3D High-Precision Angle Position Sensor IC

1. Features

- AEC-Q100 Grade0 qualified
- ISO26262 ASIL-B qualified
- Based on the IMC 3D induction principle, supporting angle and linear displacement detection in selectable XY, XZ, or YZ planes, as well as 3D position detection in XYZ space.
- Wide operating temperature range: -40°C to 160°C.
- Selectable output interfaces: Analog voltage, PWM (Pulse-Width Modulation), digital SPI, SAE J2716-compliant SENT, and 2-wire current-mode PSI5 (V2.3).
- Programmable linear transfer characteristic, configurable via arbitrary 4/8 points or 16/32-segment piecewise linear curves.
- 32-bit programmable user ID for device identification and traceability.
- Comprehensive on-chip diagnostic functions.
- Wire break diagnosis (VDD open, VSS open).
- Over-current and over-voltage protection; under-voltage detection.

Fig.1 Encapsulation Schematic Diagram

2. Applications

- Accelerator Pedal Sensor
- Steering Wheel Angle Sensor
- Gear Shifter Position Detection
- Throttle Valve and EGR Valve
- Turbocharger Actuator
- Rotary Knob Switch
- Vehicle Body Height
- 3D Joystick

3. Description

The SC69431 is a new generation of position sensor chip based on the principle of IMC 3D magnetic induction. The chip integrates two pairs of perpendicularly placed Hall chip arrays and a magnetic collector. The signal is amplified by a preamplifier and sampled by the internal analog-to-digital converter circuitry, and the chip's proprietary DSP circuitry performs the angular algorithms, and finally outputs absolute angular, linear, and 3D positions through a variety of interface formats.

The SC69431 provides a variety of output methods: analog output, pulse width modulated PWM output, 4-wire digital SPI bus mode, digital SENT output, 2-wire current type PSI5 output. The output curve can be selected from any 4-point, 8-point, or range-selectable 16-segment, 32-segment, and other sub-curve programming methods.

The SC69431 is a sensor chip primarily targeted at automotive applications, provides a rich set of on-chip diagnostic functions. The chip was designed and developed following the ISO 26262 standard and is ASIL-B rated.

Package options: Single-channel SOP-8, dual-channel redundant TSSOP-16, and SIP-3. All packages are lead-free and compliant with EU RoHS requirements.

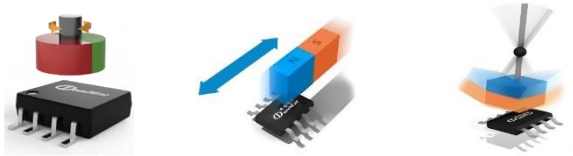

Fig.2 Product schematic diagram

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4. Terminal Configuration

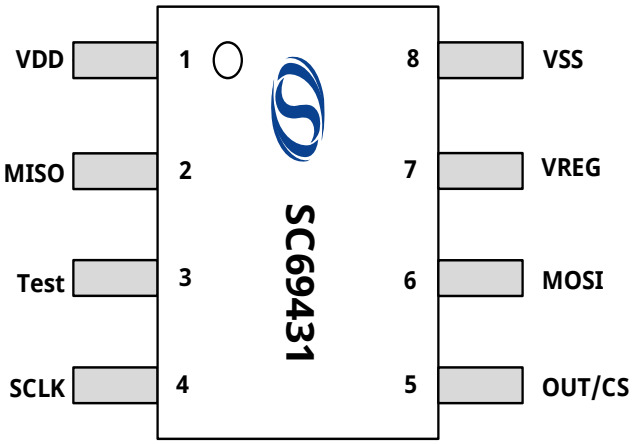


Fig.3 SOP-8 Pin Description

Name	Terminal	Type	Description
VDD	1	Power supply	Power input
MISO	2	Test/Digital Output	Test pin, ground; MISO: Master in Slave out data pin for SPI
Test	3	Test	Test Pins, Ground; Ground; Test Pins, Ground
SCLK	4	Test/Digital Input	Test pin, ground; SCLK: SPI clock signal input.
OUT/CS	5	Outputs/Digital Input	Analog output; PWM; SENT; CS: SPI enable input pin
MOSI	6	Test/Digital Input	Test pin, ground; MOSI: Master-out slave-in data pin for SPI
VREG	7	Power output	Internal power supply
VSS	8	Ground	Ground

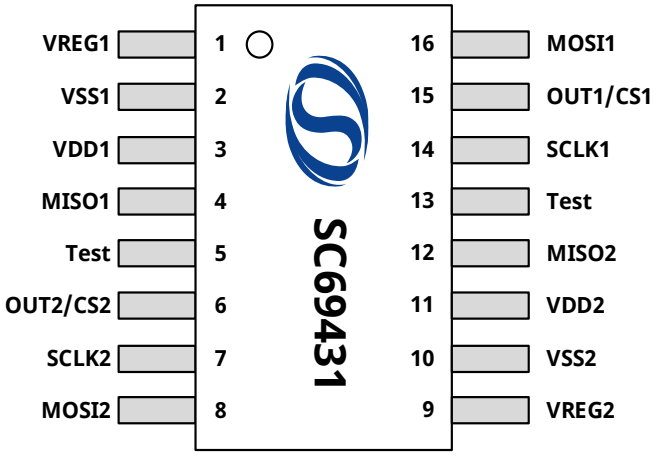


Fig.4 TSSOP-16 Pin Description

Name	Terminal	Type	Description
VREG1	1	Power output	Chip 1 - Internal power supply
VSS1	2	Ground	Chip 1 - Ground
VDD1	3	Power supply	Chip 1 - Power Input
MISO1	4	Digital Input	Chip 1 - MISO: Master-out Slave-in Data Pin for SPI
Test	5	Test	Chip 2 - test pin, connect to ground
OUT2/CS2	6	Outputs/Digital Input	Chip 2 - Analog output; PWM; SENT; CS:SPI enable input pin
SCLK2	7	Test/Digital Input	Chip 2 - test pin, connect to ground; SCLK: SPI clock signal input.
MOSI2	8	Digital Input	Chip 2 - MOSI: Master-out Slave-in Data Pin for SPI
VREG2	9	Power output	Chip 2 - Internal power supply
VSS2	10	Ground	Chip 2 - Ground
VDD2	11	Power supply	Chip 2 - Power Input
MISO2	12	Test/Digital Output	Chip 2 - test pin, connect to ground; MISO: master-in-slave-out data pin for SPI
Test	13	Test	Chip 1 - test pin, connect to ground
SCLK1	14	Test/Digital Input	Chip 1 - test pin, connect to ground; SCLK: SPI clock signal input.
OUT1/CS1	15	Outputs/Digital Input	Chip 1 - Analog output; PWM; SENT; CS: SPI enable input pin
MOSI1	16	Digital Input	Chip 1 - MOSI: Master-out Slave-in Data Pin for SPI

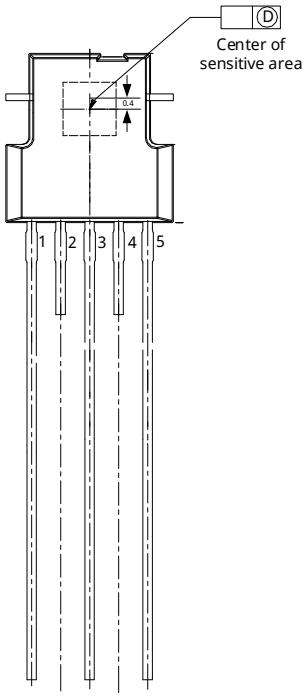


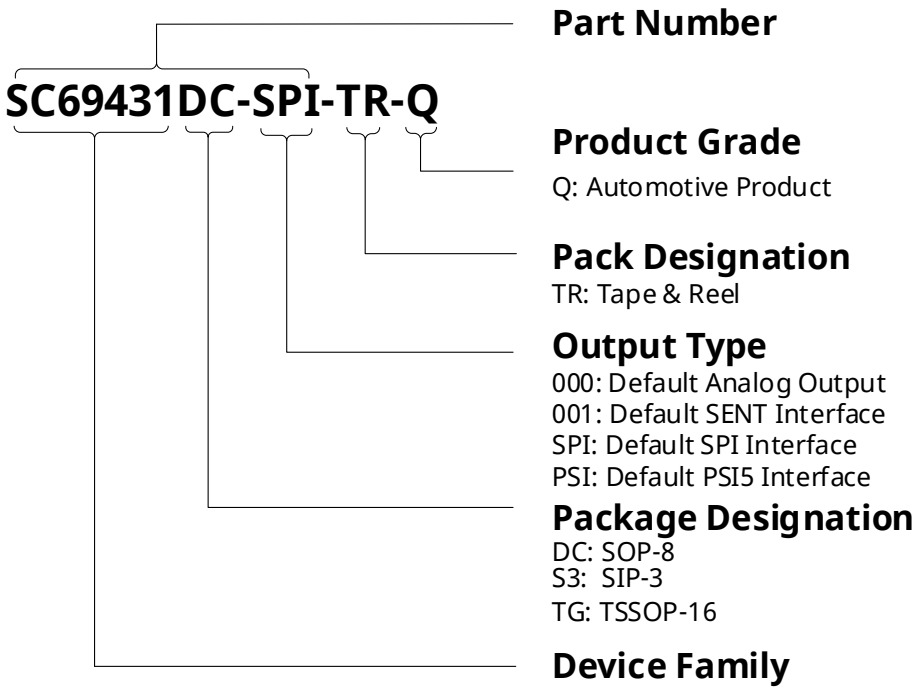
Fig.5 SIP-3 Pin Description

Name	Terminal	Type	Description
VDD	1	Power supply	Power input/PSI5-OUT
VSS	3	Ground	Ground
OUT	5	Power output	Analog output; PWM; SENT

5. Ordering Information

Ordering Information	Output	Ambient (℃)	Package	Pack	Quantity
SC69431DC-000-TR-Q	Analog	-40~160	SOP-8	Tape&Reel	4000 pieces/reel
SC69431DC-PSI-TR-Q	SPI	-40~160	SOP-8	Tape&Reel	4000 pieces/reel
SC69431DC-SPI-TR-Q	PSI5	-40~160	SOP-8	Tape&Reel	4000 pieces/reel
SC69431TG-000-TR-Q	Analog	-40~160	TSSOP-16	Tape&Reel	3000 pieces/reel
SC69431TG-SPI-TR-Q	SPI	-40~160	TSSOP-16	Tape&Reel	3000 pieces/reel
SC69431S3-000-TR-Q	Analog	-40~160	single SIP3	Tape&Reel	2600 pieces/reel
SC69431S3-001-TR-Q	SENT	-40~160	single SIP3	Tape&Reel	2600 pieces/reel
SC69431S3-PSI-TR-Q	PSI5	-40~160	single SIP3	Tape&Reel	2600 pieces/reel

Ordering Information Format



6. Absolute Maximum Ratings

Within the natural temperature range of operation (unless otherwise specified) (1)

Symbol	Parameter	Test Conditions	Min.	Max.	Units
V_{DD}	Supply Voltage	t<48h	-14	28	V
		t<60s	-18	37	V
V_{OUT}	Output voltage	t<48h	-10	24	V
		t<60s	-10	30	V
V_{spiOUT}	SPI Output Voltage		-0.3	8	V
I_R	Reverse Output Current		-40	160	mA
T_A	Operating Temperature		-40	160	℃
T_{STG}	Storage Temperature		-40	160	℃
H	Magnetic Field Strength		-1	1	T

Note:

(1) 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 Conditons	Min.	Max.	Units
V_{ESD_HBM}	HBM	according to standard AEC-Q100-002E HBM (SOP8/TSSOP16 package)	-6	6	kV
V_{ESD_HBM}	HBM	according to standard AEC-Q100-002E HBM (SIP3 package)	-8	8	kV
V_{ESD_CDM}	CDM	according to standard AEC-Q100-011C CDM	-750	750	V

8. Dual-chip Isolation Parameters

Symbol	Parameter	Test Conditons	Min.	Max.	Units
IsoR	Isolation resistor		4		MΩ

9. Operating Characteristics

Electrical Characteristics

(Operating conditions: T_{AMB} = -40~160℃, V_{DD} = 4.5~5.5V, unless otherwise specified)

Symbol	Parameters	Test Conditions	Min.	Typ.	Max.	Units
V_{DD}	Supply voltage	5V mode	4.5	5.0	5.5	V
$V_{DD\_3.3V}$		V_{REG} and V_{DD} are connected to 3.3V at the same time, U_{VLO_3P3EN}=1	3.15	3.3	3.6	V
V_{DD}		PSI5	4.1		12	V
I_{DD}	Supply current	Single path SOP-8	-	7.5	10	mA
I_{surge}	Isurge current	Single path SOP-8	-	-	25	mA
I_{OCP}	Overcurrent alarm	Single path SOP-8	-	25	35	mA
$I_{ERRSTART}$	Starting current error	PSI5	-2	-	2	mA
Δ_{IS}	Sink current	PSI5-Normal power mode	22	26	30	mA
		PSI5-Low power mode	11	13	15	mA
IS_{DRIFT}	Static current offset	PSI5	-4		4	mA
V_{REG}	Regulated voltage	5V mode	3.13	3.3	3.47	V
V_{REGOVP}	Regulated voltage overdrive detection		3.5	3.7	3.89	V
V_{REGUVL}	Regulated voltage low detection		2.8	2.9	3.0	V
VDD_{startH}	Starting voltage	5V mode	3.8			V
$VDD_{startHyst}$	Starting voltage hysteresis	5V mode		100		mV
V_{UVLO}	Undervoltage detection voltage	U_{VLO_3P3}=0	3.8	3.9	4.1	V
		U_{VLO_3P3}=1	2.6	2.8	3.0	V
$V_{UVLOHYS}$	Undervoltage detection hysteresis		50	100	200	mV
V_{OVP}	Overvoltage protection voltage		6.0	6.2	6.5	V
		PSI5	22	24	26	V
$V_{OVPHYST}$	Overvoltage detection hysteresis		50		200	mV
		PSI5	0.8	1.4	2.0	V
I_{short}	Output short-circuit current	Shorted to ground, analog output	-	-	15	mA
		Shorted to ground, PWM, SENT push-pull outputs	-	-	30	mA
		Shorted to power, analog output	-	-	15	mA
		Short-Circuit to power, PWM, SENT push-pull outputs	-	-	30	mA
R_L	Analog output load resistance	Pull-up resistor, connected to power supply	4.7	10	-	kΩ
		Pull-down resistor, connected to ground	4.7	10	-	kΩ

Electrical Characteristics (Continued)

R_{L_PWM}	PWM output load resistance	Pull-up resistor, connected to power supply	1	-	-	kΩ
		Pull-down resistor, connected to ground	1	-	-	kΩ
Vsat_lo	Analog output saturation level	Pull-up resistor R≥10k, connected to power supply	-	0.5	2	$\%V_{DD}$
		Pull-up resistor R≥4.7k, connected to power supply	-	2.5	3	$\%V_{DD}$
Vsat_hi		Pull-down resistor R≥4.7k, connected to ground	95	98	-	$\%V_{DD}$
		Pull-down resistor R≥10k, connected to ground	97	99	-	$\%V_{DD}$
VsatD_lo	Digital output level	Pull-up resistor R≥10k, connected to the power supply	-	0.5	1	$\%V_{DD}$
		Pull-up resistor R≥1k, connected to the power supply	-	6	10	$\%V_{DD}$
VsatD_hi		Pull-down resistor R≥1k, connected to ground	85	90	-	$\%V_{DD}$
		Pull-down resistor R≥10k, connected to ground	97.5	98	-	$\%V_{DD}$
Dsat_lo	Active diagnostic output level	Pull-up resistor R≥10k	-	0.5	1	$\%V_{DD}$
		Pull-up resistor R≥4.7k	-	1	2	$\%V_{DD}$
Dsat_hi		Pull-down resistor R≥10k	97.5	98.5	-	$\%V_{DD}$
		Pull-down resistor R≥4.7k	95	97	-	$\%V_{DD}$
$BV_{SS}PD$	Passive diagnostic output level (Open drain)	V_{SS} Open, pull-down resistor, R≤10k	-	0.5	1.6	$\%V_{DD}$
$BV_{SS}PU$		V_{SS} Open, pull-up resistor, R≥1k, pull-up to 5V	99.5	100	-	$\%V_{DD}$
$BV_{DD}PD$		V_{DD} Open, pull-down resistor, R≥1k	-	0	0.5	$\%V_{DD}$
$BV_{DD}PU$		V_{DD} Open, pull-up resistor, R≤10k, pull-up to 5V	97	99.5	-	$\%V_{DD}$
Clamp_lo	Programmable clamp voltage	Programmable	0	-	100	$\%V_{DD}$
Clamp_hi		Programmable	0	-	100	$\%V_{DD}$

Note:

(1)Based on the description in the table above, the SC69431 can meet the output range settings for the typical application of Fig.6

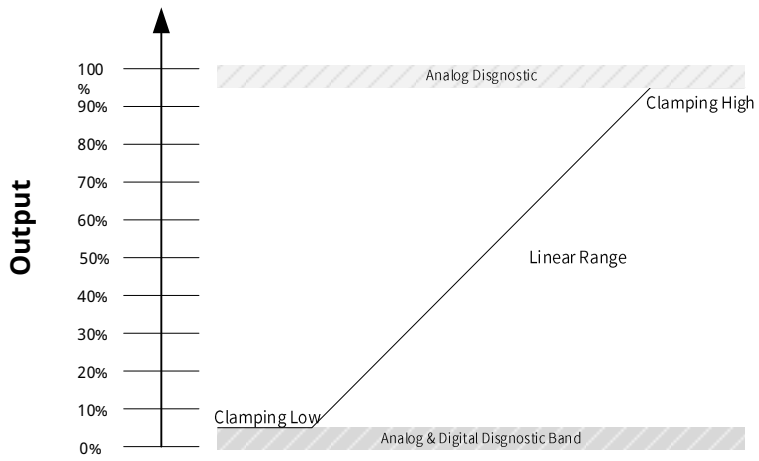


Fig.6 Example of Output Range for Typical Application

Timing parameters - basic timing

Symbol	Parameters	Test Conditions	Min.	Typ.	Max.	Units
F_{CK}	Master Clock Frequency	Full Temperature Test	7.8	8.2	8.5	MHz
$\Delta F_{CK,T}$	Main Clock Frequency Temperature Offset		-3	-	3	%FCK
Tper	Data Refresh Frequency		-	200	250	μs
Ts	Step Response Time		-	400	500	μs
T_{POR}	Power-On Reset		-	40	-	μs
T_{INIT}	Initialization Time		-	3	5	ms

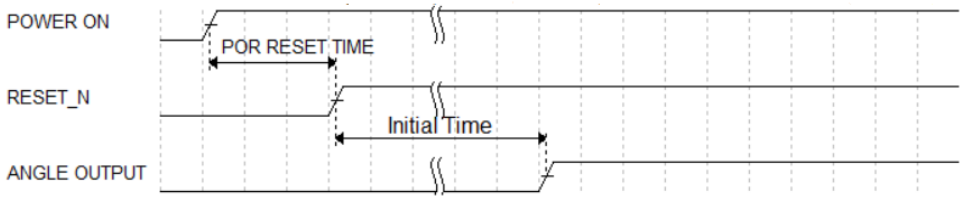


Fig.7 Power-on reset timing sequence

Timing parameters - EEPROM Timing

Symbol	Parameters	Test Conditions	Min.	Typ.	Max.	Units
t_{PS}	Power-on Reset Time			100		μs
t_{PW}				100		μs
TIDLE	Standby Time			20		ms

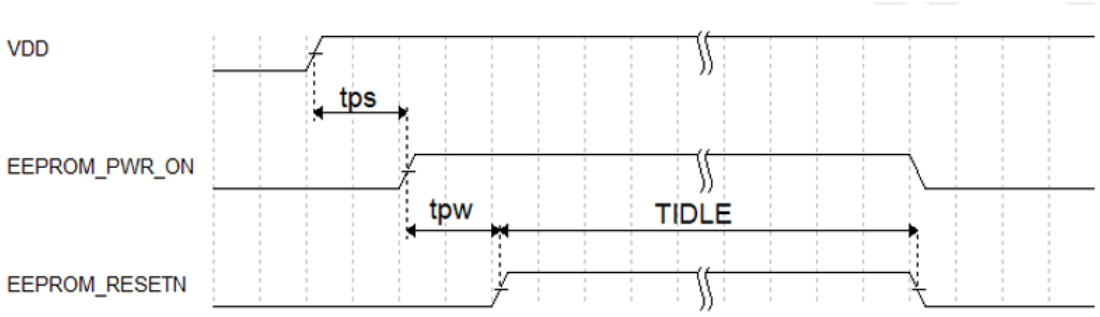


Fig.8 EEPROM Timing

Timing parameters - PWM Output

Symbol	Parameters	Test Conditions	Min.	Typ.	Max.	Units
F_{PWM}	PWM Frequency	Frequency range	100		2000	Hz
F_{PWM_Init}	PWM Frequency Initial Tolerances	25°C			±2%	F_{PWM}
F_{PWM_EOL}	Tolerances	25°C			±1%	F_{PWM}
ΔF_{PWM}	PWM Frequency Temperature Drift	PWM frequency temperature drift			±3%	F_{PWM}
T_{rise_LSD}	PWM Output Rise Time(Open-Drain Output)	4.7nF, R_L=1kΩ pull-up		10		μs
		10nF, R_L=1kΩ pull-up		20		μs
T_{rise_PP}	PWM Output Rise Time (Push-Pull Output)	4.7nF, R_L=1kΩ pull-up		3		μs
		10nF, R_L=1kΩ pull-up		4		μs
T_{fall_LSD}	PWM Output Fall Time (Open-Drain Output)	4.7nF, R_L=1kΩ pull-up		2		μs
		10nF, R_L=1kΩ pull-up		4		μs
T_{fall_PP}	PWM Output Fall Time (Push-Pull Output)	4.7nF, R_L=1kΩ pull-up		2		μs
		10nF, R_L=1kΩ pull-up		4		μs

Timing parameters - SPI Output

Symbol	Parameters	Test Conditions	Min.	Typ.	Max.	Units
V_{IH}	High Level Input Voltage		0.6*V_{DD}	-	V_{DD}	V
V_{IL}	Low Level Input Voltage		0	-	0.4*V_{DD}	V
V_{IH}	High Level Output Voltage		V_{DD}-0.4	-	V_{DD}	V
V_{IL}	Low Level Output Voltage		0		V_{SS}+0.4	V
t_{SCLK}	Clock Cycle		450	500	-	ns
t_{SCLK_LO}	Clock low level		225	-	-	ns
t_{SCLK_HI}	Clock high level		225	-	-	ns
t_{MISO}	Output data delay time		-	-	210	ns
t_{MOSI}	Data capture setup time		-	30	-	ns
t_1	Initial clock delay time		225	-	-	ns
t_2	Initial output data establishment time		-	90	120	ns
t_3	Communication completion enable keep time		225	-	-	ns
t_4	Communication completion output retention time		-	90	120	ns
tSyncPulse	Synchronized Pulse Period		520	-	1000	ns

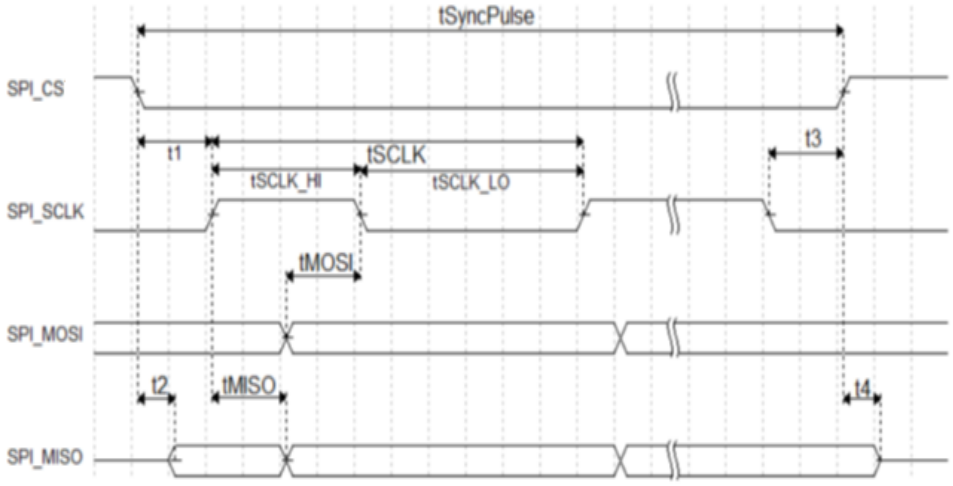


Fig.9 SPI Timing

Timing parameters – SENT Output

Symbol	Parameters	Test Conditions	Min.	Typ.	Max.	Units
$TICK_{time}$	Tick Time		1.5	-	6	us
N_{nibble}	Number of data Nibble		3	6	-	-
T_{rise}	SENT edge rise time	Between 1.1V and 3.8V	-	12.5	18	us
T_{fall}	SENT edge fall time	Between 1.1V and 3.8V	-	5.3	6.5	us
Npp	SENT frame cycle (no pause bit)		154	-	270	ticks
Ppc	SENT frame cycle (with pause bit)		282	-	922	ticks
A.1	Sensor type	Dual Body Position Sensor	-	-	-	-
A.3		Single Reliable Sensor	-	-	-	-
T_{FRAME}	SENT frame cycle (slow)	Standard data sequence (40 frames)	-	691	-	ms
		Extended Data Sequence (24 frames)	-	415	-	ms

Timing parameters – PSI5 Output

Symbol	Parameters	Test Conditions	Min.	Typ.	Max.	Units
T_{cycle}	Communication cycle			300		μs
				500		μs
				1000		μs
T_{bit}	bit time	125 kbit/s	7.6	8	8.4	μs
		189 kbit/s	5	5.3	6	μs
T_{SHOLD}	Synchronization pulse hold time		9			μs
T_{RISE}	Current slope rise time		0.33		1	μs
TFALL	Current slope fall time		0.33		1	μs
MSR	Mark/Space Ratio	(tfall, 80 - trise, 20) / TBit (tfall, 20 - trise, 80) / TBit	47	50	53	%

Accuracy Parameters - Analog Output

Symbol	Parameters	Test Conditions	Min.	Typ.	Max.	Units
R_{ADC}	ADC Resolution		-	15	-	bits
R_{DAC}	Analog Output Resolution		-	12	-	bits
INL	DAC Integral Nonlinearity Error		-4	-	4	LSB
DNL	DAC Differential Nonlinearity Error		0.05	-	3	LSB
ΔE_{L_XY}	XY Inherent Linearity Error		-1	-	1	Deg
ΔE_{L_XZ}	XZ Inherent Linearity Error		-2.5	-	2.5	Deg
ΔE_{L_YZ}	YZ Inherent Linearity Error		-2.5	-	2.5	Deg
ΔEtemp	Angular Temperature Drift Error	XY	-0.5	-	0.5	Deg
ΔEratio	Proportional Output Error	$4.5V \le V_{DD} \le 5.5V$	-0.05	0	0.5	%VDD
N_{pk-pk}	Output Noise		-	0.05	0.2	Deg

Accuracy Parameters - PWM Output

Symbol	Parameters	Test Conditions	Min.	Typ.	Max.	Units
RSP	PWM Output Resolution		-	12	-	bits
J_{DC}	PWM % Duty Cycle Jitter (Open-Drain Output)	125Hz,4.7nF, R_L=1kΩ, Resistor Pull-Up	-	±0.003	±0.016	%DC
		250Hz,4.7nF, R_L=1kΩ, Resistor Pull-Up	-	±0.005	±0.02	%DC
		500Hz,4.7nF, R_L=1kΩ,Resistor Pull-Up	-	±0.009	±0.035	%DC
		1000Hz,4.7nF, R_L=1kΩ,Resistor Pull-Up	-	±0.003	±0.016	%DC
		2000Hz,4.7nF, R_L=1kΩ,Resistor Pull-Up	-	±0.005	±0.02	%DC
J_{DC}	PWM % Duty Cycle Jitter (Push-Pull Output)	125Hz,4.7nF, R_L=1kΩ, Resistor Pull-Up	-	±0.003	±0.016	%DC
		250Hz,4.7nF, R_L=1kΩ, Resistor Pull-Up	-	±0.005	±0.02	%DC
		500Hz,4.7nF, R_L=1kΩ, Resistor Pull-Up	-	±0.009	±0.035	%DC
		1000Hz,4.7nF, R_L=1kΩ,Resistor Pull-Up	-	±0.003	±0.016	%DC
		2000Hz,4.7nF, R_L=1kΩ,Resistor Pull-Up	-	±0.005	±0.02	%DC
J_{PWM}	PWM Frequency Jitter (Open-Drain Output)	125Hz-2000Hz,4.7nF, R_L=1kΩ,Resistor Pull-Up	-	±0.04	±0.15	Hz
J_{PWM}	PWM Frequency Jitter (Push-Pull Output)	125Hz-2000Hz,4.7nF, R_L=1kΩ,Resistor Pull-Up	-	±0.04	±0.15	Hz

Magnetic parameter

Symbol	Parameters	Test Conditions	Min.	Typ.	Max.	Units
N_P	Magnetic Pole Number		-	2	-	
B_x, B_y	XY Plane Magnetic Field Strength	$\sqrt{B_X^2 + B_Y^2}$	-	-	70	mT
B_z	Z-Axis Magnetic Field Strength		-	-	126	mT
B_{Norm}	Useful Magnetic Field Strength	$\sqrt{B_X^2 + B_Y^2}$ (X-Y mode) $\sqrt{B_X^2 + \left(\frac{1}{G_{IMC}} B_Z\right)^2}$ (X-Z mode) $\sqrt{B_Y^2 + \left(\frac{1}{G_{IMC}} B_Z\right)^2}$ (Y-Z mode)	10	20	-	mT
G_{IMC}	Imc Gain		-	1.19	-	
D_{mag}	Magnet Diameter		-	8	-	mm
H_{mag}	Magnet Thickness		-	2.5	-	mm
AG	Magnet To Chip Gap		2	-	5	mm
	Magnetic material		-	NdFeB 35	-	

10. Block Diagram

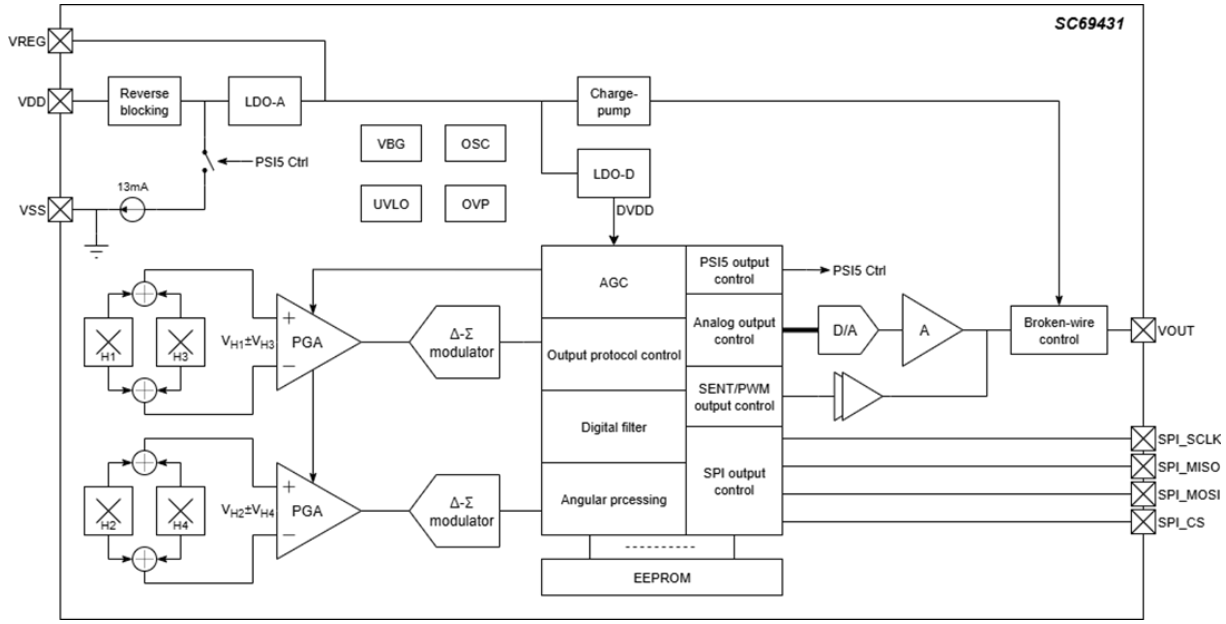


Fig.10 Functional block diagram

11. Function Description

User programmable parameters

Parameters	Description	Default				Bits
		-000	-001	-SPI	-PSI	
General Parameter Settings						
MAP_{XYZ}	Output mapping selection	0	0	0	0	3
K	Sensitivity fitness coefficients for X(Y), Z	1.5	1.5`	1.5	1.5	15
OUT_mode	Output mode	1	2	0	4	3
PWM_POL	PWM polarity	0	-	-	-	1
PWMT	PWM frequency	1000	-	-	-	16
OUT_CONFIG	PWM/SENT output configuration	3	3	-	-	2
USER_ID1	User ID	0	0	0	0	8
USER_ID2	User ID	0	0	0	0	8
USER_ID3	User ID	0	0	0	0	8
USER_ID4	User ID	0	0	0	0	8
EEPROM_LOCK_CODE	EEPROM lock code / EEPROM lock key	0	0	0	0	8
SENT configuration parameters						
SENT_FC_FORMAT	SENT frame data format selection	-	1	-	-	1
SENT_CH2_DATA	Channel 2 data configuration	-	2	-	-	2
SENT_INIT_DATA	SENT startup initialization data configuration	-	0	-	-	1
SENT_NIBBLE_NUMBER	Channel 2 data nibble count selection	-	1	-	-	1
SENT_TICK_TIME	SENT tick time configuration	-	0	-	-	3
SENT_LEGACY_CRC	CRC calculation options	-	0	-	-	1
SENT _SERIAL_CONFIG	Enhanced serial message selection	-	1	-	-	1
SENT_SLOW_EXTENDED	Serial message sequence selection	-	0	-	-	1
SENT_SLOW_BFIELD	Serial message extension sequence magnetic field configuration	-	1	-	-	1
SENT_PAUSE_OPTION	Selection of the measurement mode and the corresponding output protocol	-	1	-	-	1
SENT_REV	SENT version	-	4	-	-	3
SENT_MAN_CODE	factory code	-	0	-	-	12
SENT_FRAME_LENGTH	frame length	-	297	-	-	10
T_SENT	Slope control	0	1	0	0	1
SENT_SENSOR_TYPE	Sensor type	-	0x50	-	-	8
SENT_CHANNEL_X1	CHANNEL X1	-	0	-	-	12

User programmable parameters(Continued)

SENT_CHANNEL_X2	CHANNEL X2	-	0	-	-	12
SENT_CHANNEL_Y1	CHANNEL Y1	-	0	-	-	12
SENT_CHANNEL_Y2	CHANNEL Y2	-	0	-	-	12
SENT_SENSOR_ID1	Sensor ID1	-	0	-	-	12
SENT_SENSOR_ID2	Sensor ID2	-	0	-	-	12
SENT_SENSOR_ID3	Sensor ID3	-	0	-	-	12
SENT_SENSOR_ID4	Sensor ID4	-	0	-	-	12
SENT_OEM_CODE1	OEM Code 1	-	0	-	-	12
SENT_OEM_CODE2	OEM Code 2	-	0	-	-	12
SENT_OEM_CODE3	OEM Code 3	-	0	-	-	12
SENT_OEM_CODE4	OEM Code 4	-	0	-	-	12
SENT_OEM_CODE5	OEM Code 5	-	0	-	-	12
SENT_OEM_CODE6	OEM Code 6	-	0	-	-	12
SENT_OEM_CODE7	OEM Code 7	-	0	-	-	12
SENT_OEM_CODE8	OEM Code 8	-	0	-	-	12
PSI5 configuration parameters						
PSI5_OUT_MODE	PSI5 Output Mode	-	-	-	3	2
PSI5_PAYLOAD_SIZE	Effective data length	-	-	-	20	5
PSI5_ERROR_DETECTION	Error Detection Methods	-	-	-	0	1
PSI5_CYCLE_TIME	communications cycle	-	-	-	0	2
PSI5_TRANSMIT_SPEED	data transfer speed	-	-	-	1	1
PSI5_FORMAT_PRECEISION	Data frame format accuracy	-	-	-	1	1
PSI5_TRIGGER_LEVEL	Synchronized pulse trigger level setting	-	-	-	1	1
PSI5_SYNC_TH	Sync pulse trigger level setting	-	-	-	1	1
PSI5_TS[1..4]_ENABLE	Timeslot Enable	-	-	-	0x1,0x0, 0x0,0x0	1
PSI5_TS[1..4]_SENSOR	Transmitted time slot data selection	-	-	-	0x0,0x0, 0x0,0x0	3
PSI5_TS[1..4]_STARTTIME	time slot start time	-	-	-	0x000,0x000, 0x000,0x000	11
PSI5_INIT_PHASES	Initialization Configuration	-	-	-	0	2
PSI5_INIT_I_DURATION	Initialization 1 phase cycle	-	-	-	100	8
PSI5_INIT_II_EXTRA_FIELDS	Initialization 2 Stage Extended Data Enable	-	-	-	0	1
PSI5_INIT_II_REPETITION	Initialization 2-stage repetition count	-	-	-	1	2
PSI5_INIT_III_REPETITION	Initialization 3-stage repetition count	-	-	-	0	8
PSI5_INIT_METAINFO	PSI5 version	-	-	-	6	4
PSI5_INIT_INITLENGTH	Initialization 2-stage data length	-	-	-	9	8

PSI5_INIT_VENDORID	Supplier ID	-	-	-	6	8
PSI5_INIT_SENSORTYPE	Sensor type	-	-	-	6	4
PSI5_INIT_SENSORPARAMS	Sensor specified parameters	-	-	-	0	8
PSI5_INIT_SENSORCODE	Sensor Manufacturer Specified Parameters	-	-	-	0	8
PSI5_INIT_SENSORAPPCODE	Product version information	-	-	-	0	12
PSI5_INIT_PRODUCTIONDATE	date of manufacture	-	-	-	0	16
Diagnostic Function Setting						
DIAG_EN	Diagnostic Enable Bit				1	1
DIAG_MASK	Diagnostic Mask Register				127	8
DC_FAULT	Output duty cycle of PWM when supply voltage is too low				0	8
DC_FTL	Output duty cycle of PWM when magnetic field is too low				0	8
GAIN_THRESHOLD_LOW	Analog op amp second stage gain low thresholds				0	5
GAIN_THRESHOLD_HIGH	Analog op amp second stage gain high thresholds				31	5
FIELDTHOLD_LOW	low field strength threshold				0	8
FIELDTHOLD_HIGH	High field strength threshold	-	-	-	255	8
TEMPTHRESHOLD_LOW	low-temperature threshold	-	-	-	0	7
TEMPTHRESHOLD_HIGH	High-temperature threshold	-	-	-	127	7
DIAG_DEBOUNCE	Diagnostic de-jittering time	-	-	-	0	3
Linear Transfer Curve Setting Parameters						
CLAMP_HIGH	Output High Clamp	100%	-	-	-	16
CLAMP_LOW	Output Low Clamp	0%	-	-	-	16
DP	Breakpoint/Zero Point	0	-	-	-	16
CW	direction of rotation	1	-	-	-	1
WORK_RANGE_GAIN	16-point/32-point calibrated operating angle range (degrees)	360	-	-	-	16
LNR_POINTS	Calibration point selection	3	-	-	-	2
LNR_A_X	4-point calibration , X-axis coordinates (angle)	0	0	0	0	16
LNR_B_X		0	0	0	0	16
LNR_C_X		0	0	0	0	16
LNR_D_X		0	0	0	0	16
LNR_A_Y	4-point calibration, Y-axis coordinates (%VDD)	0	0	0	0	16
LNR_B_Y		0	0	0	0	16
LNR_C_Y		0	0	0	0	16
LNR_D_Y		0	0	0	0	16
LNR_A_S	4-point calibration, slope of each segment	0	0	0	0	16
LNR_B_S		0	0	0	0	16

LNR_C_S		0	0	0	0	16
LNR_D_S		0	0	0	0	16
LNR4_S0	4-point calibration, initial slope	0	0	0	0	16
LNR4_Y5	4-point calibration, endpoint Y coordinate	0	0	0	0	16
LNR_Y0	4-point, 16-point/32-point calibration of initial point Y-coordinate	0	0	0	0	16
LNR9_Yn	8-point calibration, Y-axis coordinates (n=0~8)	0	0	0	0	9x16
LNR9_Xn	8-point calibration, X-axis coordinates (n=0~8)	0	0	0	0	9x16
LNR17_Yn	16-point calibration, Y-axis coordinates (n=0~15)	0	0	0	0	17x16
LNR_DELTAYn	32-point calibration, Y-axis coordinates (offset %) (n=0~31)	0	0	0	0	32x8
LNR_DELTA_Y_EXPAND	32-point calibration, Y-axis coordinate deviation range setting	0	0	0	0	2

Output mapping selection

MAPXYZ is used to define which magnetic field is used to calculate the angle.

Parameters	Value	Description
MAPXYZ【2:0】	0	XY Mode
	2	XZ Mode
	3	YZ model
	4	XYZ 3-axis mode

K-factor

When no mapping is selected (B1=X, B2=Y), k defines the sensitivity mismatch coefficient applied to B1 or B2. When Mapping (B1=X, B2=Y) is selected, this parameter is not used. This parameter is factory fine-tuned for Mapping (B1=Z, B2=X). It is recommended to fine-tune it when a smaller linearity error is required and a mapping different from (B1=X, B2=Y) is selected.

Output Mode

The SC69431 provides five output modes: proportional analog output, PWM output, SENT output SPI bus output, and PSI5 output. PWM and SENT support open drain output and push-pull output, while SPI only supports push-pull output.

Analog Output Mode

Parameters	Value	Description
OUT mode【2:0】	0	SPI output
	1	analog output
	2	SENT
	3	PWM
	4	PSI5
	5	Reserved
	6	Reserved
	7	Reserved

Digital pattern output settings

Parameters	Value	Description
OUT_CONFIG【1:0】	0	Digital high-impedance output
	1	Digital output NMOS Open Drain
	2	Digital output PMOS Open Drain
	3	Digital push-pull output

PWM Output Mode - Polarity Setting

Parameters	Value	Description
PWM POL	0	active low
	1	active high

PWM Output Mode - Frequency Setting

Parameters	Value	Description
PWMT【15:0】	2000-40000	100-2000Hz Frequency

PWM Output Waveform

PWM is set to PWM_POL=0,PWMT=1000Hz output duty cycle 0.0244%

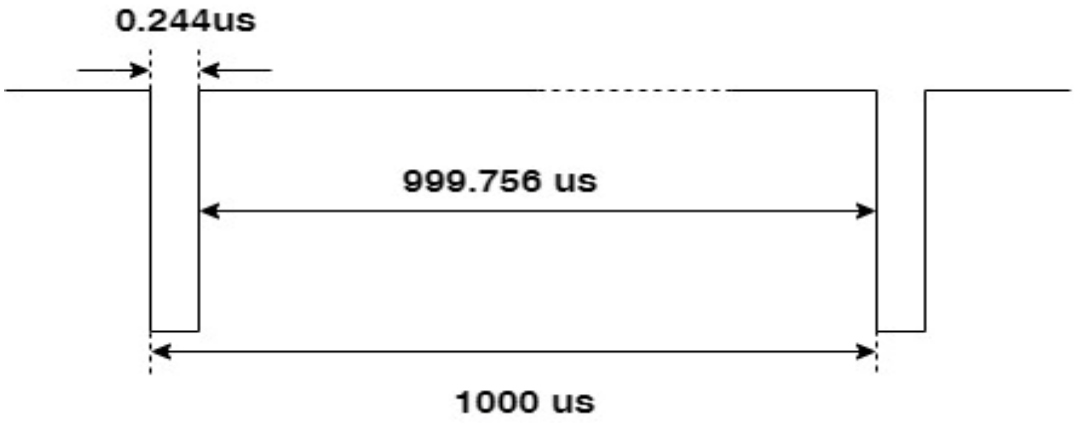


Fig.11 PWM output waveform at PWM_POL=0

PWM is set to PWM_POL=1,PWMT=1000Hz, output duty cycle 0.0244%

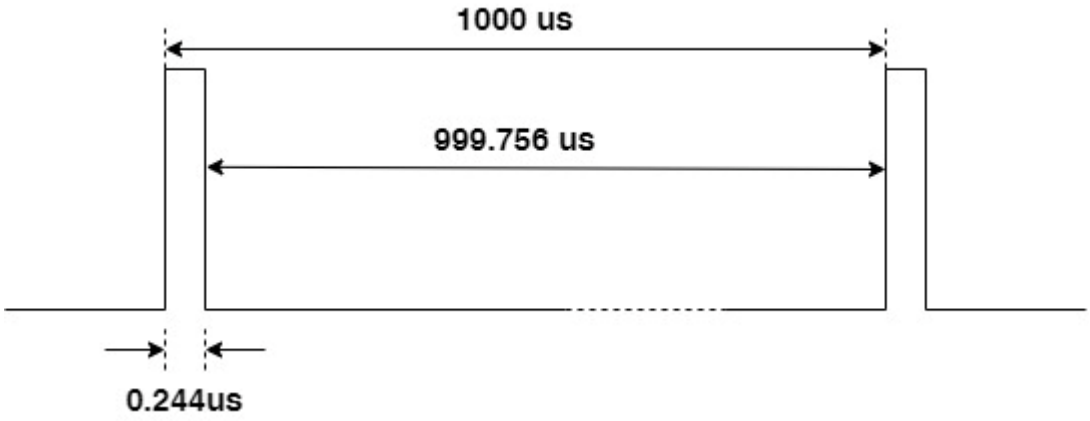


Fig.12 PWM output waveform when PWM_POL=1

SENT Protocol Output

The digital SENT output of the SC69431 is compatible with SAE J2716 APR2016.

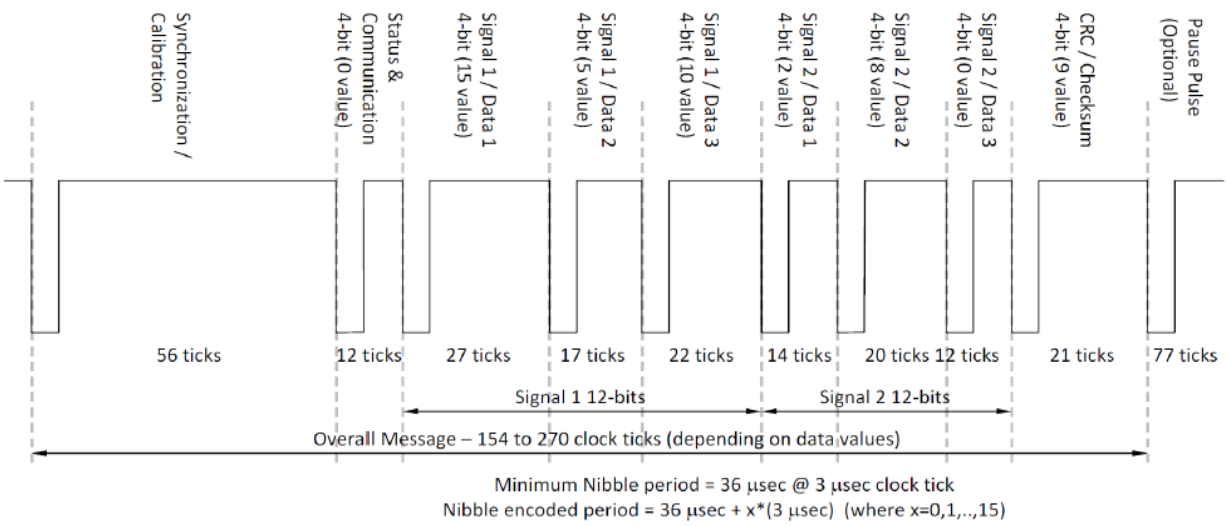


Fig.13 2-channel 12-bit data SENT message format example

SENT Protocol Output - SENT Fast Frame Data Format Selection

Parameters	Value	Description
SENT_FC_FORMAT	0	Dual Throttle Position Sensor
	1	Single safety position sensors

SENT Protocol Output - A.1 Dual Throttle Position Sensor Data Frame

The SC69431 sends a string of data words based on the dual throttle position sensors defined in SAE J2716 Appendix A.1. CH1 always sends 12-bit sensor data, while the CH2 channel content is set by SENT CH2 DATA.

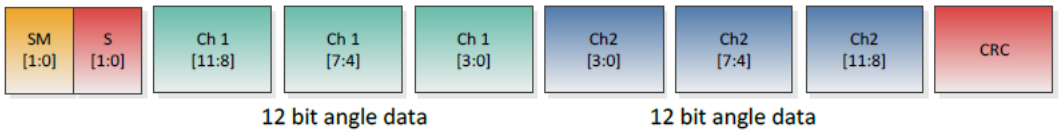


Fig.14 A.1 Dual Throttle Position Sensor Data Frame

SENT Protocol Output - Channel 2 configures the number of nibbles

Parameters	Value	Description
SENT_NIBBLE_NUMBER【0】	0	6 nibbles
	1	3 nibbles

SENT Protocol Output - Channel 2 Configuration Data

Parameters	Value	Description
SENT CH2 DATA【1:0】	0	12-bit temperature sensor data
	1	0xFF9(4089)-CH1
	2	User-defined 12-bit data
	3	0xFFF(4095)-CH1

SENT Protocol Output - A.3 Single Safe Position Sensor Data Frame

The SC69431 transmits a single safe position sensor as defined in SAE J2716 Appendix A.3 that contains the 12-bit sensor angle data and roll counter for the CH1 channel as well as the high 4 bits of angle data inverted.

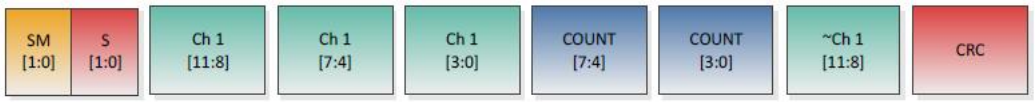


Fig.15 A.3 Single safe position sensor data frame

SENT Protocol Output - Initialize startup frame

Parameters	Value	Description
SENT INIT DATA【1:0】	0	OEM Requirements - 0xFFF
	1	SAE Compatible-0x000

SENT Protocol Output - SENT tick time configuration

Parameters	Value	Description
TICK_TIME【2:0】	0	3.0us Standard SENT
	1	Reserved
	2	Reserved
	3	1.5us Fast SENT
	4	Reserved
	5	Reserved
	6	6.0us Slow SENT
	7	Reserved

SENT Protocol Output - Frame length setting

Parameters	Value	Description
SENT_FRAME_LENGTH【9:0】	Default 297 ticks	Frame length setting

SENT Protocol Output - SENT CRC version selection

Parameters	Value	Description
SENT_LEGACY_CRC【0】	0	Versions from 2010 onwards
	1	2007

SENT Protocol Output - SENT version selection

Parameters	Value	Description
SENT_REV【2:0】	0	No version specified
	1	2007
	2	2008
	3	2010
	4	2016

SENT Protocol Output - Enhanced Serial Messaging

Enhanced Serial Messaging is a communication protocol that allows the transmission of large amounts of data and message IDs, serial data is transmitted via Status and Communication Nibble bits 2 and 3 SM [1:0]. As shown a serial message frame consists of 18 consecutive SENT data messages, all 18 frames must be successfully received (no errors, calibration pulse changes, data byte CRC errors, etc.).

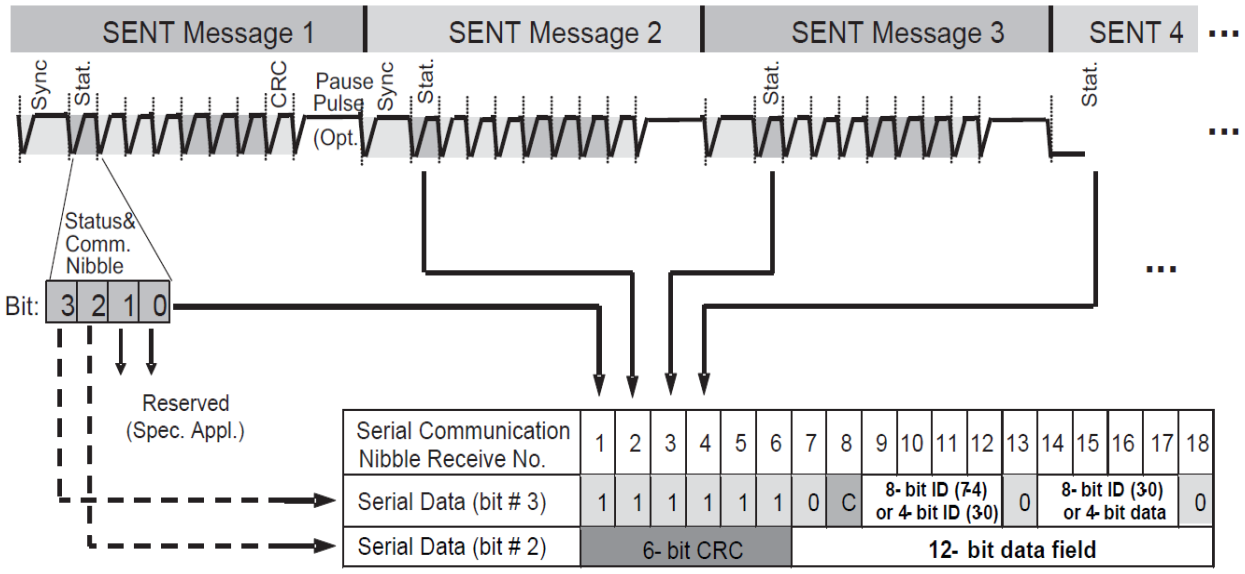


Fig.16 Enhanced Serial Message Data Format

An Enhanced Serial Message contains an Enhanced Serial Message with 12 bits of data and an 8-bit Message ID.SM[0] contains a 6-bit CRC followed by 12 bits of data. The message content is defined by the 8-bit message ID transmitted in the SM[1] channel. By default, a short sequence of 24 data is transmitted. Optionally, an extended sequence can be used so that a cycle of 40 data is transmitted.

In addition, at the end of the sequence (short or extended), the standard value of the magnetic field detected by the sensor can optionally be returned.

Num	8-Bit Id	Element	Description
Standard sequence			
1	0x01	Diagnostic error code	Diagnostic register
2	0x06	SENT standard revision	SENT_REV
3	0x01	Diagnostic error code	Diagnostic register
4	0x05	Manufacturer code	SENT_MAN_CODE
5	0x01	Diagnostic error code	Diagnostic register
6	0x03	Channel 1 / 2 Sensor type	SENT_SENSOR_TYPE
7	0x01	Diagnostic error code	Diagnostic register
8	0x07	Fast channel 1: X1	SENT_CHANNEL_X1
9	0x01	Diagnostic error code	Diagnostic register

10	0x08	Fast channel 1: X2	SENT_CHANNEL_X2
11	0x01	Diagnostic error code	Diagnostic register
12	0x09	Fast channel 1: Y1	SENT_CHANNEL_Y1
13	0x01	Diagnostic error code	Diagnostic register
14	0x0A	Fast channel 1: Y2	SENT_CHANNEL_Y2
15	0x01	Diagnostic error code	Diagnostic register
16	0x23	(Internal) temperature	Temperature register
17	0x01	Diagnostic error code	Diagnostic register
18	0x29	Sensor ID #1	SENT_SENSOR_ID1
19	0x01	Diagnostic error code	Diagnostic register
20	0x2A	Sensor ID #2	SENT_SENSOR_ID2
21	0x01	Diagnostic error code	Diagnostic register
22	0x2B	Sensor ID #3	SENT_SENSOR_ID3
23	0x01	Diagnostic error code	Diagnostic register
24	0x2C	Sensor ID #4	SENT_SENSOR_ID4
Extended sequence			
25	0x01	Diagnostic error code	Diagnostic register
26	0x90	OEM Code #1	SENT_OEM_CODE1
27	0x01	Diagnostic error code	Diagnostic register
28	0x91	OEM Code #2	SENT_OEM_CODE2
29	0x01	Diagnostic error code	Diagnostic register
30	0x92	OEM Code #3	SENT_OEM_CODE3
31	0x01	Diagnostic error code	Diagnostic register
32	0x93	OEM Code #4	SENT_OEM_CODE4
33	0x01	Diagnostic error code	Diagnostic register
34	0x94	OEM Code #5	SENT_OEM_CODE5
35	0x01	Diagnostic error code	Diagnostic register
36	0x95	OEM Code #6	SENT_OEM_CODE6
37	0x01	Diagnostic error code	Diagnostic register
38	0x96	OEM Code #7	SENT_OEM_CODE7
39	0x01	Diagnostic error code	Diagnostic register
40	0x97	OEM Code #8	SENT_OEM_CODE8
Magnetic field expansion			
41	0x80	Field Strength	Magnetic Field Strength Register (Extended Sequence)

SENT Protocol Output - Enhanced Serial Message Slow Channel Selection

Parameters	Value	Description
SERIAL_CONFIG	0	Disable Enhanced Serial Messaging Slow Channel
	1	Enable Enhanced Serial Message Slow Channel

SENT Protocol Output - Enhanced Serial Message Sequence Selection

Parameters	Value	Description
SENT_SLOW_EXTENDED	0	Short-sequence serial message selection
	1	Extended Sequence Serial Message Selection

SENT Protocol Output - When the expansion sequence is enabled, you can configure whether to use the magnetic field expansion

Parameters	Value	Description
SENT_SLOW_BFIELD	0	No magnetic field expansion
	1	With magnetic field expansion

SENT Protocol Output - PAUSE Configuration

Parameters	Value	Description
SENT_PAUSE_OPTION	0	Continuous asynchronous angle acquisition, no pause bit in SENT
	1	Continuous synchronized angle acquisition, SENT with pause bit

PSI5 Protocol Output

According to the PSI5 protocol specification, information is transmitted by modulating the current at the power supply pin VDD. the SC69431 is compliant with the PSI5 Protocol Specification v2.3, forward compatible with v2.1 and v1.3.

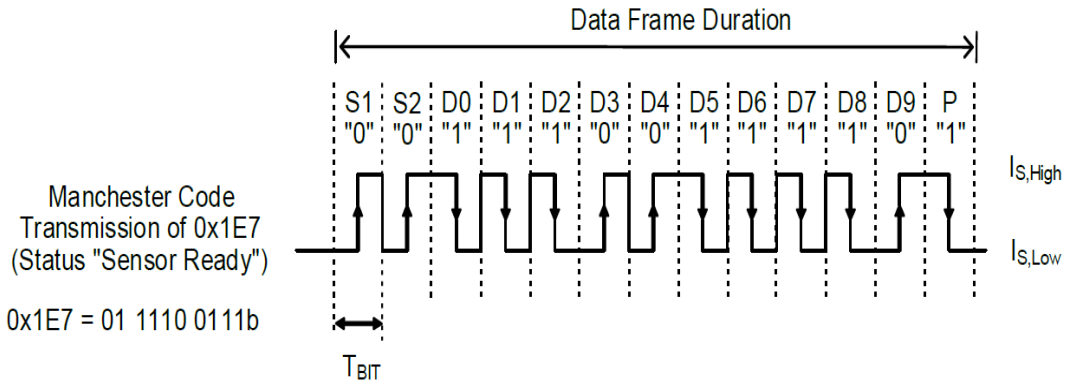


Fig.17 PSI5 Manchester coding format

PSI5 Protocol Output - Data Frame Format

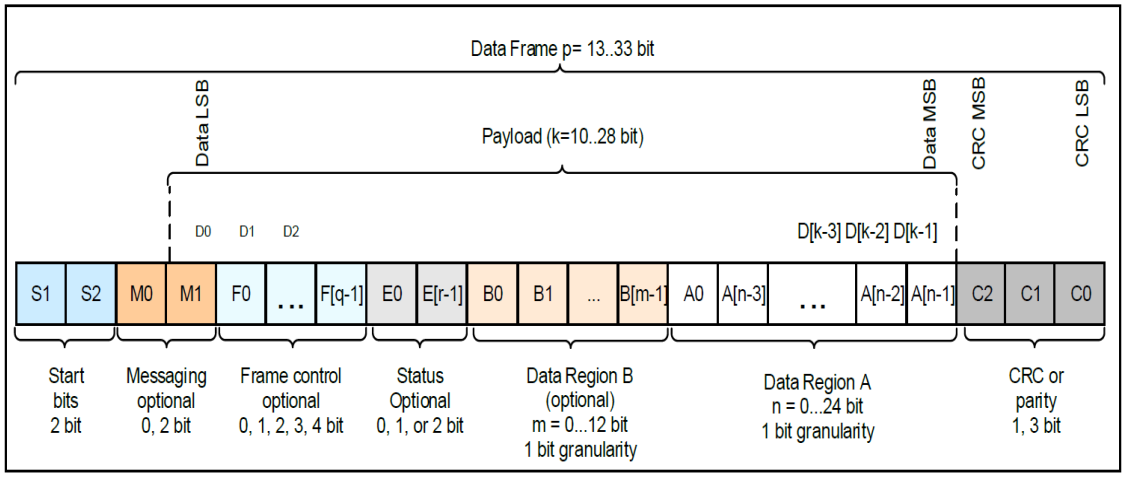


Fig.18 PSI5 data frame format

PSI5 Protocol Output - Error Detection Methods

Parameters	Value	Description
PSI5_ERROR_DETECTION【1:0】	0	CRC mode
	1	Parity check

PSI5 Protocol Output - Data Length

Parameters	Value	Description
PSI5_PAYLOAD_SIZE【4:0】	8-24	Data length
PSI5_FORMAT_PRECEISION	0	Low precision
	1	Highly accurate
PSI5_FORMAT_PRECEISION	0	Closing time slots
	1	Enable time slots
PSI5_TSx_SENSOR【2:0】	0	Angular data
	1	-
	2	Temp
	3	Magnetic fields
	4	-
PSI5_TS[1..4]_STARTTIME 【10:0】	11	Time slot start time

PSI5 Protocol Output - PSI5 Current Modulation Method

The data frame is transmitted via a current consumption modulator with Manchester coding. The low level (ISlow) indicates the static current consumption of the sensor and the high level (IShigh) is generated by the increase of the sensor Sink current (ISlow+ΔIShigh). (ISlow+ΔIS) and a high level (IShigh) is generated by an increase in sensor Sink current (ISlow+ΔIS). Selectable sink current (ΔIS) and bit duration (TBIT).

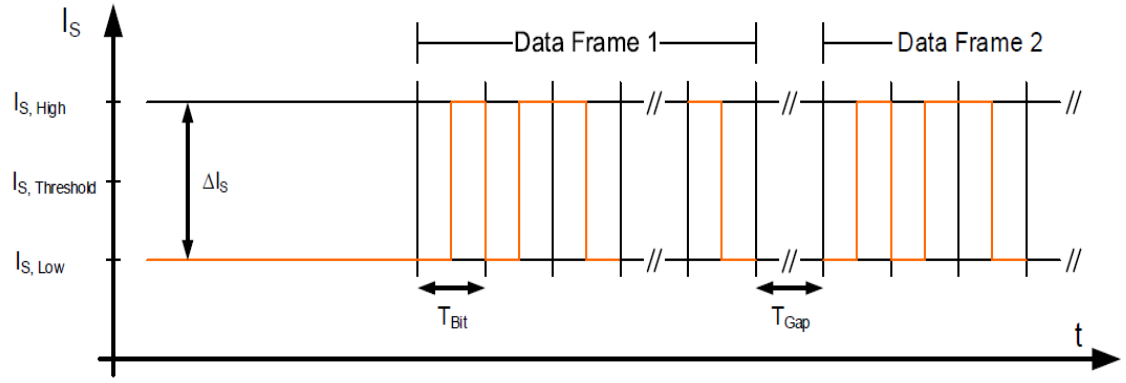


Fig.19 PSI5 data current modulation

Parameters	Value	Description
PSI5_LOWCOMMON_MODE【1:0】	0	Low current 13mA
	1	Normal current 26 mA

PSI5 Communication Mode

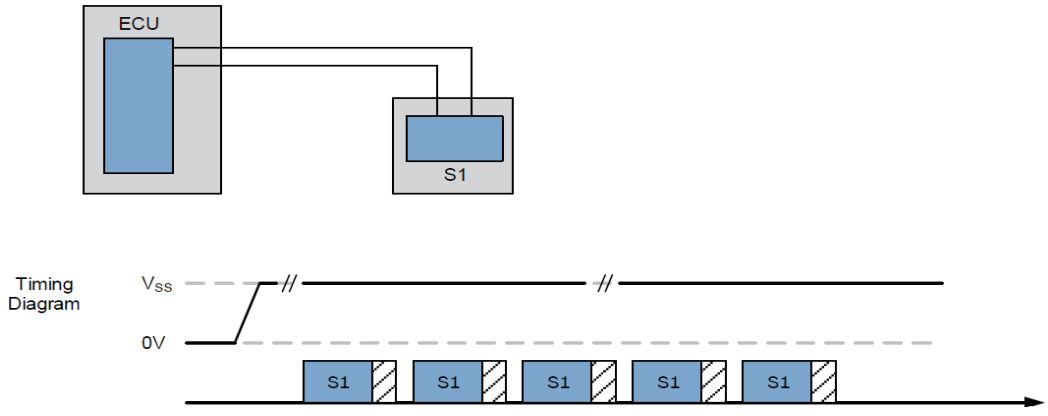


Fig.20 PSI5 Asynchronous mode

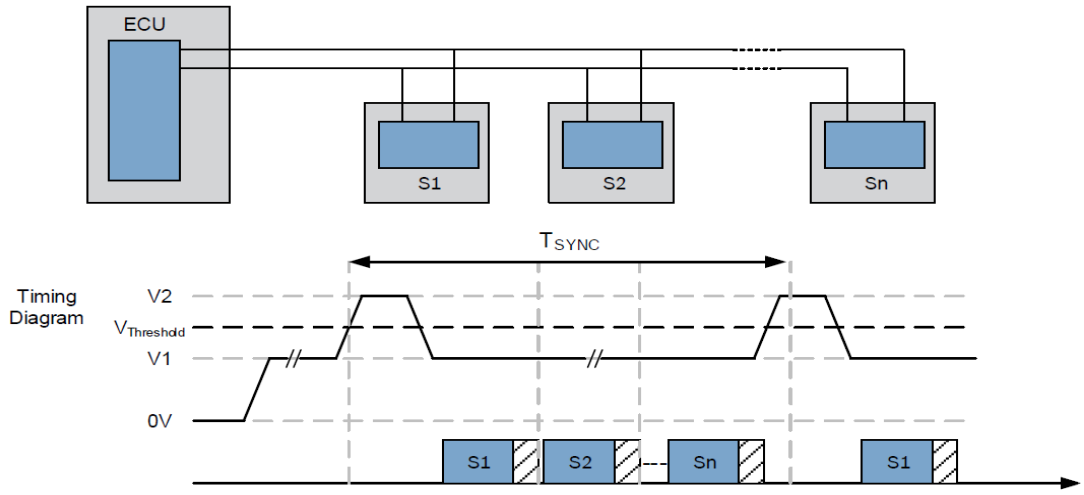


Fig.21 PSI5 Synchronous parallelism

PSI5 Protocol Output - Output Mode

Parameters	Value	Description
PSI5_OUT_MODE【1:0】	2	Asynchronous mode
	3	Synchronous parallelism

PSI5 Protocol Output - Cycle Time

Parameters	Value	Description
PSI5_OUT_MODE【1:0】	0	300us
	1	500us
	2	1000us

PSI5 Protocol Output - Transmission Speed

Parameters	Value	Description
PSI5_TRANSMIT_SPEED	0	Low speed 125 kbit/s
	1	High speed 189kbit/s

PSI5 Protocol Output - Setting of Synchronous Pulse Trigger Time

Parameters	Value	Description
PSI5_TRIGGER_LEVEL	0	Reduced synchronization pulses
	1	Standard Synchronized Pulse

PSI5 Protocol Output - Synchronized Pulse Trigger Level Setting

Parameters	Value	Description
PSI5_SYNC_TH	0	Standard synchronous pulse trigger threshold
	1	Reduced synchronization pulse trigger threshold

PSI5 Protocol Output - Sensor Initialization

Initialization Phase 1	Initialization Phase 2	Initialization Phase 3	Operating Mode
Activate (a plan)	Data content	State of affairs	Sensor or status data

PSI5 Protocol Output - Initialization Function Configuration

Parameters	Value	Description
PSI5_INIT_PHASES【1:0】	0	Normal initialization
	1	Close initialization phase 2
	2	Close initialization phases 2 and 3
	3	Reserved

PSI5 Protocol Output - Initialization Phase 1 Cycle

Parameters	Value	Description
PSI5_INIT_I_DURATION【7:0】	100	50-200ms

PSI5 Protocol Output - Length of initialization phase 2

Parameters	Value	Description
PSI5_INIT_LEN【7:0】	9	D1-D9
	32	D1-D32

PSI5 Protocol Output - Number of repetitions in initialization phase 2

Parameters	Value	Description
PSI5_INIT_II_REPETITION【1:0】	0-3	Repeat 1-4 times

PSI5 Protocol Output - Initialize phase 2 data content

Parameters	Data field	Value	Description
Forced data			
1	F1(D1)	PSI5_INIT_METAINFO	PSI5 version
2	F2(D2，D3)	PSI5_INIT_INITLENGTH	Initialize data length
3	F3(D4，D5)	PSI5_INIT_VENDORID	Supplier ID
4	F4(D6，D7)	PSI5_INIT_SENSORTYPE	Sensor type
5	F5(D8，D9)	SI5_INIT_SENSORPARAMS	Sensor specified parameters
Extended data			
6	F6(D10，D11)	PSI5_INIT_SENSORCODE	Parameters specified by the sensor manufacturer
7	F7(D12-D14)	PSI5_INIT_SENSORAPPCODE	Product version information
8	F8(D15-D18)	PSI5_INIT_PRODUCTIONDATE	production date
9	F9(D19-D22)	SEMI_ID	SEMI_ID

PSI5 Protocol Output - Initialization Phase 3

Parameters	Value	Description
“Sensor ready”	0x1E7	status data
“Sensor defect”	0x1F4	status data

PSI5 Protocol Output - Number of repetitions in initialization phase 3

Parameters	Value	Description
PSI5_INIT_III_REPETITION【7:0】	0-255	Repeat 1-256 times

Four-Wire SPI Protocol Output (Slave)

SC69431 SPI is used as a full-duplex serial communication, in one master-slave communication the host can send commands and receive the result of the last command at the same time.SC69431 is used as a slave and is controlled by the chip-select signal, SPI_CS.SPI communication is activated when SPI_CS is set to a low level, and SPI communication is terminated when SPI_CS is set to high. SPI_SCLK is used as a clock for SPI communication, which is sent from the host to SC69431.The signals of MISO and MOSI are changed on the rising edge of the clock and captured on the falling edge of the clock. SCLK is used as the clock for SPI communication and is sent from the host computer to the SC69431.The signals of MISO and MOSI are changed on the rising edge of the clock and are captured on the falling edge of the clock.

Command	Data transmission direction	Byte 0	Byte 1	Byte 2	Byte 3
Reads 18-bit angle values	master-to-slave	0x54	0x00	0x00	CRC8
	slave to master (1)	0x54|Angle[17:16]	Angle[15:8]	Angle[7:0]	CRC8
Read the temperature	master-to-slave	0x7C	0x00	0x00	CRC8
	slave to master	0x7C	Temp[11:8]	Temp[7:0]	CRC8
Read the magnetic field strength	master-to-slave	0x7D	0x00	0x00	CRC8
	slave to master	0x7D	0x00	Value[7:0]	CRC8
Read XYZ	master-to-slave	0x64	X:87 Y:89 Z:8B	0x00	CRC8
	slave to master	0X64	XYZ[15:8]	XYZ[7:0]	CRC8

Note:

*(1) Target Output angle Angle = (Angle[17:0]) /262144 * 360*

Traceable Information

At the factory, each device contains the Semiment factory ID and user ID for traceable purposes.

Parameters	Value
USER_ID1【7:0】	0-255
USER_ID2【7:0】	0-255
USER_ID3【7:0】	0-255
USER_ID4【7:0】	0-255
SEMI_ID【15:0】	0-65535

EEPROM Write Protection

Parameters	Value	Description
EEPROM_LOCK_CODE【6:0】	0xAD	EEPROM read-only
	Other values	EEPROM can be read, written, and erased.

Diagnostic

- ### Diagnostic Enable

Parameters	Value	Description
DIAG_EN	0	Close Diagnostics
	1	Enable Diagnostics

Diagnostic Mask Register

Corresponding to mask position 0, the fault will not trigger diagnosis; corresponding to mask position 1, the fault will trigger diagnosis.

BIT7	BIT6	BIT5	BIT4	BIT3	BIT2	BIT1	BIT0
CRC Checksum Error	GAINF overflow	Current diagnosis	Digital Voltage Fault	CORDIC overflow	Fieldstreng thoverflow	ADC overflow	Temperature overflow

Analog Diagnostic Settings

Parameters	Value	Description
DIAG_MO【1:0】	0	Digital High Resistance State Output
	1	Digital Output NMOS OpenDrain
	2	Digital Output PMOS OpenDrain
	3	Digital push-pull output

PWM Diagnostic Settings

Parameters	Value	Description
DC_FAULT【7:0】	0-255	Output duty cycle of PWM when supply voltage is too low
DC_FTL【7:0】	0-255	Output duty cycle of PWM when magnetic field is too low

Diagnostic Threshold

参数	数值	描述
GAIN_THRESHOLD_LOW【4:0】	0-31	Low threshold of gain for the second-stage operational amplifier
GAIN_THRESHOLD_HIGH【4:0】	0-31	High threshold of gain for the second-stage operational amplifier
TEMPTHRESHOLD_LOW【6:0】	0-127	low temperature threshold
TEMPTHRESHOLD_HIGH【6:0】	0-127	high temperature threshold
FIELDTHOLD_LOW【7:0】	0-255	Low threshold of field strength
FIELDTHOLD_HIGH【7:0】	0-255	High threshold of field strength

- **Diagnostic debounce time setting**

Parameters	Value	STEP_UP TIME(ms)	STEP_DOWN TIME(ms)
DIAG_DEBOUNCE【2:0】	0	20	20
	1	20	30
	2	20	40
	3	40	40
	4	60	80
	5	80	100
	6	100	120
	7	120	140

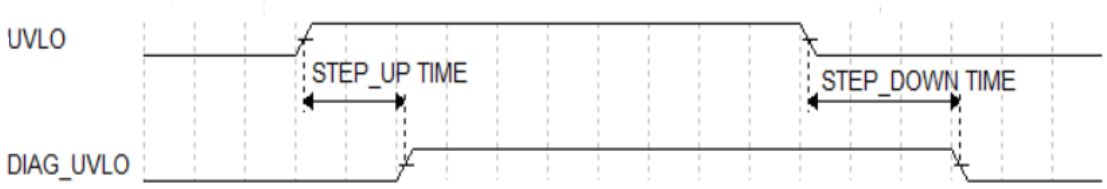


Fig.22 Diagnostic de-jittering timings

Output Clamp Setting

The output clamp setting is used to limit the output voltage range.CLAMP_LOW sets the output voltage minimum and CLAMP_HIGH sets the output voltage maximum. Both parameters work for 4-point, 8-point, 16-point, and 32-point correction modes.

Parameters	Value	Description
CLAMP_LOW	0-100%	Low clamping
CLAMP_HIGH	0-100%	High clamping

Breakpoint/Zero-DP

The breakpoint and zero point of the SC69431 are the same point, which can be programmed at any point on the circumference, and all angles are based on the breakpoint or zero point. DP is the jump point between 0 and 360 degrees, for applications with less than 360 degrees of travel, DP should not be set in the same position as the start of the working travel, but must be set outside the working travel.

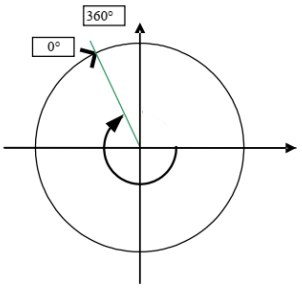


Fig.23 Schematic diagram of DP points

Parameters	Value	Description
DP	0-360	Breakpoint/Zero (degrees)

The CW parameter defines the direction of rotation of the magnet.

Counterclockwise is defined as rotation in 1-4-5-8 pin order (SOP-8 package) or 1-8-9-16 pin order (eTSSOP-16L package); clockwise is defined as the opposite direction, rotation in 8-5-4-1 pin order (SOP-8 package) or 16-9-8-1 pin order (TSSOP-16L package).

Parameters	Value	Description
CW	0	Counterclockwise
	1	Clockwise

4-Point Calibration Mode

The SC69431 allows the user to divide the output curve through 4 points into up to 5 segments using the 4-point calibration mode, allowing the number of calibration points to be reduced to 2 or 3. The Y coordinate (-50%~100%) and X coordinate (0°~360°) of the 4 calibration points, and the slope of the 5 segments (LNR_S0,LNR_S1,LNR_S2,LNR_S3,LNR_S4) are fully set by the user. . To calculate the slope, two endpoints of the curve, 0 degree start and 360 degree end, are needed to calculate LNR_S0 and LNR_D_S.

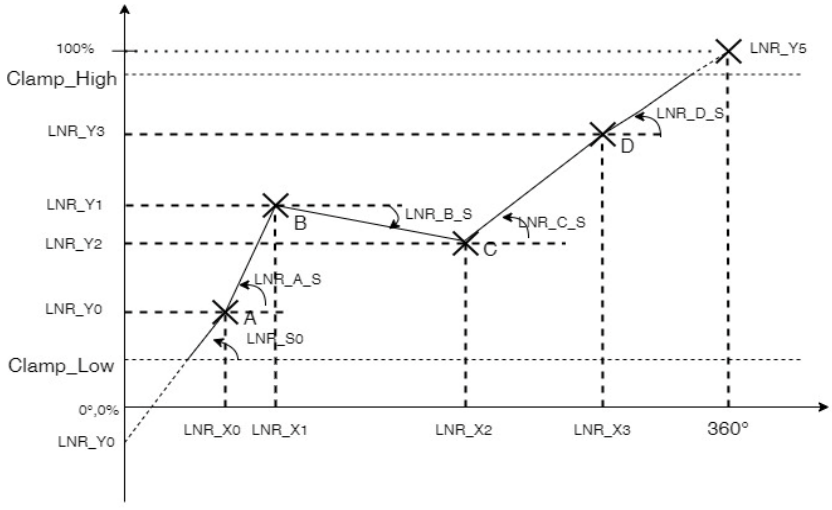


Fig.24 4-point calibration plot

8-Point Arbitrary Point Calibration Mode

The SC69431 allows the user to program the output curve desired by the user by customizing the X-coordinate (0°~ 360°) and Y-coordinate (0%~100%) of any 8 calibration points. However, the slope cannot be set and can only be calculated from two neighboring points. A default fixed calibration point [0°, 0%] is also required as a starting point.

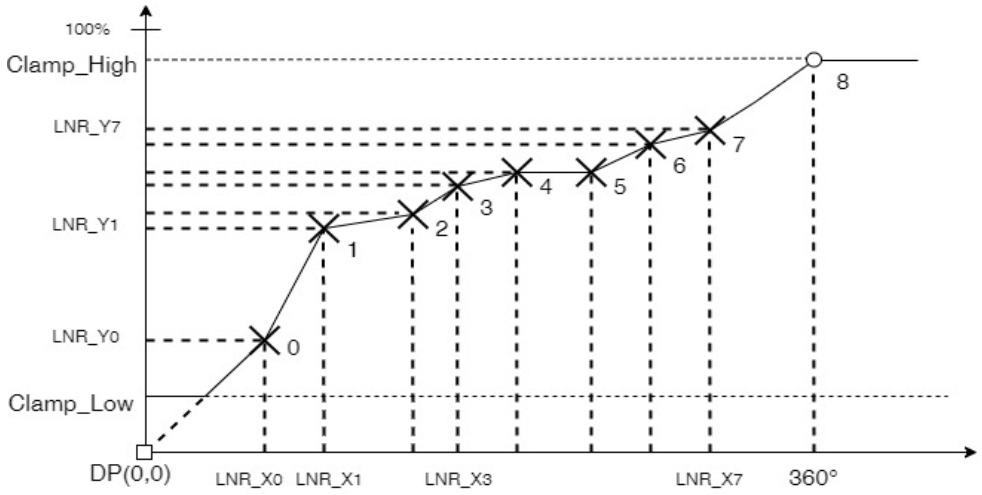


Fig.25 8-point calibration plot

16-Point Calibration Mode

The 16-point calibration mode allows the user to set only the Y-axis value of the coordinate point. x-axis coordinates are defined by the W value, which is divided into 16 segments within the WORK_RANGE range. y-point coordinates are allowed to range from -50% to +150% of the clamped voltage, which allows the clamped voltage to be in-between a certain segment (as shown in the following figure). But the output is still clamped voltage.

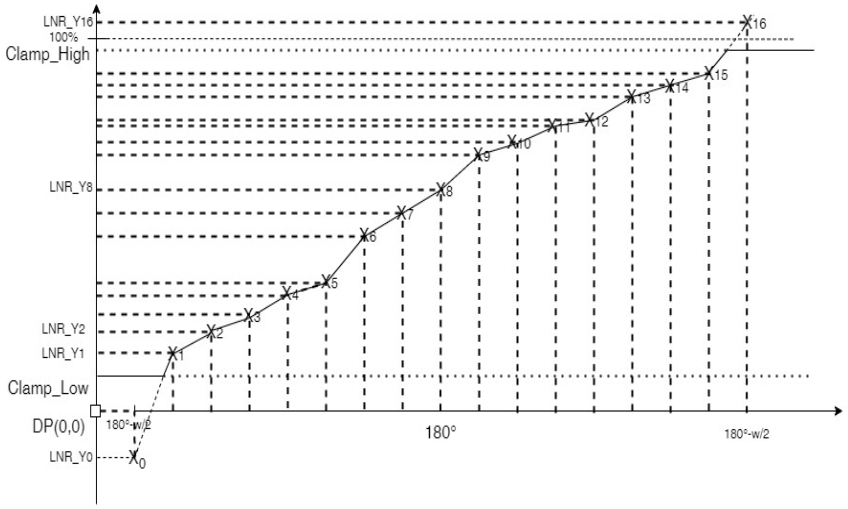


Fig.26 16-point calibration plot

32-point calibration mode

The work range W is defined by Workrange and is divided into 32 segments centered at 180°. The Y-axis coordinates consist of only 8 bits of data, so they are not absolute values but incremental coordinates. The two endpoints are (180°-w/2, 0%) and (180°+w/2,100%) to define an ideal curve, and ΔY is the fine-tuned value of Y corresponding to the X coordinate of the horizontal axis.

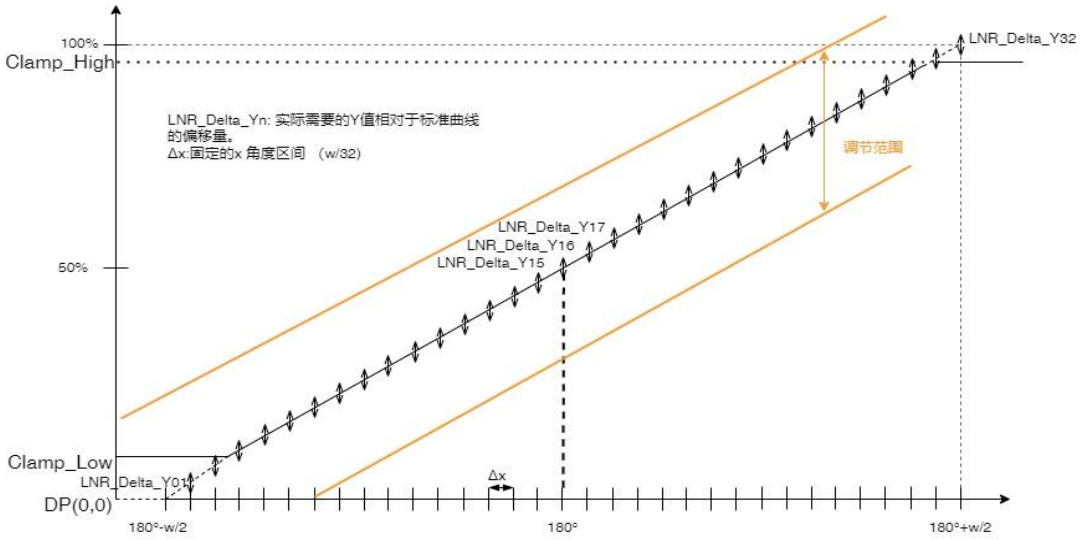


Fig.27 32-point calibration plot

32-point calibration, Y-axis coordinate deviation range setting

Parameters	Value	Description
LNR_DELTA_Y_EXPAND【1:0】	0	Tolerance range ±3.125%
	1	Tolerance range ±6.25%
	2	Tolerance range ±12.5%
	3	Tolerance range ±25%

Angle Range Selection

$$W = \frac{WORK\_RANGE\_GAIN \times 360°}{0XFFFF}$$

Angular range $\theta_{min} = \frac{360°-w}{2}, \theta_{max} = \frac{360°+w}{2}$

θ_{min} indicates the angle at 0% output, and θ_{max} indicates the angle at 100% output. In order to correct the output properly, the angle range needs to be set to an integer multiple greater than 16.

Example of angular range setting:

$WORK\_RANGE\_GAIN$	w (°)	θ_{min} (°)	θ_{max}(°)	△X，16pts(°)	△X，32pts(°)
0x1000	22.50034	168.7498	191.2502	1.406271	0.703136
0x1100	23.90661	168.0467	191.9533	1.494163	0.747082
0x1200	25.31289	167.3436	192.6564	1.582055	0.791028
0x1300	26.71916	166.6404	193.3596	1.669947	0.834974
0x2000	45.00069	157.4997	202.5003	2.812543	1.406271
0x2100	46.40696	156.7965	203.2035	2.900435	1.450217
0x2200	47.81323	156.0934	203.9066	2.988327	1.494163
0x2300	49.2195	155.3902	204.6098	3.076219	1.538109
0x3000	67.50103	146.2495	213.7505	4.218814	2.109407
0x3100	68.9073	145.5463	214.4537	4.306706	2.153353
0x3200	70.31357	144.8432	215.1568	4.394598	2.197299
0x3300	71.71984	144.1401	215.8599	4.48249	2.241245
0x4000	90.00137	134.9993	225.0007	5.625086	2.812543
0x4100	91.40764	134.2962	225.7038	5.712978	2.856489
0x4200	92.81392	133.593	226.407	5.80087	2.900435
0x4300	94.22019	132.8899	227.1101	5.888762	2.944381
0xFA00	351.5679	4.216068	355.7839	21.97299	10.9865
0xFB00	352.9741	3.512932	356.4871	22.06088	11.03044
0xFC00	354.3804	2.809796	357.1902	22.14878	11.07439
0xFD00	355.7867	2.106661	357.8933	22.23667	11.11833
0xFE00	357.193	1.403525	358.5965	22.32456	11.16228
0xFF00	358.5992	0.700389	359.2996	22.41245	11.20623
0xFFFF	360	0	360	22.5	11.25

12. Typical Application Circuit

Analog/PWM/SENT SOP-8 Package Application Circuits

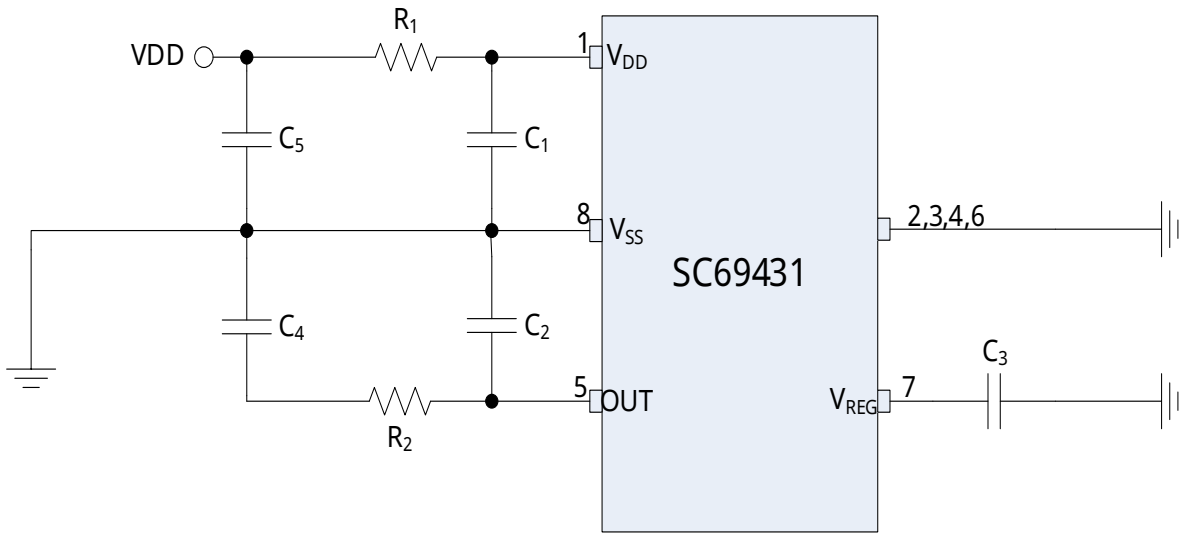


Fig.28 Analog/PWM/SENT SOP-8 Reference Circuit Diagram

Analog Output Reference

Component	Min.	Typ.	Max.	Description
R1	-	0Ω	10Ω	Reducing the impact of EMC increases the output error
R2	-	0Ω	51Ω	Reduce the impact of EMC
C1	100nF	100nF	-	Placement near pins
C2	47nF	100nF	-	Placement near pins
C3	47nF	100nF	220nF	Placement near pins
C4	-	1nF	10nF	Reduce the impact of EMC and place it close to the connector end
C5	-	1nF	10nF	Reduce the impact of EMC and place it close to the connector end

Digital Output (PWM) Reference

Component	Min.	Typ.	Max.	Description
R1	-	0Ω	33Ω	Reducing the impact of EMC affects the output of high level
R2	-	0Ω	51Ω	Reducing the impact of EMC affects the output of high and low levels
C1	100nF	100nF	-	Placement near pins
C2	2.2nF	4.7nF	22nF	Placement near pins
C3	47nF	100nF	220nF	Placement near pins
C4	-	1nF	10nF	Reduce the impact of EMC and place it close to the connector end
C5	-	1nF	2.2nF	Reduce the impact of EMC and place it close to the connector end

Digital Output (SENT) Reference Value

Component	Min.	Typ.	Max.	Description
R1	-	0Ω	10Ω	Reducing the impact of EMC affects the output of high level
R2	-	-	-	
C1	100nF	100nF	-	Placement near pins
C2	1nF	4.7nF	22nF	Placement near pins
C3	47nF	100nF	220nF	Placement near pins
C4	-	1nF	10nF	Reduce the impact of EMC and place it close to the connector end
C5	-	-	1nF	Reduce the impact of EMC and place it close to the connector end

Analog/PWM/SENT TSSOP-16 Package Application Circuit

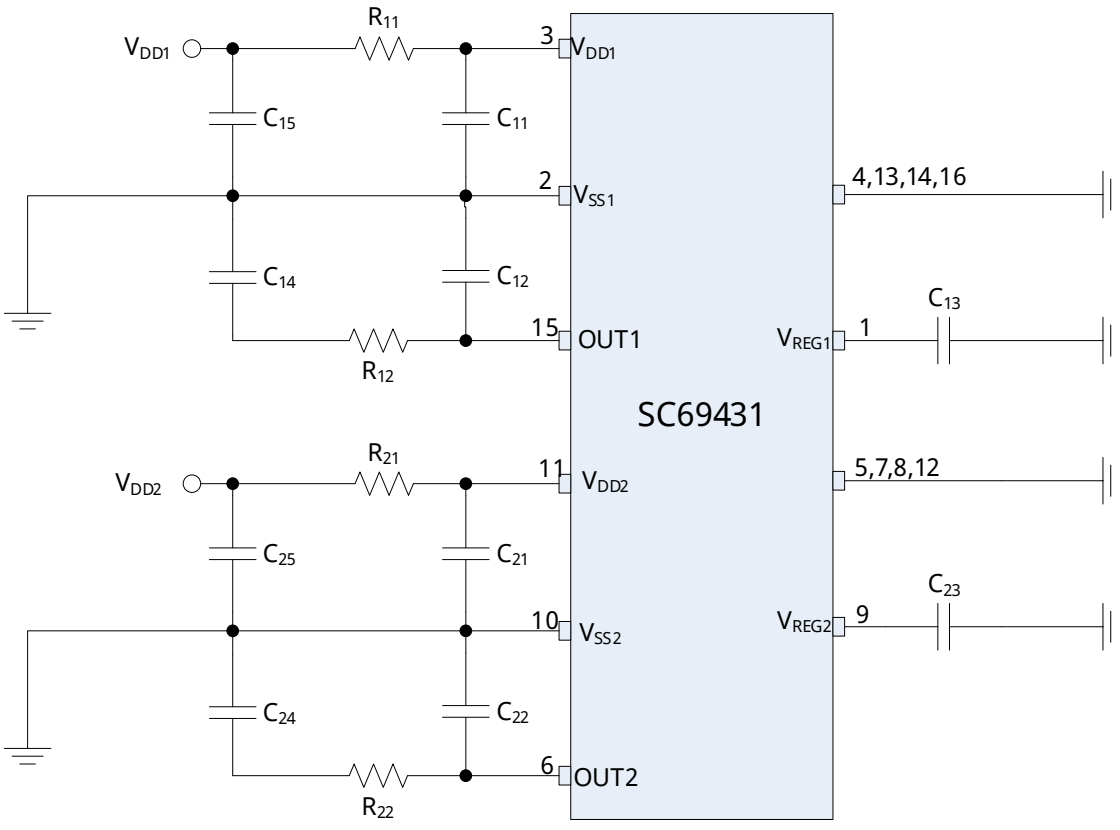


Fig.29 Analog/PWM/SENT TSSOP-16 Reference Circuit Diagram

Analog Output Reference Value

Component	Min.	Typ.	Max.	Description
R11, R21	-	0Ω	10Ω	Reduces EMC effects and increases measurement errors
R12, R22	-	0Ω	51Ω	Reduces EMC effects and increases measurement errors
C11, C21	100nF	100nF	-	Placement near pins
C12, C22	47nF	100nF	-	Placement near pins
C13, C23	47nF	100nF	220nF	Placement near pins
C14, C24	-	1nF	10nF	Reduced EMC impact, placed close to the connector end
C15, C25	-	1nF	10nF	Reduced EMC impact, placed close to the connector end

Digital Output (PWM) Referencev Value

Component	Min.	Typ.	Max.	Description
R11, R21	-	0Ω	33Ω	Reduces EMC effects affecting the output high level
R12, R22	-	0Ω	51Ω	Reduces EMC effects, affecting output high and low levels
C11, C21	100nF	100nF	-	Placement near pins
C12, C22	2.2nF	4.7nF	22nF	Placement near pins
C13, C23	47nF	100nF	220nF	Placement near pins
C14, C24	-	1nF	10nF	Reduced EMC impact, placed close to the connector end
C15，C25	-	1nF	2.2nF	Reduced EMC impact, placed close to the connector end

Digital Output (SENT) Reference Value

Component	Min.	Typ.	Max.	Description
R11, R21	-	0Ω	33Ω	Reduces EMC effects affecting the output high level
R12, R22	-	-	-	
C11, C21	100nF	100nF	-	Placement near pins
C12, C22	1nF	4.7nF	22nF	Placement near pins
C13, C23	47nF	100nF	220nF	Placement near pins
C14, C24	-	1nF	10nF	Reduced EMC impact, placed close to the connector end
C15，C25	-	-	1nF	Reduced EMC impact, placed close to the connector end

PSI5 SOP-8 Package Application Circuit

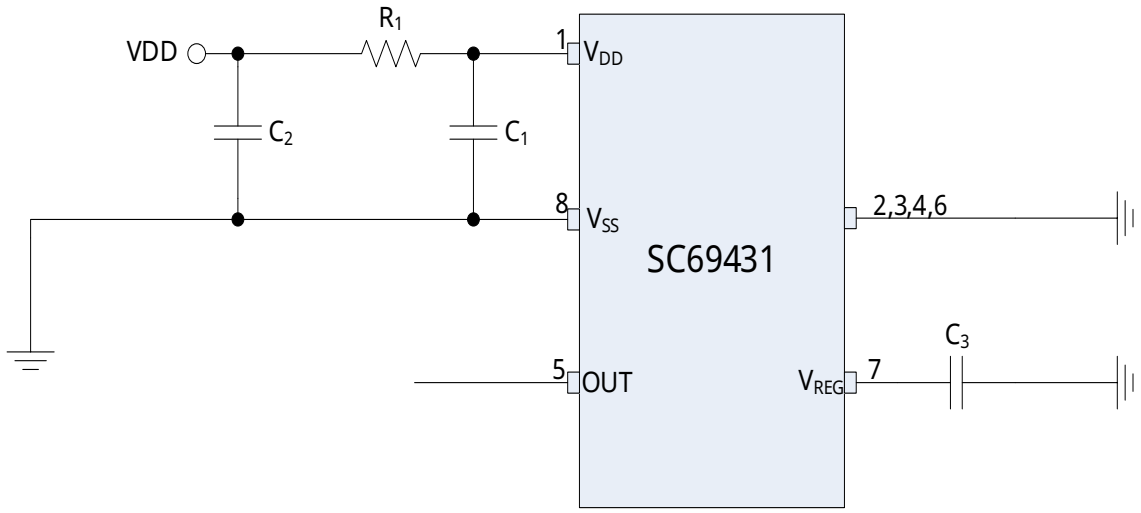


Fig.30 PSI5 SOP-8 Reference Circuit Diagram

Component	Min.	Typ.	Max.	Description
R1	-	0Ω	10Ω	
C1	9nF	10nF	24nF	Placement near pins
C2	500pF	-	1nF	Reduced EMC impact, placed close to the connector end
C3	47nF	100nF	220nF	Placement near pins

PSI5 TSSOP-16 Package Application Circuit

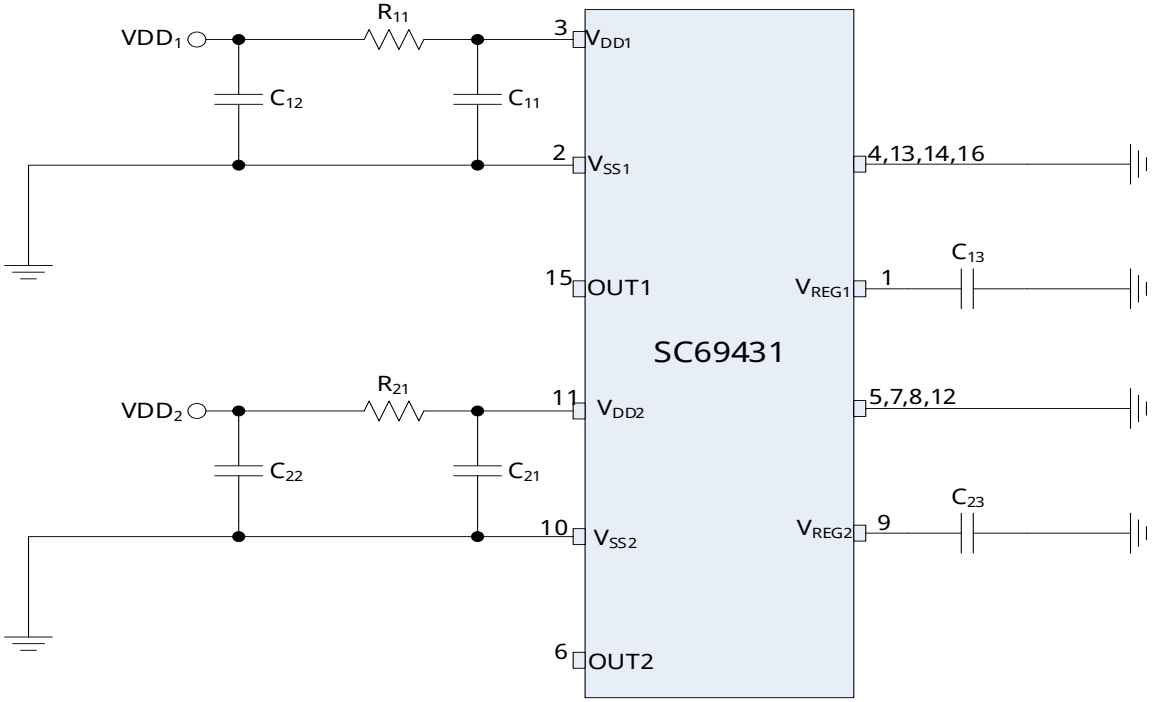


Fig.31 PSI5 TSSOP-16L Reference Circuit Diagram

Component	Min.	Typ.	Max.	Description
R11, R21	-	0Ω	10Ω	
C11, C21	9nF	10nF	24nF	Placement near pins
C12, C22	500pF	-	1nF	Reduced EMC impact, placed close to the connector end
C13, C23	47nF	100nF	220nF	Placement near pins

SPI SOP-8 Package Application Circuit

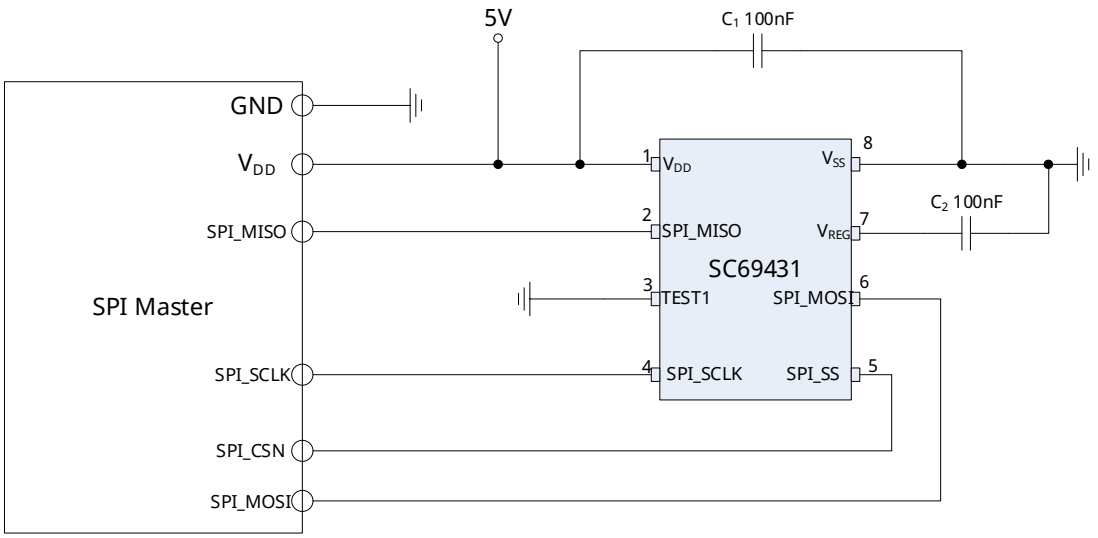


Fig.32 SPI SOP-8 Reference Circuit Diagram

SPI TSSOP-16 Package Application Circuit

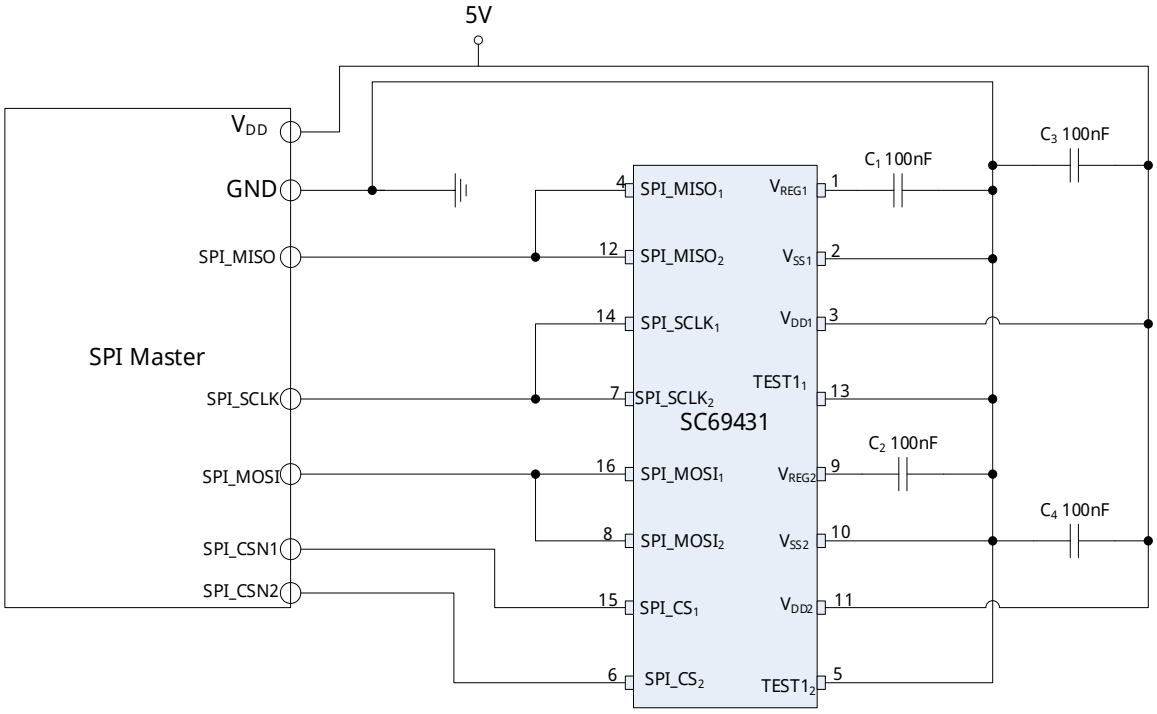


Fig.33 SPI TSSOP-16 Reference Circuit Diagram

SIP-3 Single Package Application Circuit

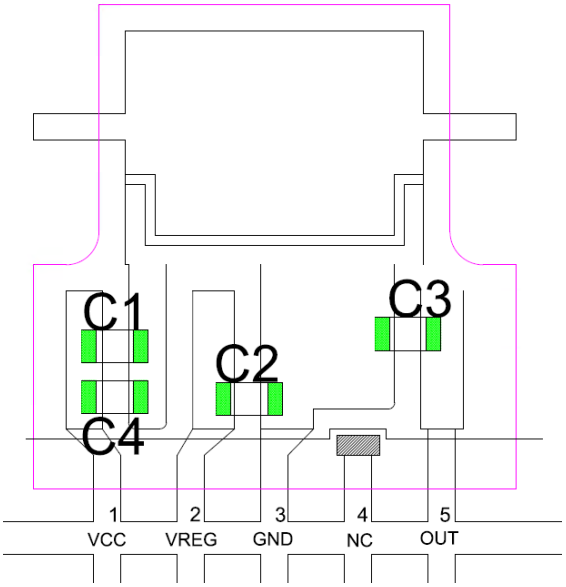
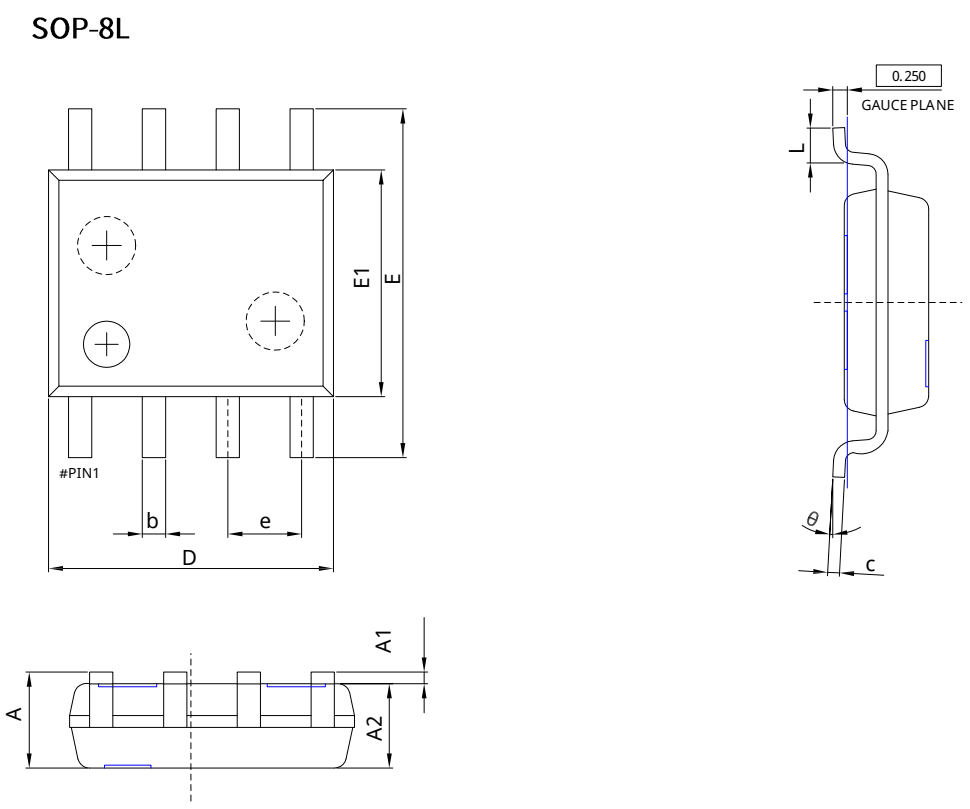


Fig.34 SIP3 Single Chip Reference Circuit Diagram

Component	Min.	Typ.	Max.	Description
Analog Output				
C1		100nF	-	
C2	-	100nF	-	
C3	-	100nF	-	
C4		2.2nF		
PWM Output				
C1	-	100nF	-	
C2	-	100nF	-	
C3	-	2.2nF	-	
C4		2.2nF		
SENT Output				
C1	-	100nF	-	
C2	-	100nF	-	
C3	-	2.2nF	-	
C4		2.2nF		
PSI5 Output				
C1	-	10nF	-	
C2	-	100nF	-	
C3		100nF		
C4		0nF		

13. Packaging Information

SOP-8 Package Type



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	1.450	1.750	0.057	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	4.700	5.100	0.185	0.201
E	5.800	6.200	0.228	0.244
E1	3.800	4.000	0.150	0.157
e	1.270(BSC)		0.050(BSC)	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

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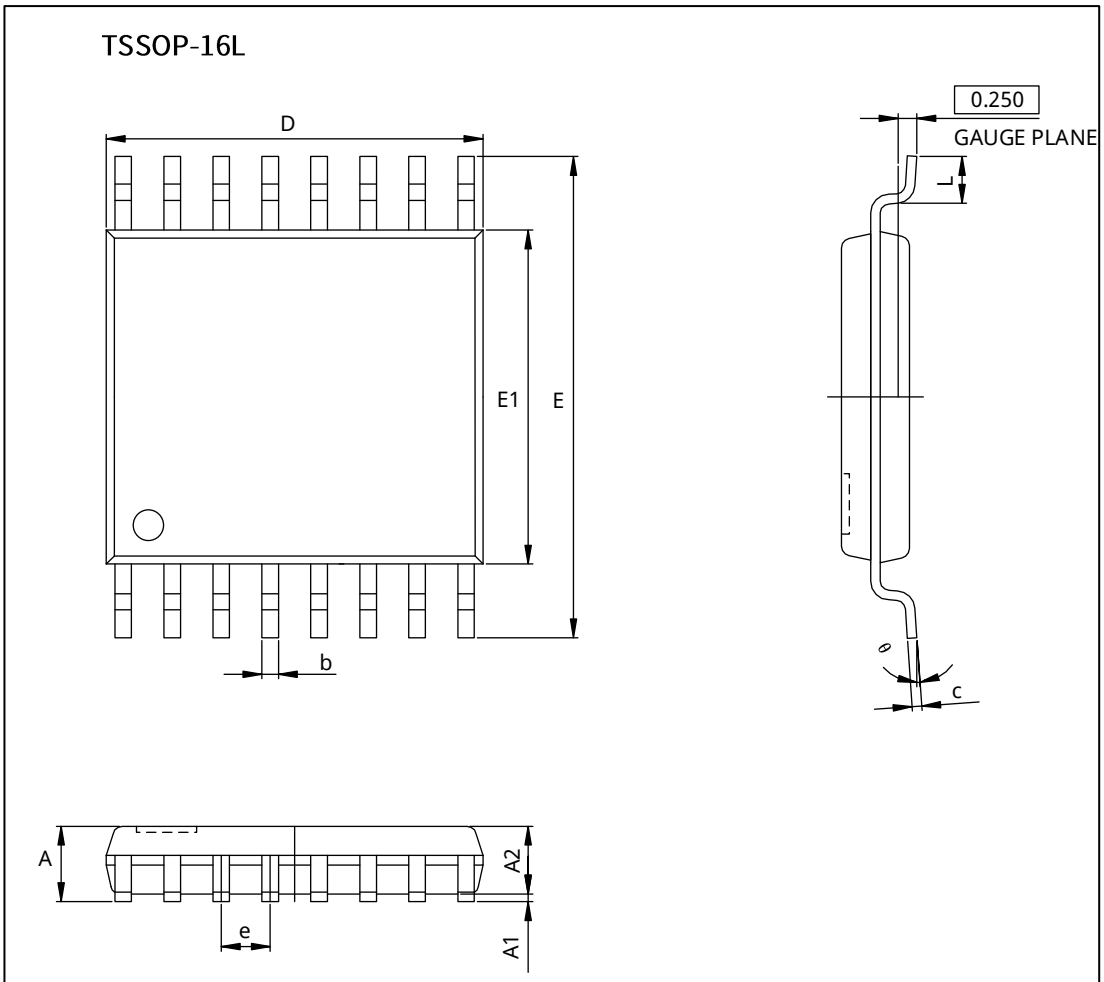
Fig.35 SOP-8 package dimensions

TSSOP-16 Package Type



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	-	1.200	-	0.047
A1	0.050	0.150	0.002	0.006
A2	0.800	1.000	0.031	0.039
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D	4.900	5.100	0.193	0.201
E	6.250	6.550	0.252(BSC)	
E1	4.300	4.500	0.169	0.177
e	0.650(BSC)		0.026(BSC)	
L	0.500	0.700	0.020	0.028
θ	1°	7°	1°	7°

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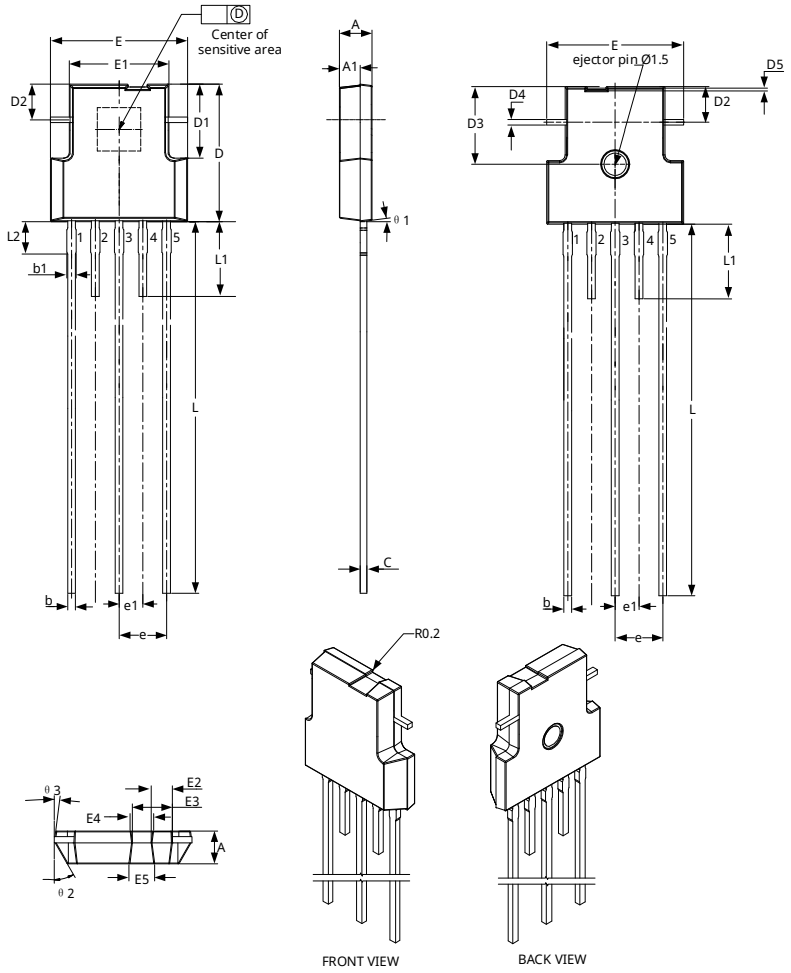
Fig.36 TSSOP-16 package dimensions

SIP-3 Package Type

SIP-3L



Symbol	DIMENSIONS		
	Millimeters		
	MIN.	TYP.	MAX.
E	7.23	7.33	7.43
E1	5.23	5.33	5.43
E2	0.90	1.00	1.10
E3	2.05	2.15	2.25
E4	1.20	1.30	1.40
E5	1.15	1.25	1.35
b	0.33	0.43	0.53
b1	0.40	0.50	0.60
c	-	0.36	-
D	7.25	7.35	7.45
D1	3.85	3.95	4.05
D2	1.80	1.90	2.00
D3	4.05	4.15	4.25
D4	0.20	0.30	0.40
D5	0.14	0.15	0.16
Ⓓ	-	0.30	-
A	1.65	1.75	1.85
A1	1.00	1.10	1.20
e	2.54 TYP.		
e1	1.27 TYP.		
L	18.90	19.90	20.90
L1	3.90	4.00	4.10
L2	0.90	1.00	1.10
θ 1	7° TYP.		
θ 2	30°TYP.		
θ 3	7° TYP.		

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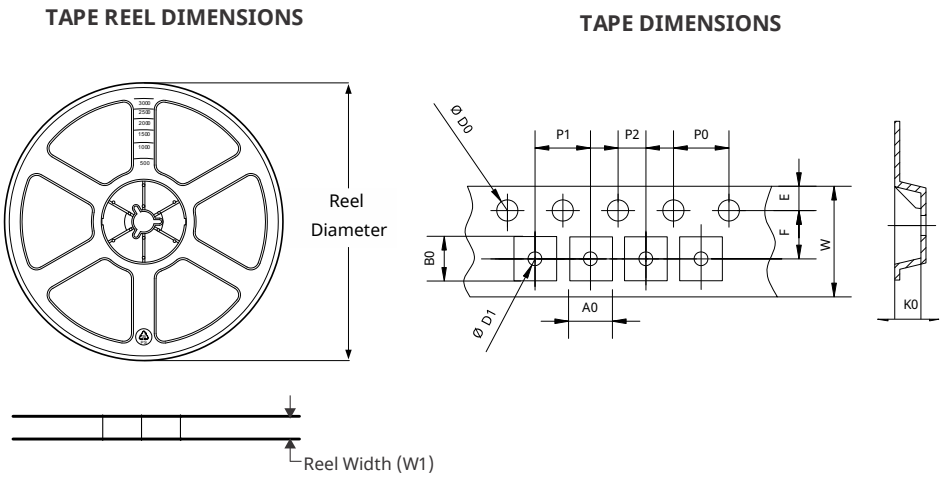
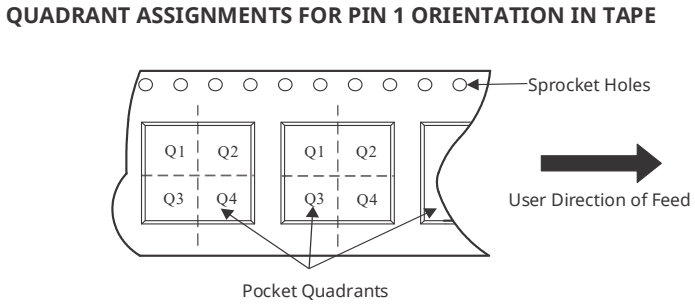
Fig.37 SIP-3 package dimensions

14. Packing Information

14.1 SOP8 Tape&Reel Dimensions



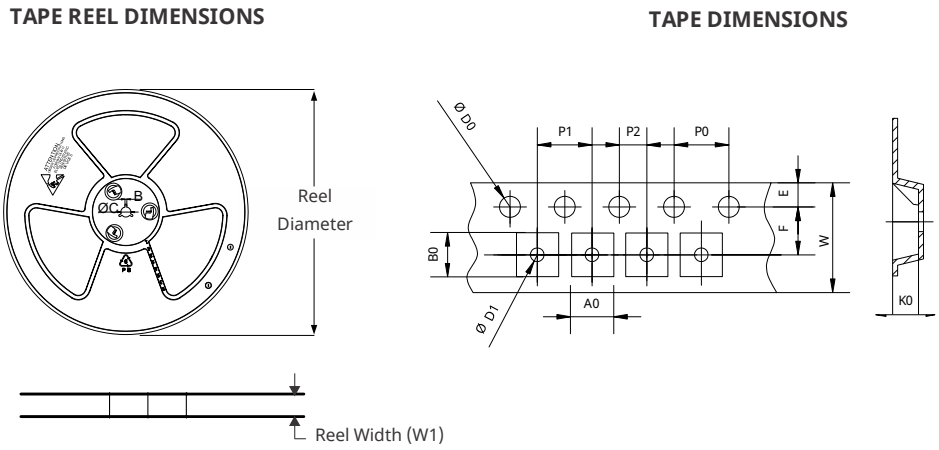


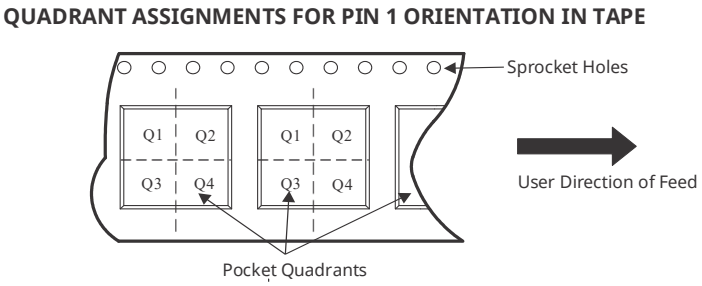
*All dimensions are nominal

Package Type	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	W (mm)	Pin1 Quadrant
SOP8	4000	330	13.0	4.00	8.00	2.00	6.40	5.40	2.10	12.00	Q1

Fig.38 SOP8 Tape&Reel dimensions

14.2 TSSOP16 Tape&Reel Dimensions



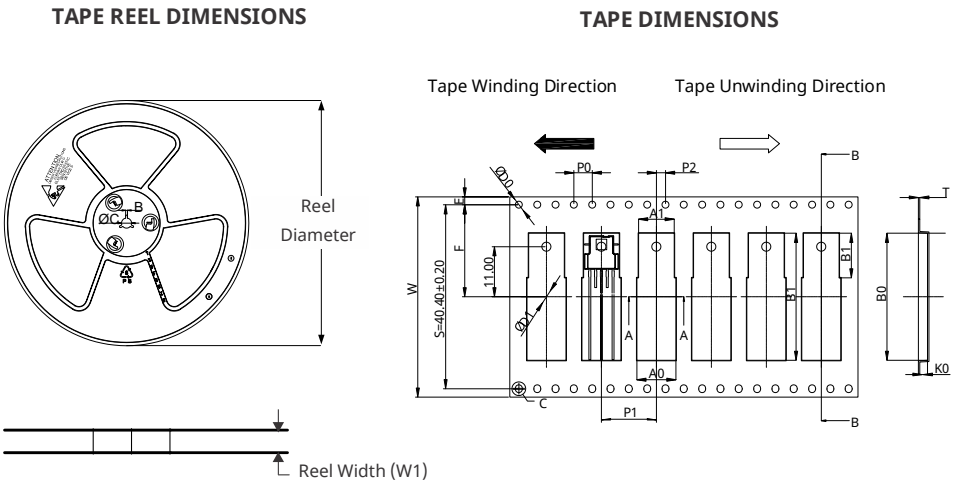


*All dimensions are nominal

Package Type	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	W (mm)	Pin1 Quadrant
TSSOP16	3000	330	16.4	4	8.00	2.00	6.80	5.40	1.60	16.00	Q1

Fig.39 TSSOP16 Tape&Reel dimensions

14.3 SIP3 Tape&Reel Dimensions



*All dimensions are nominal

Package Type	Reel Diameter (mm)	Reel Width W1 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	W (mm)
SIP-3L	330	44.5	4.00	12.00	2.00	8.50	27.90	2.00	44.00

Fig.40 SIP3 Tape&Reel dimensions

15. Revision History

Revision	Date	Description
Draft	2024-10-28	Initial draft
Rev.V0.1	2025-7-15	Draft update
Rev.V0.2	2025-8-20	Parameter updates
Rev.V0.3	2025-10-31	Update SIP-3 pin description、User programmable parameters, etc.

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