Dual Channel Angular Hall Effect Sensor with Sine-Cosine Output

1. Features

- Sine and cosine output signals
- Supply voltage: 3V to 5.5V
- Current consumption in sleep mode: <25μA
- Fast wake-up from sleep: <10μs
- Magnetic rotation speed up to 80,000 RPM
- Wide operating temperature range: -40℃ to 125℃
- PKG Type
  - DFN3*3
  - DFN1616

2. Applications

- Motor control
- Electric toothbrushes
- Game controllers and peripherals
- Position sensors

3. Description

The SC4251 is an integrated Hall-effect position sensor designed to scan permanent magnets. The IC can be configured to enter an ultra-low power mode, making it highly suitable for battery-powered applications such as robotic vacuum cleaners, cordless power tools, wireless game controllers, and peripherals.

In normal operating mode, the signal conditioning unit generates sine and cosine voltage signals corresponding to the external magnetic field, which can be used for angle calculation. Users can control the chip's operating mode by applying a logic level signal to the SLEEP pin. When the SLEEP pin is pulled high, the device enters sleep mode, with an operating current of <25μA, and the output becomes invalid (high-impedance mode). When the SLEEP pin is pulled low, the device returns to normal mode.

This sensor features a wide supply voltage range, operating from 3V to 5.5V, and a temperature range of -40℃ to 125℃. The device is packaged in a lead-free, 100% matte tin frame plating.

Not To Scale

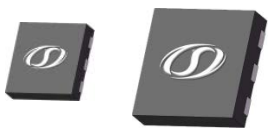


Fig.1 DFN1616(Left) & DFN3*3(Right) Package Outline

CONTENTS

4. Terminal Configuration

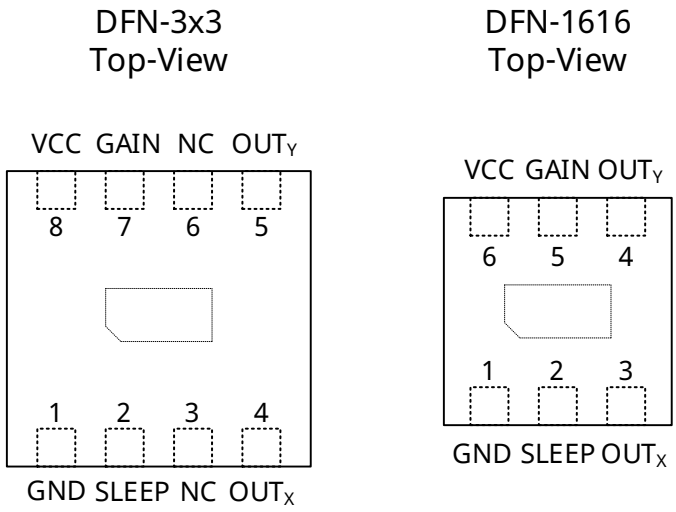


Fig.2 DFN3*3 Pin definition(Left) & DNF1616 Pin definition(Right)

Name	Number		Description
	DFN3*3	DFN1616	
GND	1	1	Ground terminal
SLEEP	2	2	Toggle Sleep mode
NC	3	-	No connection
OUT_X	4	3	Analog output X
OUT_Y	5	4	Analog output Y
NC	6	-	No connection
GAIN	7	5	Gain selection
VCC	8	6	Power supply

5. Ordering Information

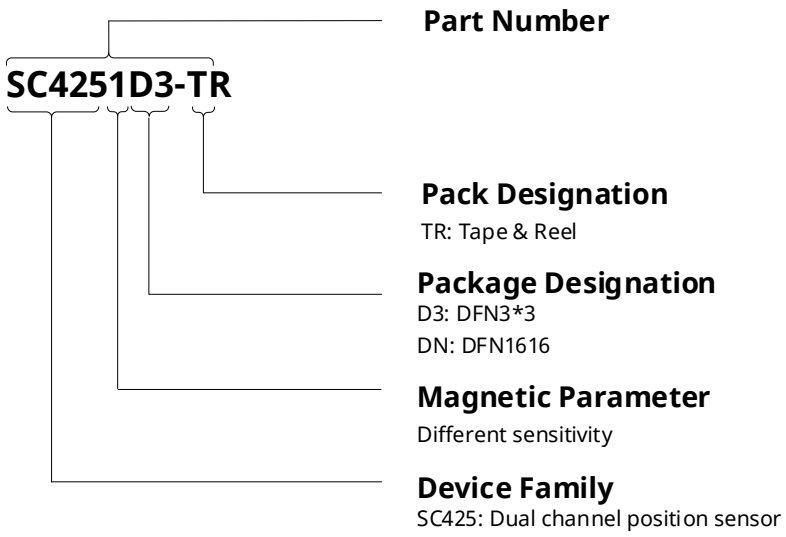
Ordering Information	Sens(mV/Gs) (1)	Ambient, T_A(℃)	Package	Packing	Quantity
SC4251D3-TR (2)	1.0	-40-125	DFN3*3	TR	5000
SC4251DN-TR	1.0	-40-125	DFN1616	TR	4000

Note:

(1) This sensitivity data is for GAIN pin grounded application conditions

(2) TR: Tape & Reel

5.1. Order information format description



6. Absolute Maximum Ratings

Symbol	Parameter	Notes	Min.	Max.	Units
$V_{CC\ abs}$	Positive Supply Voltage	V_{CC}=0-->5.5V	-	18	V
$V_{ccr\ abs}$	Negative Supply Voltage	V_{CC}=0-->-1.0V	-0.3	-	V
$V_{OUT\ ABS}$	Positive Output Voltage	V_{OUT}=0-->5.5V	-	18	V
$V_{OUTR\ ABS}$	Negative Output Voltage	V_{CC}=0-->-1.0V	-0.3	-	V
T_A	Operating Temperature Range		-40	125	℃
T_{STG}	Storage Temperature Range		-55	165	℃
$T_{J(max)}$	Maximum Junction Temperature		-	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.

7. ESD Protection

Symbol	Parameter	Test conditions	Min.	Max.	Units
V_{ESD_HBM}	HBM	Refer to ANSI/ESDA/JEDEC JS-001 standard(1)	-4	+4	kV
V_{ESD_CDM}	CDM	Refer to ANSI/ESDA/JEDEC JS-002 standard(2)	-750	+750	V

Note：
(1) JEDEC document JEP155 states that 4000V HBM allows safe manufacturing using standard ESD control processes.
(2) JEDEC document JEP157 states that 740V CDM allows safe manufacturing using standard ESD control processes.

8. Thermal characteristics

Symbol	Parameter	Test conditions	Value(1)	Units
$R_{\theta JA}$	DFN3*3	Single-layer PCBS, JEDEC 2s2p and 1s0p are defined in JESD 51-7 and JESD 51-3	100	℃/W
	DFN1616		186	

Note：

(1) The maximum operating voltage must meet the requirements of power consumption and junction temperature, refer to thermal characteristics

9. Operating Characteristics

9.1 Electrical Parameter

（TA=25℃, VDD=3.3V, unless otherwise noted)

Symbol	Parameter	Test Condition	Min	TYP	MAX	Unit
V_{CC}	Operating Voltage		3	3.3	3.6	V
			4.5	5	5.5	V
I_{CC}	Operating Current	V_{CC} = 3.3V, B = 0mT	-	5	-	mA
		V_{CC} = 5V, B = 0mT	-	8	-	mA
$I_{CC-SHDN}$	Sleep Current	SLEEP-->3.3V	-	25	-	uA
t_{PO}	Power-On Time	V_{CC} = 3.3V, B = 0mT, V_{OUT}=90% of Full-Scale	-	30	-	us
t_{WK}	Sleep Wake-Up Time	SLEEP-->0V, V_{OUT} from high resistance to normal output	-	10	-	us
I_{OUT}	Output Load Current		-	-	2	mA
C_{OUT}	Output Load Capacitance		-	-	1	nF
f_{BW}	Output Bandwidth（-3dB）		-	30	-	kHz
t_{PD}	Output Delay		-	7	-	us
f_C	Chopping Frequency		-	500	-	kHz
V_{HSLEEP}	Sleep Input High Voltage	Sleep enable	$0.7V_{CC}$	-	-	V
V_{LSLEEP}	Sleep Input Low Voltage	Sleep disable	-	-	$0.3V_{CC}$	V

9.2 Magnetic Parameter

（TA=25℃, VDD=3.3V, unless otherwise noted）

Symbol	Parameter	Test Condition	Min	TYP	MAX	Unit
Hext	Operating Magnetic Field Strength	Measured on chip surface	100	400	800	Gs
fmag	Magnetic Field Frequency		-	1.33	-	kHz
fmag	Magnetic Rotation Speed		-	80000	-	rpm
D_{SENS}	Hall Sensor Array Diameter		-	400	-	um
X_{DIS}	Maximum Magnetic Axis Displacement Relative to Hall Sensor Array Center		-	0.2	-	mm
Vpp	Differential Peak-to-Peak Output Amplitude	Vpp = Vpk(Px) – Vpk(Nx)	0.8	-	2.4	V
V_{QT}	Quiescent Voltage	B = 0mT, T_A = 25°C, V_{CC} = 3.3 V Bidirectional	1.58	1.65	1.72	V
		B = 0mT, T_A = 25°C, V_{CC} = 5 V Bidirectional	2.43	2.5	2.57	V
V_{QAT}	Quiescent Voltage Temperature Drift	B = 0Gs, V_{CC} = 3.3 V, T_A = -40°C to 125°C versus 25°C	-	±1% ×VCC	-	V
V_{QAT}	Quiescent Voltage Temperature Drift	B = 0Gs, V_{CC} = 5 V, T_A = -40°C to 125°C versus 25°C	-	±1% ×VCC	-	V
V_{QRE}	Quiescent Voltage Ratio Error		-	±0.2	-	%
V_{QAL}	Quiescent Voltage Lifetime Drift	1000 hours of high-temperature operating stress	-	10	-	mV
S	Sensitivity	GAIN pin grounded，T_A = 25°C	-	1.0	-	mV/Gs
		GAIN pin connected to power, T_A = 25°C	-	1.5	-	mV/Gs
S_{TC}	Sensitivity Temperature Coefficient	T_A = -40°C to 125°C versus 25°C	0.04	0.12	0.2	%/°C
S_{LE}	Sensitivity Linearity Error		-	±1	-	%
S_{SE}	Sensitivity Symmetry Error		-	±1	-	%
S_{RE}	Sensitivity Ratio Error	T_A = 25°C, V_{CC} = 3 V - 3.6 V, with respect to V_{CC} =3.3 V	-3	-	+3	%
S_{AL}	Sensitivity Lifetime Drift	1000 hours of high-temperature operating stress	-	0.5	-	%

Note:

1Gs = 0.1mT

10. Block Diagram

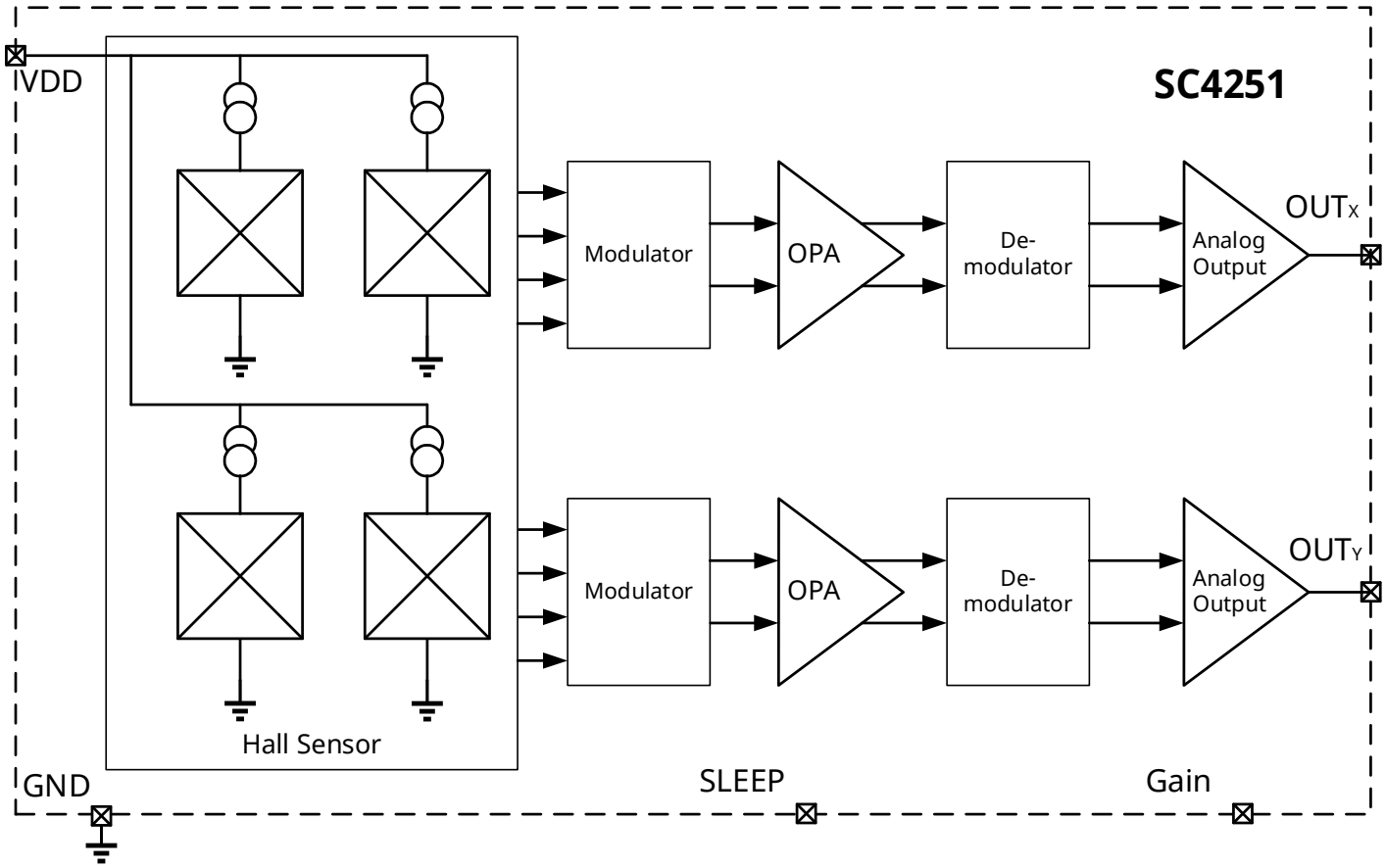


Fig.3 Block Diagram

11. Function Description

Quiescent Output Voltage (V_{OUTQ}): "Static output voltage" refers to the output voltage of the chip when there is no magnetic field. Theoretically, the output voltage of SC4251 is equal to VCC/2, but due to the interference of bias voltage, sensitivity, packaging stress and other factors, the static output voltage does have a certain deviation from the theoretical value. At the factory, the actual static voltage can be modified to the theoretical value of ±50mV. The static output voltage is to some extent affected by the temperature coefficient, which statistically means that the static output voltage will also change with the change of temperature (the higher the sensitivity, the more obvious).

Sensitivity(S)

$$Sens = [VOUT(B1) - VOUT(B2)]/(B1 - B2)$$

When the South Pole magnetic field perpendicular to the chip tagged side approaches, the output voltage increases proportionally, until it reaches supply voltage. Conversely, when the North Pole magnetic field perpendicular to the chip tagged side approaches, the output voltage decreases proportionally, until it reaches ground level. Sensitivity is defined as the specific value of the output voltage variation and the magnetic field variation, commonly in mV/Gs or mV/mT.

Power-On Time (t_{PO}): Power-On Time (t_{PO}) is defined as the time it takes for the output voltage to settle within ±10% of its steady-state value under an applied magnetic field after the power supply has reached its minimum specified operating voltage (VCC(min)) as shown in Figure 4.

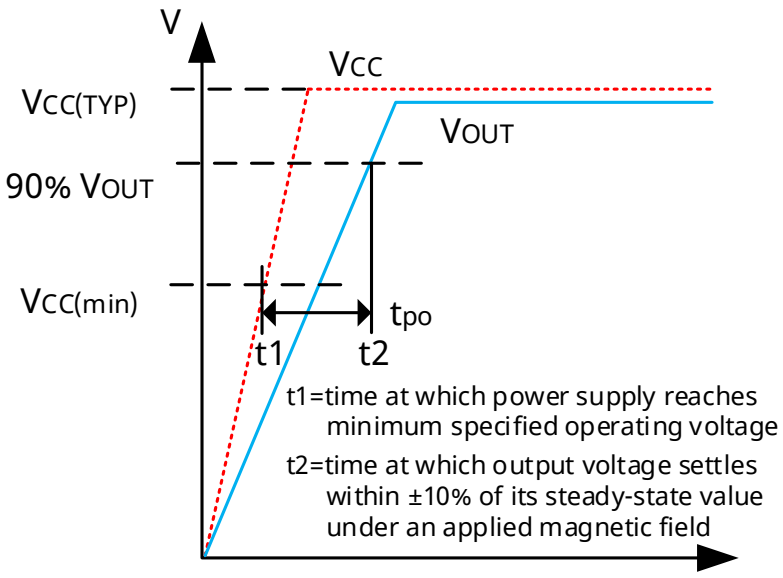


Fig.4 Power-On Time Definition

Propagation Delay (T_{PD}): The time interval between a) when the applied magnetic field reaches 20% of its final value, and b) when the output reaches 20% of its final value (see Figure 5).

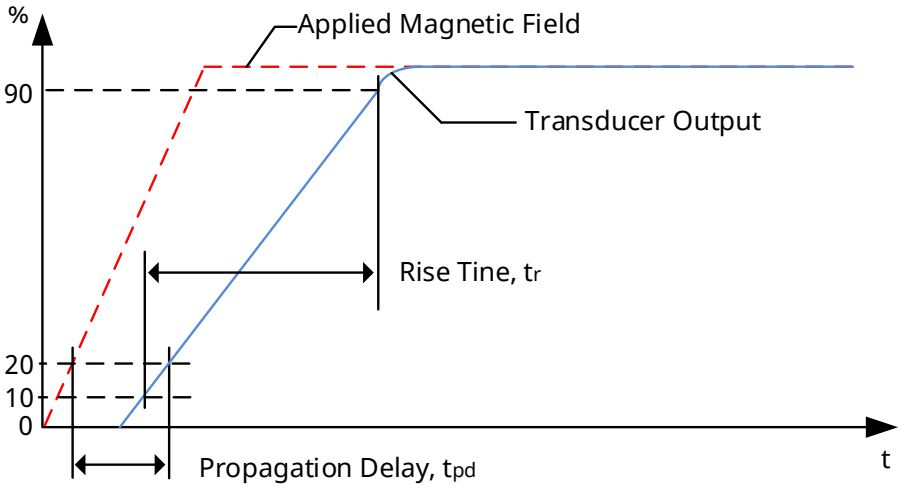


Fig.5 Propagation Delay and Rise Time Definitions

12. Typical Application

(When the SLEEP mode is not required in practical applications, the chip sleep pin is connected to GND)

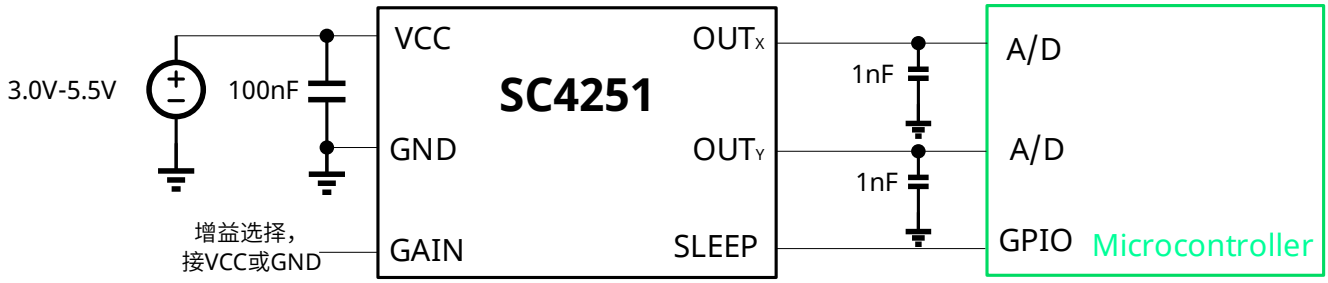


Fig.6 Typical Application Circuit

When the magnet is rotated counterclockwise, the poles also cover the PSIN and NSIN sensors, resulting in the sine and cosine signals shown in Figure 7.

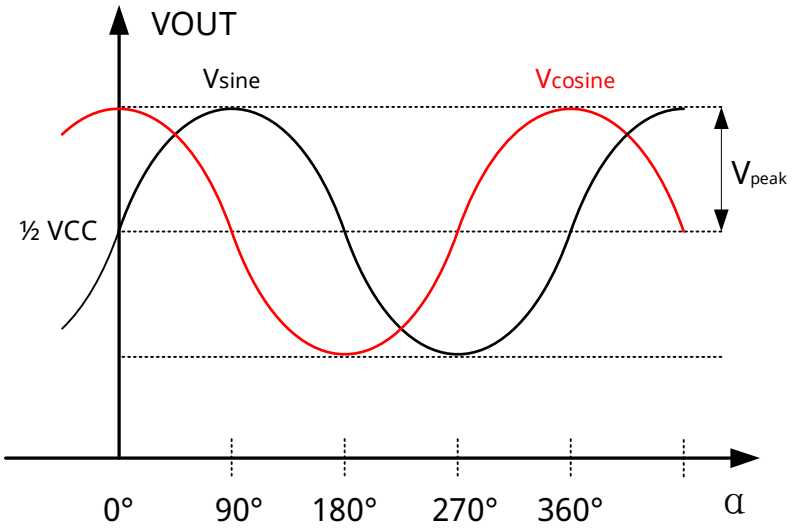
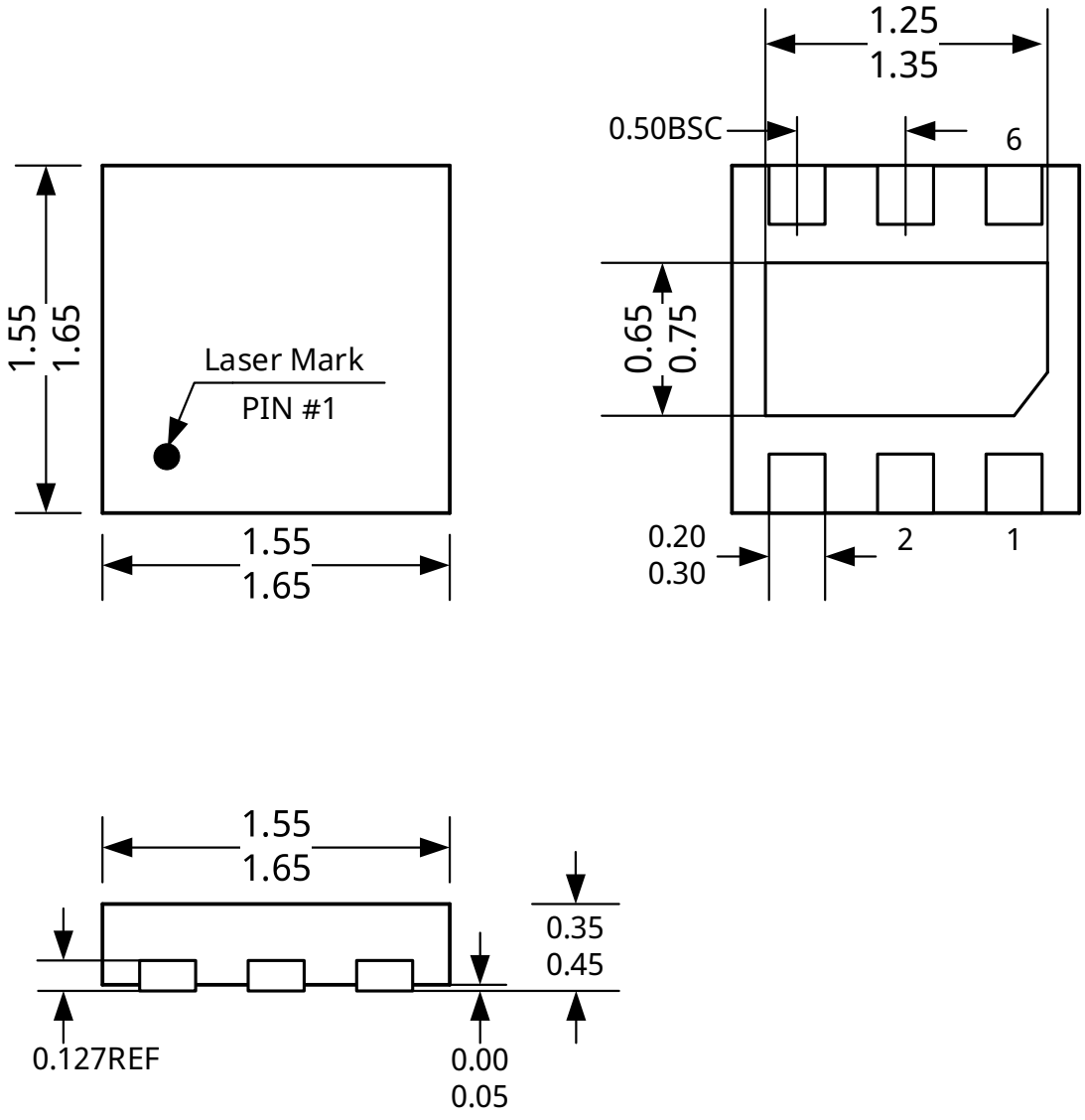


Fig.7 Sine and cosine output signal

13. Package Information "DFN1616(DN)"

6-PIN
DFN1616 Package

Unit：mm



Notes:

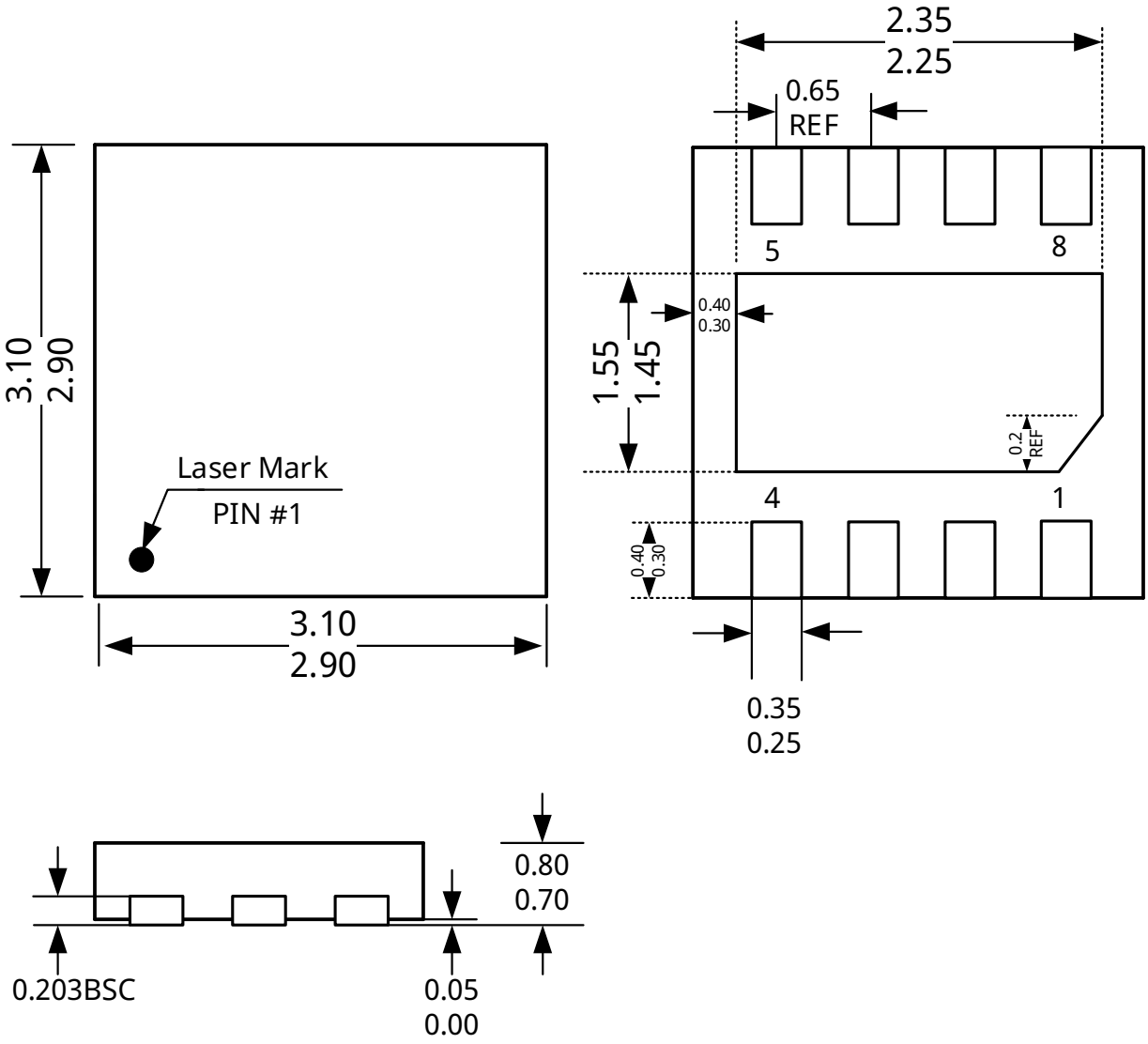
1. Exact body and lead configuration at vendor's option within limits shown.
2. Height does not include mold gate flash.

Where no tolerance is specified, dimension is nominal.

14. Package Information "DFN3*3(D3)"

8-PIN
DFN3*3 Package

Unit：mm



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.

15. Revision History

Revision	Date	Description
Rev.0.1	2024-07-25	Preliminary datasheet
Rev.A1.0	2024-12-19	Unified datasheet format