAG5173-Q1 updates the result registers at the end of a conversion. I^2C read of the result register must be synchronized with the conversion update time to avoid reading a result data while the result register is being

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updated. For applications with a tight timing budget, use the $\overline{INT}$ signal to notify the primary when a conversion is complete.

8.4 Power Supply Recommendations

A decoupling capacitor close to the device must be used to provide local energy with minimal inductance. TI recommends using a ceramic capacitor with a value of at least 0.01 μF. Connect the TEST pin to ground.

8.5 Layout

8.5.1 Layout Guidelines

Magnetic fields pass through most nonferromagnetic materials with no significant disturbance. Embedding Hall effect sensors within plastic or aluminum enclosures and sensing magnets on the outside is common practice. Magnetic fields also easily pass through most printed circuit boards (PCBs), which makes placing the magnet on the opposite side of the PCB possible.

8.5.2 Layout Example

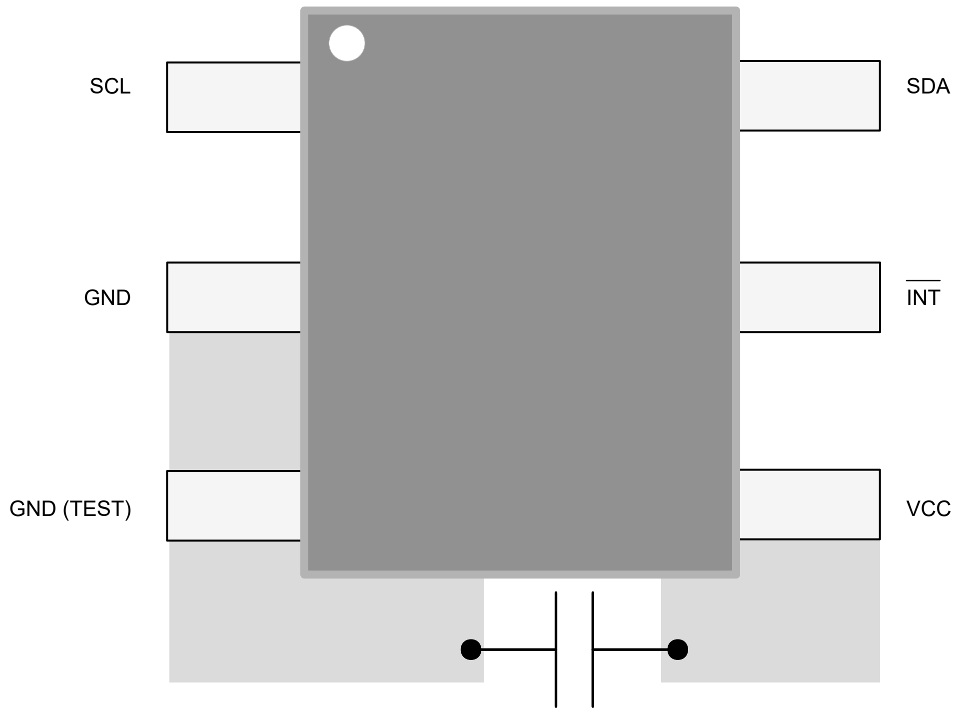

图 8-14. Layout Example With TMAG5173-Q1

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9 Device and Documentation Support

9.1 文档支持

9.1.1 Related Documentation

For related documentation see the following:

- Texas Instruments, *HALL-ADAPTER-EVM User's Guide* (SLYU043)
- Texas Instruments, *TMAG5173 Evaluation Manual user's guide* (SLYU058)
- Texas Instruments, *Angle Measurement With Multi-Axis Linear Hall-Effect Sensors* application report (SBAA463)
- Texas Instruments, *Absolute Angle Measurements for Rotational Motion Using Hall-Effect Sensors* application brief (SBAA503)
- Texas Instruments, *Limit Detection for Tamper and End-of-Travel Detection Using Hall-Effect Sensors* application brief (SBOA514)

9.2 接收文档更新通知

要接收文档更新通知，请导航至 ti.com 上的器件产品文件夹。点击*订阅更新* 进行注册，即可每周接收产品信息更改摘要。有关更改的详细信息，请查看任何已修订文档中包含的修订历史记录。

9.3 支持资源

TI E2E™ 支持论坛是工程师的重要参考资料，可直接从专家获得快速、经过验证的解答和设计帮助。搜索现有解答或提出自己的问题可获得所需的快速设计帮助。

链接的内容由各个贡献者“按原样”提供。这些内容并不构成 TI 技术规范，并且不一定反映 TI 的观点；请参阅 TI 的《使用条款》。

9.4 商标

TI E2E™ is a trademark of Texas Instruments.
所有商标均为其各自所有者的财产。

9.5 静电放电警告

静电放电 (ESD) 会损坏这个集成电路。德州仪器 (TI) 建议通过适当的预防措施处理所有集成电路。如果不遵守正确的处理和安装程序，可能会损坏集成电路。

ESD 的损坏小至导致微小的性能降级，大至整个器件故障。精密的集成电路可能更容易受到损坏，这是因为非常细微的参数更改都可能会导致器件与其发布的规格不相符。

9.6 术语表

TI 术语表	本术语表列出并解释了术语、首字母缩略词和定义。

10 机械、封装和可订购信息

下述页面包含机械、封装和订购信息。这些信息是指定器件可用的最新数据。数据如有变更，恕不另行通知，且不会对此文档进行修订。有关此数据表的浏览器版本，请查阅左侧的导航栏。

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10.1 Package Option Addendum

Packaging Information

Orderable Device	Status(1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan(2)	Lead/Ball Finish(6)	MSL Peak Temp(3)	Op Temp (°C)	Device Marking(4) (5)
PTMAG5173A1 QDBVRQ1	ACTIVE	SOT-23	DBV	6	3000	Call TI	Call TI	Call TI	-40 to 125	
PTMAG5173A2 QDBVRQ1	ACTIVE	SOT-23	DBV	6	3000	Call TI	Call TI	Call TI	-40 to 125	
PTMAG5173B1 QDBVRQ1	PREVIEW	SOT-23	DBV	6	Call TI	Call TI	Call TI	Call TI	Call TI	
PTMAG5173B2 QDBVRQ1	PREVIEW	SOT-23	DBV	6	Call TI	Call TI	Call TI	Call TI	Call TI	
PTMAG5173C1 QDBVRQ1	PREVIEW	SOT-23	DBV	6	Call TI	Call TI	Call TI	Call TI	Call TI	
PTMAG5173C2 QDBVRQ1	PREVIEW	SOT-23	DBV	6	Call TI	Call TI	Call TI	Call TI	Call TI	
PTMAG5173D1 QDBVRQ1	PREVIEW	SOT-23	DBV	6	Call TI	Call TI	Call TI	Call TI	Call TI	
PTMAG5173D2 QDBVRQ1	PREVIEW	SOT-23	DBV	6	Call TI	Call TI	Call TI	Call TI	Call TI	

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PRE_PROD Unannounced device, not in production, not available for mass market, nor on the web, samples not available.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material).

(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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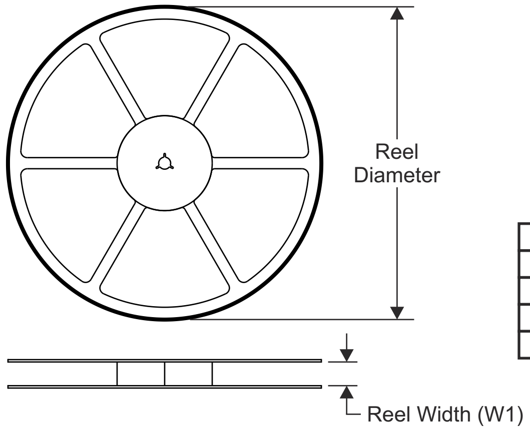
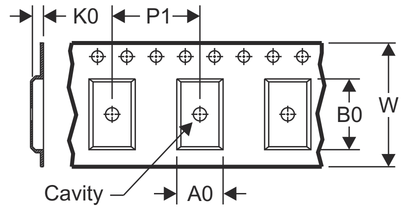
ADVANCE INFORMATION

10.2 Tape and Reel Information

REEL DIMENSIONS

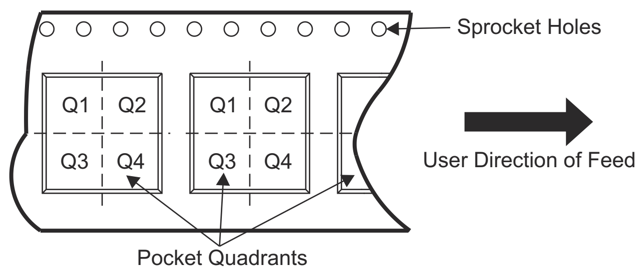


TAPE DIMENSIONS



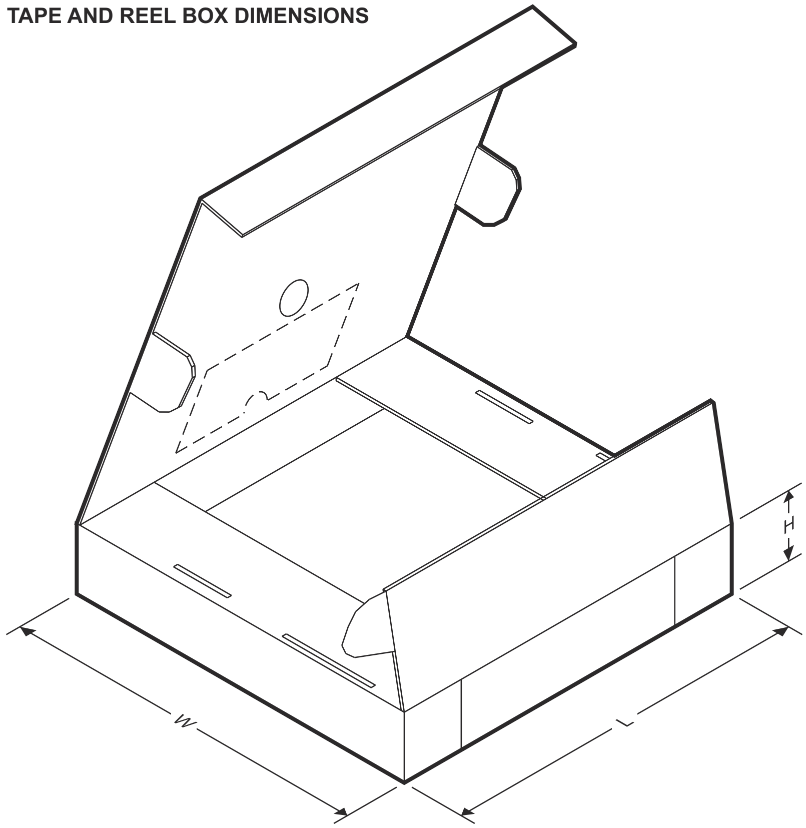
A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
PTMAG5173A1QDBVR Q1	SOT-23	DBV	6	3000	178	9	3.3	3.2	1.4	4	8	Q3
PTMAG5173A2QDBVR Q1	SOT-23	DBV	6	3000	178	9	3.3	3.2	1.4	4	8	Q3

TAPE AND REEL BOX DIMENSIONS



Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
PTMAG5173A1QDBVRQ1	SOT-23	DBV	6	3000	190	190	30
PTMAG5173A2QDBVRQ1	SOT-23	DBV	6	3000	190	190	30

ADVANCE INFORMATION

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TMAG5173A1QDBVRQ1	ACTIVE	SOT-23	DBV	6	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 125	3A1Q	Samples
TMAG5173A2QDBVRQ1	ACTIVE	SOT-23	DBV	6	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 125	73A2	Samples
TMAG5173B1QDBVRQ1	ACTIVE	SOT-23	DBV	6	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 125	73B1	Samples
TMAG5173B2QDBVRQ1	ACTIVE	SOT-23	DBV	6	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 125	73B2	Samples
TMAG5173C1QDBVRQ1	ACTIVE	SOT-23	DBV	6	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 125	73C1	Samples
TMAG5173C2QDBVRQ1	ACTIVE	SOT-23	DBV	6	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 125	73C2	Samples
TMAG5173D1QDBVRQ1	ACTIVE	SOT-23	DBV	6	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 125	73D1	Samples
TMAG5173D2QDBVRQ1	ACTIVE	SOT-23	DBV	6	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 125	73D2	Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

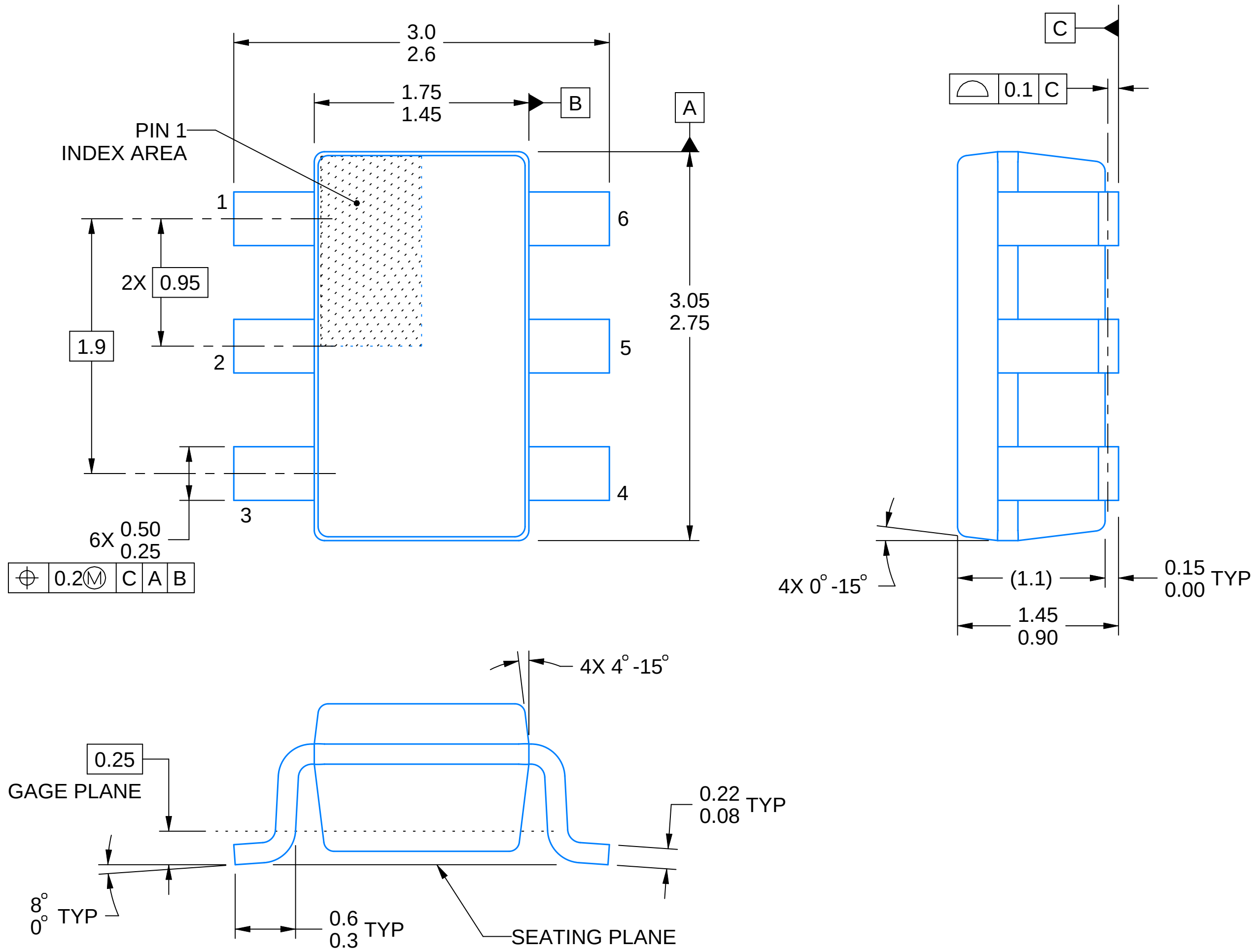
(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

PACKAGE OUTLINE

DBV0006A

SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR



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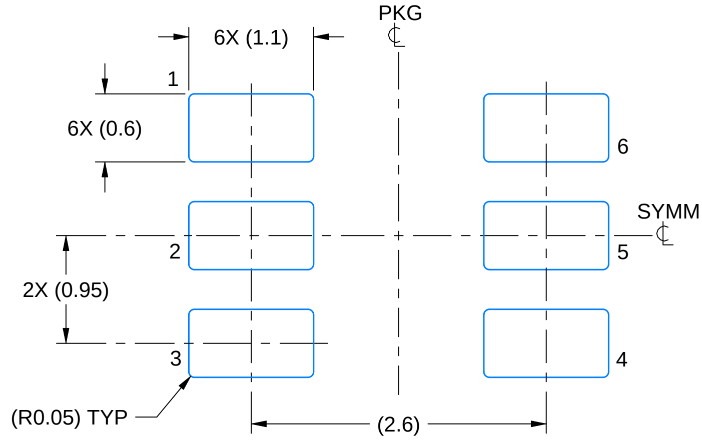
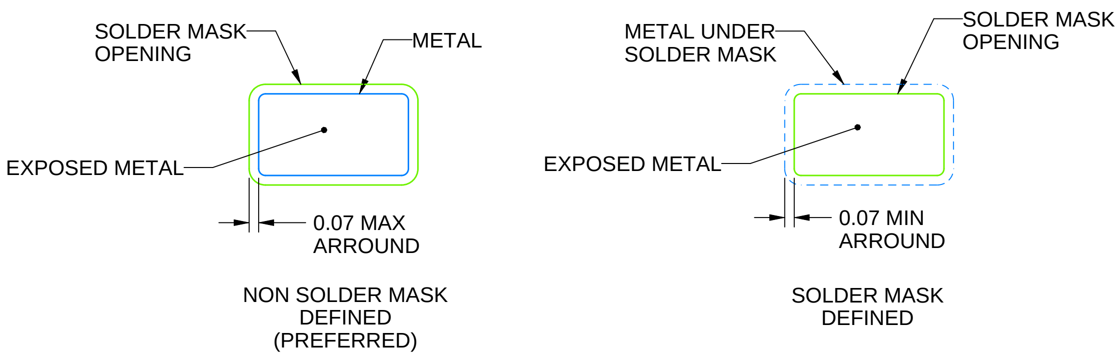
NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.25 per side.
4. Leads 1,2,3 may be wider than leads 4,5,6 for package orientation.
5. Refernce JEDEC MO-178.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:15X



SOLDER MASK DETAILS

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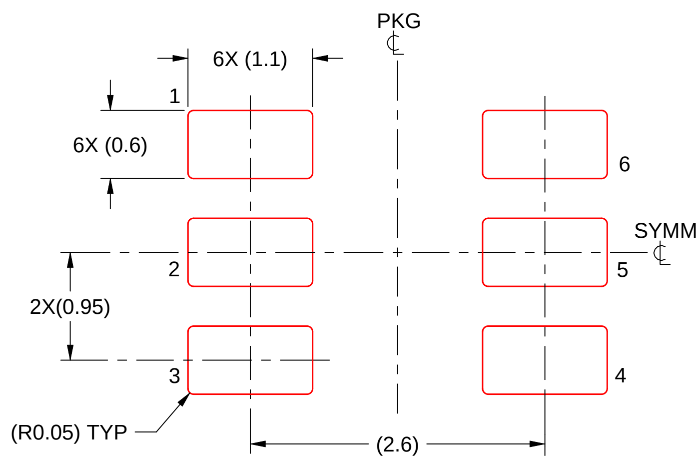
NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE:15X

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NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

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