MLX90291

SMD Programmable Linear Hall Sensor IC Featuring PWM Output

Melexis
Microelectronic Integrated Systems

Features and Benefits

- ❑ Programmable Hall effect sensor
  - ❑ 12-bit 125Hz PWM output signal proportional to the magnetic flux density
  - ❑ Switch function
- ❑ Measurement range from ±15mT to ±400mT
- ❑ Low noise output signal (PWM jitter)
- ❑ Programmable through the connector (supply, ground & output)
- ❑ 16 bit customer ID number (48 bit MLX ID for traceability purposes)
- ❑ SOIC8 package RoHS compliant
- ❑ Lead free component, suitable for lead free soldering profile 260°C

Application Examples

- ❑ Rotary position sensor
- ❑ Linear position sensor
- ❑ Contactless switch

Ordering Information

Part No.	Temperature Code	Package Code	Option code
MLX90291BC	K (-40°C to 125°C)	DC (SOIC8)	-

1 Functional Diagram

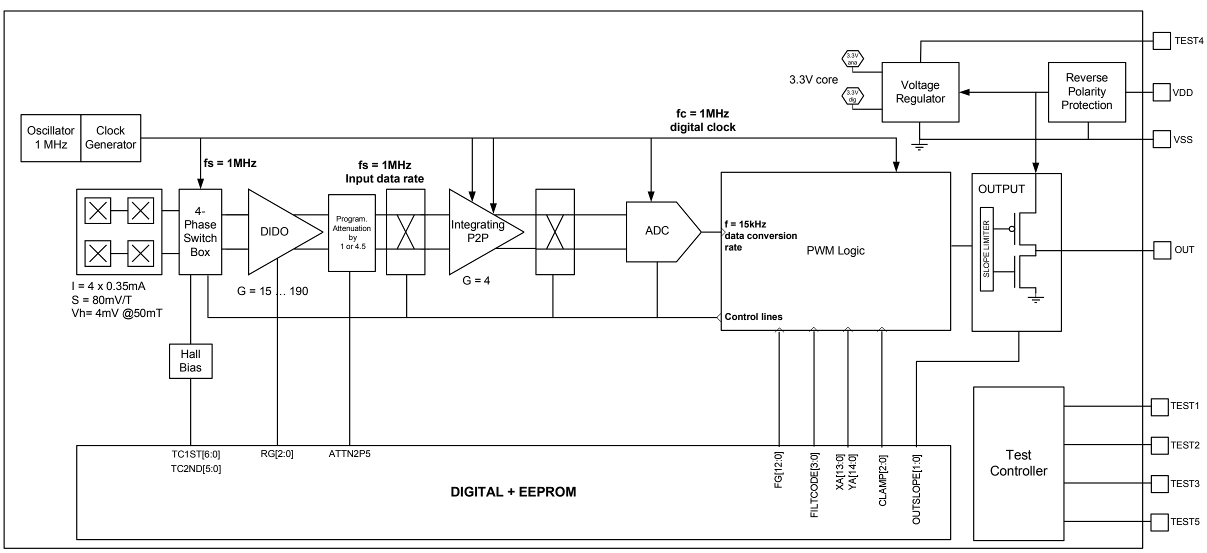

Figure 1: Block diagram

2 General Description

The MLX90291 is a monolithic programmable linear hall sensor IC, which can provide a PWM output signal proportional to the externally applied magnetic flux density or act as a switch with a programmable threshold level. The transfer characteristic of the MLX90291 is fully programmable (offset, gain, clamping levels, …).

3 Table of Contents

4 History

Rev 001 Initial version (April 2011)

5 Glossary of Terms

Tesla	Units for the magnetic flux density, 1 mT = 10 Gauss
TC	Temperature Coefficient in ppm/°C
NC	Not Connected
ADC	Analog-to-Digital Converter
PTC	Programming Through Connector
POR	Power on Reset
INL	Integral Non Linearity
DNL	Differential Non Linearity
PWM	Pulse Width Modulation

6 Absolute Maximum Ratings

Parameter	Symbol	Value	Units
Positive Supply Voltage (over-voltage)	Vdd	+20	V
Reverse Supply Voltage Protection		-10 -14 (200s max, T_A = +25°C)	V
Positive Output Voltage		+10 +14 (200s max, T_A = +25°C)	V
Output Current	Iout	20	mA
Reverse Output Voltage(1)		-5	V
Reverse Output Current(1)		-50	mA
Operating Ambient Temperature Range	T_A	-40 to +150	°C
Storage Temperature Range	T_S	-55 to +150	°C
Magnetic Flux Density		± 10	T

Table 1: Absolute maximum ratings

(1) Realized through an on-chip resistor along the output line

Exceeding the absolute maximum ratings may cause permanent damage. Exposure to absolute maximum rated conditions for extended periods may affect device reliability.

7 Pin Definitions and Descriptions

Pin №	Name	Type	Function
1	VDD	Supply	Supply Voltage
2	VSS	Ground	Ground Voltage
3	TEST4	N/A	MLX Test and factory calibration
4	OUT	Digital	Sensor output signal
5	TEST5	N/A	MLX Test and factory calibration
6	TEST3	N/A	MLX Test and factory calibration
7	TEST2	N/A	MLX Test and factory calibration
8	TEST1	N/A	MLX Test and factory calibration

Table 2: Pin definition and description – S08 package

It is recommended to connect the MLX test pins to the Ground for optimal EMC results. See section 14 for a recommended application diagram

8 General Electrical Specifications

Operating Parameters T_A = -40°C to 125°C, Vdd = 5.0 V, using recommended application diagram, unless otherwise specified.

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Nominal Supply Voltage	V_{DD}		4.5	5	5.5	V
Supply Current	I_{DD}			8	10	mA
Peak Supply Current	I_{DDpeak}	During power-up and PWM switching			15	mA
Reset Voltage (POR)	V_{POR}		2.2		2.7	V
POR Threshold Hysteresis	$V_{PORHYST}$			0.3		V
Operating Threshold (rising)	$V_{OPERATING}$			3.3	3.8	V
Under-Voltage Threshold (falling)	V_{UNDER}	Immediate diagnostic low without reset in case of recovery	2.7	3		V
Operating / Under-Voltage Threshold	V_{HYST}			0.1		V
Programming Voltage	V_{PROG}	Not Locked Part Output = High Impedance	6.7	7.4	7.7(1)	V
Overvoltage detection	V_{OVER}	Output = High Impedance	7.5(1)	8.5		V
Load resistance range (Pull-up/down)	R_L	Pull-up OUT to 5V	2	4.7		kΩ
Load Capacitor range	C_L	Between OUT and GND		10		nF
Output Saturation Voltage Push Pull Mode	$V_{SATPPHI}$	I_{OUT} = + 2mA	V_{DD} – 0.3			V
	$V_{SATPPLO}$	I_{OUT} = – 2 mA			0.3	V
Output Saturation Voltage Open Drain Mode	V_{SATOD}	I_{OUT} = – 2 mA Output = Low (Driver ON)			0.3	V
Output Leakage Current Open Drain Mode	I_{LEAKOD}	V_{OUT} = + 5 V Output = High (Driver OFF)		2	10	µA
Output Short Circuit Current	$I_{OUTSCGND}$	Current limitation fully ON	+ 15		+ 28	mA
	$I_{OUTSCVDD}$	Current limitation fully ON	– 28		– 15	mA

Table 3: General electrical parameters

(1) No overlap possible at the same temperature

9 Magnetic specification

Operating Parameters T_A = -40°C to 125°C, Vdd = 5.0 V, unless otherwise specified.

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Magnetic Flux Density range	B		±15	±40	±400	mT

Table 4: Magnetic specification

10 Timing specification

Operating Parameters T_A = -40°C to 125°C, Vdd = 5.0 V, unless otherwise specified

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Power Up Sequence	t_{ON1}	0 < V_{DD} < V_{POR}		F(V_{DDSR})		ms
	t_{ON2}	V_{POR} < V_{DD} < $V_{OPERATING}$		F(V_{DDSR})		ms
	t_{ON3}	V_{DD} > $V_{OPERATING}$		1		Cycle
Power Supply Slew rate(external)	V_{DDSR}		0.0005		5	V/µs
EEPROM Check	t_{EEPROM}	EEPROM dump + CRC check		0.5	1	ms
Main Oscillator Frequency	F_{OSC}	Tolerance ± 10%	921	1024	1127	kHz
Tick Time	t_{TICK}			0.98		µs
PWM Cycle Duration	$Cycle_{PWM}$	2^{13} t_{TICK}		8		ms
PWM Output Frequency	F_{PWM}	$F_{OSC}/2^{13}$		125		Hz
Sampling Frequency	F_{SAMPLE}	Analog sampling		Fosc		
Conversion Rate @ F_{OSC} = 1024 kHz	F_{CONV}	Measurement: 40 analog samples Conversion (ADC): 25 µs		70		µs
Low pass filtering (First order filter) @ F_{OSC} = 1024 kHz @ -3 db	F_{FILTER}	FILTCODE = 9 FILTCODE = 8 FILTCODE = 7 FILTCODE = 6 FILTCODE = 5 FILTCODE = 4 FILTCODE = 3 FILTCODE = 2		4 9 17 35 70 139 279 557		Hz
Output Slope current generator	I_{SLOPE}	OUTSLOPE = 0 OUTSLOPE = 1 OUTSLOPE = 2 OUTSLOPE = 3		4 6 11 20		mA

Table 5: Timing specification of the analog output

11 PWM output specification

Operating Parameters T_A = -40°C to 125°C, Vdd = 5.0 V, unless otherwise specified

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
PWM Output Clamping	SCG_{PWM}	CLAMP = 0 CLAMP = 1 CLAMP = 2 CLAMP = 3 CLAMP = 4 CLAMP = 5 CLAMP = 6	1 4 5 6 7 8 9		99 96 95 94 93 92 91	%DC
PWM Output Offset	PWM_{OQ}	Programming Range	0		100	%DC
PWM Output Offset Resolution	PWM_{OQRES}	Programming Resolution		0.025		%DC
PWM Output Slope	S	10%-90% Swing	0.1	1	6.4	%DC/mT
PWM Output Slope Resolution	S_{RES}	% of Slope target value (fine gain)		0.025		%
PWM Resolution	LSB_{PWM}	12 bits		0.0125		%DC
SWITCH Low Level Threshold range	$SWITCH_{LO}$	Switch mode Programming range	0		100	%
SWITCH High Level Threshold	$SWITCH_{HIG}$	Switch mode Programming range	0		100	%
SWITCH Programming resolution	$SWITCH_{RE}$	Switch mode Resolution		0.025		%
PWM Linearity	DNL_{PWM} INL_{PWM}	13 bits resolution 40 mT – 1%DC/mT	-1 -2		1 2	LSB_{PWM}
PWM Jitter	JIT_{PWM}	S = 1% DC/mT F_{PWM} = 125 Hz Filter setting: m=32	– 2		+ 2	LSB_{PWM}
PWM Clamping Accuracy	$Clamp_{ACC}$		– 2		+ 2	LSB_{PWM}
Intrinsic Offset Thermal Drift	Δ^TOffset	25 °C to - 40 °C 25 °C to 125 °C	– 0.1		+ 0.1	mT
Thermal Sensitivity Drift	$\Delta^T S$	After calibration @ MLX full temperature range	– 150	0	+ 150	ppm/°C
Sensitivity thermal coefficient resolution	RES	Incremental TC Adjust 5 bits over ± 800ppm/°C		50		ppm/°C

Table 6: PWM output specification

12 Fault modes

Operating Parameters T_A = -40°C to 125°C, Vdd = 5.0 V, unless otherwise specified

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Output signal in Fault state	$Fault_{OUT}$	EEPROM parity fail	4		-	V
Parity Fail Criterion	n_{PARITY}	Successive CRC fails before	-	2	-	Count
Broken VSS	VBR_{VSS}	Pull-Up resistor = 5K	4			V
Broken VDD	VBR_{VDD}	Pull-Up resistor = 5K	4			V

Table 7: Fault modes

13 Programmable Items

13.1 Parameter table

Parameter	Bits	Comment
OUTMODE	1	Push pull or open drain output drive
ROUGHGAIN	3	Rough gain preamplifier
FINEGAIN	13	Digital fine gain adjustment from -3.999 to +3.999
XA	14	Offset before gain
YA	15	Offset after gain, (Xa,Ya) defines the zero Gauss point
CLAMP	3	Clamp high and clamp low level
FILTCODE	4	Digital output filter
OUTSLOPE	2	Output Slope Control
DCDEF	1	PWM Duty Cycle Definition
TC1ST	7	Sensitivity temperature drift correction 1st order
TC2ND	6	Sensitivity temperature drift correction 2nd order
OFFDRIFT	6	Residual Offset Correction
SWITCH	1	PWM/Switch mode
PLATEPOL	1	Invert Sensitivity Sign
ATTN2P5	1	Attenuator block switch
CSTID	16	Melexis ID

Table 8: Customer programmable items

13.2 Output mode configuration (OUTMODE)

OUTMODE configures the output driver.

OUTMODE	Output Driver
0	PWM Open-drain
1	PWM Push-pull

Table 9: Output configuration

13.3 Sensitivity programming (ROUGHGAIN, FINEGAIN)

ROUGHGAIN[2:0]

This 3-bit register controls the gain of the pre-amplifier.

- The MSB controls the enable of the PREAMP function with a gain of 4.3 (~2mA extra I_{DD})
- The 2 LSB control the gain of the MAINAMP

Value	Typical Gain
0	15.0
1	21.6
2	31.1
3	44.8
4	64.5
5	92.9
6	133.7
7	192.6

Table 10: ROUGHGAIN versus amplifier gain

FINEGAIN[12:0]

Value defines the digital gain adjustment

- The code 1024 corresponds to a gain of 1
- The MSB is the sign bit which acts as a polarity bit
- FINEGAIN gain range is from -3.9999 to +3.99999

13.4 Offset / output quiescent voltage programming (XA, YA)

XA[13:0]

PWM mode: Offset trimming before FINEGAIN block
Switch mode: Threshold for the output to switch

YA[14:0]

PWM mode: Offset trimming after FINEGAIN block
Switch mode: Hysteresis for the output to switch

Both parameters together define the zero Gauss point in PWM mode

In switch mode, XA is used to set the threshold and YA to set the hysteresis

Case YA > 0	Case YA < 0	Output State
ADC < 4.XA – 16.YA	ADC < 4.XA	Set to Zero
ADC > 4.XA	ADC > 4.XA - 16.YA	Set to One
Otherwise	Otherwise	Unchanged

Table 11: Output state as function of XA and YA in switch mode

13.5 Clamping level programming (CLAMP)

CLAMP[2:0] defines the clamping level of the PWM output

CLAMP	Minimal output [%DC]	Maximal output [%DC]
0	1	99
1	4	96
2	5	95
3	6	94
4	7	93
5	8	92
6	9	91
7	10	90

Table 12: CLAMP parameter versus output.

13.6 Bandwidth and filter programming (FILTCODE)

FILTCODE[3:0] allows adjusting the internal bandwidth of the sensor in order to optimize for speed or resolution.

FILTCODE	Cut off frequency [Hz]	Attenuation [dB]	Tau [ms]
2	557	-8.0	0.29
3	279	-11.2	0.57
4	139	-14.4	1.14
5	70	-18.1	2.29
6	35	-22.4	4.57
7	17	-27.1	9.14
8	9	-32.3	18.29
9	4	-38.1	36.57

Table 13: FILTCODE settings PWM mode

13.7 Current limitation (OUTSLOPE)

2 Bit register to set the current limitation for slew rate control

OUTSLOPE	Current limitation [mA]
0	4
1	6
2	11
3	20

Table 14: Current limitation

13.8 PWM Mode duty cycle definition (DCDEF)

The PWM duty cycle definition is as follows.

DCDEF	PWM duty cycle definition
0	tLow / (tLow + tHigh)
1	tHigh / (tLow + tHigh)

Table 15: PWM duty cycle definition

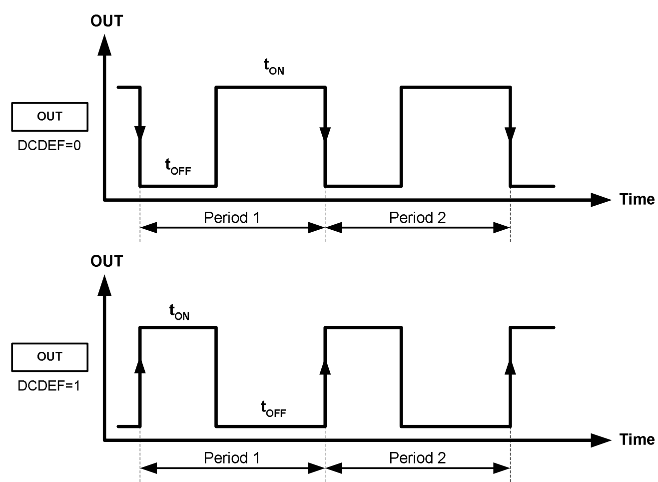

Figure 2: Two different PWM modes

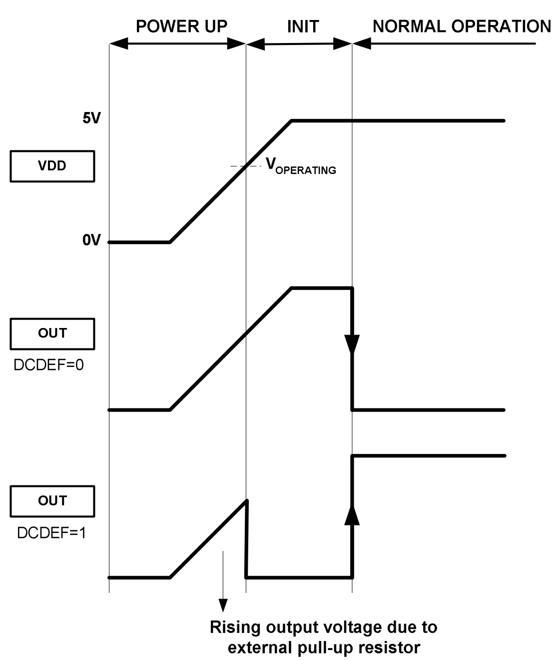

Figure 3: Power-on behaviour of the two different modes

13.9 Sensitivity and temperature drift programming (TC1ST, TC2ND)

TC1ST[6:0]

Programming first order sensitivity temperature drift

Value	Typical 1st order TC
0	+2740ppm/°C
63 or 64	0ppm/°C
127	-2950ppm/°C

Table 16: TC1ST parameter

TC2ND[5:0]

Programming second order sensitivity temperature drift

Value	Typical 2nd order TC
0 or 32	0 ppm/°C²
31	+6.8 ppm/°C²
63	-6.1 ppm/°C²

Table 17: TC2ND parameter

13.10 Offset temperature drift programming (OFFDRIFT)

OFFDRIFT[5:0] parameter defines the offset behaviour over temperature (1st order)

Value	Offset drift correction
0 or 32	0 mV/°C
31	+0.9 mV/°C
63	-0.9 mV/°C

Table 18: OFFDRIFT parameter versus correction

13.11 Functional mode (SWITCH)

Value	Offset drift correction
0	PWM output mode
1	Switch output mode

Table 19: SWITCH parameter

13.12 Polarity (PLATEPOL)

PLATEPOL parameter changes the sign of the measured sensitivity
Default value = 0

13.13 Attenuator (ATTN2P5)

Switch to control the attenuation block in the signal path

Value	ATTN2P5
0	Attenuation factor = 1
1	Attenuation factor = 4.5

Table 20: Attenuation settings

13.14 Customer ID (CSTID)

16-bit customer programmable ID

14 Recommended Application Diagrams

14.1 Resistor and Capacitor Values

Part	Description	Value	Unit
C1	Decoupling, EMI, ESD	10	nF
C2	Supply capacitor, EMI, ESD	100	nF
R1	Pull up or pull down resistor	4.7	kΩ

Table 21: Resistive and capacitive values for the recommended application diagrams

14.2 Pull down resistor for diagnostic low

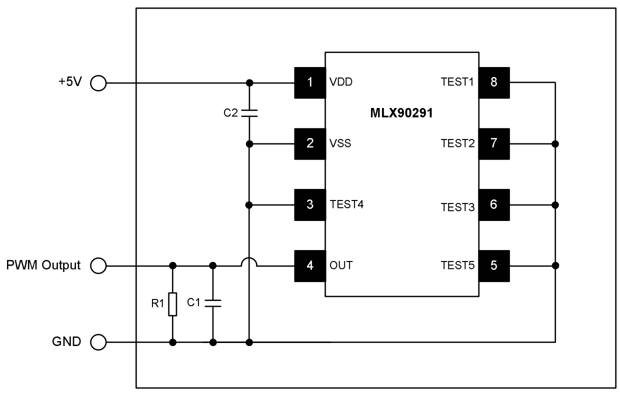

Figure 4: Diagnostic low

14.3 Pull up resistor for diagnostic high

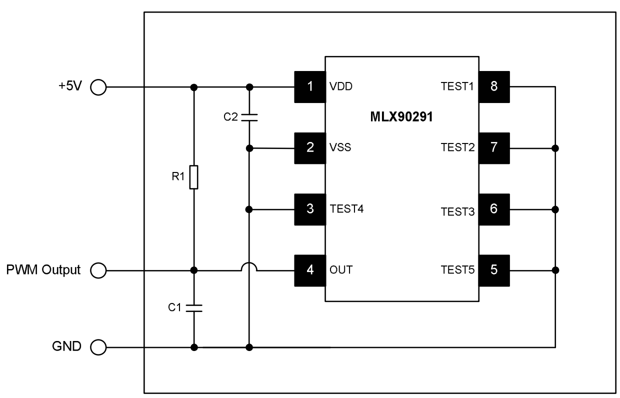

Figure 5: Diagnostic high

15 Standard information regarding manufacturability of Melexis products with different soldering processes

Melexis devices are qualified using state-of-the-art practices in accordance with automotive and environmental requirements.

Through qualifications, various soldering techniques are considered; please refer to “Soldering recommendations for Melexis products” for more information.
(http://www.melexis.com/Asset/Soldering_Application_Note_and_Recommendations_DownloadLink_5446.aspx).

For components normally soldered using Surface Mounted Device techniques (eg: Reflow process), Melexis has defined and qualified Moisture Sensitivity Level and Peak Temperature in accordance with the Jedec J-STD-020 standard. Delivered material is conditioned accordingly. Moisture Sensitivity Level and Peak Temperature information can be found on the label identifying the material.

In case you intend to use a reflow soldering process for through hole devices (Melexis’ package codes: SA, UA, VA, VK, VM), please contact Melexis to verify your soldering process compatibility.

The application of Wave Soldering for SMD’s is allowed only after consulting Melexis regarding assurance of adhesive strength between device and board.

Based on Melexis commitment to environmental responsibility, Europe legislations (Direction on the Restriction of the Use of Certain Hazardous substances, RoHS) and customer requests, Melexis has deployed Pb free leadfinish (typically Matte Tin) on all ASSP products.

For through hole devices (Melexis’ package codes: SA, UA, VA, VK, VM) Trim&Form, please refer to “Trim & Form recommendations for Melexis products” for more information.
(http://www.melexis.com/Assets/Trim_and_form_recommendations_DownloadLink_5565.aspx)

16 ESD Precautions

Electronic semiconductor products are sensitive to Electro Static Discharge (ESD).
Always observe Electro Static Discharge control procedures whenever handling semiconductor products.

17 Package Information

17.1 SOIC8 Package Dimensions

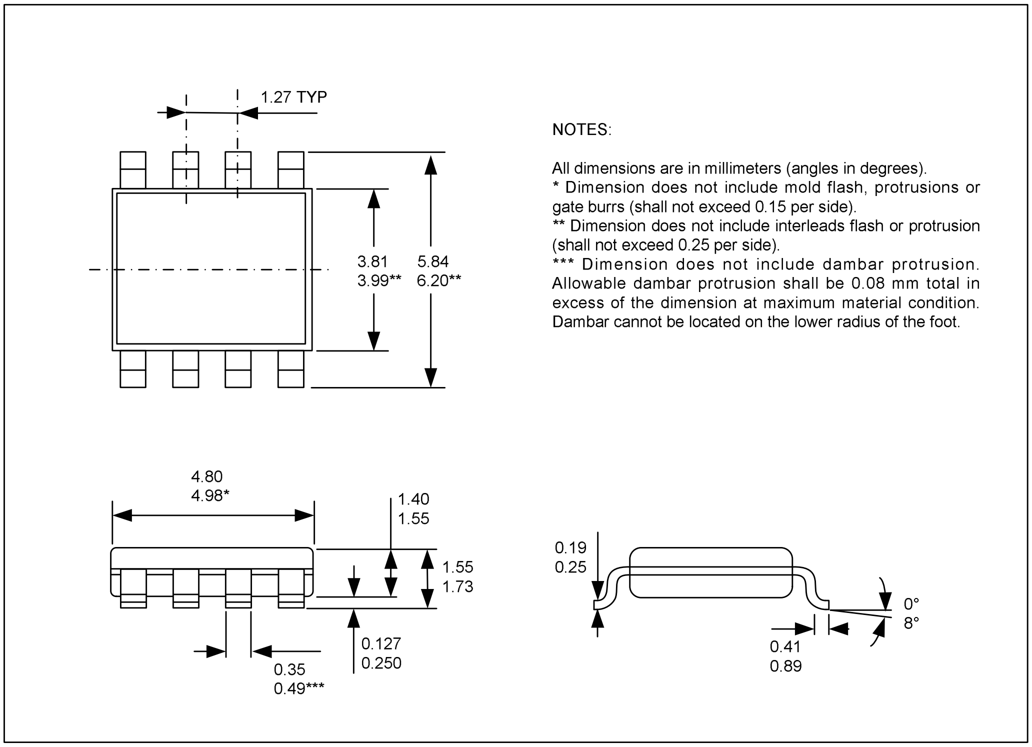

Figure 6: Package dimensions

17.2 SOIC8 Pin Out and Marking

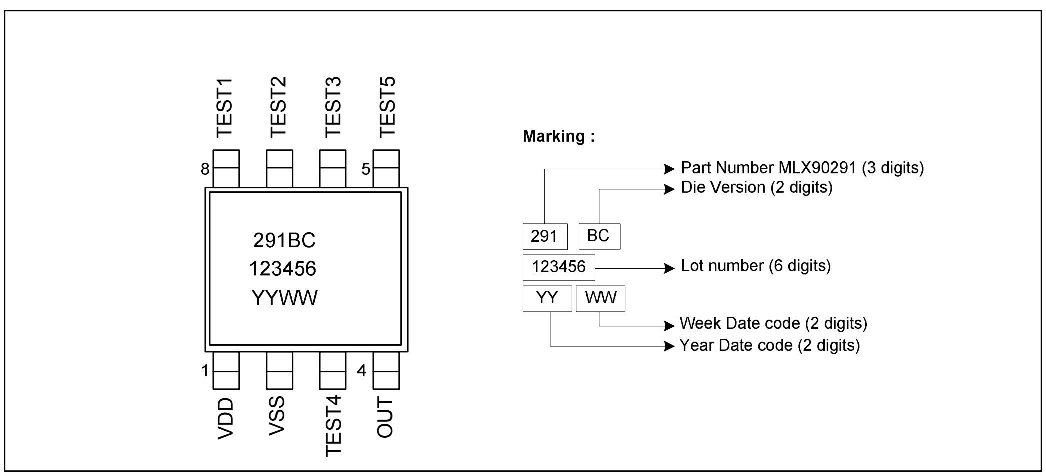

Figure 7: Pin out and marking

17.3 SOIC8 Hall plate positioning

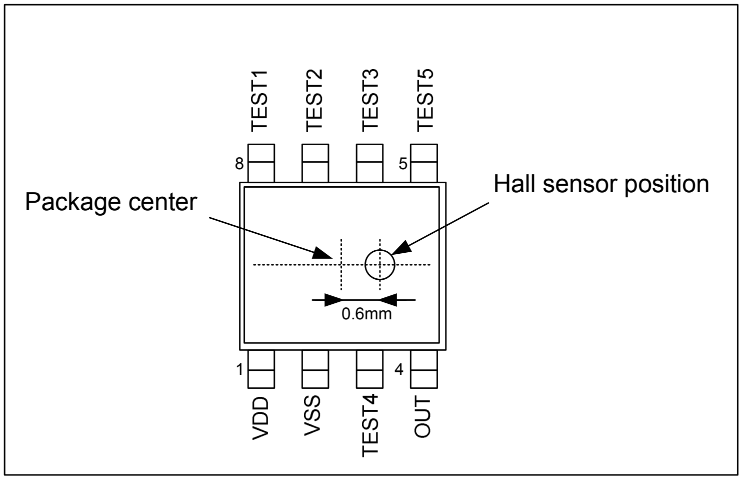

Figure 8: Hall Plate positioning

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