Application Note

NOVOSENSE

Automotive Bridge Sensor Conditioner Based on NSA9260

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ABSTRACT

NSA9260 is a highly integrated and AEC-Q100 qualified IC for automotive bridge sensor conditioning. The NSA9260 integrates an instrument PGA, a 24-bit primary signal measurement channel, a 24-bit temperature measurement channel and sensor calibration logic. With the internal calibration algorithm built in the MCU, the NSA9260 supports to compensate the temperature drift of zero and span up to the 2nd order, and also the linearity up to the 3rd order. The calibration coefficients are stored in a 64-byte EEPROM. The NSA9260 also supports Over-voltage and Reverse-voltage protection. It can provide analog output and PWM output with 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
- Instrumentation amplifier with programmable gain from 1X to 256X
- 1X~8X ADC digital gain
- 24-bit ADC for primary signal measurement
- 24-bit ADC for temperature measurement
- 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-Byte EEPROM
- Ratiometric or absolute voltage output
- PWM output supported
- Specific OWI interface
- SSOP16 package
- Qualified according to AEC-Q100 Grade 0
- Operation temperature: -40℃~150℃

2.Function

2.1.Sensor Excitation Module

The NSA9260 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 a constant voltage source, no matter internal or external one, 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.

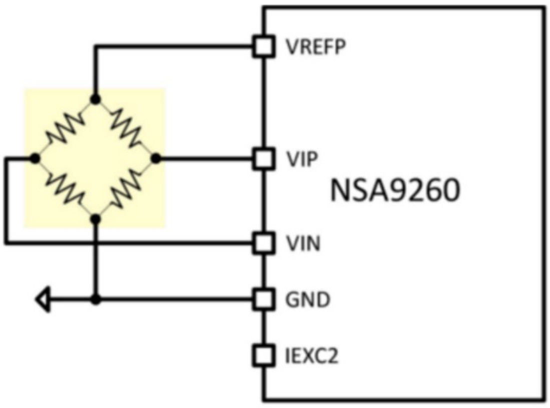

Figure 2.1 Bridge Sensor Using Constant Voltage Source

2.1.2.Constant Current Source

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

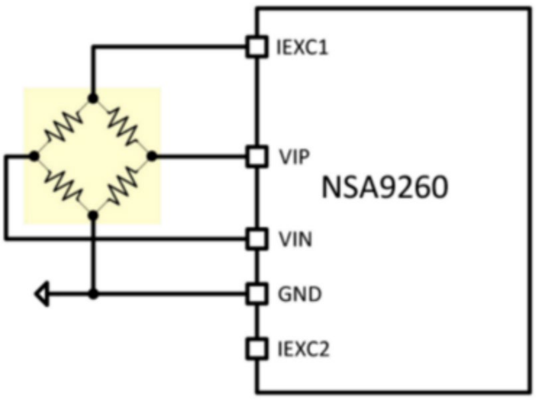

Figure 2.2 Bridge Sensor Using Constant Current Source (Internal Resistor Mode)

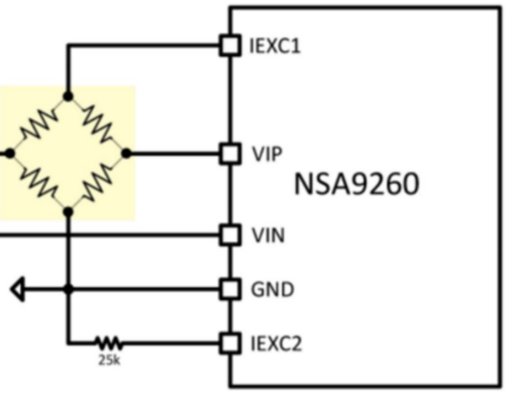

Figure 2.3 Bridge Sensor Using Constant Current Source (External Resistor Mode)

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 NSA9260 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 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 with a set of built-in calibration coefficients, and turn into the data that represents the temperature in the following format,

$$T = TDATA/2^{16} + 25℃$$

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, hence not used in the sensor module due to the high cost.

Figure 2.4 shows a diagram of using the bridge itself as the temperature sensor with constant voltage source supply. There is a resistor in series with low temperature drift. 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 responds to the temperature change of the sensor most directly, but it requires a certain temperature characteristic of the sensor bridge resistance, i.e. more than 1800 ppm/℃. Too little temperature drift will cause the temperature sensor calibration to fail.

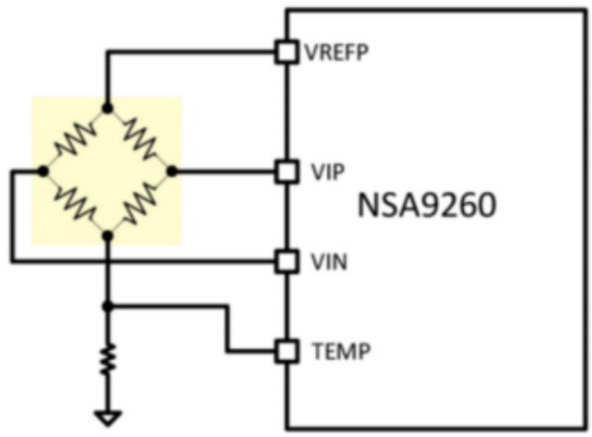

Figure 2.4 Using Bridge Resistance as Temperature Sensor (Constant Voltage Source)

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 measurement accuracy of pressure and temperature channel may be a little worse than that with constant voltage supply, as the temperature drift using constant current source is a little worse.

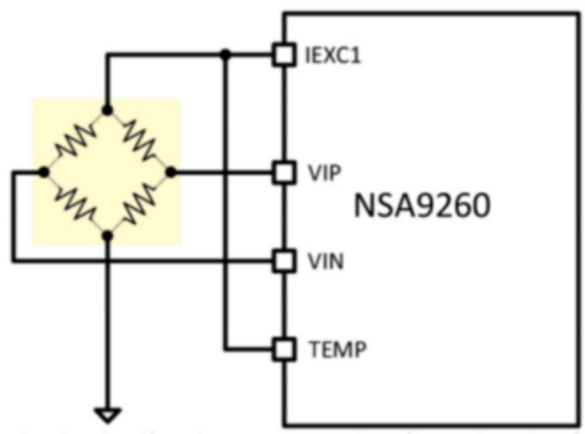

Figure 2.5 Using Bridge Resistance as Temperature Sensor (Constant Current Source)

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.

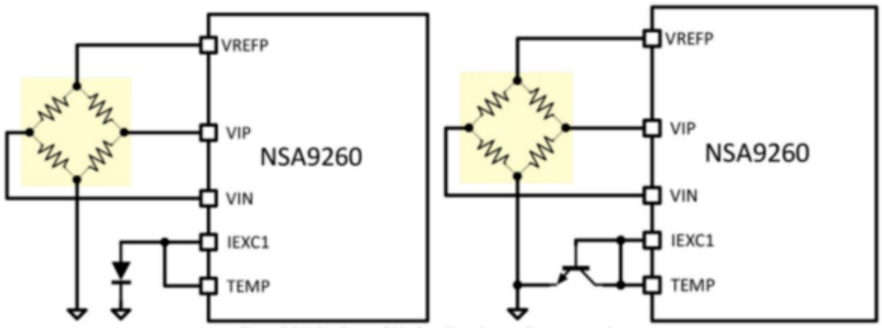

Figure 2.6 Using External Diode or Transistor as Temperature Sensor

2.3.Analog Output Mode

The NSA9260 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

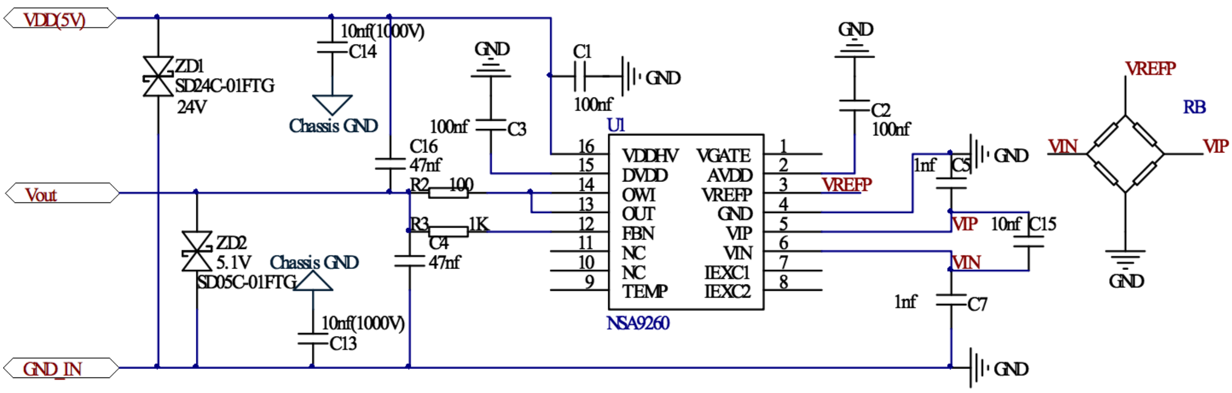

Figure 3.1 Schematic of Analog Voltage Output(using internal temperature sensor)

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

Diode ZD1 (SD24C) for bi-directional transient voltage suppression protects against ESD and other high voltage transients. SD24C 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 ZD2 (SD05C) on VOUT port protects the OWI, OUT and FBN pins from damage caused 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.

C13, C14 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.

C1 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.

C16, C4 improve the noise immunity of the system and make the output more stable. R2, R3 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
C1	Cap	0603	100nf
C2	Cap	0603	100nf
C3	Cap	0603	100nf
C4	Cap	0603	47nf
C5	Cap	0603	1nf
C7	Cap	0603	1nf
C13	Cap	1206	10nf(1000V)
C14	Cap	1206	10nf(1000V)
C15	Cap	0603	10nf
C16	Cap	0603	47nf
R2	Res	0603	100
R3	Res	0603	1K
RB	Resistor Bridge	-	-
U1	NSA9260	SSOP16	-
ZD1	SD24C-01FTG	SOD323	24V
ZD2	SD05C-01FTG	SOD323	5.1V

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

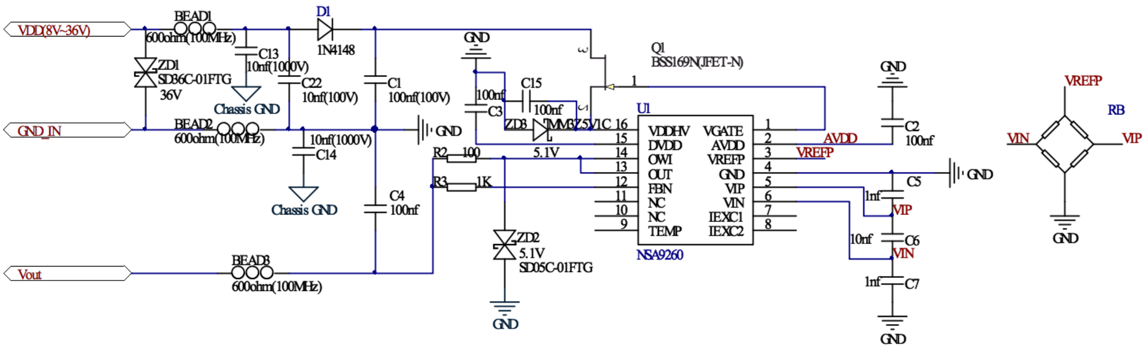

Figure 3.2 Schematic of Analog Voltage Output with High Voltage Input (JFET)

Table 3.2 BOM of Analog Voltage Output with High Voltage Input (BJT) Schematic

Comment	Designator	Footprint	Value
BEAD1	Inductor	0603	600ohm(100MHz)
BEAD2	Inductor	0603	600ohm(100MHz)
BEAD3	Inductor	0603	600ohm(100MHz)
C1	Cap	0603	100nf(100V)
C2	Cap	0603	100nf
C3	Cap	0603	100nf
C4	Cap	0603	100nf
C5	Cap	0603	1nf
C6	Cap	0603	10nf
C7	Cap	0603	1nf
C13	Cap	1206	10nf(1000V)
C14	Cap	1206	10nf(1000V)
C15	Cap	0603	100nf
C22	Cap	0603	10nf(100V)
D1	1N4148	SOD323	-
Q1	BSS169N(JFET-N)	SOT23	-
R2	Res	0603	100
R3	Res	0603	1K
RB	Resistor Bridge	-	-
U1	NSA9260	SSOP16	-
ZD1	SD36C-01FTG	-	36V
ZD2	SD05C-01FTG	-	5.1V
ZD3	MM3Z5V1C	SOD323	-

4.Revision History

Revision	Description	Author	Date
1.0	Initial version	Feifei Sun	30/2/2023

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