GSA301

Very High Precision, Programmable Linear Hall-Effect Sensor IC with High-Bandwidth(250 kHz) and Fast Response

FEATURES

- Very High Precision, Low Temperature Drift
  - Ratiometry Error Offset: ±0.5%
  - Typical linearity error: ±0.1%
  - Typical sensitivity drift over temperature: ±0.2%
- High Bandwidth, Fast Response
  - Typical bandwidth: 250kHz
  - Typical response time: 1.5μs
- AEC-Q100, automotive qualified

DESCRIPTION

GSA301 incorporates a GaAs Hall element with Silicon fundamental circuit to provide a linear current sensor IC. The IC is sensitive to magnetic flux density orthogonal to the IC package surface and the output is an analog voltage proportional to the applied flux density. The GSA301 is designed to be used in conjunction with a ferromagnetic core to provide highly accurate current sensing. The gain and offset drift over temperature is factory-programmed and delivers a solution with typical 0.2% sensitivity and 5 mV offset error from 25°C to 125°C.

PACKAGE

T094

TYPICAL APPLICATIONS

- Automotive Drives
- Current Sensor
- Motor Control
- BMS

TYPICAL APPLICATION CIRCUIT

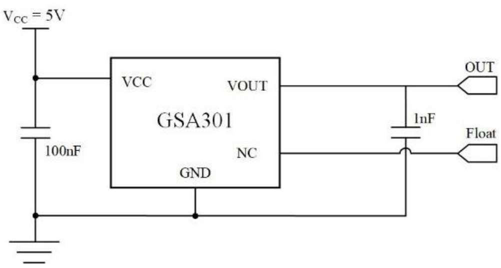


Figure 1 Typical Application Circuit Diagram

THERMAL SENSITIVITY DRIFT

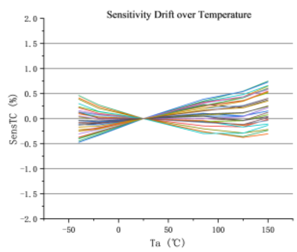


Figure 2 Sensitivity Drift over Temperature

CONTENTS

1. ABSOLUTE MAXIMUM RATINGS

Characteristic[1]	Symbol	Unit	Min.	Typ.	Max.
Supply Voltage	V_{CC}	V	-0.3	-	6.5
Maximum Output Current	I_{OUT}	mA	-45	-	45
Reverse Output Voltage	VO_{REV}	V	-0.3	-	-
Positive Output Voltage	V_{OUT}	V	-	-	Vcc+0.3
Storage Temperature	T_{stg}	℃	-55	-	150
Operating Ambient Temperature	T_A	℃	-40	-	125
Maximum Junction Temperature	$T_{J(max)}$	℃	-	150	-
Maximum Field Range	B	mT	-450	-	450

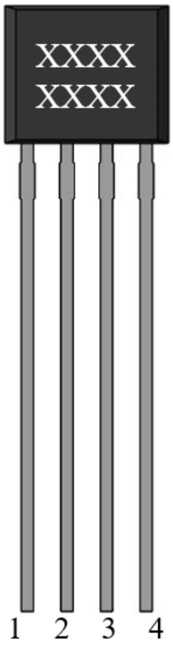
Note: Operation outside the absolute maximum ratings may cause permanent device damage. Absolute maximum ratings do not imply functional operation of the device at these or any other conditions beyond those listed under recommended operating conditions. If used outside the recommended operating conditions 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. The maximum detection range is the range that can be linearly detected when programming the minimum sensitivity.

2. ESD RATINGS

Characteristic	Symbol	Unit	Test Conditions	Value
Human Body Model	V_{HBM}	kV	Compliant with ANSI/ESDA/JEDEC JS-001 standard [1]	±4
Charged Device Model	V_{CDM}	kV	Compliant with ANSI/ESDA/JEDEC JS-002 standard [2]	±1

Note：[1] JEDEC document JEP155 states that 500V HBM can achieve safe production under standard ESD control procedures.
[2] JEDEC document JEP157 states that 250V CDM can achieve safe production under standard ESD control processes.

3. PINOUT DIAGRAM



Type A:

Number	Name	Description
1	VCC	Supply Voltage
2	GND	Ground
3	VOUT	Output signal, also used for programming
4	NC	Not Connected and it must float

Type B:

Number	Name	Description
1	VCC	Supply Voltage
2	VOUT	Output signal, also used for programming
3	NC	Not Connected and it must float
4	GND	Ground

Figure 3 Pinout Diagram

4. SELECTION GUIDE

Part Number	Pinning
GSA301-A	1-Vcc, 2-GND, 3-Vout, 4-NC
GSA301-B	1-Vcc, 2-Vout, 3-NC, 4-GND

5. FUNCTIONAL BLOCK DIAGRAM

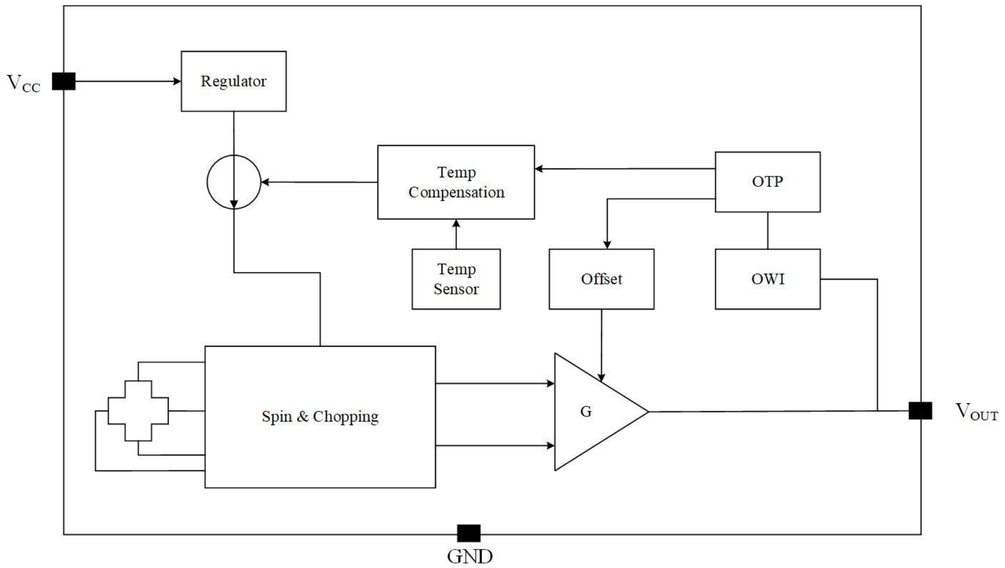


Figure 4 Functional Block Diagram

6. ELECTRICAL CHARACTERISTICS

T_A=25°C, V_{CC}=5V, C_{VCC}=100nF, C_L=1nF, *Sens*=5mV/Gs (Unless otherwise noted)

Characteristic[1]	Symbol	Unit	Test Conditions	Min.	Typ.	Max.
Supply Feature						
Supply Voltage	V_{CC}	V	-	4.5	5	5.5
Supply Current	I_{CC}	mA	-	-	7.6	15
Power-On Reset Voltage	$V_{POR(H)}$	V	*Vcc* rising	2.1	2.2	2.4
	$V_{POR(L)}$	V	*Vcc* failing	1.9	2	2.1
Power-On Reset Hysteresis	$V_{POR(HYS)}$	mV	/	-	200	-
Power-On Time	t_{PO}	ms	/	-	1	-
Output Feature						
DC Output Resistance	R_{OUT}	Ω	/	-	0.5	10
Output Load Resistance	R_L	kΩ	V_{OUT} - *GND*	4.7	-	-
Output Load Capacitance	C_L	nF	/	-	-	10
Output Voltage Saturation	$V_{OUT(SATH)}$	V	-	4.9	-	
	$V_{OUT(SATL)}$	V	-	-	-	0.1
Output Noise	V_{ON}	mV_{RMS}	Cut-Off Frequency =250kHz	-	4	-
Propagation Delay Time	t_{pd}	us	C_L=1nF, R_L=10kΩ	-	0.7	1
Response Time	$t_{RESPONSE}$	us	R_L=10kΩ, Cut-Off Frequency =600kHz	-	0.5	-
			R_L=10kΩ, Cut-Off Frequency =500kHz	-	0.7	-
			R_L=10kΩ, Cut-Off Frequency =250kHz	-	1.5	
			R_L=10kΩ, Cut-Off Frequency =50kHz	-	3	-
Rise Time	t_r	us	R_L=10kΩ, Cut-Off Frequency =250kHz	-	1.2	-
Output Slew Rate	*SR*	V/us	/	-	1.67	-
Internal Bandwidth	*BW*	kHz	Small signal -3dB, *Sens*=5mV/Gs	-	250	-
Chopping Frequency	f_c	MHz	-	-	1	-

Continued on the next page…

5. ELECTRICAL CHARACTERISTICS(CONTINUED)

T_A=25°C, V_{CC}=5V, C_{VCC}=100nF, C_L=1nF, *Sens*=5mV/Gs (Unless otherwise noted)

Characteristic[1]	Symbol	Unit	Test Conditions	Min.	Typ.	Max.
Quiescent Output Voltage [2]						
Quiescent Output Range	$V_{OUT(Q)PR}$	V	After programming	2.495	-	2.505
Number of Fine QVO Programming Bits	*QVO*	Bit	/	-	14	-
Average Quiescent Voltage Output Programming Step Size	$Step_{VOUT(Q)}$	mV	/	-	0.2	-
Sensitivity						
Sensitivity Range	*Sens*	mV/Gs	/	0.1	-	15
Coarse Sensitivity Programming Bits	$Sens_{COARSE}$	Bit	/	-	8	-
Fine Sensitivity Programming Bits	$Sens_{FINE}$	Bit	/	-	14	-
Quiescent Voltage Output Error						
Quiescent Voltage Output Temperature Error	$\Delta V_{OUTQ)TC}$	mV	T_A = -40℃~125℃	-6	±2	6
Ratiometry Error Offset	Rat_{V0}	%	Vcc=4.5~5.5V	-0.5	-	0.5
Sensitivity Error						
Sensitivity Drift over Temperature	$\Delta Sens_{TC}$	%	T_A = 25°C ~ 125°C	-1.5	-	1.5
			T_A = -40°C ~ 25°C	-1	-	1
Sensitivity Nonlinearity Error	Lin_{ERR}	%	≤ 1000Gs	-0.2	±0.05	0.2
			≤ 3000Gs	-0.5	-	0.5
Symmetry Sensitivity Error	SYM_{ERR}	%	/	-0.2	±0.05	0.2
Sensitivity Ratiometry Error	Rat_{ERR}	%	Vcc=4.85~5.15V	-0.5	-	0.5
			Vcc=4.5~5.5V	-1.5	-	1.5

Continued on the next page…

5. ELECTRICAL CHARACTERISTICS(CONTINUED)

T_A=25°C, V_{CC}=5V, C_{VCC}=100nF, C_L=1nF, *Sens*=5mV/Gs (Unless otherwise noted)

Characteristic[1]	Symbol	Unit	Test Conditions	Min.	Typ.	Max.
Life Time[3]						
QVO Lifetime Drift	$V_{QVOLife}$	mV	after Reliability Tests	-	2	-
Sens Lifetime Drift	$Sens_{ERR\_Life}$	%	after Reliability Tests	-	±0.5	-

Note：

[1] These parameters are obtained from laboratory testing with 3σ data.

[2] IC have ratiometric mode. In this mode, Output voltage fluctuates with the supply voltage.

[3] Total QVO Lifetime Drift and Sens Lifetime Drift is obtained by Reliability Tests such as HAST, THB, HTOL.

6. CHARACTERISTICS DIAGRAM

6.1 Temperature Drift (*Vcc* = 5V, *Sens* = 10 mV/Gs, *B* = 200 Gs, C_{VCC}=100nF, C_L = 0nF)

Quiescent Voltage Output Temperature Error ΔV_{OETC}

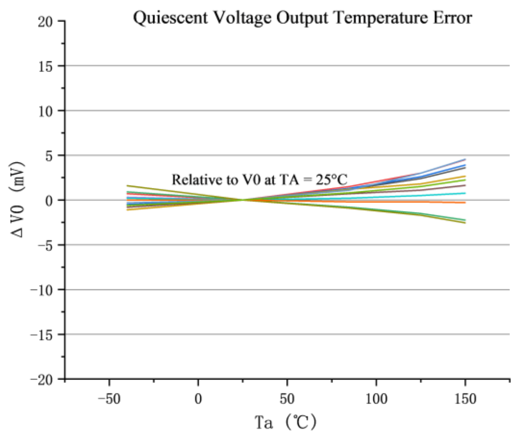


Figure 5 Quiescent Voltage Output Temperature Error

Sensitivity Drift over Temperature $\Delta Sens_{TC}$

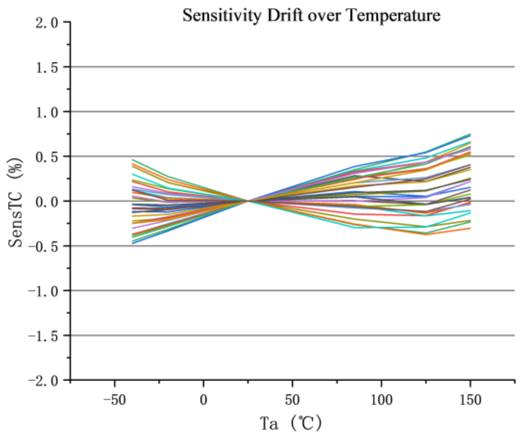


Figure 6 Sensitivity Drift over Temperature

6.2 Output Characteristic Curve (U-B Curve, *Sens* = 5mV/Gs)

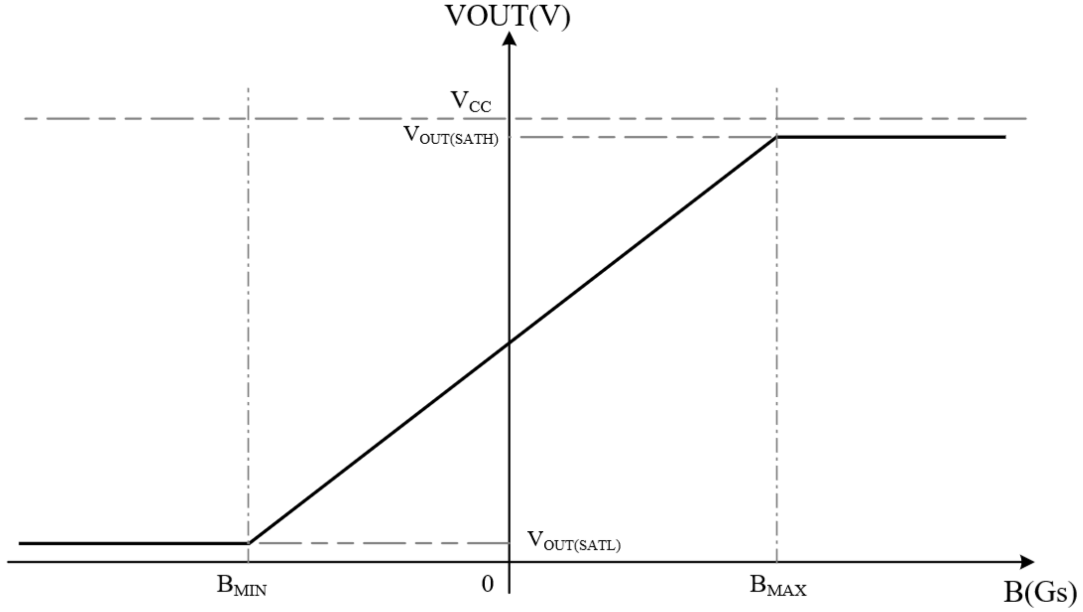


Figure 7 Output Characteristic Curve

6.3 Response Time $t_{RESPONSE}$ (V_{CC} = 5V, *Sens* = 5 mV/Gs, C_{VCC}=100nF, C_L = 1nF)

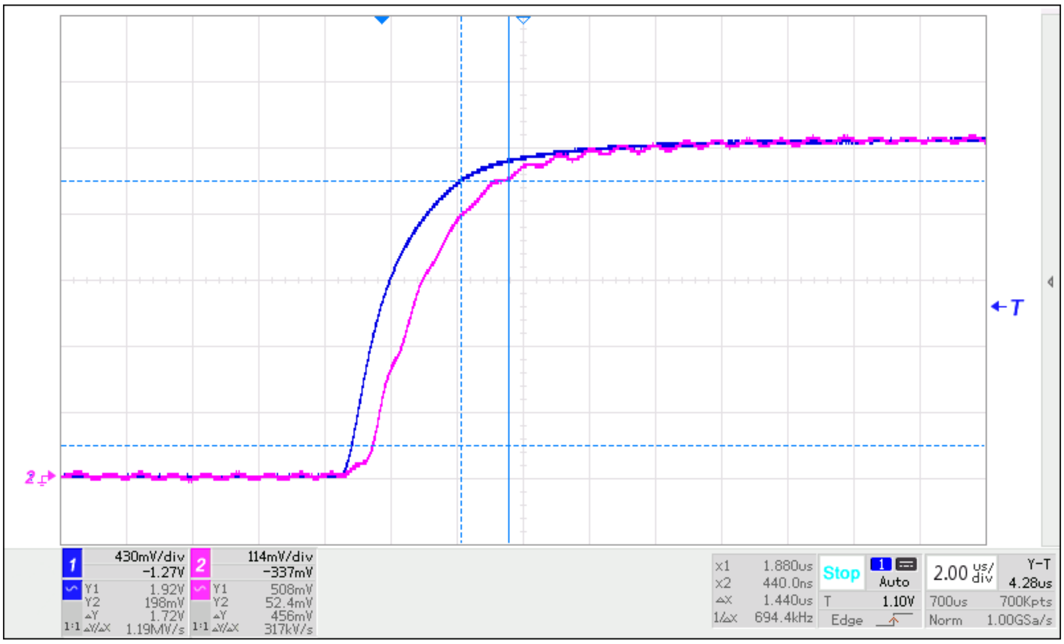


Figure 8 Response Time

6.4 Output Delay Time t_{pd} (V_{CC} = 5V, *Sens* = 5 mV/Gs, C_{VCC}=100nF, C_L = 1nF)

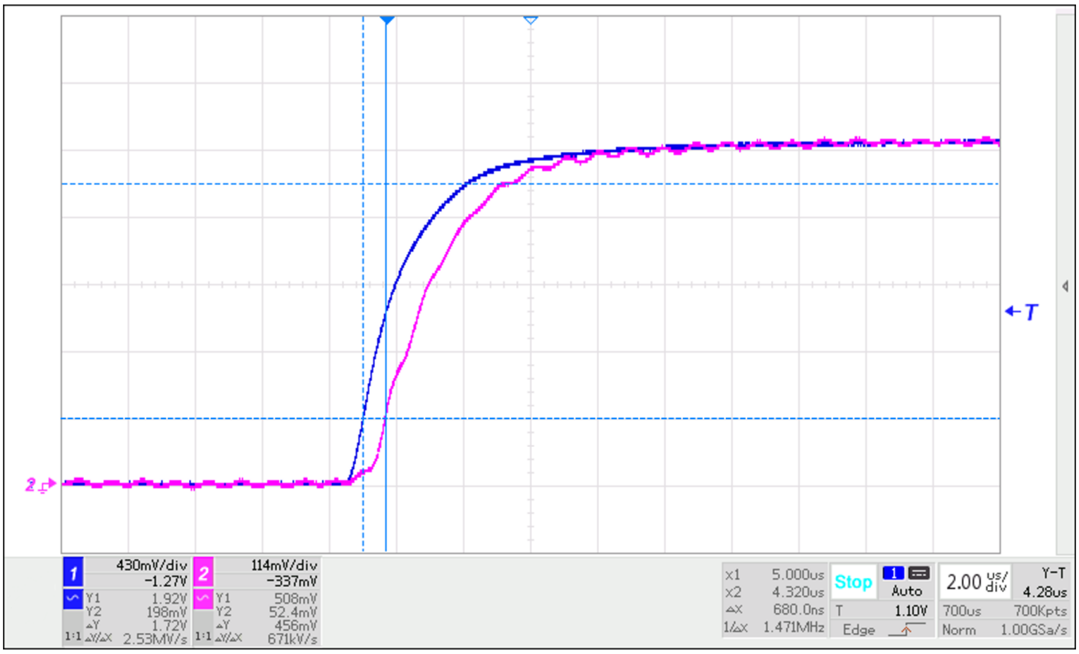


Figure 9 Output Delay Time

6.5 Power-On Time t_{PO} (V_{CC} = 5V, *Sens* = 5 mV/Gs, C_{VCC}=100nF, C_L = 1nF)

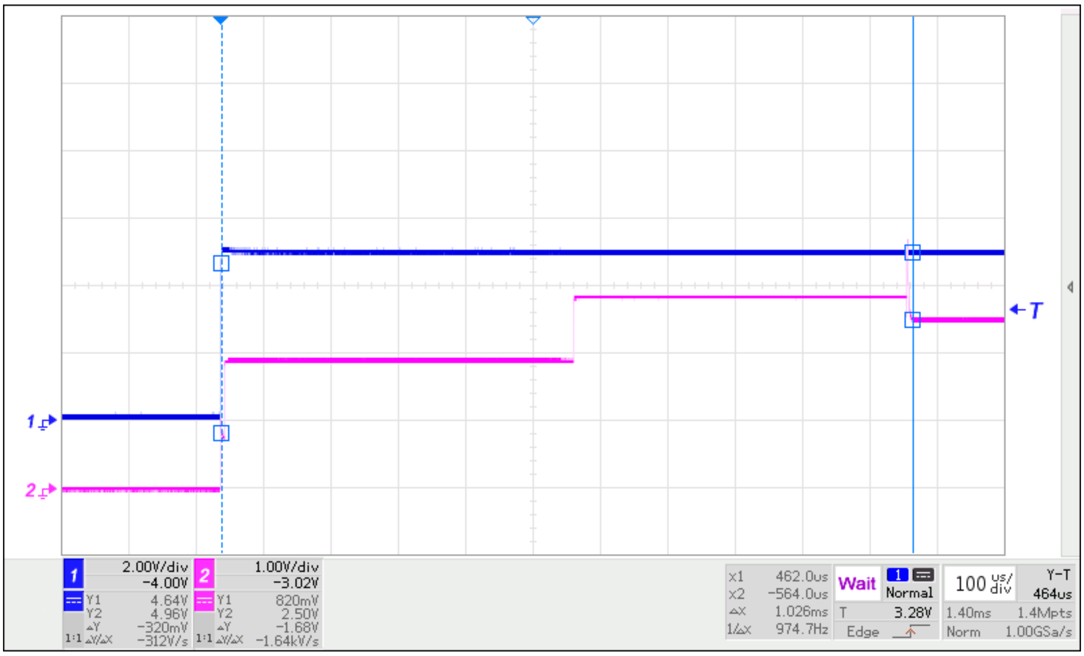


Figure 10 Power-On Time

7. PARAMETERS DESCRIPTION

7.1 Sensitivity ***Sens*** (mV/Gs)

The sensitivity is the ratio between the output of the GSA301 and the input magnetic field. For devices, as the output will scale with the supply, sensitivity is expressed as [%V_{DD}]/Gs. For simplicity, in the datasheet the sensitivity will be always expressed in mV/Gs.

$$Sens = \frac{V_{OUT-B} - V_{OUT-0}}{B}$$

7.2 Sensitivity Drift over Temperature ***ΔSens$_{TC}$*** (%)

Over the entire operating temperature range is defined as:

$$\Delta Sens_{TC} = \frac{\Delta Sens}{Sens_{25℃}} * 100\% = \frac{Sens_T - Sens_{25℃}}{Sens_{25℃}} * 100\%$$

7.3 Sensitivity Nonlinearity error ***Lin$_{ERR}$*** (%)

Ideally, under the same supply voltage and ambient temperature conditions, the output sensitivity of the device is the same for two different magnetic field sizes. In practical application, there is a difference in sensitivity for the measurement of two different magnetic field sizes, and nonlinear error describes the difference digitally. Definition formula is shown in below:

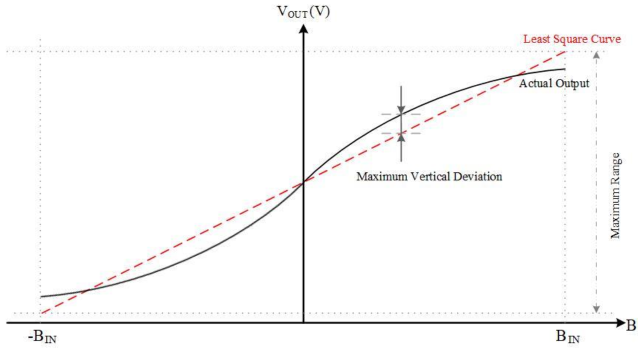


Figure 11 Maximum output deviation

$$Lin_{ERR} = \frac{MFD}{F.S.} * 100\% = \frac{MFD}{V_H - V_L} * 100\%$$

7.4 Ratiometry Error ***Rat$_{ERR}$*** (%)

The GSA301 device features a ratiometric output. This means that the Quiescent Voltage Output ($V_{OUT(Q)}$), magnetic sensitivity, Sens, are proportional to the Supply Voltage (Vcc). In other words, when the supply voltage increases or decreases by a certain percentage, each characteristic also increases or decreases by the same percentage. Ratiometry Error is the difference between the measured change in the supply voltage relative to 5 V, and the measured change in each characteristic.

The formula is as follows:

$$Rat_{ERR-Sens} = \left[1 - \frac{\frac{V_{OUT(VCC)}}{V_{OUT(5V)}}}{\frac{V_{CC}}{5V}}\right] * 100\%$$

$$Rat_{ERR-V0} = \left[1 - \frac{\frac{V_{0(VCC)}}{V_{0(5V)}}}{\frac{V_{CC}}{5V}}\right] * 100\%$$

7.5 Rise time ***tr*** & Response time ***t$_{RESPONSE}$***

Rise time is the time interval between the sensor output voltage reaches 10% of its full-scale value and it reaches 90% of its full-scale value.

Response time is the time interval between the sensed primary current reaches 90% of its final value and the sensor output voltage reaches 90% of its full-scale value.

Rise time and response time is shown in the figure：

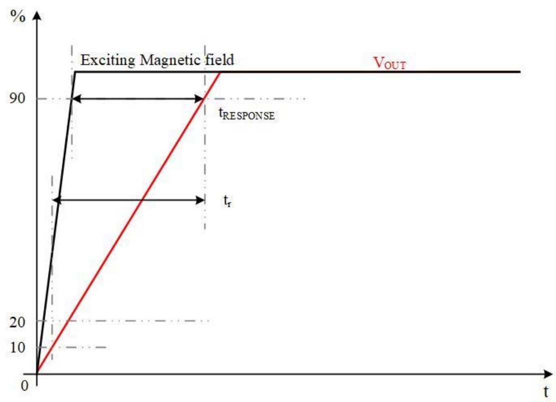


Figure 12 Rise time and response time

7.6 Saturation output voltage $V_{OUT(SATH)}$&$V_{OUT(SATL)}$

$V_{OUT(SATH)}$ is the maximum output of the chip under the positive magnetic field.

$V_{OUT-SAT(L)}$ is the maximum output of the chip under negative magnetic field.

As shown in the figure 7.

7.7 Symmetry Sensitivity Error $SYM_{ERR}(\%)$

The magnetic sensitivity of device is constant for any two applied magnetic fields of equal magnitude and opposite polarities. Sym_{ERR} (%) is measured and defined as:

$$SYM_{ERR} = \left(1 - \frac{Sens_{Bpos}}{Sens_{Bneg}}\right) * 100\%$$

7.8 Coarse Sensitivity Programming Bits $Sens_{COARSE}$

Coarse Sensitivity Programming Bits is determined by its driving current, temperature compensation coefficient and magnification, among which, the magnification is composed of G1, G2, Gain, Go, G1 (3bit), G2 (3bit) and Go (2bit) are coarse adjustment bits for a total of 8 bits, which can determine 256 sets of coarse adjustment multiples in the range of 2.8368 × ~ 200×.

7.9 Fine Sensitivity Programming Bits $Sens_{FINE}$

Fine Sensitivity Programming Bits is determined by its driving current, temperature compensation coefficient and magnification, where the magnification is composed of G1, G2, Gain, and Go, and Gain is a fine adjustment position with a total of 14 bits, which can determine 16384 sets of fine adjustment multiples in the range of 1/3× ~ 1 ×.

7.10 Number of Fine QVO Programming Bits ***QVO***

The zero point of the linear Hall IC is determined by VEXC, Gain, Go and Zero, and the overall sensitivity is generally confirmed first, and then the zero point is confirmed during calibration, where Zero is the zero adjustment part after confirming the sensitivity, a total of 14 bits, and 16384 groups of fine-tuning ratio coefficients can be confirmed in the range of 0 × ~ 1×.

7.11 Quiescent Voltage Output Temperature Error $\Delta V_{OUT(Q)TC}$

Due to internal component tolerances and thermal considerations, the Quiescent Voltage Output ($V_{OUT(Q)}$) may drift from its nominal value through the operating ambient temperature (T_A).

7.12 Power-On Time t_{PO}

When the supply is ramped to its operating voltage, the device requires a finite amount of time to power its internal components before responding to an input magnetic field. Power-On Time (T_{PO}) is defined as the time interval between the power supply has reached its minimum specified operating voltage (V_{UVLOD}) and the sensor output has settled within ±10% of its steady-state value under an applied magnetic field.

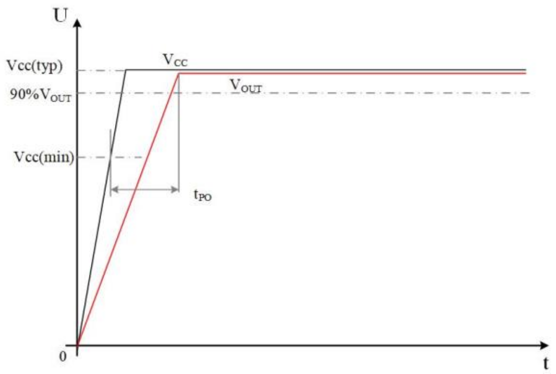
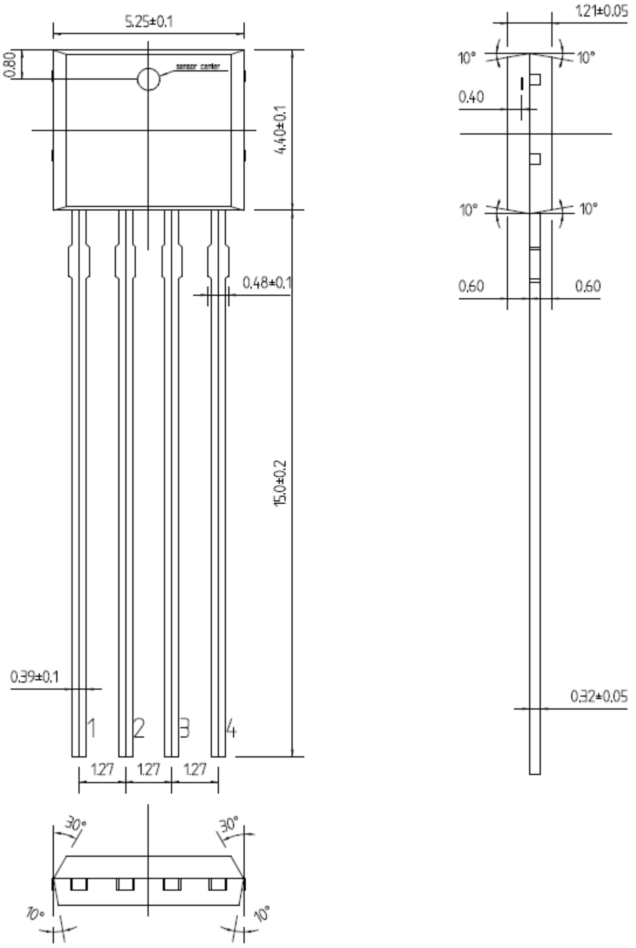


Figure 13 Power-On Time

8. PACKAGE OUTLINE

8.1 Package Outline Drawing



Note：Unmarked tolerances are controlled according to ±0.1mm while the Angle tolerance is ±5°.

Figure 14 Package Outline Drawing

8.2 PCB Layout Reference View

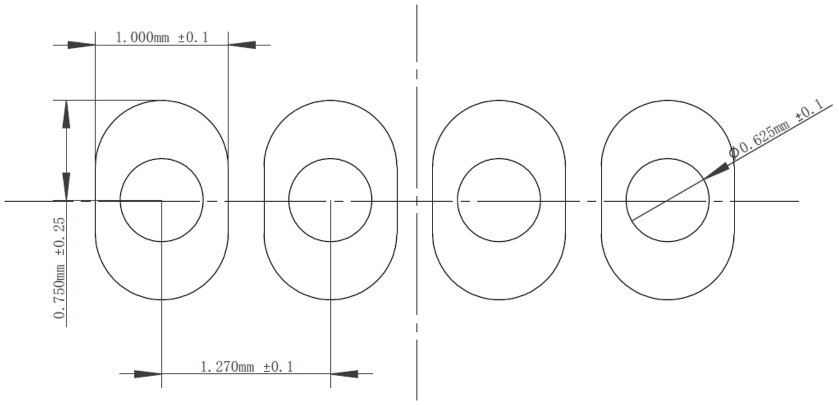
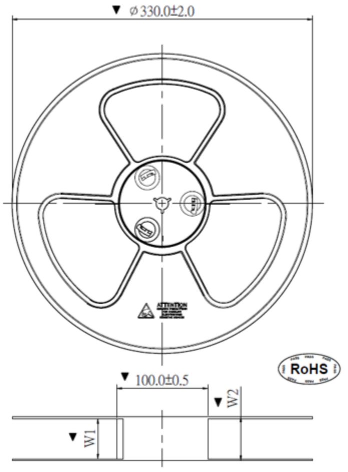


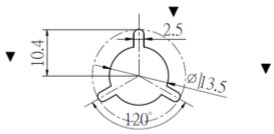
Figure 15 PCB Layout Reference View

9. REEL & STORAGE INFORMATION

9.1 Packaging

9.1.1 reel, 4000pcs/reel



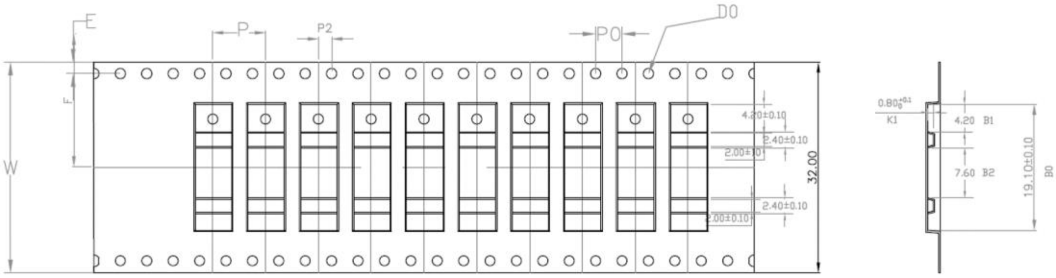


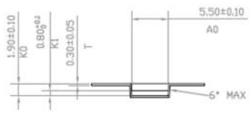
General linear tolerance: ±0.2mm

Number	Size（mm）			Revision Mrak
	MIN	NOM	MAX	
W	3.90	4.00	4.10	
W1	0.43	0.48	0.53	
W2	0.45	0.56	0.66	
W3	1.07	1.27	1.47	

s

Figure 16 reel





W	32.00±0.30	P	8.00±0.10	A0	5.50±0.10	B0	19.10±0.10
S0	———	P0	4.00±0.10	A1		B1	4.20±0.10
E	1.75±0.10	P2	2.00±0.10	A2		B2	7.60±0.10
F	14.2±0.10	D0	$ø1.50^{+0.25}_{-0}$	K0	1.90±0.10		
T	0.3±0.05	D1		K1	$0.80^{+0.10}_{-0}$		

Figure 17 Braid diagram

9.1.2 bag, 300pcs/bag

Figure 18 bag

9.2 Storage Information

The product should be stored at MSL3 standard.

10. SAFETY WARNING

The environmental requirements of this product are as follows:

10.1 ESD control should be done when touching the product.

10.2 The use of this product shall comply with the relevant provisions of local laws and regulations.

11. REVISION HISTORY

REVISION HISTORY		
Number Description Date	Number Description Date	Number Description Date
V1.0	English version first release	2022-12
V1.1	Changed the range of POD	2023-01
V1.2	Add some parameters and modify the template	2024-09