MLX90251

Programmable Linear Hall Effect Sensor

Features and Benefits

Analog Signal Processing
Quad Switched Hall Plate / Chopper Stabilized Amplifier
Ratiometric Output for A/D Interface
Adjustable Output Quiescent Voltage (Voq)
Adjustable Sensitivity
Adjustable Low-Pass Filter
Adjustable Output Driver Configuration
Adjustable Clamping Voltage
Adjustable Thermal Voq Drift
Adjustable Sensitivity Temperature Coefficient (1st & 2nd Order)
Adjustable Internal Bias Point

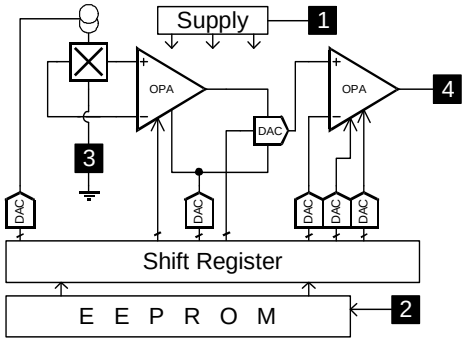
Applications

Linear Position Sensing
Rotary Position Sensing
Current Sensing

Ordering Information

Part No.	Temperature Suffix	Package Code	Option code
MLX90251	L (-40°C to 150°C)	VA (4 leads)	-
MLX90251	K (-40°C to 85°C)	VA (4 leads)	-

1. Functional Diagram



Pin 1 – Vdd (Supply)
Pin 2 – Test
Pin 3 – Vss (Ground)
Pin 4 – Output

2. Description

The MLX90251 is a Programmable Linear Hall Effect sensor IC fabricated utilizing Silicon-CMOS technology. It possesses active error correction circuitry, which virtually eliminates the offset errors normally associated with analog Hall effect devices. All the parameters of the MLX90251 transfer characteristic are fully programmable for even greater versatility.

The Voq (Vout @ B = 0 Gauss), sensitivity, direction of slope, the magnitude of sensitivity drift over temperature (TC – 1st & 2nd order), the clamping level, the thermal Voq drift and the bandwidth, are all programmable.

The ratiometric output voltage is proportional to the supply voltage. When using the supply voltage as a reference for an A/D converter, fluctuations of ±10% in supply voltage will not affect accuracy. When programmed for a conventional sensitivity (with a positive gain), the voltage at the output will increase as a South magnetic field is applied to the branded face of the MLX90251. Conversely, the voltage output will decrease in the presence of a North

magnetic field. The MLX90251 has a very stable thermal compensation for both the sensitivity and the Voq over a broad temperature range.

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3. Glossary of Terms

1 mT = 10 Gauss: Magnetic flux density units.
Voq = Output Quiescent Voltage i.e. Vout for B = 0 Gauss
TC = Sensitivity Temperature Coefficient (in ppm/Deg.C.)

4. Absolute Maximum Ratings

Supply Voltage, V_{DD} (overvoltage)	24 V
Supply Voltage, V_{DD} (operating)	6.5 V
Reverse Voltage Protection (100 ms max)	- 24 V
Output Voltage	24 V
Reverse Output Voltage	-0.7 V
Output Current, I_{OUT}	25 mA
Operating Temperature Range, T_A	-40°C to 150°C
Storage Temperature Range, T_S	-55°C to 165°C
Magnetic Flux Density	Infinite

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

5. MLX90251 Electrical Specifications

DC Operating Parameters T_A as specified by the Temperature suffix (L : -40°C to 150°C – K : -40°C to 85°C), V_{DD} = 5 V (unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Nominal Supply Voltage	Vddnom		-	5	-	V
Supply Voltage	Vdd	(operating - full accuracy)	4.5	-	5.5	V
Supply Voltage	Vddred	(operating - reduced accuracy)	4	-	6.0	V
Max Supply Voltage	Vddmax	(overvoltage protection)	24	-	-	V
Reverse Supply Voltage	Vddrev	(permanent)	- 14.5	-	-	V
Nominal Supply Current	Iddnom	Vdd = Vddnom	4.0	6.0	8.0	mA
Supply Current	Idd	Vdd = 4.5 … 5.5 V	3.0	-	9.0	mA
Supply Current	Iddred	Vdd = 4.0 … 6.0 V	2.0	-	10.0	mA
Reverse Supply Current	Iddrev	Vdd = Vddrev	-65		-40	V
Short Circuit Supply Current	Iddshort1	Vdd = Vddnom Out shorted to Gnd / Vddnom Permanent	20		30	mA
Short Circuit Supply Current	Iddshort2	Vdd < 6 V Out shorted to Vdd Permanent	25		35	mA
Output Voltage Swing	Voutpd	Pull Down Load – no clamping (to Ground)	1		98	%Vdd
Output Voltage Swing	Voutpd	Pull Up Load – no clamping (to Vddnom)	2		99	%Vdd
Output Short-Circuit Current	Ioutsc	Vdd = Vddnom Output shorted to Gnd / Vddnom Permanent	15		25	mA
Power-on Delay	Tpo				5	ms

6. MLX90251 Programmable Features

6.1. Internal Bias Point

The Internal Bias Point (AGND) can be adjusted by changing the corresponding 10 bits code. The parameter has similar effect to the Voq (or Offset) adjust. It allows actually a shift of the whole Voq adjust window in the range -100 %Vdd…200%Vdd.

In other words, the MLX90251 can provide the right transfer characteristic even with a strictly unipolar magnetic span (virtual Voq).

This parameter is adjusted by Melexis depending on the customer application requirements.

6.2. Main Oscillator Frequency

The oscillator frequency of the MLX90251 (with minimal gain setting) can be adjusted in the range 0.7MHz…1.3MHz thanks to a 4 bits code. This oscillator frequency FCKADJ will be adjusted by Melexis at 1.1MHz if the customer application does not require any other value.

The oscillator frequency is automatically linked to the requested sensitivity of the device especially the Rough Gain parameter (RG – see section 6.13).

6.3. Chopping Frequency

The refresh frequency of the chopper stabilized stage (dynamic offset cancellation) is adjusted through the parameter CKANA (2 bits). This frequency is actually a division of the main frequency (see section 6.2): the ratio 1, 2, 4 and 8 are available.

Rough Gain (RG)	Chopping frequency for CKANA = 0	Chopping frequency for CKANA = 1	Chopping frequency for CKANA = 2	Chopping frequency for CKANA = 3
0…3	1100 kHz	550 kHz	275 kHz	137 kHz
4…7	550 kHz	275 kHz	137 kHz	69 kHz
8…11	275 kHz	137 kHz	69 kHz	34 kHz
12…15	137 kHz	69 kHz	34 kHz	17 kHz

The refresh frequency of the output of the MLX90251 is directly linked to the chopping frequency

Rough Gain (RG)	Refresh frequency for CKANA = 0	Refresh frequency for CKANA = 1	Refresh frequency for CKANA = 2	Refresh frequency for CKANA = 3
0…3	275 kHz	137 kHz	69 kHz	34 kHz
4…7	137 kHz	69 kHz	34 kHz	17 kHz
8…11	69 kHz	34 kHz	17 kHz	8.6 kHz
12…15	34 kHz	17 kHz	8.6 kHz	4.3 kHz

The chopping frequency is adjusted by Melexis based on the customer application requirements. There is a trade-off between impulse response time (or bandwidth) and accuracy.

6.4. DIDO Speed

The DIDO is the first amplifier of the analog signal processing chain. It is a part of the chopper amplifier. The parameter SLOW (1 bit) can be used to select its speed and therefore its accuracy. It contributes to the accuracy (thermal drift, noise) of the whole IC.

6.5. Multiplexed DAC Refresh Frequency

The DAC controlling the internal bias, the Voq and the clamping levels is actually multiplexed. The refresh rate of the DAC can be fixed by using the 2 bits code of CKDAC. The refresh rate is automatically linked to the main oscillator frequency.

It will be adjusted at Melexis in order to meet the optimal thermal drift requirement.

CKDAC	Main Oscillator Frequency	DAC Refresh Frequency	Hold Time
0	1100 kHz	137 kHz	1.8 µs
1	550 kHz	69 kHz	3.6 µs
2	275 kHz	34 kHz	7.3 µs
3	137 kHz	17 kHz	14.5 µs

6.6. Clamping Levels

The output swing of the MLX90251 can be clamped between 2 independent levels called the clamping levels. The minimum (resp. maximum) value is referred as Clamp Lo (resp. Clamp Hi).

The parameters controlling those levels are CLAMPLOW and CLAMPHIGH and they are both 10 bits code. The programming range is 0 to 100%Vdd for both levels with a resolution of ca. 5 mV.

6.7. Thermal Voq Drift

The thermal Voq drift parameter is a 4 bits code allowing an improvement of the accuracy of the transfer characteristic over temperature. This parameter is fixed by Melexis during the tri-temp test of the part.

6.8. Diagnostic Output Level

The MLX90251 memory content is secured through a CRC. This self-diagnostic feature brings the output in a defined range. To get rid of the output load influence, this fault-level (FAULTLEV) can be fixed to either Gnd (to be used with pull-down load) or Vdd (to be used with pull-up load).

This parameter is programmed in the application itself.

6.9. Filter

The MLX90251 includes 2 programmable filters placed in the chopper stages and in the fine gain stages. Those 2 filters are controlled through a 4 bits code.

The code 0 corresponds to minimum filtering i.e. maximum speed (impulse response time) but maximum noise.
The code 15 provides the maximum filtering i.e. minimum speed and minimum noise on the output.

The code is fixed in the application.
It is important to notice that the noise is also linked to the gain settings and therefore, the filter option

needs to be used accordingly to meet the best performances.

The table below shows the output noise (in mVrms) Vs. the filter setting for given RG and FG settings.

Rough Gain	Fine Gain	Filter 0	Filter 2	Filter 4	Filter 6	Filter 8	Filter 10	Filter 12	Filter 14
0	0	0.83	0.58	0.41	0.39	0.79	0.60	0.35	0.28
0	1023	2.29	1.47	0.76	0.74	1.89	1.52	0.46	0.43
3	0	1.60	1.10	0.88	0.78	1.56	1.08	0.49	0.48
3	1023	4.03	3.00	2.03	1.79	4.02	2.86	1.02	1.01
4	0	0.99	0.78	0.49	0.50	1.02	0.65	0.33	0.35
4	1023	2.39	1.92	1.19	1.00	2.56	1.63	0.60	0.60
7	0	2.91	1.93	1.39	1.27	2.91	1.93	0.76	0.79
7	1023	7.55	4.99	3.90	3.17	7.44	4.99	1.82	1.75
8	0	1.31	0.91	0.72	0.59	1.40	0.90	0.40	0.39
8	1023	3.56	2.54	1.62	1.41	3.66	2.41	0.78	0.84
11	0	4.55	2.96	2.20	1.78	4.55	2.95	1.18	1.10
11	1023	11.75	7.66	5.57	4.82	11.74	7.68	2.78	2.65
12	0	2.12	1.41	1.00	0.90	2.25	1.36	0.61	0.53
12	1023	5.58	3.75	2.28	2.14	5.60	3.14	1.24	1.15
15	0	7.89	5.01	3.88	3.15	7.92	5.00	1.79	1.71
15	1023	20.37	13.01	9.90	8.08	20.47	12.91	4.48	4.36

6.10. Slope

The slope of the MLX90251 transfer characteristic can be fixed (parameter INVERTSLOPE) to accommodate application requirements and/or the magnet polarity. The slope is inverted in the first stage of the IC i.e. where the Hall signal is generated.

6.11. Output Amplifier Configuration

The output buffer configuration can be selected to tune the response time of the amplifier itself, to accommodate any capacitive load and also to improve the saturation voltage (output swing).

MODE	Maximum Output Current (Isc)	Capacitive Load	Response Time for 20%/80%	Vsat with 5kΩ load to opposite supply
0	25 mA	Cl < 100nF	4 µs	0.75%Vdd
1	6mA	Cl < 47nF	15µs	1.5%Vdd
2	25 mA	Cl > 150nF	= Isc / Cl	0.75%Vdd
3	6mA	Cl > 33nF	= Isc / Cl	1.5%Vdd

6.12. Output Quiescent Voltage (Voq)

The Voq can be adjusted with a 10 bits resolution in the window allowed by the AGND setting (see section 6.1).
The Voq is adjusted in the customer application through the parameter OFFSET. It actually fixes the offset of the output transfer characteristic.

6.13. Rough Gain

The sensitivity of the MLX90251 is controlled through several parameters linked to dedicated internal amplification stages.

One of those is the rough gain setting (parameter RG) that provides a 4 bits adjust.

As described above, the refresh frequency is adapted automatically to the RG setting to match the chopper gain-bandwidth product.

The RG affects both stages (DIDO / DTS) of the chopper amplifier. The table below shows the chopper amplifier gain Vs. the parameter RG.

RG	DIDO Gain	DTS Gain	Total
00 (00 00)	16	1.0	16
01 (00 01)	16	1.5	24
02 (00 10)	16	2.33	37
03 (00 11)	16	4.0	64
04 (01 00)	39	1.0	39
05 (01 01)	39	1.5	59
06 (01 10)	39	2.33	91
07 (01 11)	39	4.0	156
08 (10 00)	82	1.0	82
09 (10 01)	82	1.5	123
10 (10 10)	82	2.33	191
11 (10 11)	82	4.0	328
12 (11 00)	205	1.0	205
13 (11 01)	205	1.5	308
14 (11 10)	205	2.33	477
15 (11 11)	205	4.0	820

6.14. Fine Gain

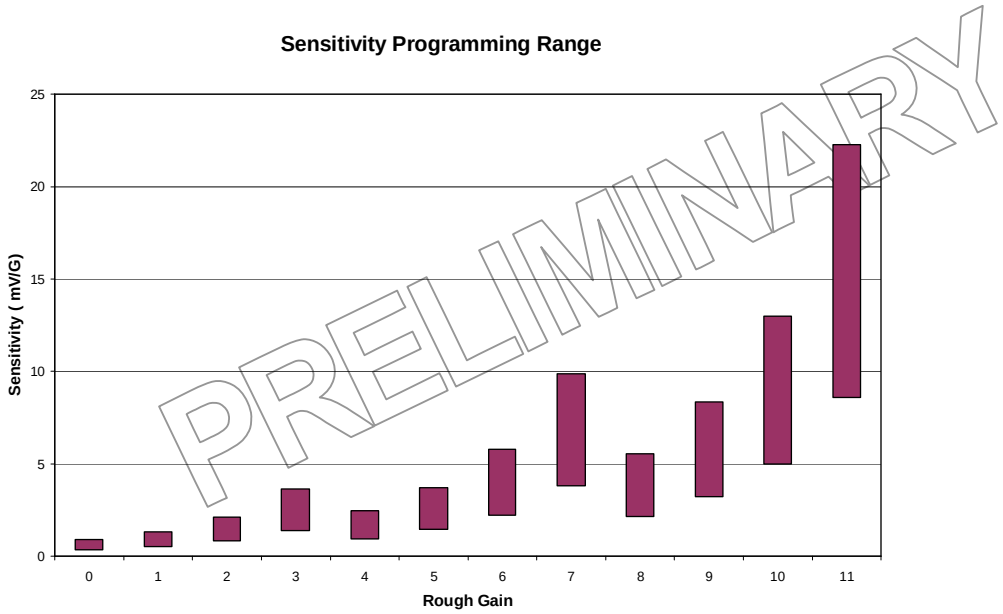
The sensitivity of the MLX90251 is controlled through several parameters linked to dedicated internal amplification stages.

One of those is the fine tuning gain stage (parameter FG) that provides a 10 bits adjust. The gain range of FG is within 1.0…2.5.

The RG and FG parameters are adjusted in the application to fix the sensitivity (gain) of the output transfer characteristic.

Note also that the bit INVERTSLOPE (see section 6.10) can be used to fix the “sign” of the sensitivity.

The following chart shows the sensitivity that can be reached by adjusting both RG and FG.



6.15. Sensitivity Temperature Coefficient

Since the flux density for the magnet used in the application (e.g. SmCo, NdFeB, ferrite,…) will have typically a negative temperature coefficient (the strength decreases if the temperature increases), the IC sensitivity needs to compensate this effect.

Therefore, the sensitivity temperature coefficient is programmed by Melexis (thanks to a tri-temp test on 100% of the parts) to compensate the temperature behaviour of the whole system used around the Hall sensor (i.e. magnet, airgap variations, mechanical variations,…).

To allow an optimal compensation, the sensitivity temperature coefficient is adjusted through a set of 3 parameters: TCW (selection of a window/range of TC – 3 bits), TC (1^{st} order compensation – 5 bits) and TC2ND (2^{nd} order compensation – 6 bits).

The programming accuracy for the TC of the sensitivity is ± 100 ppm/Deg.C.

However, for the budget error of the whole system, the compensation mismatch (system Vs. IC) tolerance has to be taken into account.

6.16. ID Number

For traceability purpose, Melexis will program a unique ID number for each IC. Actually, per lot number (present on the IC marking), the wafer number, the X and Y coordinates will be stored in the memory. There are still some locations left in the Melexis area.

However, 64 bits are also available for the customer to add a serial number of the product,...

6.17. CRC

The EEPROM content is secured thanks to a CRC validation system (3 bits).

Note:

In addition to the global CRC, each bit of the EEPROM is meant to be full redundant i.e. each bit is written in 3 separate cells and a “majority voting” is applied. The 64 ID bits available for the customer are not redundant.

6.18. Memory Melexis Lock

The part of the memory programmed by Melexis is locked through the bit MLXLOCK in order to prevent any data changes in this area.

The MLXLOCK protects the following Melexis settings: AGND, FCKADJ, SLOW, CKANA, CKDAC, DRIFT, TCW, TC, TC2ND

However, the following settings are still accessible: OFFSET, RG, FG, INVERTSLOPE, CLAMPLOW, CLAMPHIGH, FILTER, MODE, CRC, FAULTLEVEL

6.19. Memory Customer Lock

The whole memory is locked through the bit MEMLOCK in order to prevent any data changes after the final calibration in the application.

Note:

The MLX90251 can be unlocked if the Pin 2 (Test) is accessible and set in the right configuration. In normal operating condition, Pin 2 is tied to the ground internally. However, for EMI immunity, the Pin 2 will be tied to the ground externally too (i.e. Pins 2 and 3 shorted).

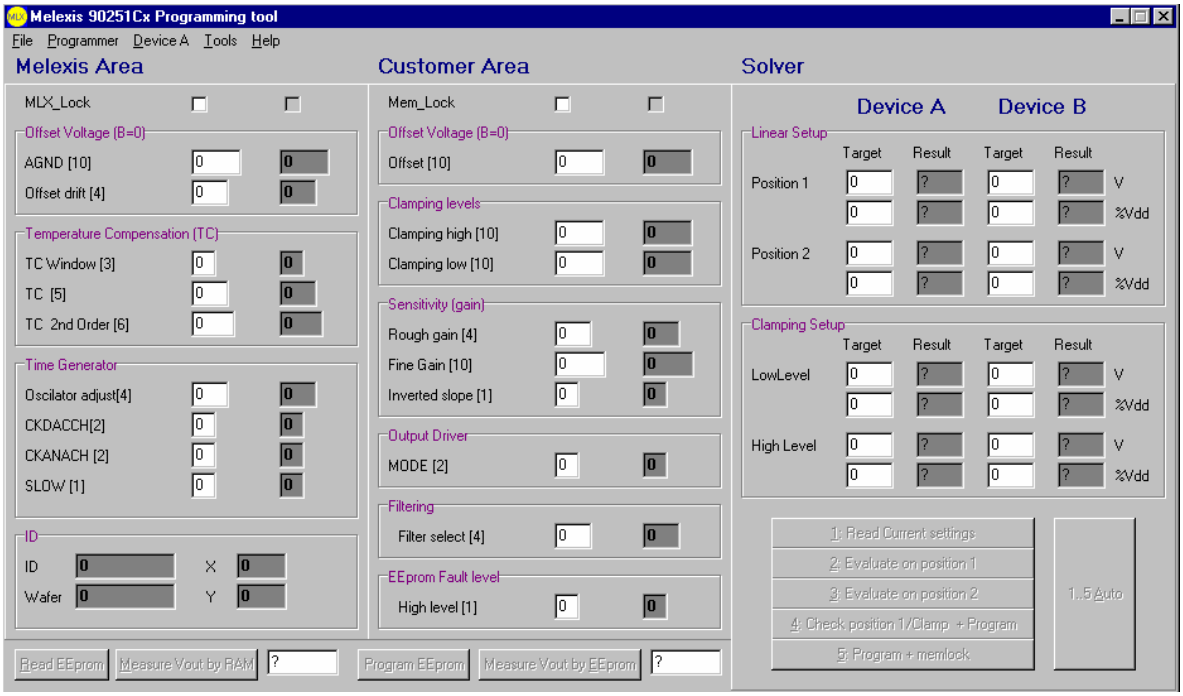
7. MLX90251 Programming Tool

The MLX90251 can be programmed by using the PTC-03 programmer and the dedicated evaluation software to load and program the parts in the application. The programming of the parts is done only through the functional pins of the IC i.e. Vdd (Supply), Vss (Gnd) and Out (Output).

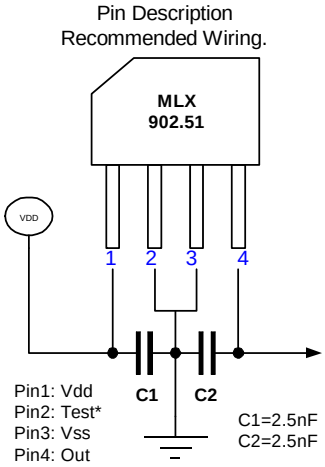
The “cockpit” of the programming software is shown on Page 12.

Note:

The MLX90251 programming is done through the output pin with the supply voltage raised up to 9 V. It should be notice that any connected components must also withstand this voltage excursion.



8. Application Information



Multilayers surface mount capacitors recommended.

**Readback diagnostic use only. Pin2 is not for programming device. For best results tie to Vss.*

Recommended Wiring

9. Reliability Information

Melexis devices are classified and qualified regarding suitability for infrared, vapor phase and wave soldering with usual (63/37 SnPb-) solder (melting point at 183degC).
The following test methods are applied:

IPC/JEDEC J-STD-020A (issue April 1999)
Moisture/Reflow Sensitivity Classification For Nonhermetic Solid State Surface Mount Devices
CECC00802 (issue 1994)
Standard Method For The Specification of Surface Mounting Components (SMDs) of Assessed Quality
MIL 883 Method 2003 / JEDEC-STD-22 Test Method B102
Solderability

For all soldering technologies deviating from above mentioned standard conditions (regarding peak temperature, temperature gradient, temperature profile etc) additional classification and qualification tests have to be agreed upon with Melexis.

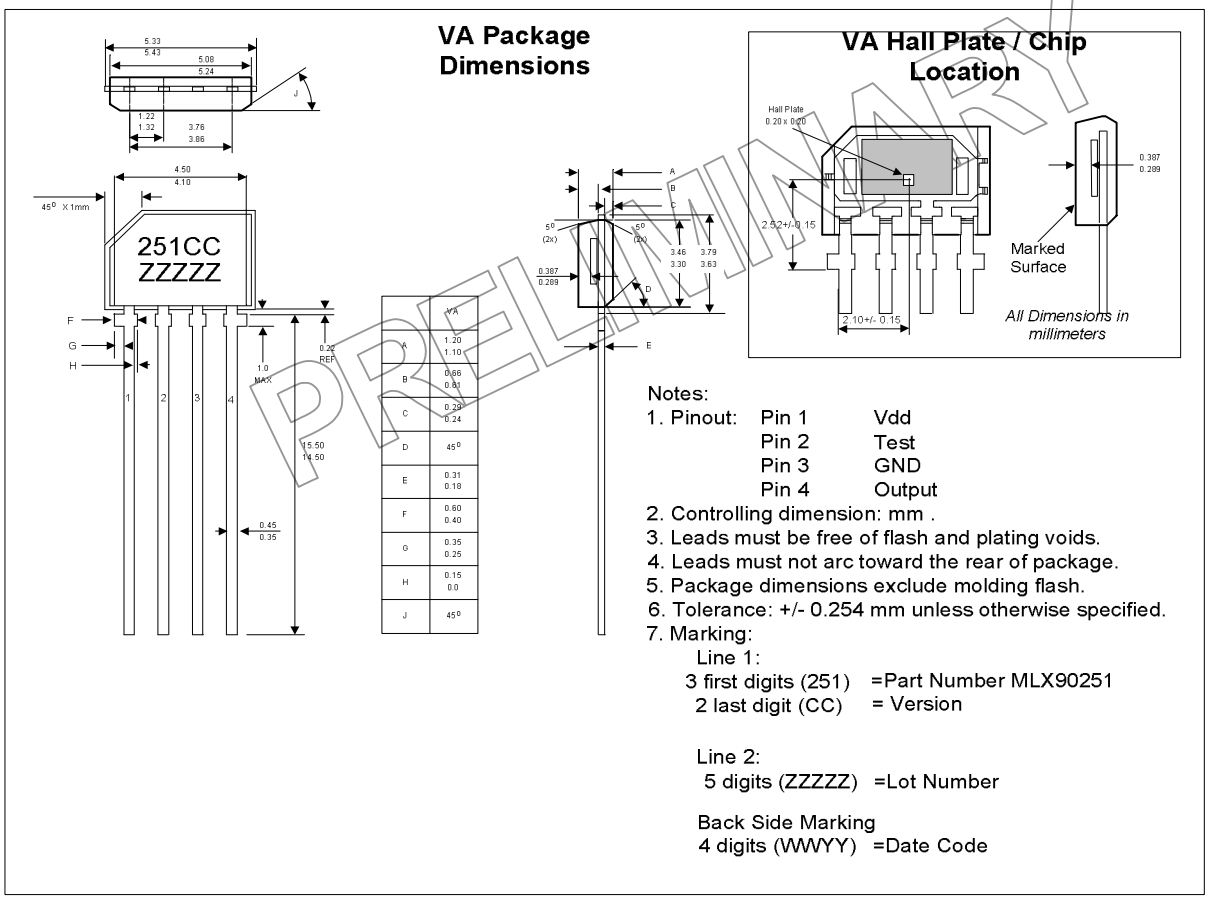
The application of Wave Soldering for SMD's is allowed only after consulting Melexis regarding assurance of adhesive strength between device and board.

For more information on manufacturability/solderability see quality page at our website:
http://www.melexis.com/

10. ESD Precautions

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

11. Package Information



	VA
A	1.20 / 1.10
B	0.66 / 0.61
C	0.23 / 0.24
D	45°
E	0.31 / 0.18
F	0.60 / 0.40
G	0.35 / 0.25
H	0.15 / 0.0
J	45°

Notes:
1. Pinout: Pin 1 Vdd
   Pin 2 Test
   Pin 3 GND
   Pin 4 Output
2. Controlling dimension: mm .
3. Leads must be free of flash and plating voids.
4. Leads must not arc toward the rear of package.
5. Package dimensions exclude molding flash.
6. Tolerance: +/- 0.254 mm unless otherwise specified.
7. Marking:
   Line 1:
   3 first digits (251) =Part Number MLX90251
   2 last digit (CC) = Version

   Line 2:
   5 digits (ZZZZZ) =Lot Number

   Back Side Marking
   4 digits (WWYY) =Date Code

12. Disclaimer

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