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SNU501

Highly Integrated Universal Sensor Interface

SNU501 Datasheet

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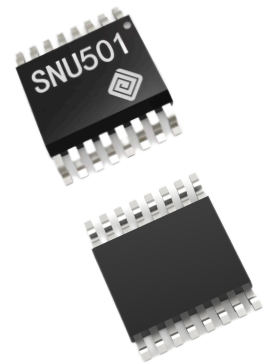
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1 Introduction

SNU501 is a interface chip for temperature and air pressure sensor which can be applied in harsh automotive environment. The chip can drive the resistance pressure sensor and then generate calibrated pressure data through the internal high resolution ADC, temperature compensation, and nonlinear calibration. The chip supports various output interface types, such as SENT, absolute analog voltage, and proportional analog voltage. The chip supports power supply over voltage and reverse connection protection, it operates over a wide temperature range of -40°C to 150°C.

1.1 Features

- Supply Voltage: 4.5V~5.5V
- OTP: 256Bytes
- Built-in high accuracy PGA
- Built-in two high-resolution 24-bit ADC
- Built-in temperature sensor and support external temperature sensor
- Support the analog diagnostic voltage output
- Resistance pressure sensor range: 3kΩ to 20kΩ
- Flexible output interface: absolute voltage, proportional voltage, and SENT
- Wide operation temperature range: -40°C to 150°C
- Support power supply over voltage and reverse connection protection from -20V to 20V
- Package: SSOP16
- Comply with RoHS directive, without hazardous substances
- Comply with AEC-Q100 Grade 0 standard



1.2 Applications

- Automotive pressure sensor
- Automotive pressure switch

1.3 Order Information

Table 1-1 Order Information

Model	Package	Ordering Number	Packing Option
SNU501	SSOP16	SNU501	Reel

2 Pin Description

2.1 Pin Configuration

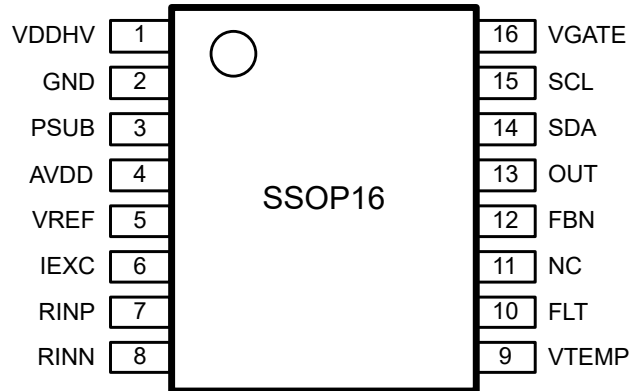


Figure 2-1 Pin Configuration(Top View)

2.2 Pin Description

Table 2-1 Pin Description

Pin No.	Name	Pin Type	Function
1	VDDHV	Supply	Power supply
2	GND	Ground	Ground
3	PSUB	Ground	Internal ground with reverse connection protection
4	AVDD	Analog IO	Supply 5V from internal regulator
5	VREF	Analog IO	Voltage reference out
6	IEXC	Analog IO	Current reference output
7	RINP	Analog IO	Positive input of resistance sensor
8	RINN	Analog IO	Negative input of resistance sensor
9	VTEMP	Analog IO	External temperature sensor input
10	FLT	Analog IO	Filter port output
11	NC		Not connect
12	FBN	Analog IO	Feed back input of output buffer
13	OUT	Analog/Digital IO	I/O port for analog or digital output
14	SDA	Digital IO	I ² C data port
15	SCL	Digital IO	I ² C clock port
16	VGATE	Analog IO	High-voltage power supply control port

3 Specification

3.1 Absolute Maximum Ratings

Table 3-1 Absolute Maximum Ratings

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Supply Voltage	V _{DDHV1}	-20		20	V	VDDHV
	V _{GATE}	-0.3		20	V	VGATE
Analog Input Voltage	V _{io,ana1}	-0.3		AVDD+0.3	V	Pins: RINP, RINN, IEXC, OUT, FBN
Operating Temperature	T _j	-40		150	°C	Normal mode
Storage Temperature	T _{storage}	-40		150	°C	Device not powered
ESD HBM	V _{ESD,HBM}	-2000		2000	V	All pins according to JS-001-2014
ESD CDM	V _{ESD,CDM}	-750		750	V	All pins according to JS-002-2014
Latch up	I _{LU}	-200		200	mA	All pins according to JEDEC 78D
Output Voltage	V _{OUT}	-0.3		AVDD+0.3	V	OWI, SENT, OUT
Output Current	I _{io,dig1}	-10		10	mA	Digital IO pins: SCL, SDA

3.2 Operating Range

Table 3-2 Operating Range

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Supply Voltage	V _{DDHV2}	4.5	5.0	5.5	V	Measurement of pressure and temperature
Supply Current	I _q	2	3	5	mA	No output load
Ambient Temperature	T _{operating}	-40		150	°C	Normal operation
	T _{otp}	-15		105	°C	Programming/erasing

3.3 Pressure Sensor

Table 3-3 Pressure Sensor

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Measurement Error ^[1]		-0.5%		+0.5%	Full scale	T _A = -40°C to 150°C
Pressure Measurement Stability Range	P _{sta}	-0.125%		+0.125%	Full scale	
Pressure Response Time ^[2]	T _p		1		ms	PODR=1.2K

[1] Above pressure error result is typical value and depends on sensor type.

[2] This value may change with configuration of ODR and Calibration setup.

3.4 Temperature Sensor

Table 3-4 Temperature Sensor

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Measurement Error	T_{Error}	-1		+1	°C	$T_A = -20^{\circ}\text{C}$ to 70°C $V_{DDHV} = 5\text{V}$
		-1.5		+1.5	°C	$T_A = -40^{\circ}\text{C}$ to 125°C $V_{DDHV} = 4.5$ to 5.5V
Temp Measurement Stability Range	T_{stab}	-0.25		+0.25	°C	Minimum 95% of the measurement range

3.5 DAC Analog Output

Table 3-5 DAC Analog Output

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
DAC Resolution	R_{DAC}		16		bits	Minimum 95% of the measurement range
Output Current	I_{DACOUT}		-5		mA	Sink current, output range: 10% to 100% AVDD
			5		mA	Source current, output range: 0% to 90% AVDD
Output Short Current	I_{DACST}	-25		25	mA	Minimum 95% of the measurement range
Load Capacitance	C_{LDAC}	5	10	100	nF	Defined for best EMC performance
DNL	DNL_{DAC}	-1		1	LSB	$R_{DAC} = 12\text{bits}$
INL	INL_{DAC}	-2		2	LSB	$R_{DAC} = 12\text{bits}$ Best Fit
High Level Output Clamp Range	$R_{g_{clampH}}$	50		100	%	
DAC Output RMS Noise	$V_{NOISE,RMS}$		500		μV	
Low Level Output Clamp Range	$R_{g_{clampL}}$	0		50	%	
Output Clamp Range Step	STP_{clamp}		16		LSB	$R_{DAC} = 12\text{bits}$

3.6 Oscillator

Table 3-6 Oscillator

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Frequency Range	F_{OSC}		9.8304		MHz	1MHz optional
Frequency Tolerance	$F_{osc,rg}$	-1%		+1%	Full scale	$T_A = 0^{\circ}\text{C}$ to 70°C
		-2%		+2%	Full scale	$T_A = -40^{\circ}\text{C}$ to 150°C

3.7 Power On Reset

Table 3-7 Power On Reset

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Power On Reset Level	V_{POR}		1.9		V	Measured at Pin AVDD
Power On Reset Release Level	V_{THR}		2.0		V	Measured at Pin AVDD
Power On Reset Time	t_{POR}			0.2	ms	

3.8 Voltage Regulator

Table 3-8 Voltage Regulator

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Regulated Output Voltage AVDD	V_{AVDD}		5.5		V	
External Capacitance at AVDD Pin	C_{AVDD}		0.2	0.4	μF	

3.9 OTP Memory

Table 3-9 OTP Memory

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Program Temperature	T_{otp}		25		$^{\circ}\text{C}$	
Program Supply Voltage	V_{wotp}	6.9	7	7.2	V	
OTP Memory Data Retention Time	t_{Retotp}	10			y	Defect rate < 1ppm over lifetime for typical mission temperature profile

3.10 Digital I/O Pins

Table 3-10 Digital I/O Pins

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Input Low Voltage	V_{IL}			$0.2 V_{AVDD}$	V	
Input High Voltage	V_{IH}	$0.8 V_{AVDD}$			V	
Output Low Voltage	V_{OL}			$0.2 V_{AVDD}$	V	$I_{OL}=4\text{mA}$
Output High Voltage	V_{OH}	$0.8 V_{AVDD}$			V	$I_{OL}=4\text{mA}$
Digital Pin Output Current	$I_{out,DIG}$	-4		4	mA	
Digital Pin Input Capacitance	$C_{in,DIG}$			10	pF	

4 Functional Description

SNU501 is a interface chip for temperature and air pressure sensor. The chip can drive the resistance pressure sensor and then generate calibrated pressure data. Two high resolution sigma-delta ADCs are applied to evaluate analog input signals such as temperature, air pressure, power voltage. An DSP cell is applied to perform calibration according to sensor's feature. On-chip memory is integrated to store customer's specific configuration, the unique ID of chip and calibration data. You can easily choose different kinds of output interface types such as SENT, absolute voltage, proportional voltage.

4.1 Block Diagram

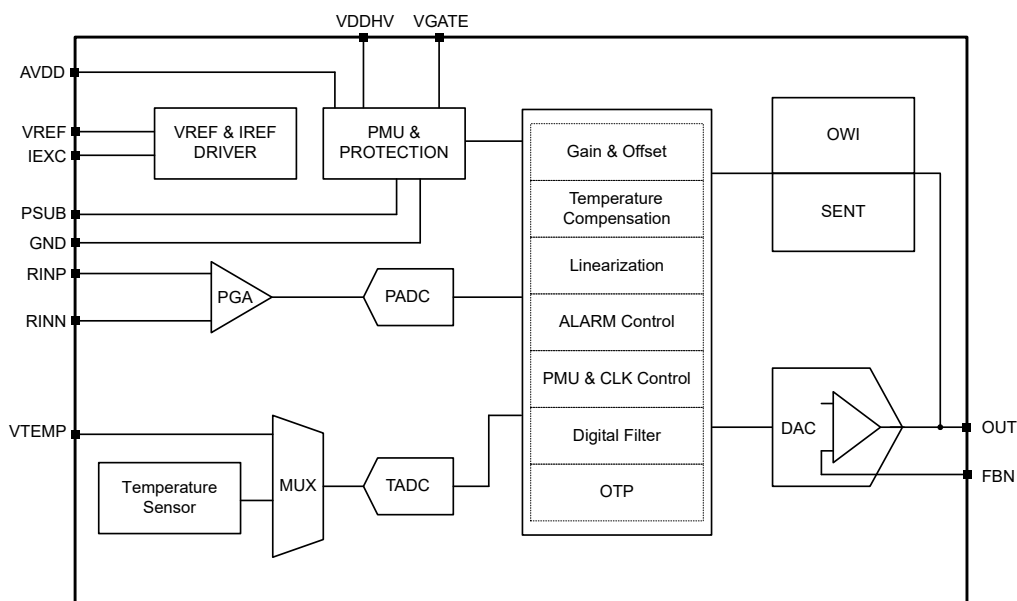


Figure 4-1 Block Diagram

4.2 Analog front end

The pressure measurement channel includes a programmable gain amplifier PGA, 24-bit sigma-delta ADC (PADC), and digital filters. An appropriate gain should be configured to match the ADC input signal range. Programmable gain amplifier PGA, the gain can be configured as: 1X, 2X, 4X, 6X, 8X, 16X, 24X, 32X, 48X, 64X, 96X, 128X, 196X, 256X, 512X.

4.3 ADC

The temperature and pressure measurements are each converted by two ADCs. ADC supports differential input range: $-VREF \times 0.75$ to $+VREF \times 0.75$.



Figure 4-2 Pressure and Temperature Ratio Output

The following table shows 5 different ADC modes selection:

Table 4-1 ADC Application Mode

ADC mode	Signal	Description
1	RV_DAC	Bridge voltage application, DAC analog output.
2	RV_SENT	Bridge voltage application, SENT digital output.
3	RVRT_SENT	Bridge voltage and bridge temperature application, SENT digital output.
4	RVET_SENT	Bridge voltage and external application, SENT digital output.
5	RVIT_SENT	Bridge voltage and internal temperature application, SENT digital output.

For ADC mode 1, always output pressure data. But for mode 2~5 with SENT interface, user can output pressure and temperature data with ratio config 1:10x (x is an integer, range is 0~255).

The PADC performs the analog to digital conversion. The output of the ADC is digitally filtered with 24-bit resolution. The reference voltage of the ADC is VREF.

The PADC output can be expressed by the following equation:

$$PDATA = \frac{VIN}{VREF} \times GAIN_P \times 2^{23}$$

The bandwidth and Output Data Rate (ODR) of the digital filter can be set by 'ODR_P'. ODR can be set from 1.2kHz to 5Hz.

Table 4-2 Pressure Data Rate

ORD_P	Pressure data rate	Description
0	Reserved	
1	Reserved	
2	1.2kHz	
3	600Hz	
4	300Hz	
5	150Hz	
6	75Hz	
7	37.5Hz	
8	20Hz	notch filter option, configuration with 60Hz notch
9	20Hz	notch filter option, configuration with 50Hz notch
10	10Hz	notch filter option, configuration with 60Hz notch
11	10Hz	notch filter option, configuration with 50Hz notch
12	5Hz	notch filter option, configuration with 60Hz notch
13	5Hz	notch filter option, configuration with 50Hz notch
14,15	Reserved	

4.4 Temperature sensor

The temperature measurement channel measures the working temperature of the sensor and performs temperature compensation on the sensor signal. This channel works independently of the pressure channel. The SNU501 supports both internal and external temperature sensor, selected by the EXT_TEMP register. The output of the temperature sensor is digitized by a 24-bit ADC (TADC) and digitally filtered. The ODR setting of the temperature measurement channel is the same as the pressure signal channel, set by ODR_T. The temperature data can be read from TDATA register and output via the SENT interface.

The internal temperature sensor is factory calibrated, with its calibration coefficients stored in OTP, the chip can provide a temperature reading in degree Celsius, in the format of

$$T = \frac{\text{TDATA}}{2^{23}} \times A + B$$

A and B are temperature calibration coefficients.

When external temperature sensor mode is selected, the temperature sensing signal input from the VTEMP pin is buffered for TADC conversion. The reference voltage of the TADC is also VREF. The gain of the TADC can be 1X, 2X and 4X. The relationship between TDATA and the temperature input is:

$$\text{TDATA} = \frac{\text{VTEMP}}{\text{VREF}} \times \text{GAIN}_T \times 2^{23}$$

Table 4-3 Temperature Data Rate

ORD_T	Temperature data rate
0	Reserved
1	Reserved
2	1.2kHz
3	600Hz
4	300Hz
5	150Hz
6	75Hz
7	37.5Hz
8,9	20Hz
10,11	10Hz
12,13	5Hz
14,15	Reserved

4.5 Analog output

The analog output port is used to output an analog signal representing pressure. The analog interface automatically cooperates with the OWI communication window after power-on, and the analog output is high impedance during the window period.

4.6 SENT output

The device output result at pin OUT with SENT protocol frame, it supports SAE J2716.

The chip uses fast and serial message channels and supports pause pulses to create SENT transfers with a constant number of clock ticks.

The SENT interface supports the OWI communication window after power-on. In the communication window, the communication can be calibrated through the OWI command sequence.

4.7 Power supply over voltage and reverse connection protection

The power management block can protect the chip within the range of $\pm 20V$ of chip power supply and avoid damage.

5 Application Circuit

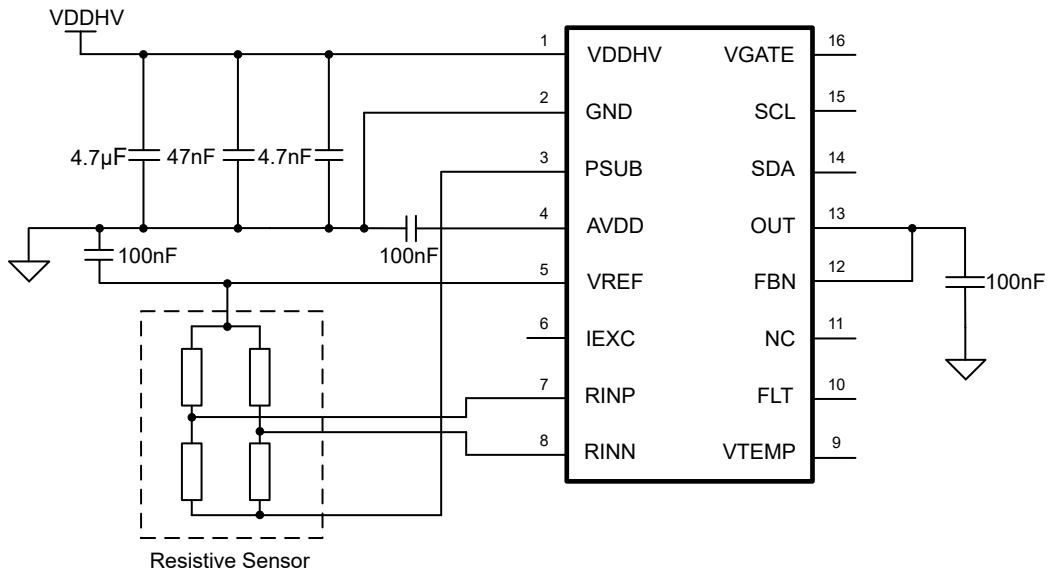
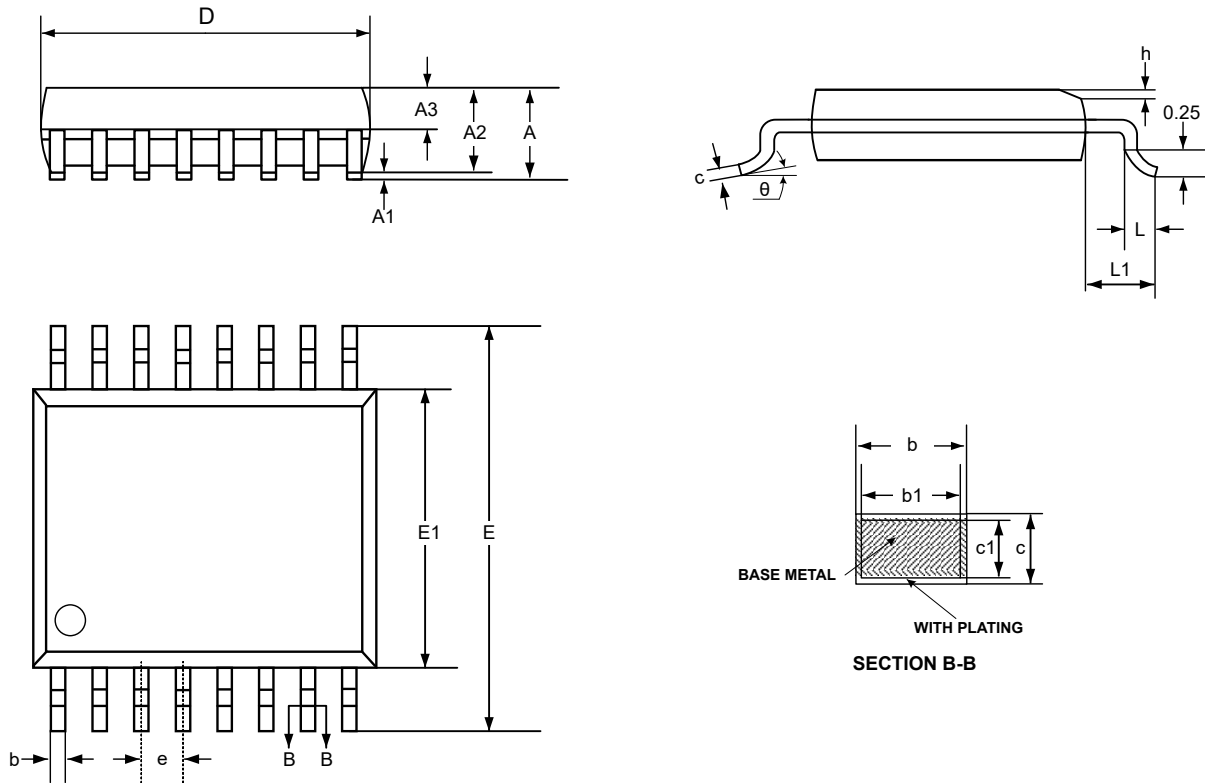


Figure 5-1 Application Circuit

6 Package Dimension (mm)



Symbol	Dimensions in Millimeters		
	Min	Nominal	Max
A			1.75
A1	0.10		0.225
A2	1.30	1.40	1.50
A3	0.60	0.65	0.70
b	0.23		0.31
b1	0.22	0.25	0.28
c	0.20		0.24
c1	0.19	0.20	0.21
D	4.80	4.90	5.00
E	5.80	6.00	6.20
E1	3.80	3.90	4.00
e	0.635 BSC		
h	0.25		0.5
L	0.5	0.65	0.80
L1	1.05 REF		
θ	0°		8°

Figure 6-1 Package Dimension

7 Revision History

Table 7-1 Revision History

Version	Date	Note
V1.0	2022.03.30	Initial version
V1.1	2022.11.17	1.Update Features and some descriptions. 2.Update Figure 5-1 Application Circuit and Figure 6-1 Package Dimension.
V1.2	2022.12.27	Update DAC Analog Output.