## High Accuracy Programmable Linear Output Hall Effect Sensor

Features

- Linear analog ratiometric output voltage

- Programmable magnetic sensitivity

- Programmable output quiescent voltage

- Programmable temperature compensation

- Open-circuit , over- and under- voltage detection

- Operates from 4.5 to 5.5 V supply voltage

- Operates from -40 to 150 ℃ temperature range

- Operate with static magnetic fields and dynamic Magnetic fields up to 1 kHz

- Total error < 2% over temperature range

- EMC and ESD optimized design

- SIP3-SA package

Output state
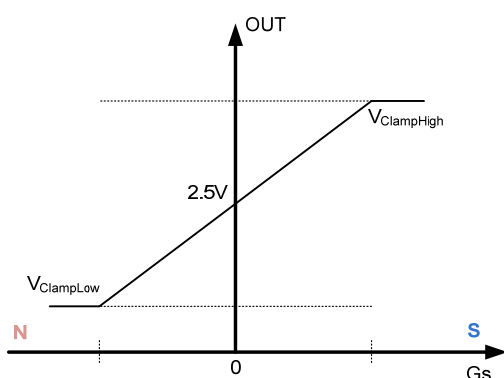
Applications

- Angle sensor

- Contactless potentiometers

- Linear position sensing

- Magnetic field and current measurement

Description

The SC4688 is a CMOS programmable ratio metric linear Hall Effect sensor IC. The linear output voltage is proportional to the magnetic flux density. The ratio metric output voltage is proportional to the supply voltage. All the parameters of the SC4688 transfer characteristic are fully programmable. The V_Q, the sensitivity, the slope polarity, the output clamping levels, and the thermal sensitivity drift are all programmable in end-user applications. The part offers open-circuit, as well as over-voltage and under-voltage detection and individual programming of different sensors which are in parallel to the same supply voltage.
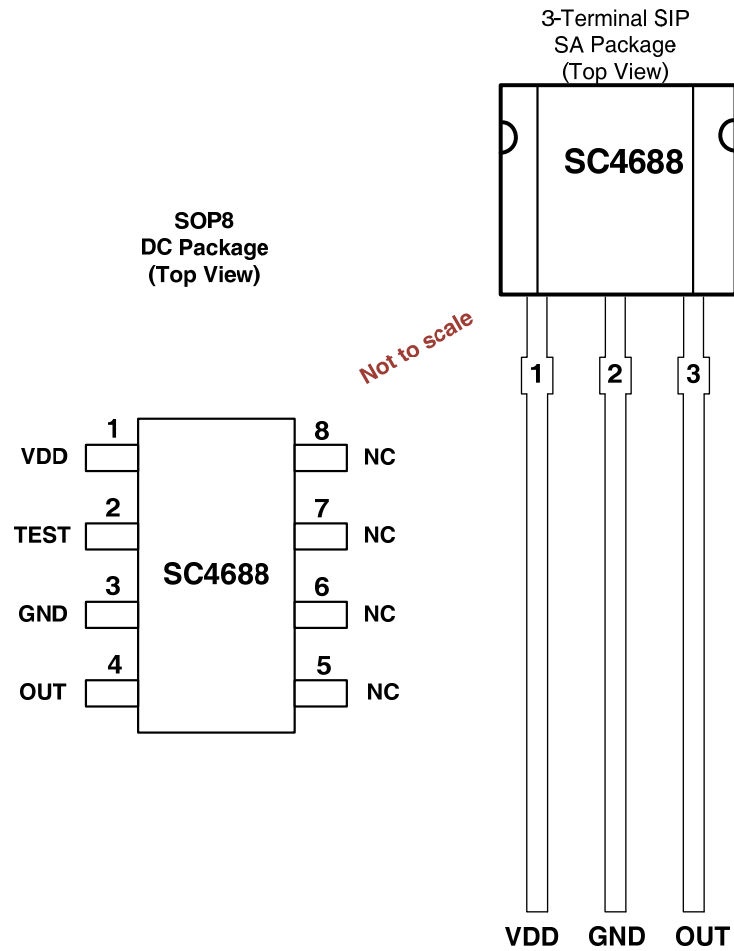
The SC4688 is programmable by modulating the supply voltage. No additional programming pin is needed. The easy programmability allows a 2-point calibration by adjusting the output voltage directly to the input signal. In addition, the temperature compensation of the Hall IC can be fit to all common magnetic materials by programming first and second order temperature coefficients of the Hall sensor sensitivity. This enables operation over the full temperature range with high accuracy.

The sensor is designed for hostile industrial and automotive applications and operates with typically 5 V supply voltage in the ambient temperature range from -40 up to 150 ℃. The SC4688 is available in the very small leaded package SIP3-SA.

Device Information

Part Number	Packing	Mounting	Ambient, T_A	Marking
SC4688SA	Bulk, 1000 pieces/bag	3-pin SIP	-40℃ to 150℃	4688
SC4688DC	Reel, 3000 pieces/reel	8-pin SOIC	-40℃ to 150℃	4688

Terminal configuration and functions

3-Terminal SIP
SA Package
(Top View)

SC4688

SOP8
DC Package
(Top View)

Not to scale

| 1 | 2 | 3 |

VDD   GND   OUT

SC4688

VDD 1   8 NC

TEST 2   7 NC

GND 3   6 NC

OUT 4   5 NC

DC Package Terminal Functions

Terminal		Type	Description
Name	Number		
VDD	1	PWR	4.5V to 5.5 V power supply
TEST	2	Input	Test PIN, Normal operation connect to GND
GND	3	Ground	Ground terminal
OUT	4	Output	Output terminal

SA Package Terminal Functions

Terminal		Type	Description
Name	Number		
VDD	1	PWR	4.5V to 5.5 V power supply
GND	2	Ground	Ground terminal
OUT	3	Output	Output terminal

Absolute Maximum Ratings

Characteristic	Symbol	Notes	Rating	Unit
Forward Supply Voltage	V_{DD}	< 96 hours	8.5	V
		< 1 hour	16	V
Reverse Supply Voltage	V_{RCC}	< 96 hours	-8.5	V
		< 1 hour	-16	V
Forward Output Voltage	V_{OUT}	< 96 hours	8.5	V
		< 1 hour	16	V
Reverse Output Voltage	V_{ROUT}		-5.5	V
Output Source Current	$I_{OUT(source)}$	V_{OUT} to GND	10	mA
Output Sink Current	$I_{OUT(sink)}$	VDD to V_{OUT}	10	mA
EEPROM Write Cycles			100	cycle
Operating Ambient Temperature	T_A		-40--150	℃
Storage Temperature	T_{STG}		-65--165	℃
Maximum Junction Temperature	$T_{J(max)}$		165	℃

Note: Stresses above those listed here may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ESD Protection

Human Body Model (HBM) tests according to: standard EIA/JESD22-A114-B HBM

Parameter	Symbol	Min.	Max.	Units
HBM ESD stress voltage	V_{ESD}	-4000	4000	V

Electrical Characteristics

| Characteristics	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
Valid through the full operating temperature range, V$_{DD}$=4.5 to 5.5V, as not otherwise specified in conditions						
Electrical Characteristics						
Supply Voltage	V$_{DD}$		4.5	5.0	5.5	V
Supply Current	I$_{DD}$	Over temperature range	~	7.5	10.0	mA
Overvoltage Protection at Supply	V$_{DDZ}$	I$_{DD}$=25mA, T$_J$=25℃,t=20ms		17.5	20.0	V
Overvoltage Protection at Output	V$_{OZ}$	I$_O$=10mA, T$_J$=25℃,t=20ms		17.0	19.5	V
Output Current	I$_{OUT}$		-1.0		1.0	mA
Load Resistor	R$_L$		4.7			kΩ
Load Capacitance	C$_L$		0.33	100.0	1000.0	nF
Accuracy Error over all	E$_A$	RL=4.7kΩ (% of supply voltage)	-3.0	0	3.0	%
Non-Linearity of Output Voltage over Temp.	INL	% of supply voltage	-1	0	1	%
Accuracy of Output Voltage at Clamping Low Voltage over Temp. Range	△V$_{OUTCL}$	RL=4.7kΩ, V$_{DD}$=5.0V	-45	0	45	mV
Accuracy of Output Voltage at Clamping High Voltage over Temp. Range	△V$_{OUTCH}$	RL=4.7kΩ, V$_{DD}$=5.0V	-45	0	45	mV
Output High Voltage	V$_{OUTH}$	V$_{DD}$=5V, -1mA<I$_{OUT}$<1mA	4.65	4.8		V
Output Low Voltage	V$_{OUTL}$	V$_{DD}$=5V, -1mA<I$_{OUT}$<1mA		0.2	0.4	V
Response Time of Output	t$_{r(O)}$	3dB filter frequency = 500Hz		1.0	2.0	ms
		3dB filter frequency = 1kHz		0.5	1.0	ms
Power-Up Time	t$_{POD}$	3dB filter frequency = 500Hz	1.4	1.7	2.0	ms
Small Signal Bandwidth	BW	B$_{AC}$ < 10mT			1	kHz
Noise Output Voltage	V$_{OUTn}$	magnetic range = 100mT		6	15	mV
Offset Drift of Analog Output	△V$_{OFFSET}$	B=0mT, -0.6<sensitivity<0.6	0	0	0.25	%V$_{DD}$
Open-Circuit Detection						
Output Voltage at open V$_{DD}$ Line	V$_{OUT}$	V$_{DD}$=5V, R$_L$=10k to GND	0	0	0.2	V
Output Voltage at open GND Line	V$_{OUT}$	V$_{DD}$=5V, R$_L$=10k to GND	4.7	4.8	5	V
Overvoltage and Undervoltage Detection						
Undervoltage detection level	V$_{DD,UV}$		3.9	4.1	4.3	V
Overvoltage detection level	V$_{DD,OV}$		7.0	8.7	10	V

Function Description Overview

The SC4688 is a monolithic integrated circuit which provides an output voltage proportional to the magnetic flux through the Hall plate and proportional to the supply voltage. The external magnetic field component perpendicular to the branded side of the package generates a Hall voltage. The Hall IC is sensitive to magnetic north and south polarity. This voltage is converted to a digital value, processed in the Digital Signal Processing Unit (DSP) according to the settings of the EEPROM registers, converted to an analog voltage with radiometric behavior, and stabilized by a push-pull output transistor stage. The LOCK register disables the programming of the EEPROM memory for all time. This register cannot be reset.

If the LOCK register is not set, the output characteristic can be adjusted by programming the EEPROM registers. The IC is addressed by modulating the supply voltage. In the supply voltage range from 4.5V up to 5.5V, the sensor generates an analog output voltage. After detecting a command, the sensor reads or writes the memory and answers with a digital signal on the output pin.

Several sensors in parallel to the same supply and ground line can be programmed individually. The selection of each sensor is done via its output pin.

The open-circuit detection provides a defined output voltage if the VDD or GND line is broken. Internal temperature compensation circuitry and the chopped offset compensation enables operation over the full temperature range with minimal changes in accuracy and high offset stability. The circuitry also rejects offset shifts due to mechanical stress from the package. The non-volatile memory consists of redundant EEPROM cells. In addition, the sensor IC is equipped with devices for over-voltage and reverse-voltage protection at all pins.

Functional Block Diagram
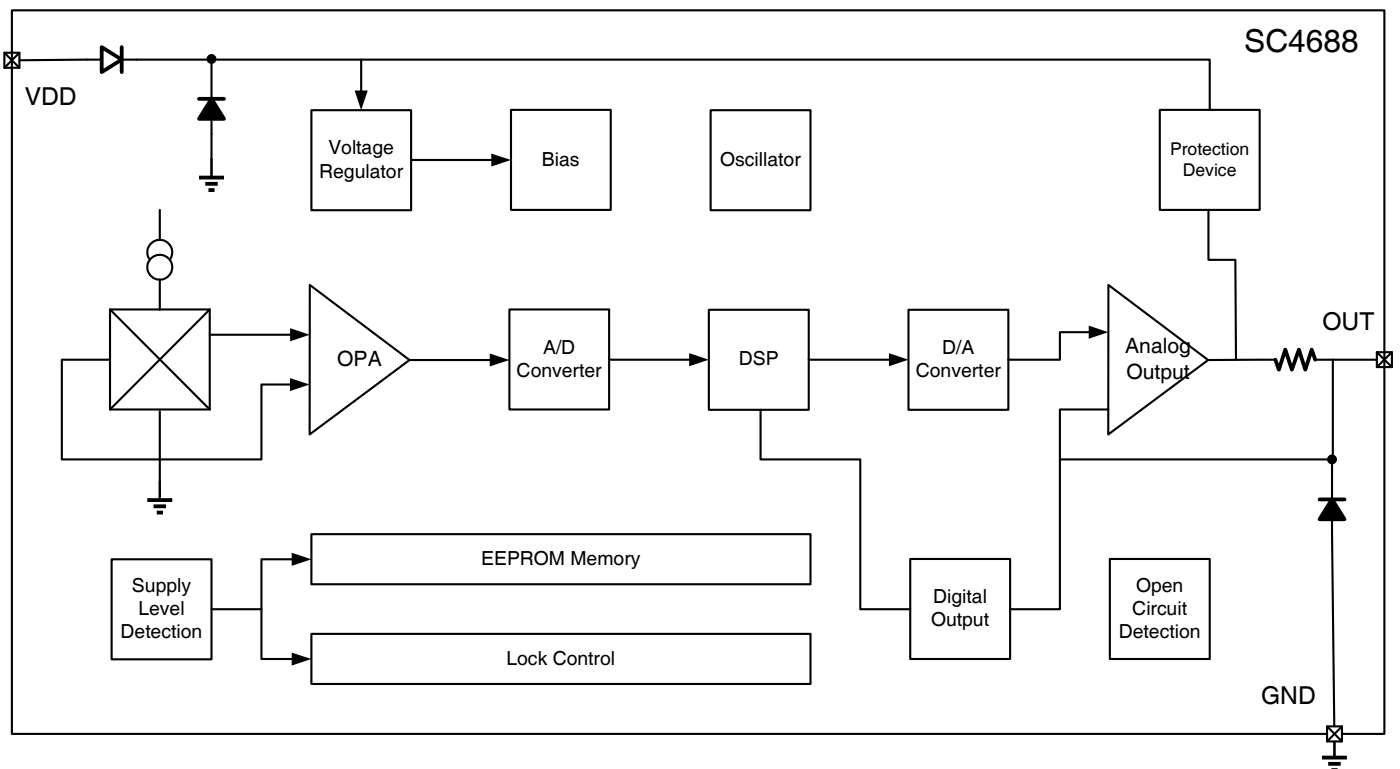
EEPROM Programming Information

The DSP is the main part of this sensor and performs the signal conditioning. The parameters for the DSP are stored in the EEPROM registers.

The EEPROM registers consist of three groups:

Group 1 contains the registers for the adaption of the sensor to the magnetic system: MODE for selecting the magnetic field range and filter frequency, TC, TCSQ and TC-range for the temperature characteristics of the magnetic sensitivity.

Group 2 contains the registers for defining the output characteristics: SENSITIVITY, VOQ, CLAMP-LOW, and CLAMP-HIGH. The output characteristic of the sensor is defined by these 4 parameters. The output voltage range can be clamped by setting the registers CLAMP-LOW and CLAMP-HIGH in order to enable failure detection (such as short-circuits to V_{DD} or GND and open connections).

GROUP 3 contains the internal registers and LOCK for the locking of all registers. The internal registers are programmed and locked during production. These registers are used for oscillator frequency trimming, A/D converter offset compensations, and several other special settings.

An external magnetic field generates a Hall voltage on the Hall plate. The ADC converts the amplified positive or negative Hall voltage to a digital value. The digital signal is filtered in the internal low-pass filter and manipulated according to the settings stored in the EEPROM. The digital value after signal processing is readable in the D/A-READOUT register. Depending on the programmable magnetic range of the Hall IC, the operating range of the A/D converter is from -30mT----+30mT up to -100mT----+100mT

Range The RANGE bits are bit 1 and 2 of the MODE register; they define the magnetic field range of the A/D converter.

Magnetic Field Range	Code
-30mT ---- +30mT	00
-60mT ---- +60mT	01
-80mT ---- +80mT	10
-100mT ---- +100mT	11

TC Register The sensor can compensate for linear temperature coefficients ranging from about -3100 ppm/k up to 1000ppm/k and quadratic coefficients from about -7ppm/K^2 to 2ppm/K^2. The full TC range is separated in the following ranges:

TC-Range (ppm/k)	Code
-3100 to -1800	00
-1750 to -550	10
-550 to +450	01
+450 to +1000	11

Sensitivity the SENSITIVITY register contains the parameter for the multiplier in the DSP. The Sensitivity is programmable between -4 and 4. For V_{DD}=5V, the register can be changed in steps of 0.00049

VOQ The VOQ register contains the parameter for the adder in the DSP. V_{OQ} is the output voltage without external magnetic field and programmable from $-V_{DD}$ up to V_{DD}. For V_{DD} = 5V the register can be changed in steps of 4.9mV

Clamping Voltage, the output voltage range can be clamped in order to detect failures like short circuits to VDD or GND or an open circuit.
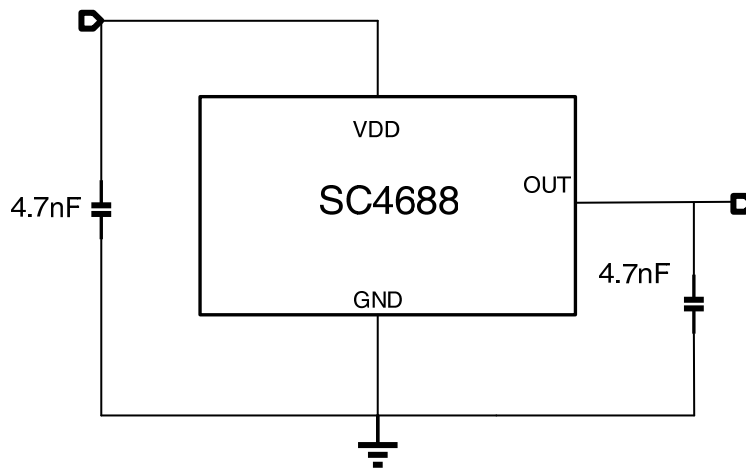
The CLAMP-LOW register contains the parameter for the lower limit. The lower clamping voltage is programmable between 0V and V_{DD}/2. For V_{DD} = 5V, the register can be changed in steps of 9.77mV.

The CLAMP-HIGH register contains the parameter for the upper limit. The upper clamping voltage is programmable between 0V and V_{DD}. For V_{DD} = 5V, the register can be changed in steps of 9.77mV.
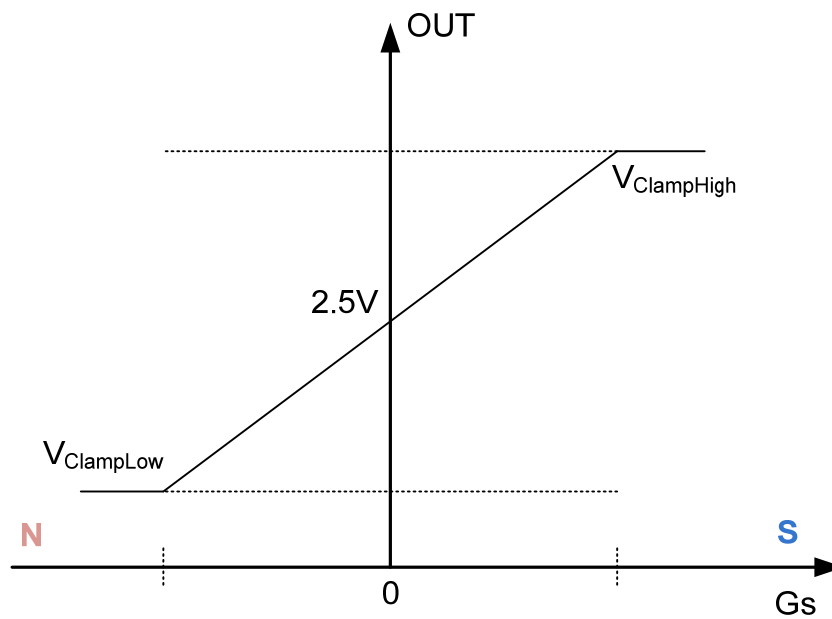
LOCKER By setting the first bit of this 2-bit register, all registers will be locked and the sensor will no longer respond to any supply voltage modulation. This bit is active after the first power-off and power-on sequence after setting the LOCK bit.   Warning: this register cannot be reset!
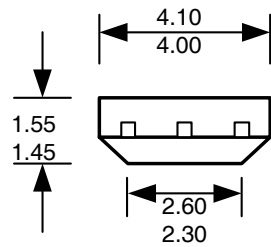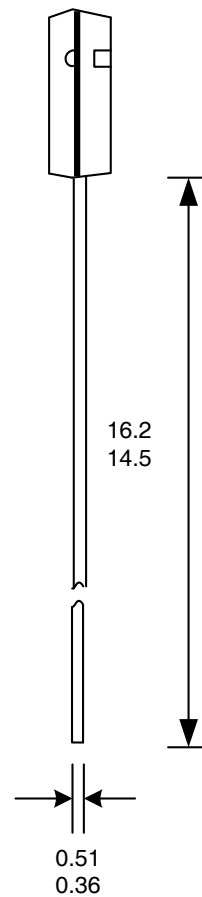
Typical Application Drawing

Transfer Function
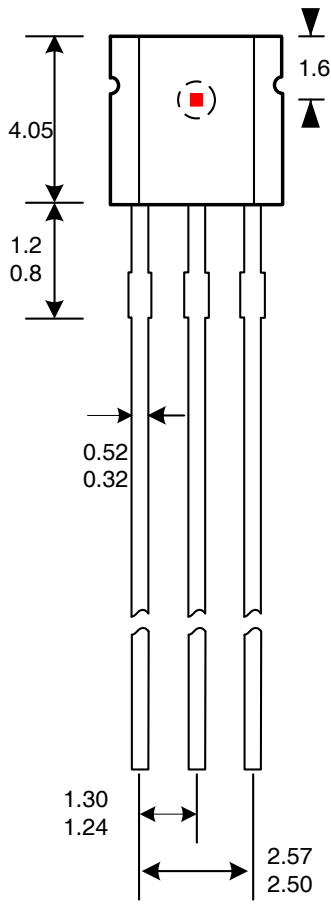
Package Designator

3-Terminal
SA Package

Dimension:mm

4.10
4.00

1.55
1.45

2.60
2.30

4.05

1.6

1.2
0.8

0.52
0.32

16.2
14.5
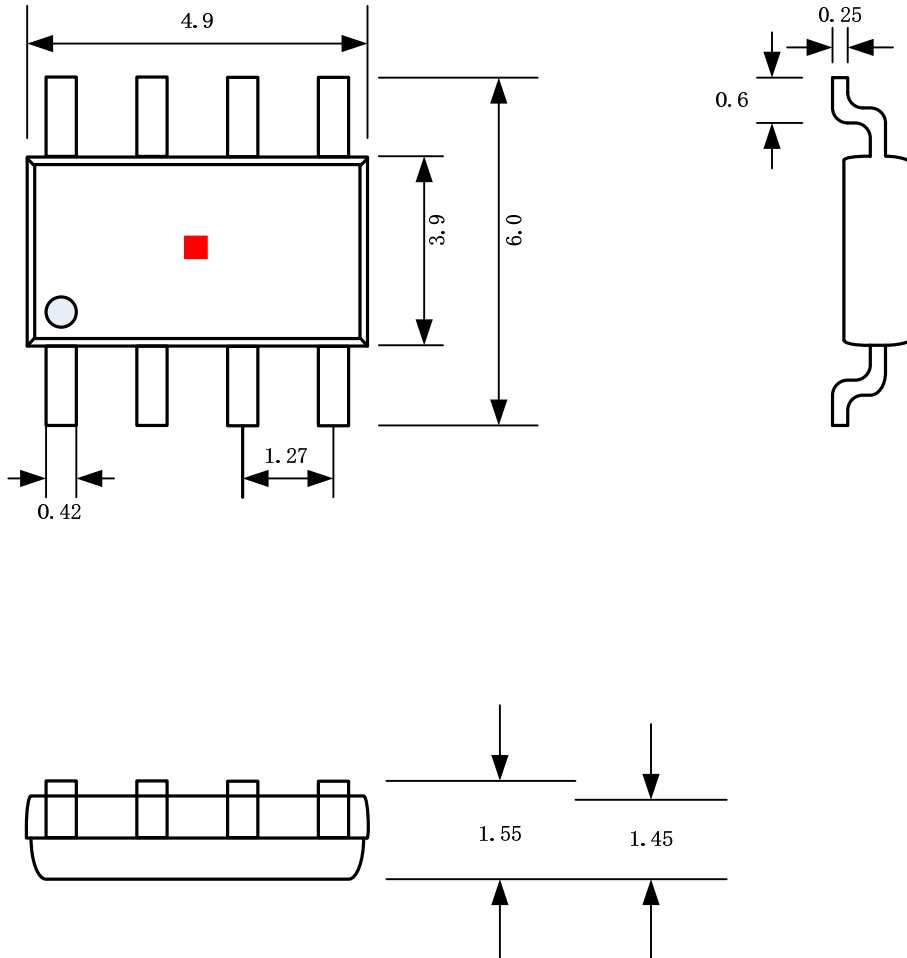
1.30
1.24

2.57
2.50

0.51
0.36

Notes:
1. Exact body and lead configuration at vendor's option within limits shown.
2. Height does not include mold gate flash.

Where no tolerance is specified, dimension is nominal.

Package Designator (DC)

4. 9

3. 9

6. 0

1. 27

0. 42

0. 25

0. 6

1. 55

1. 45

Notes:
1. Exact body and lead configuration at vendor's option within limits shown.
2. Height does not include mold gate flash.

Where no tolerance is specified, dimension is nominal.