Application Note

NOVOSENSE

Automotive Bridge Sensor Conditioner Based on NSC9260

AN-12-0029

Author: Feifei Sun

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Automotive Bridge Sensor Conditioner Based on NSC9262

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ABSTRACT

The NSC9260 is a highly integrated and AEC-Q100 qualified IC for capacitive sensor conditioning. The NSC9260 integrates an instrumentation PGA, a 24-bit ADC for primary signal measurement channel, a 24-bit ADC for temperature measurement channel and sensor calibration logic. With the calibration algorithm built in the internal MCU, the NSC9260 supports to compensate sensor offset, sensitivity, temperature drift up to 2nd order, and non-linearity up to the 3rd order. The calibration coefficients are stored in a 64-Byte EEPROM that can be programmed multiple times. The NSC9260 also supports Over-voltage and Reverse-voltage protection. It can provide analog output and PWM output. It can also support sensor diagnosis.

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1.Key Features

1.1.Introduction to the Stepping Principle

- Over-voltage and Reverse-voltage protection between -24V ~ 28V
- Voltage supply up to 36V with an external JFET
- Directly high-voltage supply up to 18V
- C/V converter with at most ±16pF differential capacitor input
- 1X~8X ADC digital gain
- 24-bit ADC for primary signal measurement
- 24-bit ADC for temperature measurement
- Sensor connection fault detection supported
- Internal and external temperature sensor supported
- Low temperature drift 16-bit DAC
- A pair of constant current sources
- Sensor calibration algorithm embedded in a built-in MCU
- 64-Bytes EEPROM
- Ratiometric or absolute voltage output
- Special OWI interface
- PWM output supported
- SSOP16 package
- Qualified according to AEC-Q100 Grade 0
- Operation temperature: -40℃~150℃

2.Function

2.1.Sensor Excitation Module

The NSC9260 uses a square wave signal as the excitation source for measuring capacitance.
The capacitor input pins can be used as differential connection or single end connection. The differential input capacitors' common pin is driven by the EXC pin. CINP and CINN connect to the other side of those two capacitors of the capacitive sensor. If single end connection is used, connect the capacitor to CINP pin.

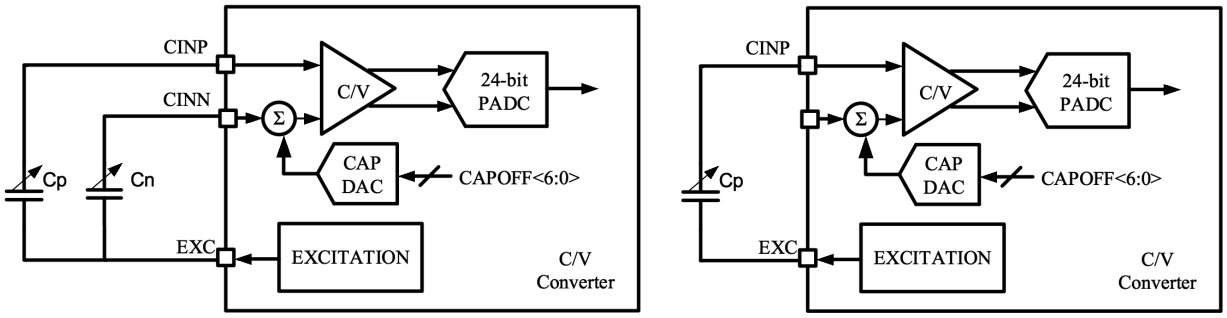

Figure 2.1 Capacitive Sensor Connection Diagram

2.2.Temperature Sensor Module

The NSC9260 can use the internal temperature sensor or an external temperature sensor. Table 2.1 below shows a comparison of the internal and external temperature sensor modes.

	Advantage	**Disadvantage**
Internal Temperature Sensor Mode	No extra components needed. No calibration required.	There is a little temperature difference between ASIC and sensor.
External Temperature Sensor Mode	Real-time indication of the sensor temperature.	An extra component is needed. Calibration required.

2.2.1.Internal temperature sensor

When using internal temperature sensor mode, it is merely required to set TADC channel gain 'GAIN_T' to 4x and set 'RAW_T' bit to '0'. Then the 24-bit TADC output raw data will be calculated after a set of built-in calibration coefficient, and turn into the data that represents the temperature in the following format,

$$T = TDATA/2^{16} + 25℃$$

2.3.Analog Output Mode

The NSCC9260 can support various analog output modes such as absolute voltage output (0~5V, 0~3.3V, 0~1.2V), ratio-metric voltage output (0~AVDD), PDM output and PWM output. PDM and PWM output directly from the VOUT pin, no peripheral circuit is required.

3.Application

3.1.Analog Voltage Output

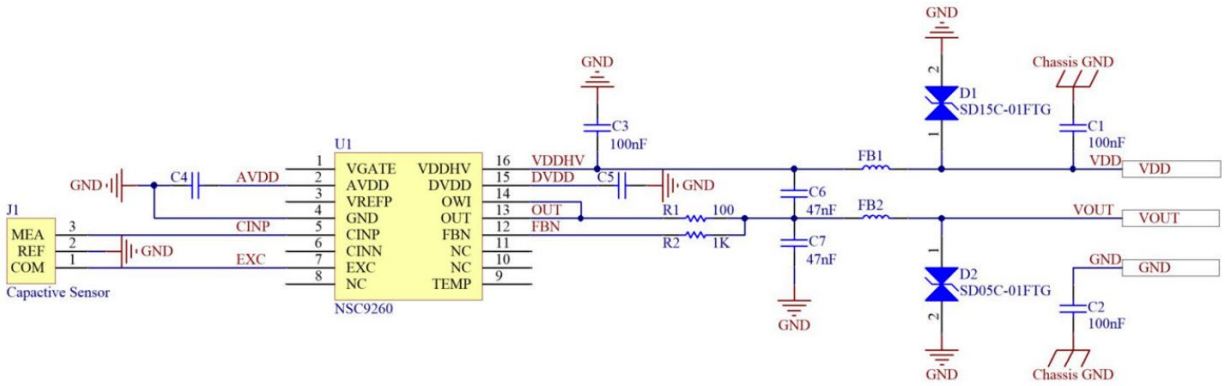

Figure 3.1 Schematic of Analog Voltage Output

The chip is powered by VDDHV and supports -24~28V (1 Hour, 70℃) Over-voltage and Reverse-voltage protection.

Diode D1 (SD15C) for bi-directional transient voltage suppression protects against ESD and other high voltage transients. SD15C can withstand 15V continuous Over-voltage and clamp the voltage at 24V at IPP = 1A, tp = 8/20μs to protect the chip from high voltage damage. If the EMC environment of the application is more severe, this TVS can be replaced with a higher-power TVS at the cost of a larger package size.

The TVS diode D2 (SD05C) on VOUT port protects the OWI, OUT and FBN pins from damage by transient high voltage pulses. These TVS diodes should be placed as close as possible to the connector. It is better to place TVS diode along the trace between connector and chip pin. This will make signal to pass through TVS diode before reaching pin of the chip and provide better protection.

C1, C2 capacitors connected between the system power and ground and the chassis ground make the shell and the system power and ground has an AC low impedance, can play the role of anti-interference of high frequency. These 2 capacitors should be close to PCB board and the shell connection. In some cases, the housing is required to have some high voltage isolation of the connector pins. In that case, these 2 capacitors need to be selected with the right voltage withstand capability. FB1, FB2 are very effective for protection against high frequency interference. Place these 2 beads close to the connector too.

C3 capacitor filters out power supply noise and keeps the power input stable. This capacitor is placed as close to the chip pins as possible, so that the power line passes through the capacitor before reaching the chip pins. The capacitance value may be increased or capacitor with different values may be added depending on the test level in the EMC real test.

C6, C7 improve the noise immunity of the system and make the output more stable. R1, R2 in the output stage can help to protect from high voltage and limit the current forced into chip pins.

Table 3.1 BOM of Analog Voltage Output Schematic

Comment	Designator	Footprint	Value
Cap	C1	0603 (or larger)	100nF (100V or larger)
Cap	C2	0603 (or larger)	100nF (100V or larger)
Cap	C3	0603	100nF
Cap	C6	0603	47nf
Cap	C7	0603	47nf
Bead	FB1	0603	BLM18AG102SH1D
Bead	FB2	0603	BLM18AG102SH1D
Res	R1	0603	100 ohm
Res	R2	0603	1 kohm
TVS	D1	SOD323	SD15C-01FTG
TVS	D2	SOD323	SD05C-01FTG
IC	U1	SSOP16	NSC9260

3.2.Analog Voltage Output with High Voltage Input(JFET)

NSC9260 supports high voltage supply up to 36V. It can convert the external high voltage supply to 5V (or 3.3V) by tuning the gate of external JFET or MOSFET (depletion mode) through VGATE pin.

Because of the voltage gap between the JEFT input and output, the JFET consumes some power that cannot be ignored. It should be noted that the actual power consumption may exceed the theoretical maximum power dissipation of some components due to the degradation of theoretical power dissipation at high ambient temperature. It is recommended to select the component in a larger package size if the module needs to work in high temperature environment.

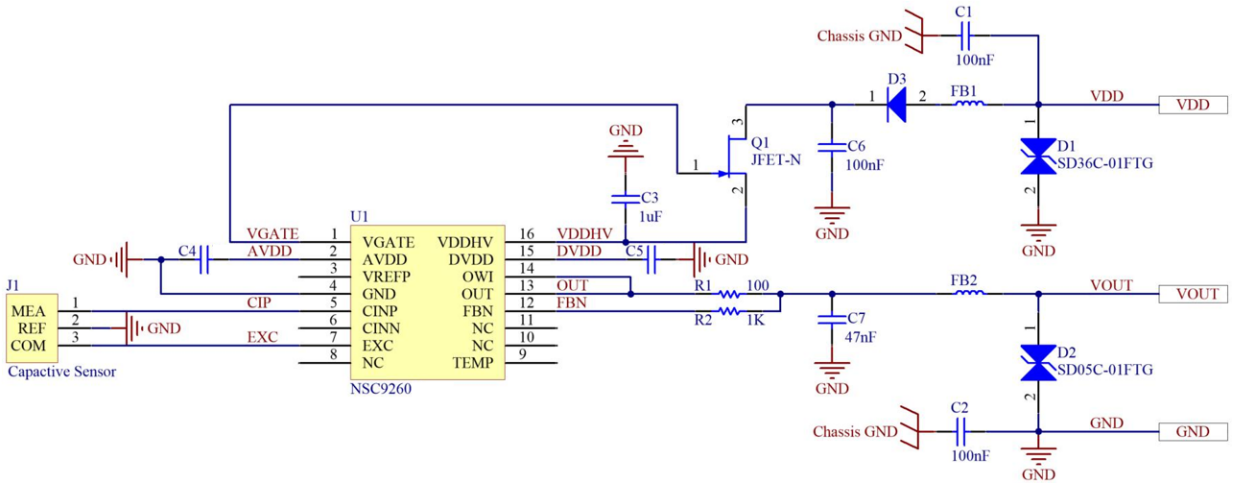

Figure 3.2 Schematic of Analog Voltage Output with High Voltage Input

Table 3.2 BOM of Analog Voltage Output with High Voltage Input Schematic

Comment	Designator	Footprint	Value
Cap	C1	0603 (or larger)	100nF (100V or larger)
Cap	C2	0603 (or larger)	100nF (100V or larger)
Cap	C3	0603	100nF
Cap	C6	0603	47nf
Cap	C7	0603	47nf
Bead	FB1	0603	BLM18AG102SH1D
Bead	FB2	0603	BLM18AG102SH1D
Res	R1	0603	100 ohm
Res	R2	0603	1 kohm
TVS	D1	SOD323	SD15C-01FTG
TVS	D2	SOD323	SD05C-01FTG
Diode	D3	SOD323	BAT46WJ
Transistor	Q1	SOT23 (or SOT223)	BSS169 (or BSP129)
IC	U1	SSOP16	NSA9260

3.3.Analog Voltage Output with High Voltage Input (BJT)

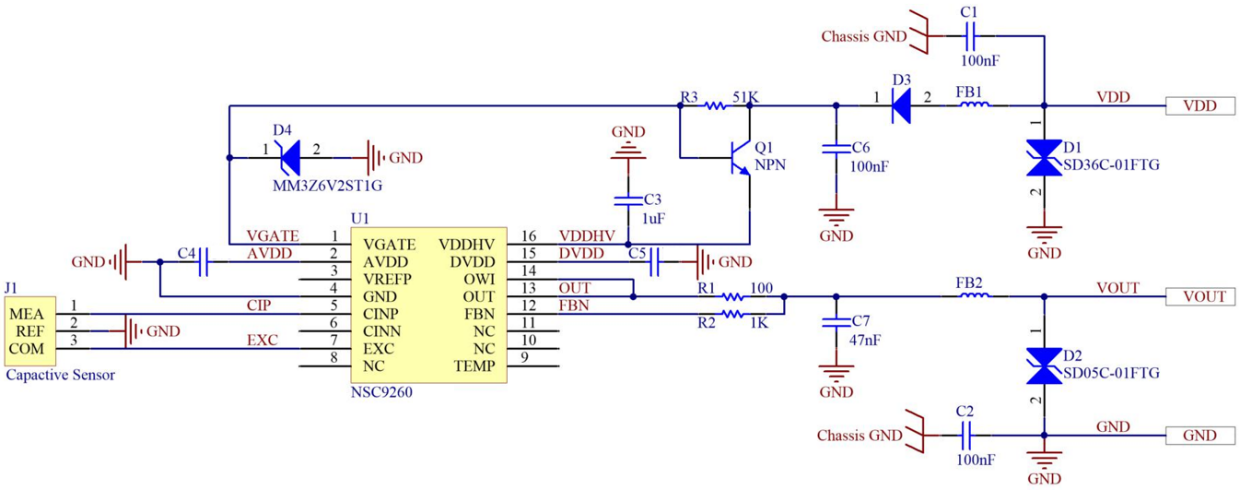

Figure 3.3 Schematic of Analog Voltage Output with High Voltage Input (BJT)

Similar to the application in Figure 3.2, an NPN BJT with a 51 kohm resistor can also be used for the high voltage regulation. An extra zener diode is recommended to mounted on VGATE pin to protect against high voltage.

Table 3.3 BOM of Analog Voltage Output with High Voltage Input (BJT) Schematic

Comment	Designator	Footprint	Value
Cap	C1	0603 (or larger)	100nF (100V or larger)
Cap	C2	0603 (or larger)	100nF (100V or larger)
Cap	C3	0603	100nF
Cap	C6	0603	47nf
Cap	C7	0603	47nf
Bead	FB1	0603	BLM18AG102SH1D
Bead	FB2	0603	BLM18AG102SH1D
Res	R1	0603	100 ohm
Res	R2	0603	1 kohm
TVS	D1	SOD323	SD15C-01FTG
TVS	D2	SOD323	SD05C-01FTG
Diode	D3	SOD323	BAT46WJ
Transistor	Q1	SOT23 (or SOT223)	BC846 (or BCP56)
IC	U1	SSOP16	NSC9260

4.Revision History

Revision	Description	Author	Date
1.0	Initial version	Feifei Sun	30/8/2023

Sales Contact: sales@novosns.com;Further Information: www.novosns.com