CC6538

Automotive Grade, High-Precision, Low Noise, Programmable, Linear Hall Effect Sensor IC,

with Advanced Temperature Compensation Technology and High Bandwidth (240kHz) Analog Output

FEATURES

- Voltage operating range: 4.5~5.5V, the gain varies linearly with V_{CC};
- The measurement range is wide and the linearity is better than 0.25%;
- The ratio of chopper, harmonic and noise power to fundamental wave is less than 1% (30kHz sine wave test);
- Response time = 1.2us (typ);
- Chopper Frequency: 1.4MHz, High Bandwidth, Low Noise, bandwidth up to 240kHz (typ);
- Low power consumption, the IC quiescent operating current is 18mA;
- The operating temperature: -40~150°C,
  The storage temperature: -40 ~165°C;
- Strong anti-interference ability, strong resistance to mechanical stress;
- Multiple protection functions: break circuit protection, reverse polarity protection, high voltage clamp, output clamp;
- Low temperature drift (<1.5%), Low lifetime drift;
- Moisture sensitivity level: MSL1;
- ESD (HBM) ±8kV；ESD (CDM) ±2kV

APPLICATIONS

- Automotive grade current sensor module
- Gear sensors
- Displacement measurement

GENERAL DESCRIPTION

CC6538 integrates Hall on a chip and adopts BCD process to achieve the integrated design of Hall and signal conditioning ASIC circuits. The chip contains a high-sensitivity Hall sensor, a Hall signal preamplifier, a high-precision Hall temperature compensation unit, oscillator, dynamic offset cancellation circuit and amplifier output module.

CC6538 adopts advanced adaptive hall temperature compensation technology, which can work normally between -40~150°C. It has a wide linear output range. Under the power supply voltage of 5V, VOUT output can vary linearly with magnetic field between 0.5 ~ 4.5V, and the linearity is up to 0.25%. Due to the integrated dynamic offset cancellation circuit, the sensitivity and quiescent output voltage are not affected by external pressure and packaging stress. The IC has the advantages of chopping frequency of 1.4MHz, bandwidth of 240kHz, fast response speed and so on. The chip integrates E-fuse, which can be programmed twice and has a fuse lock function.

The CC6538 has the functions of zero point adjustment, gain adjustment, polarity adjustment, reverse polarity protection and break circuit protection. Temperature compensation and linearity calibration, high and low temperature calibration is completed at the chip level.

CC6538 provides TO-94 package with operating temperature range of -40~150°C and storage temperature range -40~165°C, comply with halogen-free, lead-free and RoHS requirements.

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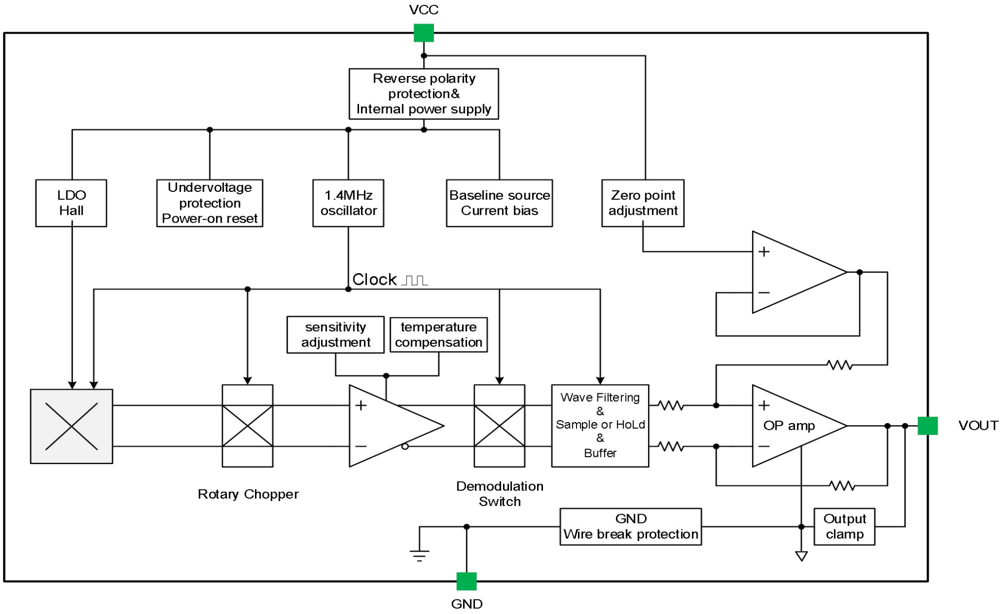
FUNCTION BLOCK DIAGRAM



ORDERING INFORMATION

Part No.	VCC（V）	Sens_Initial（mV/Gs）	Sens_Range (mV/Gs)	Package	Packing Form
CC6538T4S-002BF5-RE-AC	5	2	0.4 ~ 3.6	TO-94	tape reel, 4000 pcs/reel

PRODUCTION NAME DEFINITION

CC 6538 T4S - 002 BF 5 - RE - A C

- Programmability
  - C: Customer programmable
  - F: Factory only
- Application Area
  - A：Automotive Grade
- Packing Type
  - RE: Reel
- Supply Voltage
  - 5: VCC=5V
- Output Type and Directionality
  - B: BidIrectional
  - F: Forward
- Typical Sensitivity
  - 002: 2mV/Gs
- Package Part Number
  - T4S: TO-94 package, Straight leads
- Main Device Name
  - 6538
- CrossChip Part Number
  - Fixed to CC

Note:

Forward polarity is defined as an increase in output value when the north pole of the magnetic field is close to the screen printing surface.

Reverse polarity is defined as an increase in output value when the south pole of the magnetic field is close to the screen printing surface.

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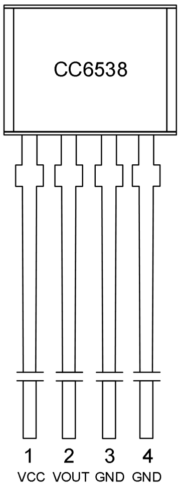
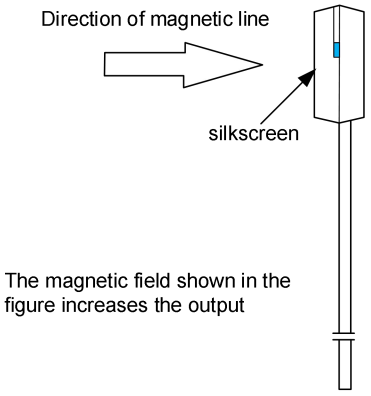
PINOUT DIAGRAM



TO94 Package

Pin Name	Number	Function
VCC	1	Supply Voltage
VOUT	2	Analog signal output, which can be connected to external ADC
GND	3	Ground
GND	4	Ground

OUTPUT POLARITY



Default polarity, programmable to reverse polarity

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ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Condition	Value	Unit
Forward Supply Voltage	V_{CC}		24	V
Reverse Supply Voltage	V_{RCC}		-24	V
Forward Output Voltage	V_{OUT}		25	V
Reverse Output Voltage	V_{ROUT}		-1.5	V
Operating Ambient Temperature	T_A		-40~150	°C
Storage Ambient Temperature	T_S		-40~165	°C
Maximum Junction Temperature	$T_{J(max)}$		165	°C
Magnetic Field Strength	B		Unlimited	mT
ESD Protection	HBM		±8	kV
	CDM		±2	kV

Note: Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

RECOMMENDED OPERATION CONDITIONS

Parameter	Symbol	Min.	Max.	Unit
Supply Voltage	V_{cc}	4.5	5.5	V
Ambient Temperature	T_A	-40	150	°C

ELECTRICAL PARAMETERS (V_{CC}=5V, T_A=25°C,unless otherwise specified)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
ELECTRICAL CHARACTERISTICS						
Supply Voltage	V_{CC}		4.5	5.0	5.5	V
Supply Current	I_{CC}	No load on VOUT		18	23	mA
Power-On Time	t_{PO}	C_{bypass}=open, C_L=1nF		75		us
Undervoltage Lockout Threshold	V_{UVLOH}	V_{CC} rises, the device function enable		4.1		V
	V_{UVLOL}	V_{CC} drops, the device function disable		3.6		V
Undervoltage Lockout Threshold Time	t_{UVLOE}	C_{bypass}=open, C_L=1nF, Sens=2mV/Gs, the time of V_{CC} drops from 5V to 3V is 1.5us		62		us
	t_{UVLOD}	C_{bypass}=open, C_L=1nF, Sens=2mV/Gs, the time of V_{CC} recovers from 3V to 5V is 1.5us		13		us
Power-On Reset Voltage	V_{PORH}			2.7		V
	V_{PORL}			2.4		V
Power-On Reset Time	t_{POR}	$t_{POR}=t_{PO} - t_{UVLOD}$		62		us
VCC Clamp Voltage	V_Z			26		V
Bandwidth	BW_i	Small signal -3dB bandwidth, C_L=1nF		240		kHz
Chopping Frequency	f_C		1.2	1.4	1.6	MHz

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Continued:

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
OUTPUT CHARACTERISTICS						
Rising Time	t_R	10% to 90% of VOUT rising edge		1.2		us
Output Response Time	t_{RES}	The time is calculated from the time when the input signal reaches 90% and the output signal reaches 90%. (The output is in 2V steps and the input rise time is 1us)		1.2		us
Output Clamp Time	t_{CLP}	C_L=1nF, B=800Gs->1200Gs, Sens=2mV/Gs		5		us
VOUT Source Current	$I_{OUT(SOURCE)}$	VOUT to GND short-circuit current		5.5	6.5	mA
VOUT Sink Current	$I_{OUT(SINK)}$	VOUT to VCC short-circuit current		35		mA
Output Clamping Voltage	V_{CLPH}	V_{CC}=5V, R_L(Pull Down)=10kΩ to GND	4.65	4.70	4.75	V
	V_{CLPL}	V_{CC}=5V, R_L(Pull Down)=10kΩ to VCC	0.25	0.30	0.36	V
Broken Wire Voltage	V_{BPKH}	R_L=10kΩ to VCC	V_{CC} - 0.1	V_{CC}		V
	V_{BPKL}	R_L=10kΩ to 0V		60	150	mV
Output Noise	V_N	T_A = 25°C, C_L=1nF, Sens=1mV/Gs		12	20	mV_{p-p}
		T_A = 25°C, C_L=1nF, Sens=1mV/Gs		1.5		mV_{RMS}
DC Output Resistance	R_{OUT}			0.7	2	Ω
Output Load Resistance	R_{LOUT}		1			kΩ
Output Load Capacitance	C_L	VOUT to GND		1	6.8	nF
QUIESCENT VOLTAGE OUTPUT CHARACTERISTICS ($V_{OUT(Q)}$)						
Initial Quiescent Voltage Output	$V_{OUT(Q)init}$		2.45	2.50	2.55	V
Quiescent Voltage Output Programming Range	$V_{OUT(Q)PR}$		2.36		2.64	V
Quiescent Voltage Output Programming Bits	$BIT_{\_VOQ}$			7		bit
Typical Quiescent Voltage Output Programming Step Size	$Step_{VOUT(Q)}$		1.9	2.3	2.8	mV
Quiescent Voltage Output Programming Resolution	$Err_{PGVOUT(Q)}$			±0.5× $Step_{VOUT(Q)}$		mV
SENSITIVITY PROGRAMMABLE CHARACTERISTICS						
Initial Sensitivity Accuracy	S_{SENS_INIT}			2		mV/Gs
Sensitivity Programming Range	$Sens_{PR}$		0.4		3.6	mV/Gs
Fine Sensitivity Programming Bits	$BIT_{\_SENS}$			10		bit
Typical Fine Sensitivity Programming Step Size	$STEP_{SENS}$		2.4	3.2	4.1	uV/Gs
Sensitivity Programming Resolution	Err_{PGSENS}			±0.5× $Step_{Sens}$		uV/Gs

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Continued:

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
SENSITIVITY TEMPERATURE COEFFICIENT						
Sensitivity Drift Through Temperature Range	$\triangle Sens_{TC}$	T_A=25°C ~ 150°C	-1.0		1.0	%
		T_A=-40°C ~ 25°C	-1.5		1.5	%
QUIESCENT VOLTAGE OUTPUT TEMPERATURE COEFFICIENT						
Quiescent Voltage Output Drift Through Temperature Range	$\triangle V_{OUT(Q)TC}$	Sens=1mV/Gs, T_A=25°C ~ 150°C	-10		10	mV
		Sens=1mV/Gs, T_A=-40°C ~ 25°C	-8		8	mV
ERROR COMPONENTS						
Linearity Sensitivity Error	Lin_{ERR}			±0.25		%
Symmetry Sensitivity Error	Sym_{ERR}			±0.25		%
Ratiometry Quiescent Voltage Output Error	$Rat_{ERRVOUT(Q)}$	$V_{OUT(Q)}$=50%V_{CC}, $\triangle V_{CC}$=10%V_{CC}	-1	0	1	%
Ratiometry Sensitivity Error	$Rat_{ERRSens}$	$\triangle V_{CC}$=10%V_{CC}	-1.5	±0.5	1.5	%
Ratiometry Clamp Error	Rat_{ERRCLP}	Through Supply Voltage Range (relative to V_{CC}=5V)		±1		%
Sensitivity Drift Over Lifetime[1]	$\Delta SENS_{LIFE}$	Sens=1mV/Gs, T_A=25°C	-1.8	-0.5	0.8	%
Quiescent Voltage Output Drift Over Lifetime	ΔQVO_{LIFE}	Sens=1mV/Gs, T_A=25°C	-3	0.5	4	mV

[1]: The lifetime stability parameters indicate the variation of chip electrical parameters before and after the reliability experiments of HTOL, PC, THB, BHAST, UHAST and TC required by AECQ100-Grade0 standard.

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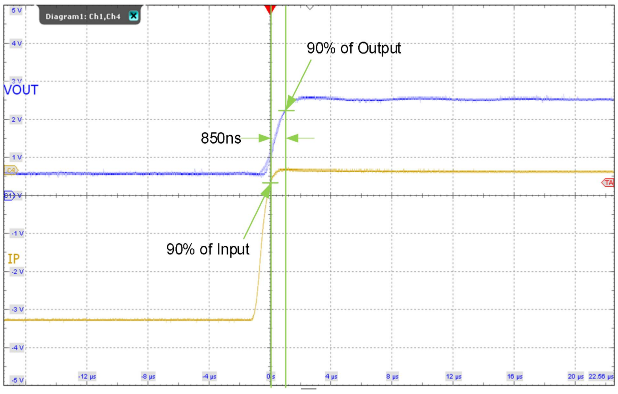
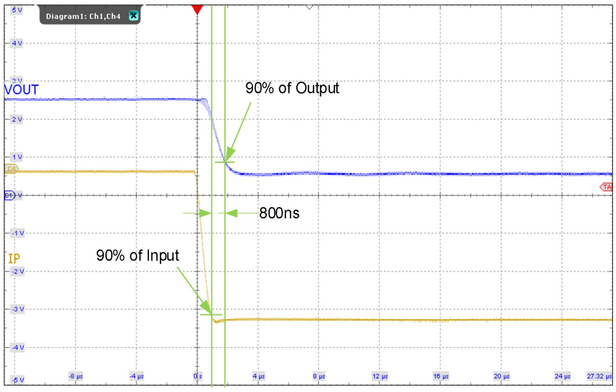
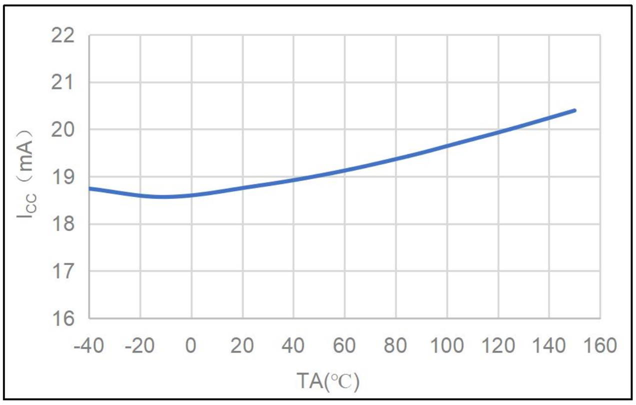
CURVED & WAVEFORM



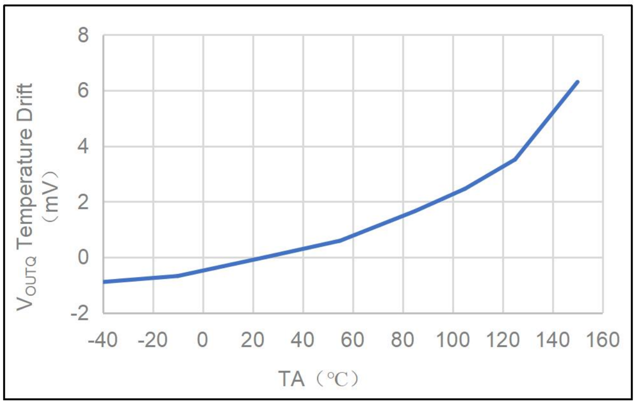
transport response rising waveform



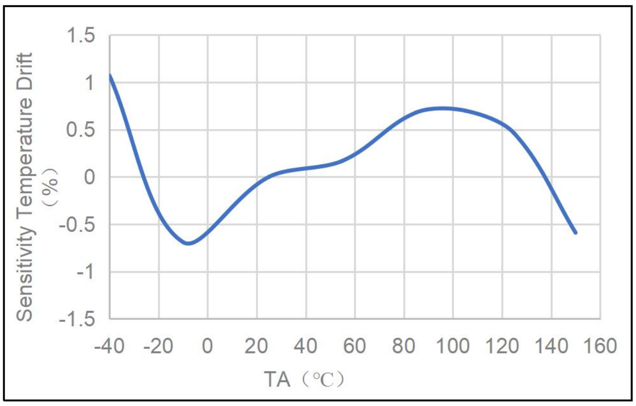
transport response falling waveform



I_{CC} Quiescent Power Consumption vs TA



V_{OUTQ} Temperature Drift vs TA



Sensitivity Temperature Drift vs TA

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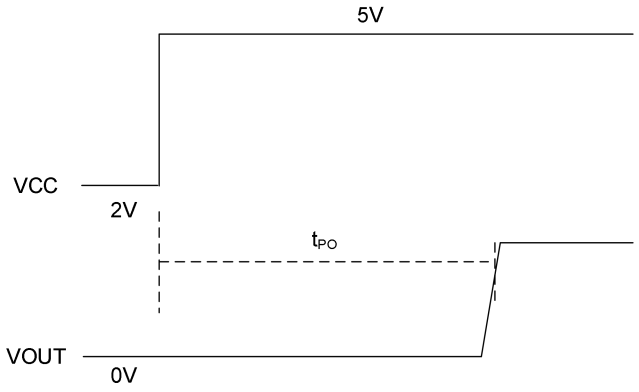
CHARACTERISTIC DEFINITIONS

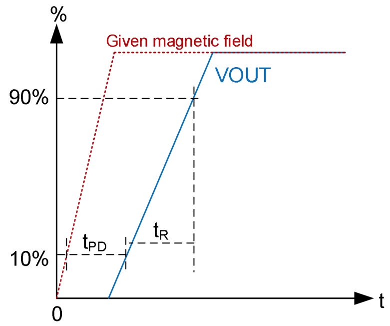
POWER-ON TIME（t_{PO}）

Power-On time is defined as the delay time that V_{CC} transitions from 2V to 5V (transition time <1us) to output voltage V_{OUT} builds to 90% .



PROPAGATION DELAY TIME (t_{PD})

Time propagation delay is defined as the time when the magnetic field rises to 10% and the output voltage reaches 10% when a step magnetic field excitation is given.

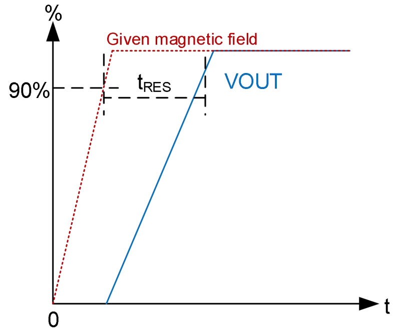


OUTPUT RISE TIME (t_R)

The output rise time is defined as the rise time of the output voltage from 10% to 90% when a magnetic field excitation is given.

OUTPUT RESPONSE TIME (t_{RES})

The output response time is defined as the time when the magnetic field rises to 90% and the output voltage reaches 90% when given a magnetic field excitation.



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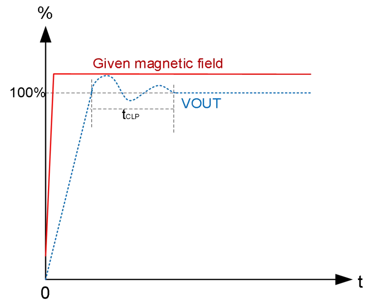
MAXIMUM OUTPUT CLAMP TIME（t_{CLP}）

When the magnetic field excitation is large enough, the output voltage will overshoot to a certain voltage, which can be stabilized to the output clamp voltage after a ringing time.

The maximum output clamp time is defined as the time from the beginning of ringing to the time when the output voltage stabilizes within ±1% error.



OUTPUT CLAMPING VOLTAGE（V_{CLP}）

The output clamping voltage is defined as: when the external magnetic field strength is out of range, the V_{OUT} output voltage being clamped to a fixed voltage value V_{CLPH} or V_{CLPL} depending on the direction of the external magnetic field.

BREAK CIRCUIT PROTECTION VOLTAGE（V_{BK}）

The break voltage is defined as: the V_{OUT} output voltage will drop to V_{BKL} (10 kΩ load resistance to 0V) or rise to V_{BKH} (10 kΩ load resistance to VCC) when the GND pin is disconnected from 0V.

PROGRAMMABLE RANGE OF V_{OUTQ} （V_{OUTQPR}）

The programmable range of quiescent output voltage is controlled between V_{OUTQPR_MIN} and V_{OUTQPR_MAX}, which ensures that the output characteristics are within the customized range in the whole temperature and working voltage range.

PROGRAMMABLE STEP OF V_{OUT}（SP_{VOUTQ}）

Programmable Step of quiescent output voltage is defined as:

$$SP_{VOUT} = \frac{V_{OUTQ\_max\,code} - V_{OUTQ\_min\,code}}{2^n - 1}$$

Where n is the programmable digit $BIT_{\_VOQ}$ of quiescent output voltage.

ERROR OF V_{OUTQ} （Err_{VOUTQ}）

Error of quiescent output voltage is generally adjusted to half of Programmable Step of quiescent output voltage.

$$Err_{VOUT} = 0.5 \times SP_{VOUT}$$

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QUIESCENT VOLTAGE OUTPUT DRIFT THROUGH TEMPERATURE RANGE（$\triangle V_{OUTQTC}$）

The quiescent output voltage temperature drift is calculated using the actual measured voltage value at TA room temperature and the measured voltage value at a specific temperature T

$$\Delta V_{OUTQTC} = V_{OUTQ\_TA} - V_{OUTQ\_T}$$

MAGNETIC SENSITIVITY （S_{SENS}）

Magnetic sensitivity is defined as the ratio of output voltage change and magnetic field change when the output voltage is between 0.5V~4.5V.

$$S_{SENS} = \frac{V_{OUTB2} - V_{OUTB1}}{B2 - B1}$$

MAGNETIC PROGRAMMABLE RANGE OF SENS ($SENS_{PR}$)

Magnetic sensitivity can be adjusted within a certain range. Over the entire operating temperature and operating voltage range, the magnetic sensitivity output characteristics can be guaranteed to be within the customized range.

MAGNETIC SENSITIVITY PROGRAMMING STEP SIZE（SP_{SENS}）

Programmable Step of magnetic sensitivity is define as:

$$STEP_{SENS} = \frac{SENS_{max\,code} - SENS_{min\,code}}{2^n - 1}$$

Where n is the Quiescent output voltage programmable bits $BIT_{\_SENS}$.

MAGNETIC SENSITIVITY DRIFT THROUGH TEMPERATURE RANGE（ΔS_{SENSTC}）

The device magnetic sensitivity changes with temperature, therefore, it is defined as:

$$\Delta S_{SENSTC} = \frac{SENS_{T2} - SENS_{T1}}{SENS_{T1}} \times 100\%$$

Where T1 and T2 represent 25°C and another ambient temperature, respectively, and the magnetic sensitivity tested at these two temperatures can obtain the temperature drift performance of the magnetic sensitivity.

LINEARITY SENSITIVITY ERROR（Lin_{ERR}）

The output requirement is linear with the magnetic field strength, and linearity sensitivity error is defined as:

$$Lin_{ERR} = \frac{|\Delta L\max|}{Y_{FS}} \times 100\%$$

△Lmax is the absolute value of the maximum deviation value between the actual characteristic curve and the fitted line. The Y_{FS} is 2V, that is, the forward full range voltage.

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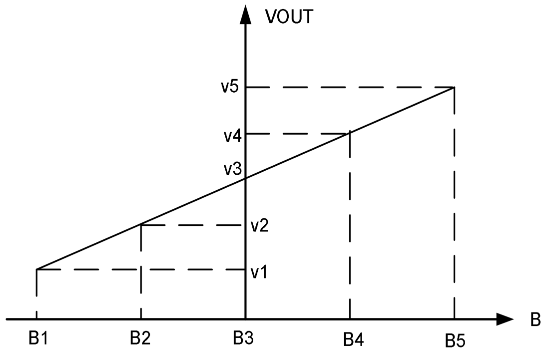
The least squares method fits the linear formula y=a+bx, which can be calculated from 5 measured data points

b，The gradient of fitted line $b = \frac{5\sum B_iV_i - \sum B_i * \sum V_i}{5\sum B_i^2 - \left(\sum B_i\right)^2}$

a，The intercept of the fitted lines $a = \frac{\sum B_i^2 * \sum V_i - \sum B_i * \sum B_iV_i}{5\sum B_i^2 - \left(\sum B_i\right)^2}$



The full-range magnetic field of the chip is Bmax, B1、B2、B3、B4 and B5 are taken as -Bmax, -Bmax/2, 0, Bmax/2 and Bmax/2 respectively; V1, V2, V3, V4, and V5 correspond to the output voltages when B1, B2, B3, B4, and B5 magnetic fields are applied, respectively.

SYMMETRY SENSITIVITY ERROR（Sym_{ERR}）

The ideal magnetic sensitivity of the chip should be symmetrical to the north and south poles of the magnetic field. In the case of the same magnetic field strength, the value of the magnetic sensitivity will be the same, but in the opposite direction. Therefore, in the actual test, the symmetry error is defined as:

$$Sym_{ERR} = \left(1 - \frac{SENS_{BPOS}}{SENS_{BNEG}}\right) \times 100\%$$

RATIOMETRY ERROR(Rat_{ERR})

The chip has the characteristic of ratio output, manifested in the proportional relationship between the quiescent output voltage (V_{OUTQ}), magnetic sensitivity (SENS), output clamp voltage (V_{CLPH} / V_{CLPL}) and the power supply voltage V_{CC}, In other words, when the power supply voltage V_{CC} increases or decreases to a certain percentage, these parameters will also increase or decrease by the same percentage. These ratio error parameters are the difference between the parameters at the voltage to be tested and the parameters at the 5V supply voltage. The following are the formulas for defining these parameters

$$Rat_{ERRVOUTQ} = (1 - \frac{V_{OUTQ(VCC)} / V_{OUTQ(5V)}}{VCC/5}) \times 100\%$$

$$Rat_{ERRSENS} = \left(1 - \frac{SENS_{(VCC)} / SENS_{(5V)}}{VCC/5}\right) \times 100\%$$

$$Rat_{ERRCLP} = (1 - \frac{V_{CLP(VCC)} / V_{CLP(5V)}}{VCC/5}) \times 100\%$$

UNDERVOLTAGE LOCKOUT THRESHOLD（UVLO）

When V_{CC} rises to V_{UVLOH}, the output is released from state 0 after t_{UVLOD}; when V_{CC} drops to V_{UVLOL}, the output is set to 0 after t_{UVLOE}.

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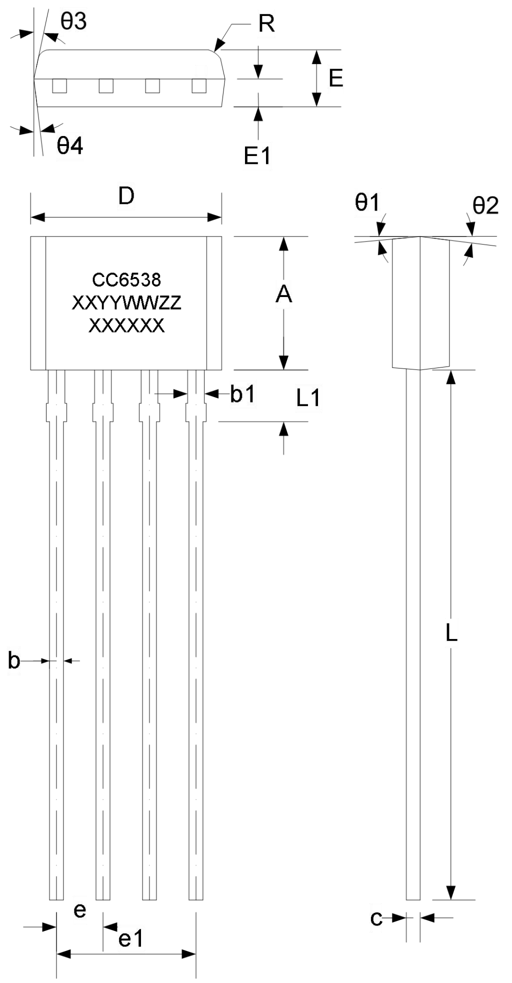
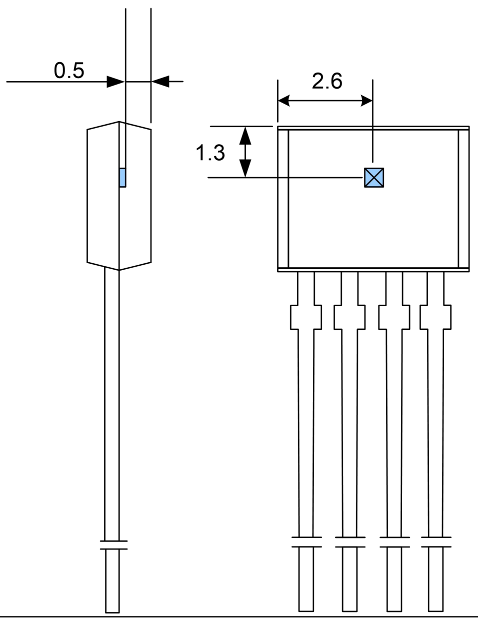
PACKAGE INFORMATION

TO-94 Package



Symbol	Size（mm）		
	Min.	Typ.	Max.
A	3.55	3.65	3.75
b	0.35	0.39	0.56
b1	-	0.46	-
c	0.36	0.38	0.51
D	5.12	5.22	5.32
E	1.46	1.56	1.66
E1	-	0.76	-
e	-	1.27	-
e1	-	3.81	-
L	13.5	14.5	15.5
L1	-	1.42	-
R	-	0.3	-
θ1	-	6°	-
θ2	-	4°	-
θ3	-	11°	-
θ4	-	6°	-

Hall Plate Location



1.Note:

All dimensions are in millimeters.

2.Marking (Chip Front Face)：

1st Line: Product name: CC6538

2nd Line: XXYYWWZZ: batch number

3rd Line: XXXXXX: Serial number within the batch number

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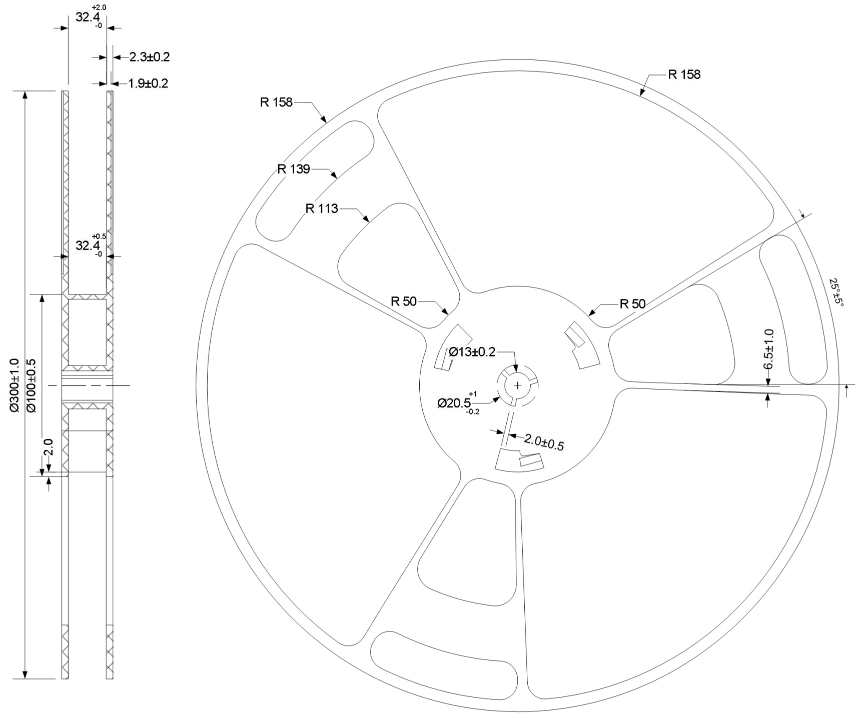
PACKING INFORMATION

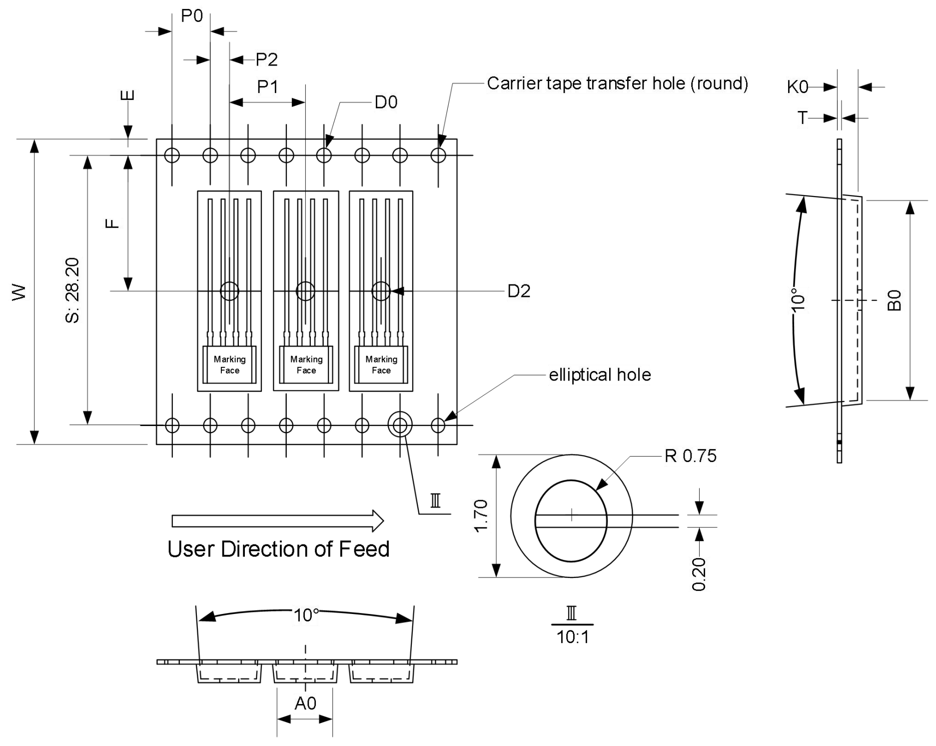
Reel Dimensions



Note：

1. When packing, the carrier tape should be emptied more than 250mm at the first end (head) and more than 350mm at the last end (tail), and sealed by heating with covering film. No cavities are allowed in the product part of the carrier.
2. All dimensions are in millimeters.
3. Tolerance ±0.25mm is not specified.

Tape dimensions



Symbol	A0	B0	K0	P0	P1	P2
Size	5.55	19.25	1.90	4.00	8.00	2.00
Symbol	T	E	F	D0	D2	W
Size	0.40±0.05	1.75	14.20	Ø1.55±0.5	Ø1.5min	32±0.2

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REVISION HISTORY

Revision Date	Description of Revision	Revision
2024.08.08	Initial released.	rev1.0

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CrossChip

CrossChip Microsystems Inc. was founded in 2013, is a national high-tech enterprise, engaged in integrated circuit design and sales. The company has strong technical strength, has more than 60 kinds of patents, mainly used in Hall sensor signal processing, with the following product lines:

- ✓ High precision linear Hall sensor
- ✓ All kinds of Hall switches
- ✓ Single phase motor drive
- ✓ Single chip current sensor
- ✓ AMR Magnetoresistance sensor
- ✓ Isolation drive class chip

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