Application Note

NOVOSENSE

Automotive Bridge Sensor Conditioner Based on NSA9260X

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ABSTRACT

The NSA9260X is a highly integrated and AEC-Q100 qualified IC for automotive bridge sensor conditioning. The NSA9260X 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 NSA9260X 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 NSA9260X 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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NOVOSENSE

1.Pin Configuration and Functions

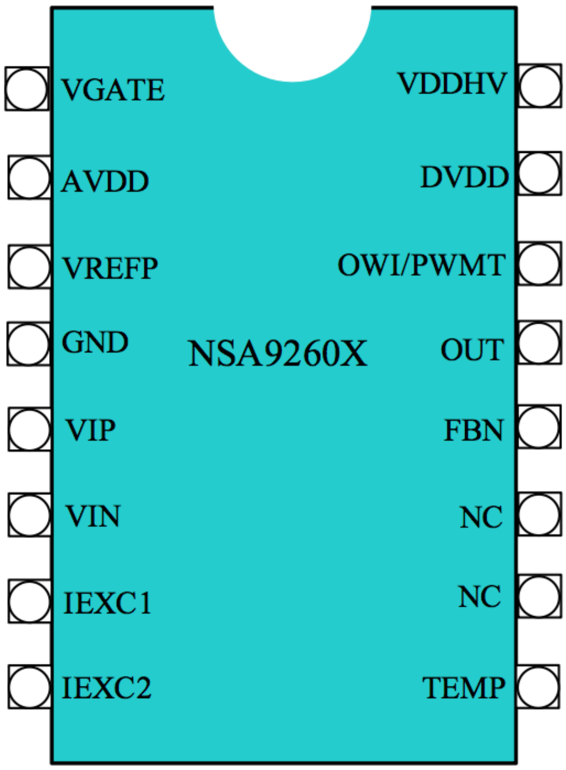

Figure 1.1 NSA9260X Pin Diagram

Table 1.1 NSA9260X Pin Configuration and Description

PIN NO.	SYMBOL	FUNCTION
1	VGATE	JFET controller output
2	AVDD	Internal analog power supply
3	VREFP	Internal Reference voltage VREF output/External Reference voltage input(set by register 0xA2)
4	GND	Ground
5	VIP	Positive analog input
6	VIN	Negative analog input

PIN NO.	SYMBOL	FUNCTION
7	IEXC1	1st constant current source
8	IEXC2	2nd constant current source/External bias resistor
9	TEMP	External temperature sensor input
10	NC	Floating
11	NC	Floating
12	FBN	Output driver feedback
13	OUT/PWMDAC	Driver output or DAC PWM output
14	OWI/PWMT	One-wire interface or Temperature channel PWM output
15	DVDD	1.8V digital supply from internal LDO
16	VDDHV	Power supply with OVP/RVP

2.Function

2.1.Sensor Excitation Module

The NSA9260X provides two kinds of excitation source: constant voltage source and constant current source.

2.1.1.Constant voltage source

If the sensor is powered by constant voltage source, no matter it is powered by internal constant voltage source or external constant voltage source, the VREFP pin should be connected to the supply of bridge sensor. The VREFP pin can be configured as a constant voltage output or as a reference voltage input.Figure 2.1 shows the typical application diagram of constant voltage source.

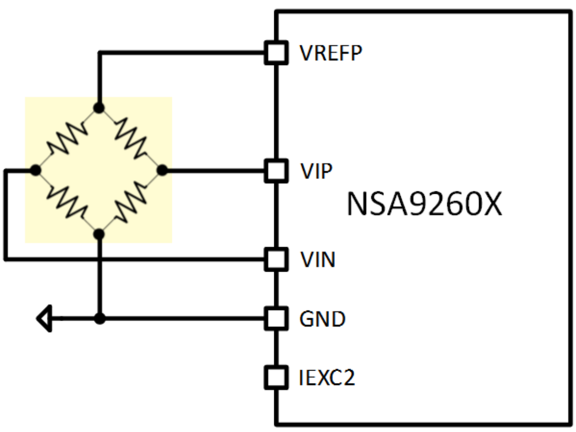

Figure 2.1 Bridge Sensor Using Constant Voltage Source

2.1.2.Constant current source

If the sensor is powered by a constant current source, up to two constant current source outputs can be used. When using external resistor mode, only one constant current source output can be used. The external resistor mode can reduce the temperature coefficient of the constant current source by using an external reference resistor with a smaller temperature drift. Figure 2.2 and figure 2.3 show the typical application diagram of constant current source.

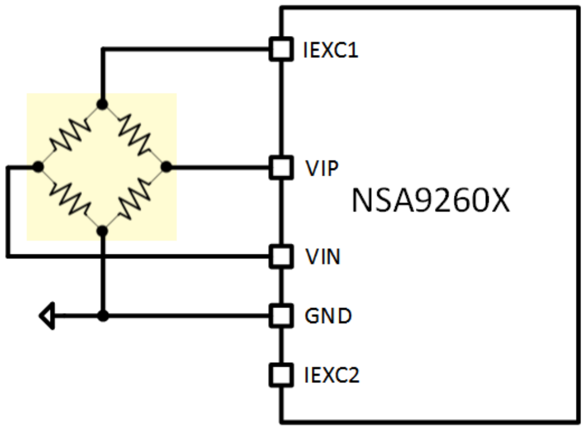

Figure 2.2 Bridge Sensor Using Constant Current Source (Internal Resistor Mode)

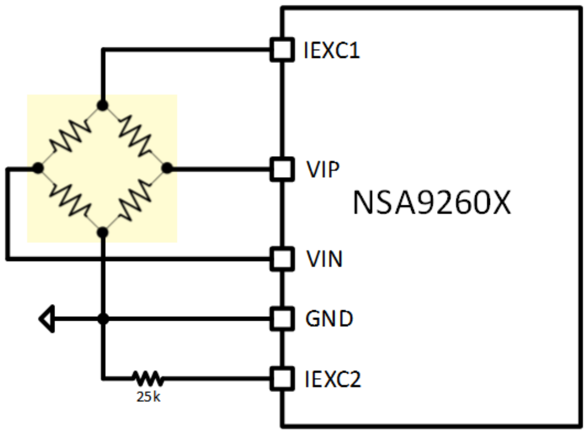

Figure 2.3 Bridge Sensor Using Constant Current Source (External Resistor Mode)

In external resistor mode, the register IEXC2<3:0> must be set to 4'b1111. The external resistor's value range is 20 ~ 33 kohm. A 25 kohm resistor with low temperature coefficient is recommended.

2.2.Temperature Sensor Module

The NSA9260X can use the internal temperature sensor or a variety of external temperature sensor modes.Table 2.1 below shows a comparison of the internal and external temperature sensor modes.

Table 2.1 Comparison of Internal and External Temperature Sensor

	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 may needed. Calibration required.

2.2.1.Internal temperature sensor

When using internal temperature sensor mode, there only need 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 built-in set of calibration coefficient and turn into the data that represents the temperature in the following format.

$$T = TDATA\ /\ 2\text{^}16 + 25\ ℃$$

2.2.2.External temperature sensor

External temperature sensors come in many forms, including thermistors, diodes, and the sensor bridge itself. Among these, thermistors are highly accurate, but more expensive. So it is not used in the sensor module because of cost.

Figure 2.4 shows a diagram of using the bridge itself as the temperature sensor with constant voltage source supply. There is a low temperature drift resistor in series. The value of this resistor is approximately 1/4 to 1/5 of the minimum value of the bridge resistance. The advantage of this application is that it is the most direct response to the temperature change of the sensor, but it requires a certain temperature characteristic of the sensor bridge resistance, more than 1800 ppm/℃. Too little temperature drift will cause the temperature sensor calibration to fail.

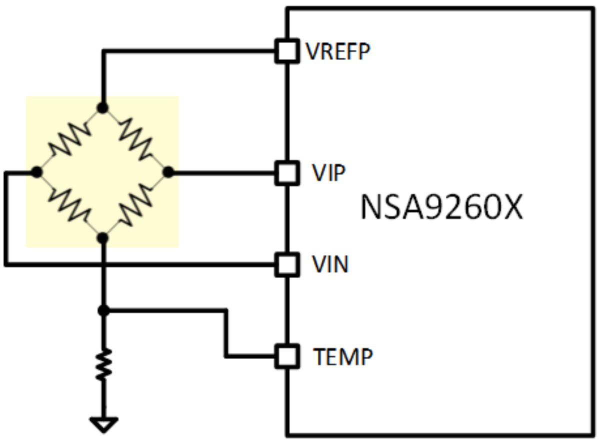

Figure 2.4 Using Bridge Resistance as Temperature Sensor (Constant Voltage Source)

Similar to Figure 2.4, Figure 2.5 shows the diagram of using bridge resistance as the temperature sensor with constant current source supply. In this application, the low temperature drift resistor is not needed. However the pressure and temperature channel measurement accuracy maybe a little worse than constant voltage supply, as the temperature drift of constant current source temperature drift is a little worse.

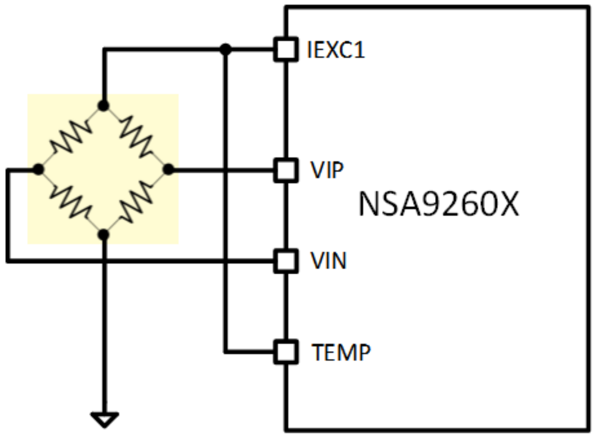

Figure 2.5 Using Bridge Resistance as Temperature Sensor (Constant Current Source)

Figure 2.6 shows a diode temperature detection circuit, which has the advantage that it can respond to the temperature change of the sensor in real time by placing the diode close to the sensor. It is also possible to use a bipolar junction transistor instead of a diode, using the Vbe of the transistor.

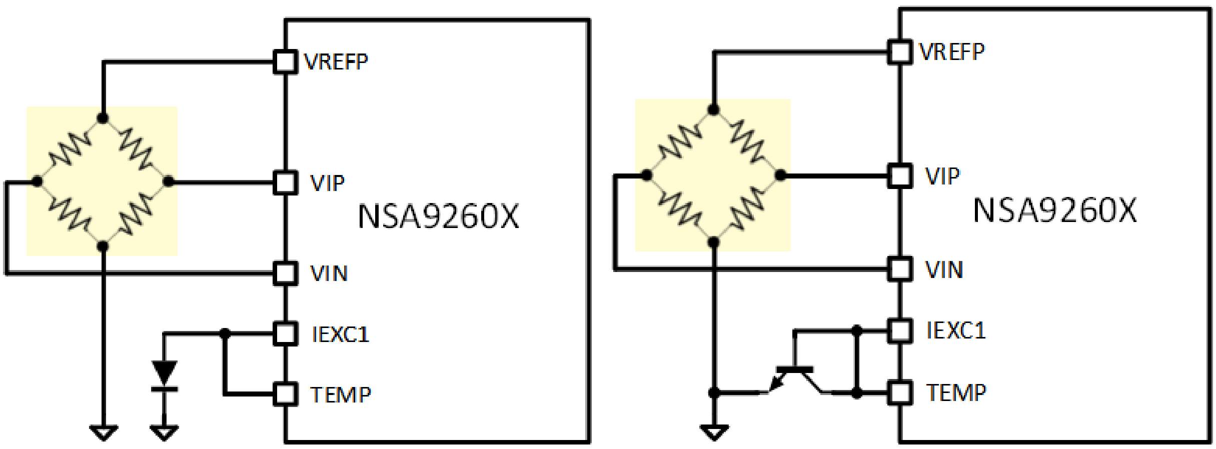

Figure 2.6 Using External Diode or Transistor as Temperature Sensor

2.3.Analog Output Mode

The NSA9260X can support various analog output modes such as absolute voltage (0~5V, 0~3.3V, 0~1.2V), ratio-metric voltage output (0~AVDD), PDM output, PWM output.PDM and PWM output directly from the VOUT pin, no peripheral circuit is required.

3.Application

3.1.Analog Voltage Output

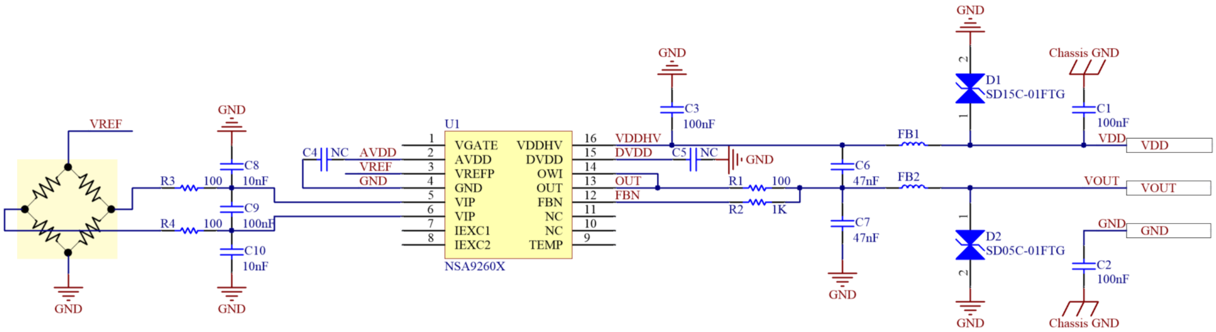

Figure 3.1 Schematic of Analog Voltage Output

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

The bi-directional transient voltage suppression diode D1 (SD15C) 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 to the connector as possible. It is better to place TVS diode through 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 the 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 capacitors filter out power supply noise and keep 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 high voltage and limit the current forced into chip pins.

R3, R4, C8, C9, C10 play a role in filtering out high frequency noise and anti-aliasing at the input.

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
Cap	C8	0603	10nF, 5%
Cap	C9	0603	100nF
Cap	C10	0603	10nF, 5%
Bead	FB1	0603	BLM18AG102SH1D
Bead	FB2	0603	BLM18AG102SH1D
Res	R1	0603	100
Res	R2	0603	1K
Res	R3	0603	100, 1%
Res	R4	0603	100, 1%
TVS	D1	SOD323	SD15C-01FTG
TVS	D2	SOD323	SD05C-01FTG
IC	U1	SSOP16	NSA9260X

Table 3.1 BOM of Analog Voltage Output Schematic

Table 3.2 lists the EMC performance of the schematic in Figure 3.1.

Table 3.2 EMC Performance of Analog Voltage Output Schematic

	Test item	Standards	Test Level	Results
1	Radiated Emission	CISRP 25：2008	Class 5	PASS
2	Conducted Emission	CISRP 25：2008	Class 5	PASS
3	ESD (1)	ISO 10605：2008	±8kV	PASS
4	Conducted Immunity (Supply Cable)	ISO 7637-2：2004	Class IV	Class A
5	Conducted Immunity (Sensor Cable)	ISO 7637-3：2007	Class IV	Class A
6	Radiated Immunity (BCI method)	ISO 11452-4：2011	Class V:300mA	Class A
7	Radiated Immunity (ALSE method)	ISO 11452-2：2004	Class V:150V/m	Class A
Note 1: Discharge network is 330Ω/330pF.				

3.2.Analog Voltage Output with High Voltage Input

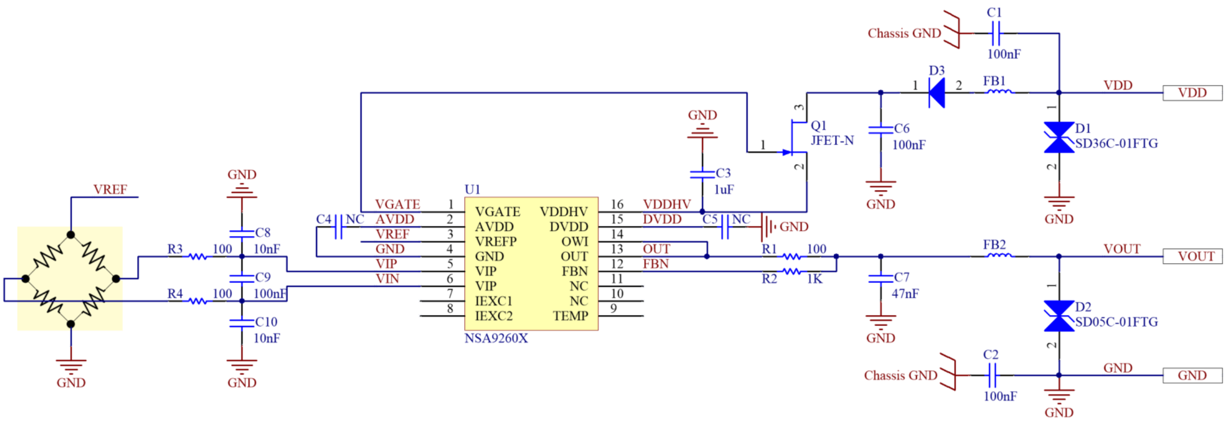

Figure 3.2 Schematic of Analog Voltage Output with High Voltage Input

NSA9260X support high voltage supply up to 36V. It can 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 the voltage gap between the JEFT input and output, the JFET consumes some power that can not be ignored. It should be noted that the actual power consumption may exceed the maximum power dissipation of some components due to the degradation of 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.

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	1uF
Cap	C6	0603	100nF
Cap	C7	0603	47nF
Cap	C8	0603	10nF, 5%
Cap	C9	0603	100nF
Cap	C10	0603	10nF, 5%
Bead	FB1	0603	BLM18AG102SH1D
Bead	FB2	0603	BLM18AG102SH1D
Res	R1	0603	100
Res	R2	0603	1K
Res	R3	0603	100, 1%

Comment	Designator	Footprint	Value
Res	R4	0603	100, 1%
TVS	D1	SOD323	SD36C-01FTG
TVS	D2	SOD323	SD05C-01FTG
Diode	D3	SOD323	BAT46WJ
Transistor	Q1	SOT23 (or SOT223)	BSS169 (or BSP129)
IC	U1	SSOP16	NSA9260X

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

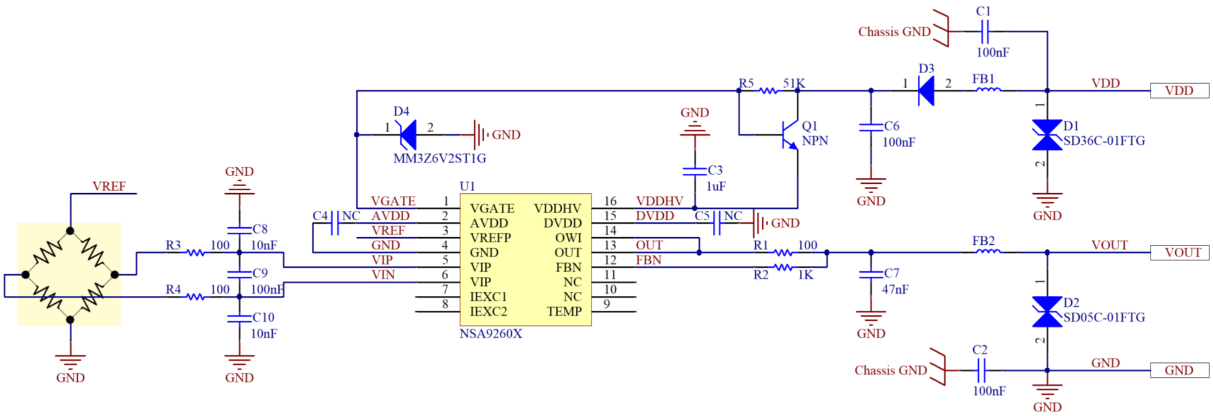

Figure 3.3 Schematic of Analog Voltage Output with High Voltage Input (BJT)

Similar to the application in Figure 3.2, a 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	1uF
Cap	C6	0603	100nF
Cap	C7	0603	47nF
Cap	C8	0603	10nF, 5%
Cap	C9	0603	100nF
Cap	C10	0603	10nF, 5%

Comment	Designator	Footprint	Value
Bead	FB1	0603	BLM18AG102SH1D
Bead	FB2	0603	BLM18AG102SH1D
Res	R1	0603	100
Res	R2	0603	1K
Res	R3	0603	100, 1%
Res	R4	0603	100, 1%
Res	R5	0603	51K
TVS	D1	SOD323	SD36C-01FTG
TVS	D2	SOD323	SD05C-01FTG
Diode	D3	SOD323	BAT46WJ
Diode	D4	SOD323	SZMM3Z6V2ST1G
Transistor	Q1	SOT23 (or SOT223)	BC846 (or BCP56)
IC	U1	SSOP16	NSA9260X

4.Revision History

Revision	Description	Author	Date
1.0	Initial version	Feifei Sun	16/6/2023

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