Application Note

NOVOSENSE

Capacitive Pressure Sensor NSC2860 Application Manual

AN-12-0033

Author: Weijie Zhou

AN-12-0033

NOVOSENSE

Capacitive Pressure Sensor NSC2860 Application Manual

ABSTRACT

NSC2860 is highly integrated ASIC for capacitive sensors. Due to NSC2860's high integration and variety of applications, this paper will introduce its hardware peripheral circuits in detail, so that users can have a targeted understanding of various typical applications.

INDEX

NOVOSENSE

Capacitive Pressure Sensor NSC2860 Application Manual

1.The Internal Main Module of NSC2860

The Internal main module of NSC2860 is shown in Figure1.1.

1、 External JFET or Bipolar to achieve high voltage power supply

2、 A C/V conversion circuit which converts the front-end capacitance signal into voltage signal

3、 The NSC2860 provides a frequency-adjustable square wave excitation

4、 Provides a variety of output methods:

(1) Analog output: 0~5V, 0~10V, 4~20mA

(2) Digital output: SPI, I2C (only supported by SSOP20 package)

(3) Others: PDM, PWM

5、 Supports temperature measurement methods

(1) Supports built-in temperature sensor

6、 Dual 24-bit high-precision ADC for main channel and temperature channel measurements.

7、 16bit DAC output.

8、 Proprietary OWI communication mode enables direct calibration of a three-wire sensor and a dual-line 4~20mA transmitter.

9、 1~ 8X ADC gain, and the rear stage 0~2X high precision adjustable sensitivity compensation.

10、 Support IIC and SPI interface.

11、 64 Byte EEPROM

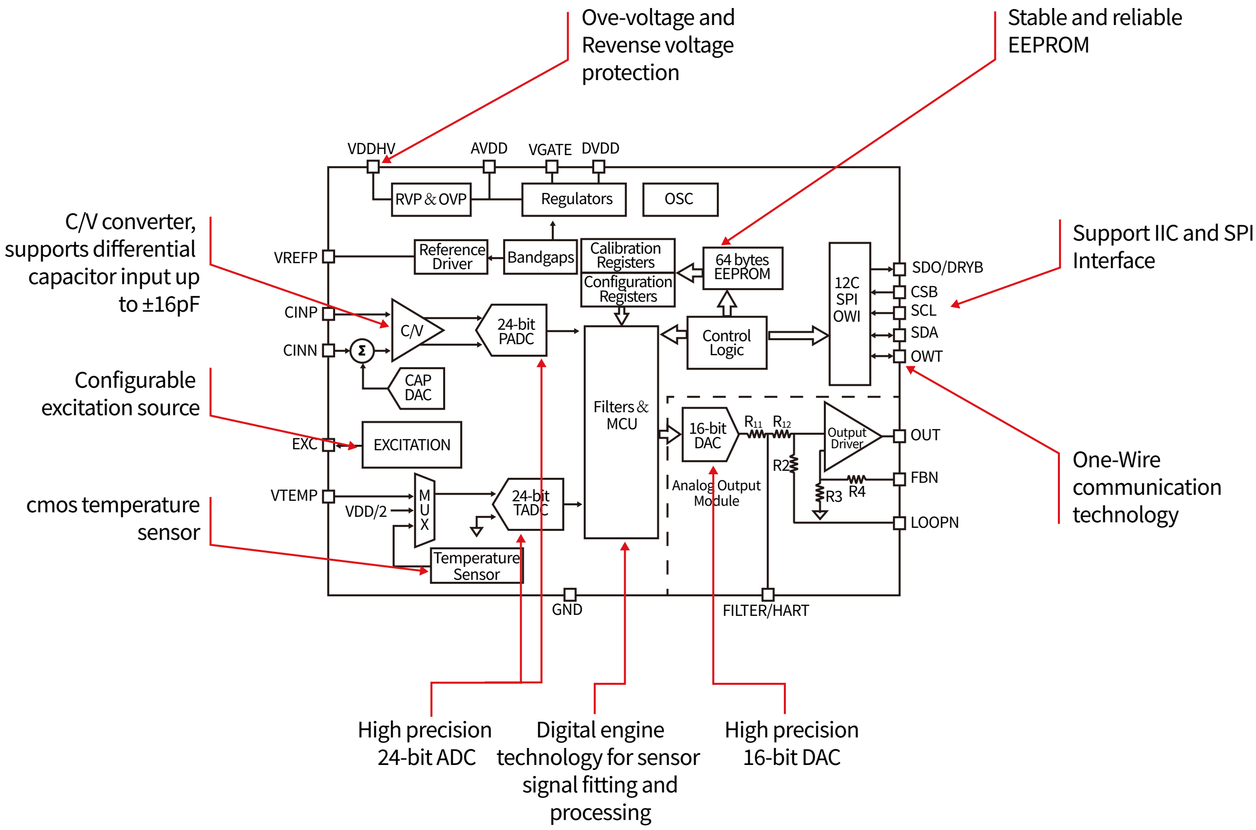

Figure 1.1 The Internal Main Module of NSC2860

2.Function Modules

2.1.Power Supply Module

The NSC2860 integrates an external JFET controller that controls JFET or Transistor via VGATE pins to generate 5V or 3.3V low-voltage power directly from the high-voltage power supply to drive the NSC2860 or other peripherals. Figure 2.1, Figure 2.2 and Figure 2.3 respectively show VDD direct power supply, JEFT and Transistor high voltage power supply, and provide device selection. The three schemes are compared as follows:

Table 2. 1 The Comparison of Power Supply Schemes

Parameters	Range Of Supply	Output Voltage	Advantage	Refer
Direct Supply	3V~5.5V	3V~5.5V	400	Refer to Figure2.1
JFET	5.5V~36V	5V/3.3V	Wider supply range	Refer to Figure2.2
Bipolar	8V~36V	5V/3.3V	Low cost	Refer to Figure2.3

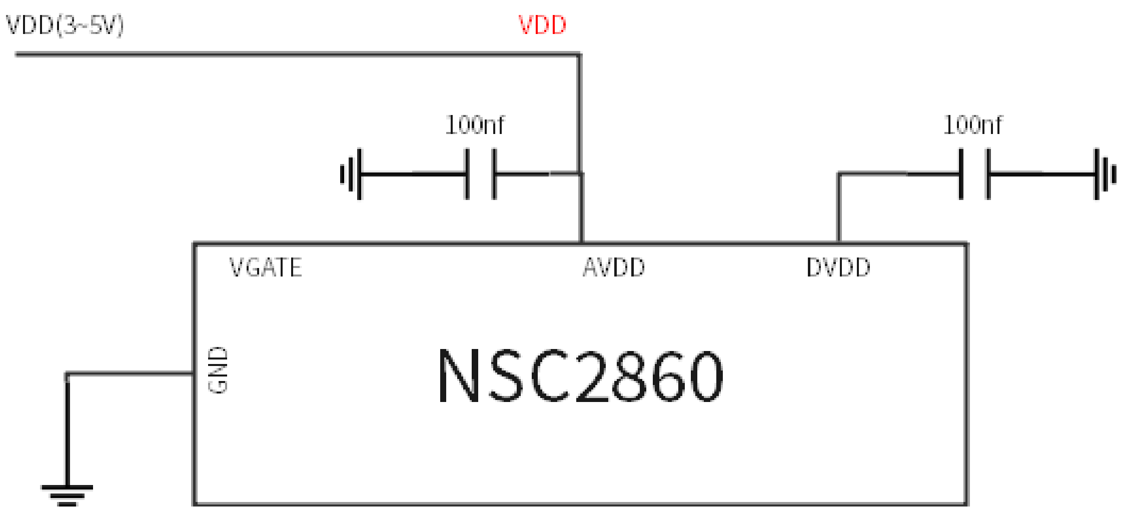

Figure 2. 1 Direct Power Supply Circuit

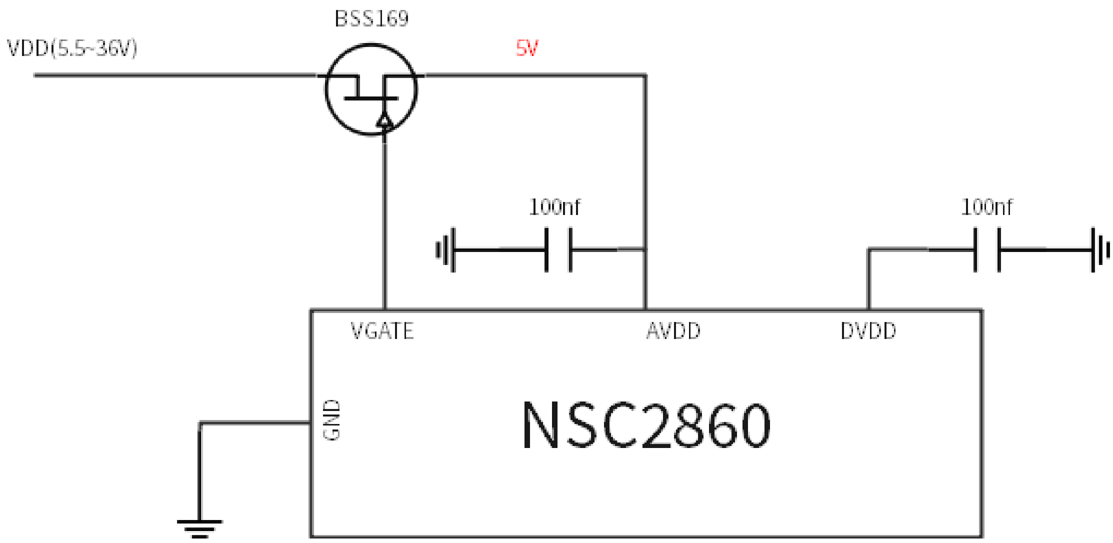

Figure 2. 2 High Voltage JFET Power Supply Circuit

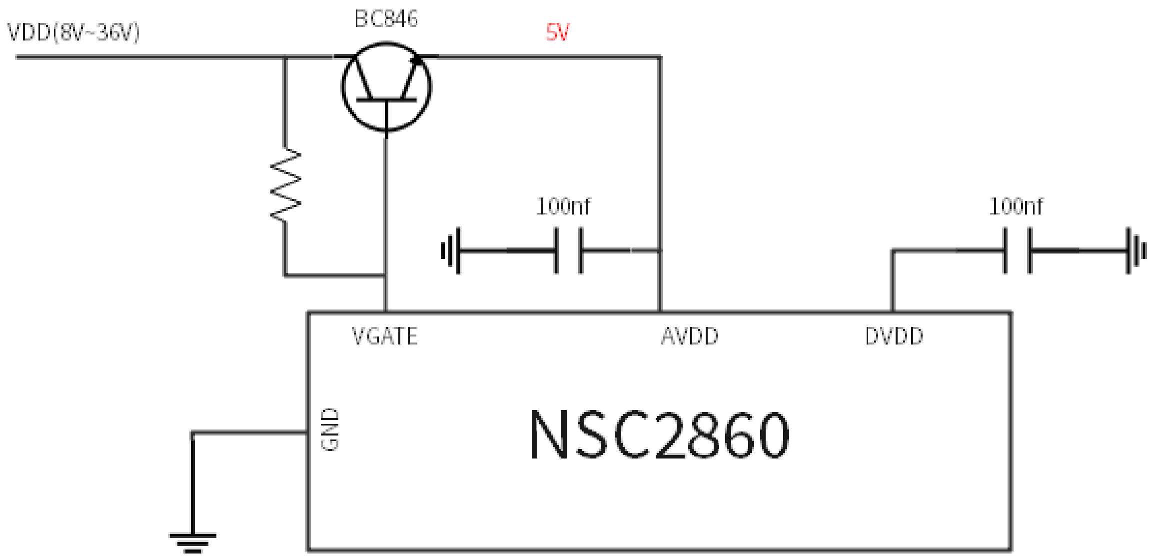

Figure 2. 3 High Voltage Transistor Power Supply Circuit

2.2.Capacitance Measurement Mode

For single-ended and differential capacitive sensors, there are three different connections for the analog input front end

2.2.1.Single-Ended Output Capacitive Sensor

The figure2.4 shows the detection mode of a single-ended output capacitance sensor

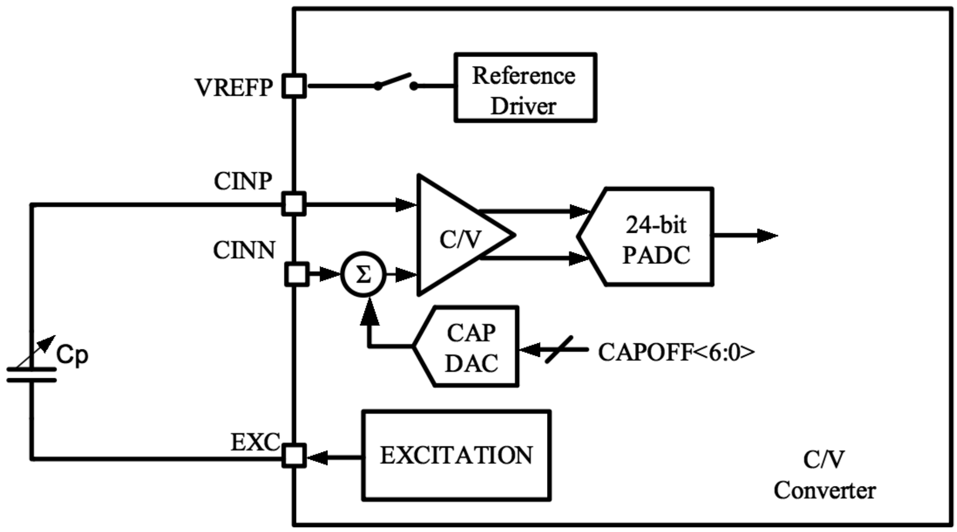

Figure 2. 4 Single-Ended Capacitance Detection Mode

2.2.2.Differential Output Capacitance Sensor

The NSC2860 supports two types of capacitance measurement modes: Drive Mode and Ground Mode. The NSC2860 generates a square wave at EXC pin with 38.4KHz or 76.8KHz frequency and VREF amplitude, which is used to drive input capacitor at Drive Mode or shield parasitic capacitor at Ground Mode.

When CV_MODE = 0, the NSC2860 is at Drive Mode, where the external input capacitors are connected as shown in Figure2.5. The common end of the differential capacitor is driven by the square wave at EXC pin at Drive Mode. Since the voltage at CINP and CINN keep constant, the input parasitic capacitance would not affect the output.

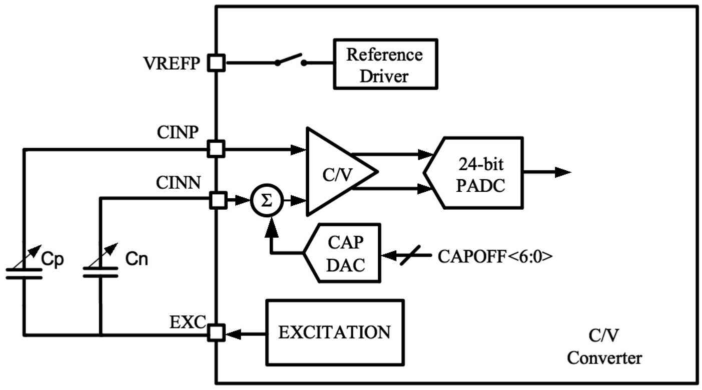

Figure 2. 5 C/V Converter at Drive Mode (CV_MODE = 0)

When CV_MODE = 1, the NSC2860 is at Ground Mode, where the common plate of the external differential input capacitors is grounded as shown in Figure 2.6. Both CINP and CINN are driven by the square wave at EXC pin, so the differential input capacitance is converted to voltage through charge and discharge. The 24-bit ADC then converts the voltage to digital output. Since the NSC2860 measures the capacitance between CINP/CINN and ground, the parasitic capacitance at CINP/-CINN would affect the measurement directly. Worse, the parasitic capacitance may be large and susceptible to environment interfere (such as displacement, humidity and so on). To exclude the parasitic capacitance, CINP and CINN can be shielded with EXC pin as shown in Figure 2.6. Ground Mode is more suitable especially when the common plate of the differential input capacitor cannot be driven by the chip directly.

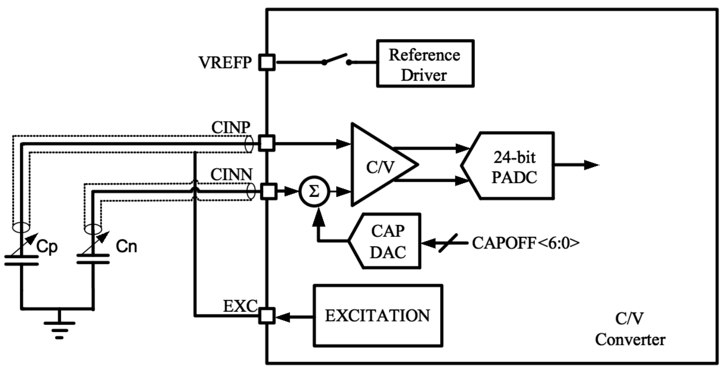

Figure 2. 6 C/V Converter at Ground Mode (CV_MODE = 1)

2.3.Output Mode

NSC2860 can flexibly support absolute voltage (0~5V, 0~3.3V, 0~1.2V), proportional voltage output (0~AVDD), 0~10V output, PDM output, PWM output, 4-20mA current output and other analog output modes. PDM and PWM output directly from the VOUT pin, without the need for peripheral circuit, the following mainly introduces the remaining several analog output mode typical hardware application circuit.

2.3.1. 4-20mA Current Output

Figure 2.7 shows the 4-20mA current output mode. The OUT pin outputs the voltage signal and adjusts the loop current through the peripheral voltage-to-current circuit. The 50ohm high precision resistor in the figure is used as the current detection feedback, so it must be a low temperature drift resistor. This 50ohm resistor directly affects the performance of the 4-20mA circuit output. The ground capacitor on the FILTER pin filters the analog signal output by the DAC, which can reduce the output noise but reduce the signal bandwidth.
The 4-20mA communication control is achieved by modulating the power supply signal, and the coupling capacitance of 22nF couplings the modulation signal from the power supply to the OWI pin of the chip. OWI signal return is by controlling OUT pin voltage, modulating current, and output digital signal.

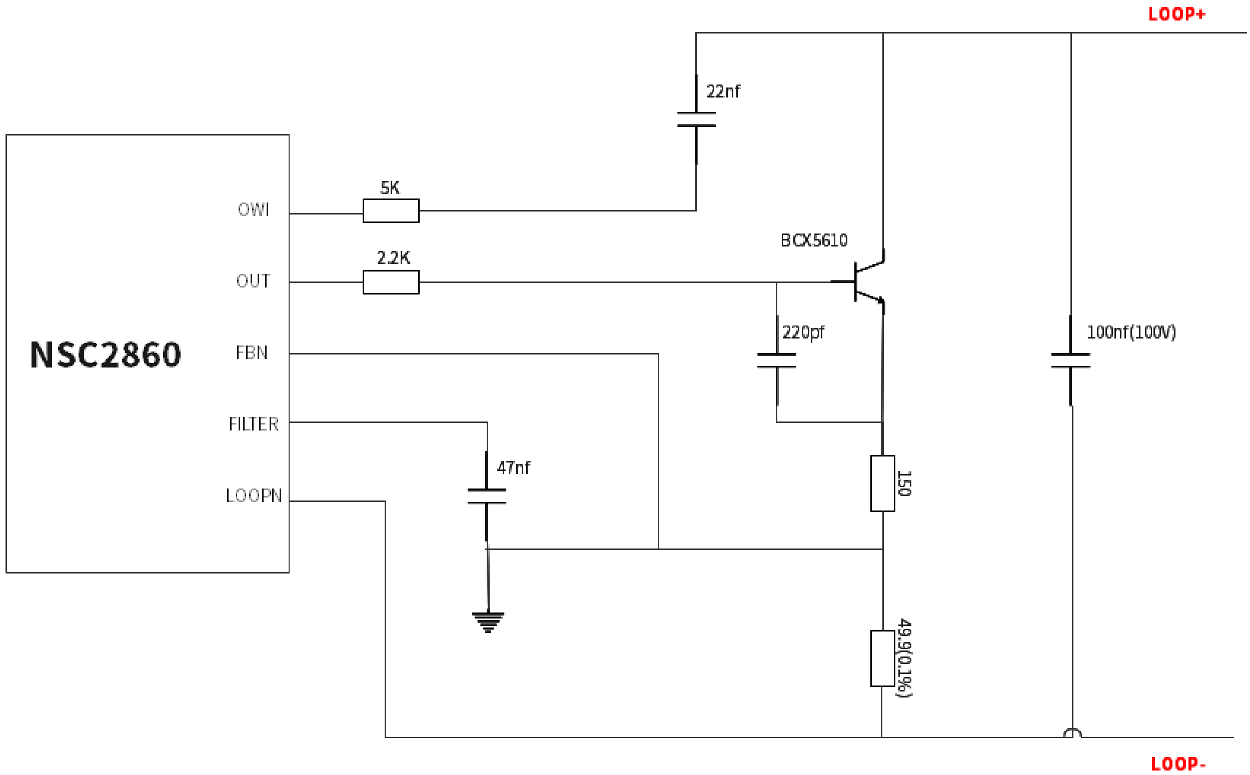

Figure 2. 7 4-20mA Current Output

2.3.2. 0-10V Voltage Output

Figure 2.8 shows the voltage output mode of 0~10V. The signal of 0~5V output by the chip OUT pin is amplified and output 0~10V through the back-end circuit. The ground capacitor on the FILTER pin filters the analog signal output by the DAC, which can reduce the output noise but reduce the signal bandwidth. The 0~10V communication control is similar to the 4~20mA communication control, which is achieved by modulating the power supply signal. The coupling capacitance of 22nF couplings the modulation signal on the power supply to the OWI pin of the chip. OWI signal return is by controlling OUT pin voltage, modulating the power supply current, output digital signal.

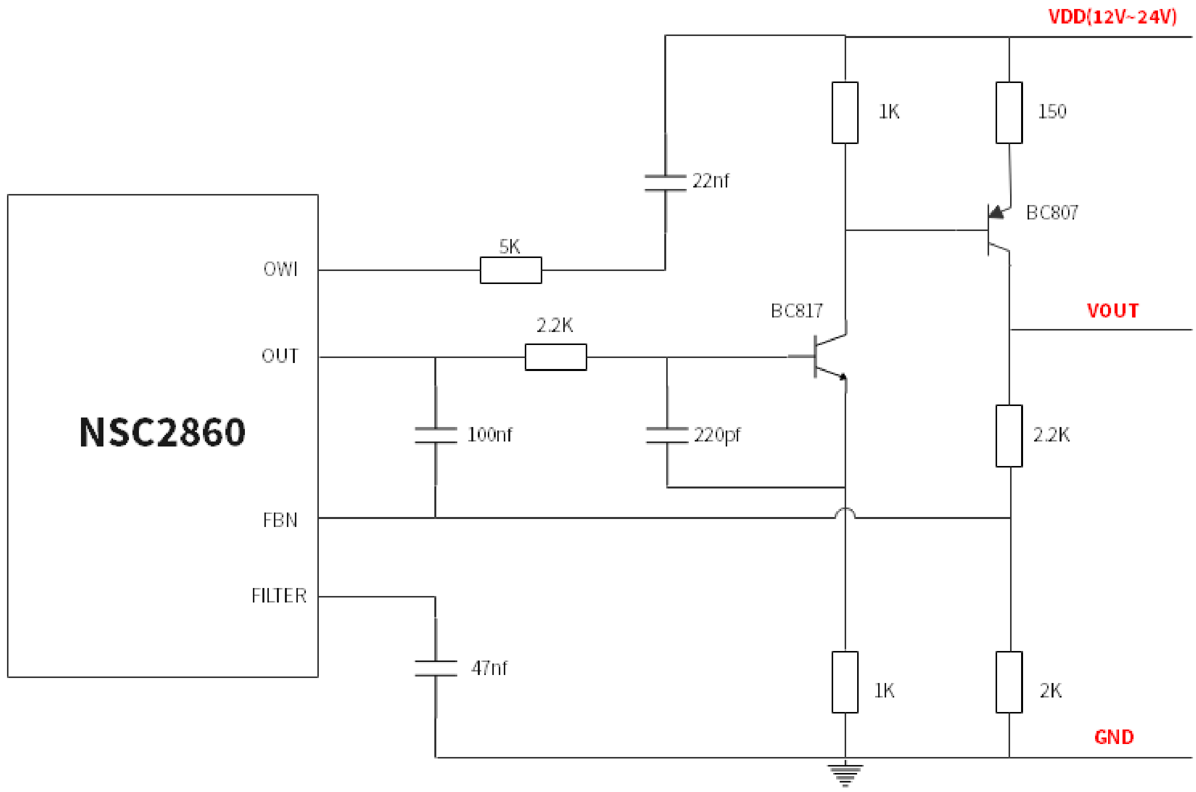

Figure 2.5 Master Reading Pressure Data

Figure 2.9 shows the 0-10V voltage output mode of an operational amplifier. The 0-5V signal output by the chip OUT pin is amplified and output 0-10V through the back-end operational amplifier circuit. The ground capacitor on the FILTER pin filters the analog signal output by the DAC to improve the output performance and reduce the signal bandwidth. The 0~10V communication control is similar to the 4~20mA communication control, which is achieved by modulating the power supply signal. The coupling capacitance of 22nF couplings the modulation signal on the power supply to the OWI pin of the chip. OWI signal return is by controlling OUT pin voltage, modulating the power supply current, output digital signal.

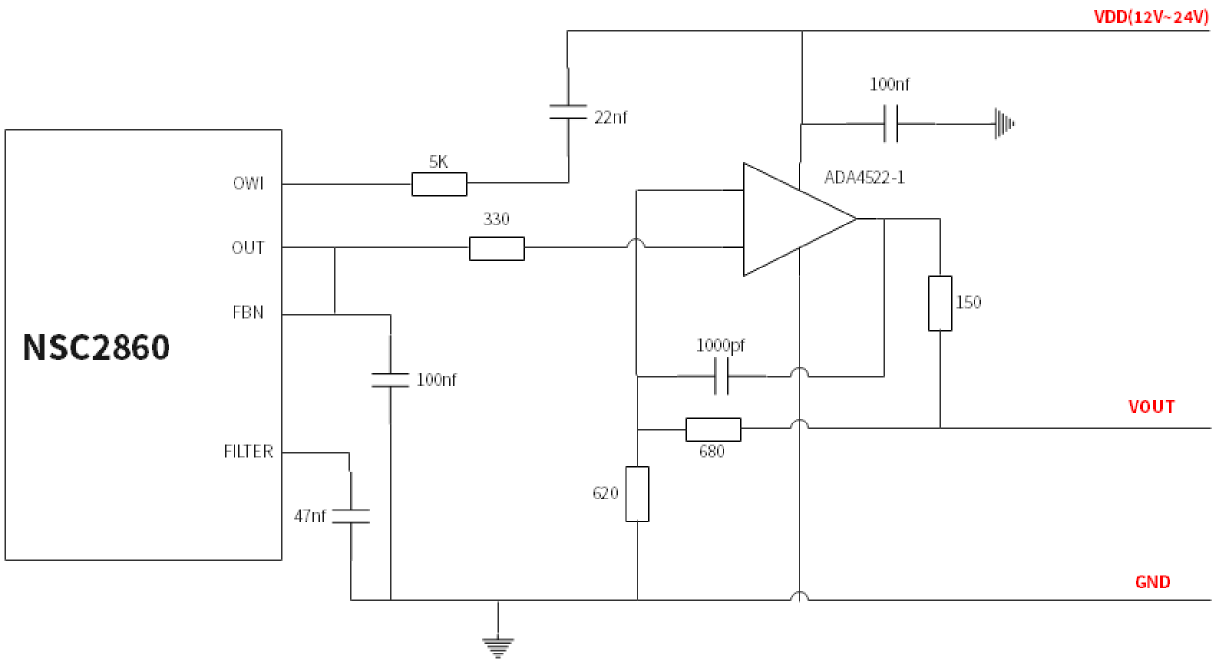

Figure 2. 9 Operating Amplifier 0-10V Voltage Output

2.3.3. 0~5V Voltage Output

Figure 2.10 is the hardware circuit diagram of 0~5V voltage output mode, which is compatible with absolute voltage (0~3.3V, 0~1.2V) output and proportional voltage output (0~AVDD) mode. Three-wire mode can realize communication control and analog output. The 100ohm and 1kohm resistors in the figure protect the pins from high voltage. The 100nF capacitor between VOUT and GND improves the noise resistance of the system and makes the output more stable.

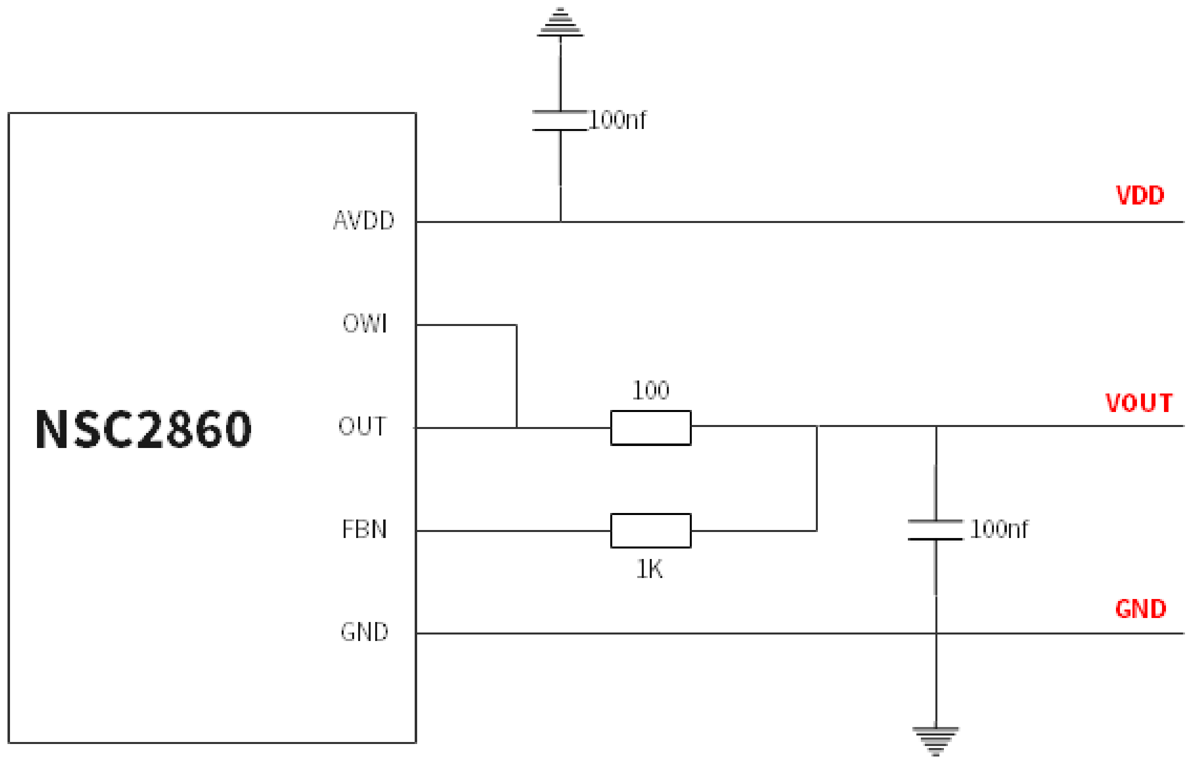

Figure 2. 10 0-5V Voltage Output

2.4.EMC Circuit Schematic

Figure 2.11 shows the complete 4-20mA typical application circuit, including the EMC protection circuit. EMC grade achieved by this circuit:

Table 2. 2 EMC Test Grades

Test Item	Standards	Level
ESD	IEC61000-4-2	±8kV contact; ±15kV air
EFT	IEC61000-4-4	±1kV Class A
Surge	IEC61000-4-5	1kV

Take the circuit in Figure 2.11 as an example to introduce the EMC protection circuit.

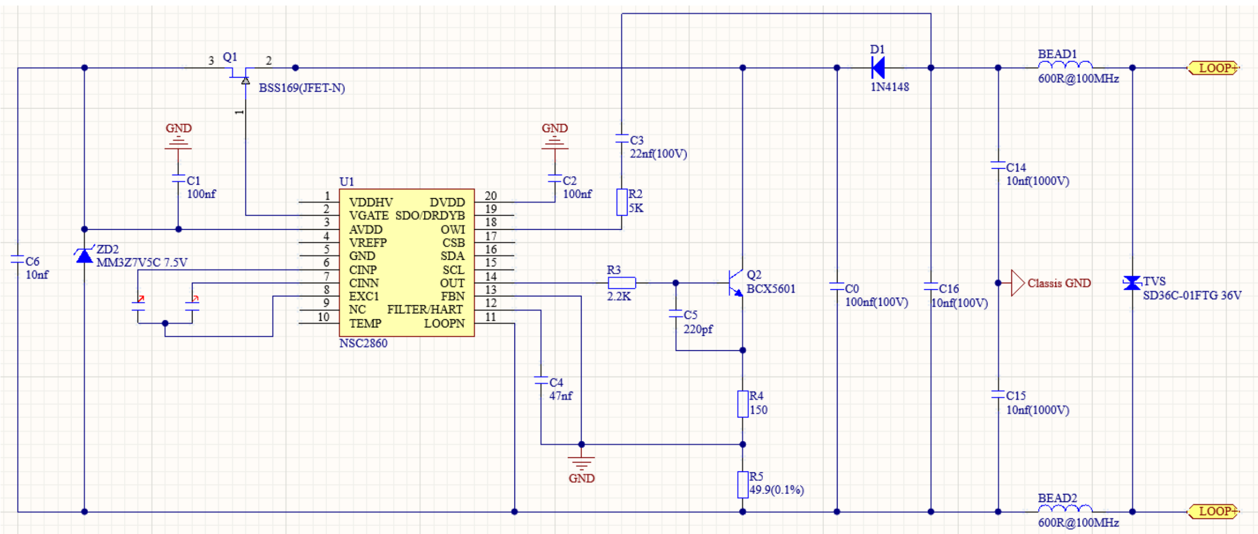

Figure 2. 11 EMC Protection Circuit

2.4.1. Power Protection

In Figure 2.11, D1 is an anti-reverse diode. The recommended model 1N4148 is required to withstand 100V reverse voltage and over 50mA forward current.

Bidirectional transient voltage suppression TVS SD36C and ceramic capacitor C16 protect ESD signals and other transient pulses from overvoltage. If the EMC environment is harsh, higher power TVS can be used.

The two magnetic beads (BEAD1 and BEAD2) on the power supply loop can inhibit the high-frequency signals coupled to the input and output lines to a certain extent. If the application environment has a relatively clear interference in a frequency band, the magnetic beads with high impedance in this band can be consciously selected. This circuit is two-wire communication, if it is three-wire communication (such as 0~10V), all the input and output lines need to be connected with a magnetic bead.

If power is supplied directly to AVDD, MM3Z7V5C is required to prevent the high voltage between AVDD and LOOP- from burning the chip. The voltage between LOOP- and GND is 1.2V at the actual 24mA output.

3.Typical Application Circuit

The difference between Driver Mode and Ground Mode is that the front-end excitation Mode is different, and the power supply circuit, communication circuit and output circuit are consistent. Therefore, the front end of the Driver Mode is used as an example to list typical application circuits commonly used

3.1.Typical Application of 4-20mA

3.1.1. JFET high voltage power supply, Driver mode, using internal temperature sensor

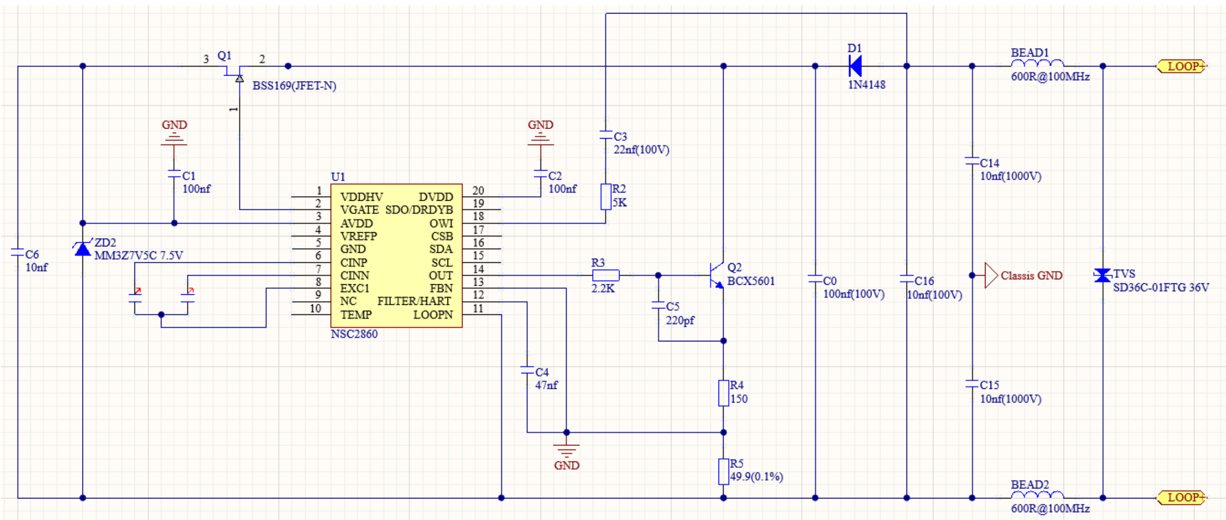

Figure 3.1 4-20mA Typical Application-1

Table 3.1 4-20mA Typical Application-1 Material List

Designator	Comment	Footprint	Value
BEAD1	Inductor	0603	600ohm(100MHz)
BEAD2	Inductor	0603	600ohm(100MHz)
C0	Cap	0603	100nf(100V)
C1	Cap	0603	100nf
C2	Cap	0603	100nf
C3	Cap	0603	22nF(100V)
C4	Cap	0603	47nf
C5	Cap	0603	220pf
C6	Cap	0603	10nf
C14	Cap	1206	10nf(1000V)
C15	Cap	1206	10nf(1000V)
C16	Cap	0603	10nf(100V)
D1	1N4148	SOD323	
Q1	BSS169N(JFET-N)	SOT23	
Q2	BCX5610	SOT89	
R2	Res	0603	5K
R3	Res	0603	2.2K
R4	Res	0603	150
R5	Res	0603	49.9(0.1%)
TVS	SD36C-01FTG	SOD323	36V
U1	NSC2860	NSC2860_TSSOP20	
ZD2	MM3Z7V5C	SOD323	7.5V

3.1.2.Bipolar high voltage power supply,Driver mode , using internal temperature sensor

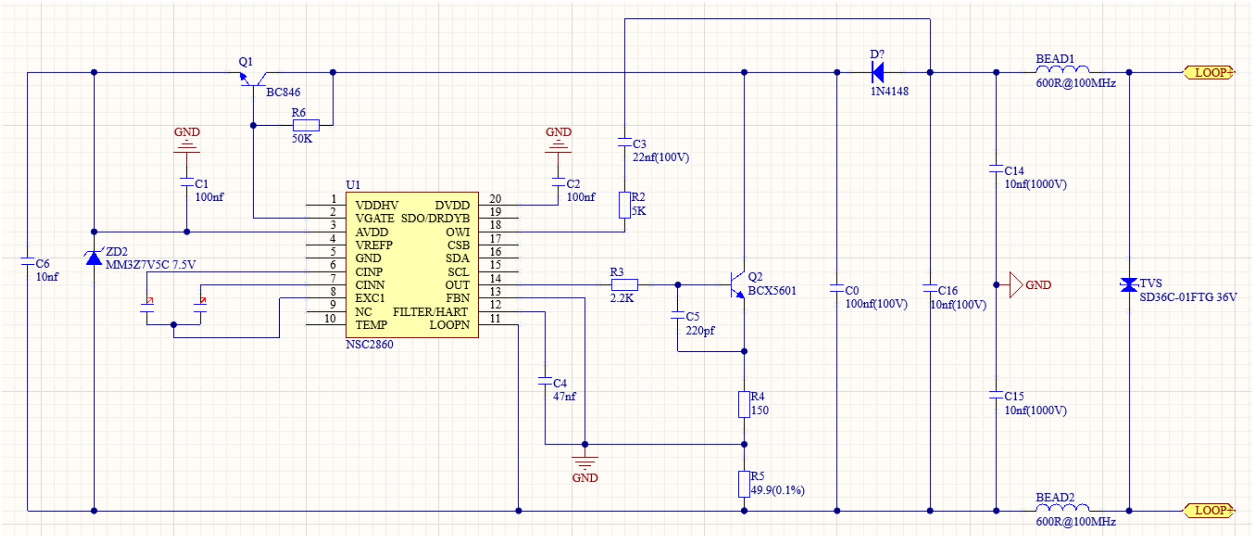

Figure 3.2 4-20mA Typical Application-2

Table 3.2 4-20mA Typical Application-2 Material List

Designator	Comment	Footprint	Value
BEAD1	Inductor	0603	600ohm(100MHz)
BEAD2	Inductor	0603	600ohm(100MHz)
C0	Cap	0603	100nf(100V)
C1	Cap	0603	100nf
C2	Cap	0603	100nf
C3	Cap	0603	22nF(100V)
C4	Cap	0603	47nf
C5	Cap	0603	220pf
C6	Cap	0603	10nf
C14	Cap	1206	10nf(1000V)
C15	Cap	1206	10nf(1000V)
C16	Cap	0603	10nf(100V)
D1	1N4148	SOD323	
Q1	BC846	SOT23	
Q2	BCX5610	SOT89	
R2	Res	0603	5K
R3	Res	0603	2.2K
R4	Res	0603	150
R5	Res	0603	49.9(0.1%)
R6	Res	0603	50K
TVS	SD36C-01FTG	SOD323	36V
U1	NSC2860	NSC2860_TSSOP20	
ZD2	MM3Z7V5C	SOD323	7.5V

3.2.0-10V Typical Application

3.2.1.JEFT high-voltage power supply, Driver mode, using internal temperature sensor

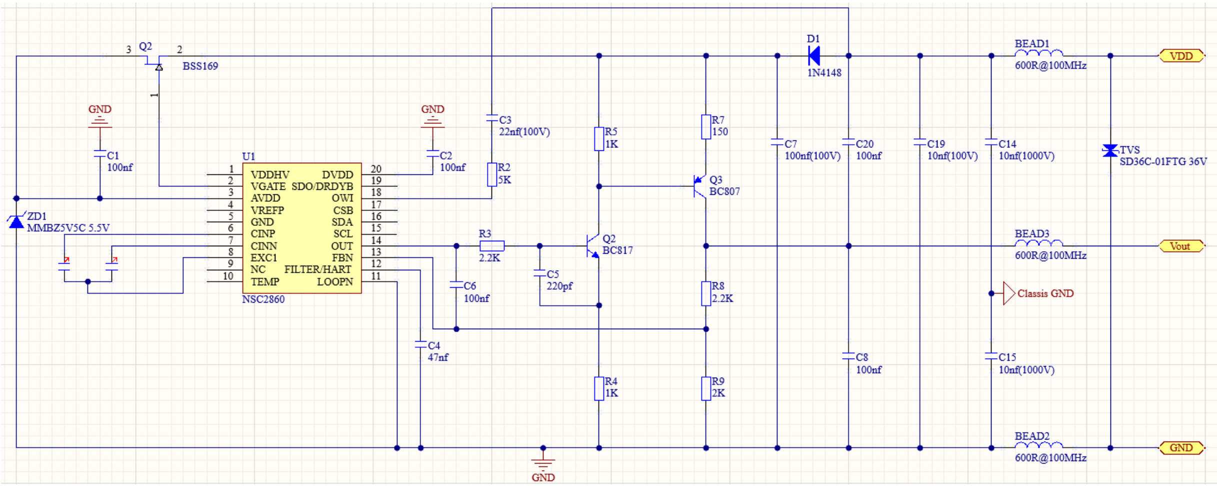

Figure 3.3 0-10V Typical Application-1

Table 3.3 0-10V Typical Application-1 Material List

Designator	Comment	Footprint	Value
BEAD1	Inductor	0603	600ohm(1MHz)
BEAD2	Inductor	0603	600ohm(1MHz)
BEAD3	Inductor	0603	600ohm(1MHz)
C1	Cap	0603	100nf
C2	Cap	0603	100nf
C3	Cap	0603	22nF(100V)
C4	Cap	0603	47nf
C5	Cap	0603	220pf
C6	Cap	0603	100nf
C7	Cap	0603	100nf(100V)
C8	Cap	0603	100nf
C14	Cap	1206	10nf(1000V)
C15	Cap	1206	10nf(1000V)
C19	Cap	0603	10nf(100V)
C20	Cap	0603	100nf
D1	1N4148	SOD323	
Q1	BSS169N(JFET-N)	SOT23	
Q2	BC817	SOT23	
Q3	BC807	SOT23	
R2	Res	0603	5K
R3	Res	0603	2.2K
R4	Res	0603	1K
R5	Res	0603	1K
R7	Res	0603	150
R8	Res	0603	2.2K
R9	Res	0603	2K
TVS	SD36C-01FTG	SOD323	36V
U1	NSC2860	NSC2860_TSSOP20	
ZD1	MM3Z5V5C	SOD323	5.5V

3.2.2.Bipolar high voltage power supply,Driver mode , using internal temperature sensor

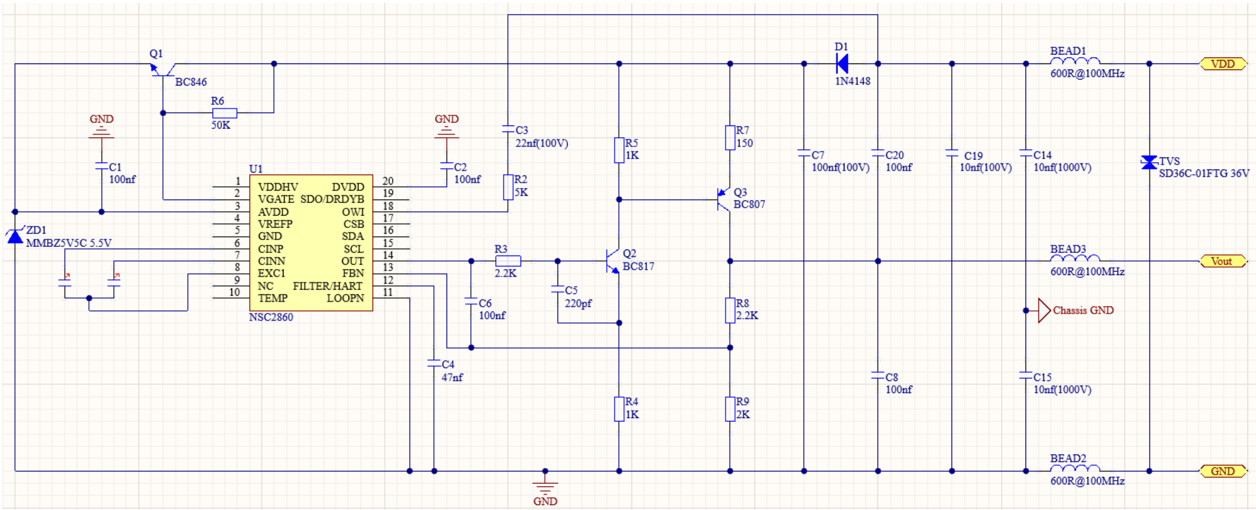

Figure 3.4 0-10V Typical Application-2

Table 3.4 0-10V Typical Application-2 Material List

Designator	Comment	Footprint	Value
BEAD1	Inductor	0603	600ohm(1MHz)
BEAD2	Inductor	0603	600ohm(1MHz)
BEAD3	Inductor	0603	600ohm(1MHz)
C1	Cap	0603	100nf
C2	Cap	0603	100nf
C3	Cap	0603	22nF(100V)
C4	Cap	0603	47nf
C5	Cap	0603	220pf
C6	Cap	0603	100nf
C7	Cap	0603	100nf(100V)
C8	Cap	0603	100nf
C14	Cap	1206	10nf(1000V)
C15	Cap	1206	10nf(1000V)
C19	Cap	0603	10nf(100V)
C20	Cap	0603	100nf
D1	1N4148	SOD323	
Q1	BC846	SOT23	
Q2	BC817	SOT23	
Q3	BC807	SOT23	
R1	Res	0603	1K
R2	Res	0603	5K
R3	Res	0603	2.2K
R4	Res	0603	1K
R5	Res	0603	1K
R7	Res	0603	150
R8	Res	0603	2.2K
R9	Res	0603	2K
TVS	SD36C-01FTG	SOD323	36V
U1	NSC2860	NSC2860_TSSOP20	
ZD1	MM3Z5V5C	SOD323	5.5V

3.2.3.0-10V op-amp output circuit, Bipolar high voltage power supply, Driver mode , using internal temperature sensor

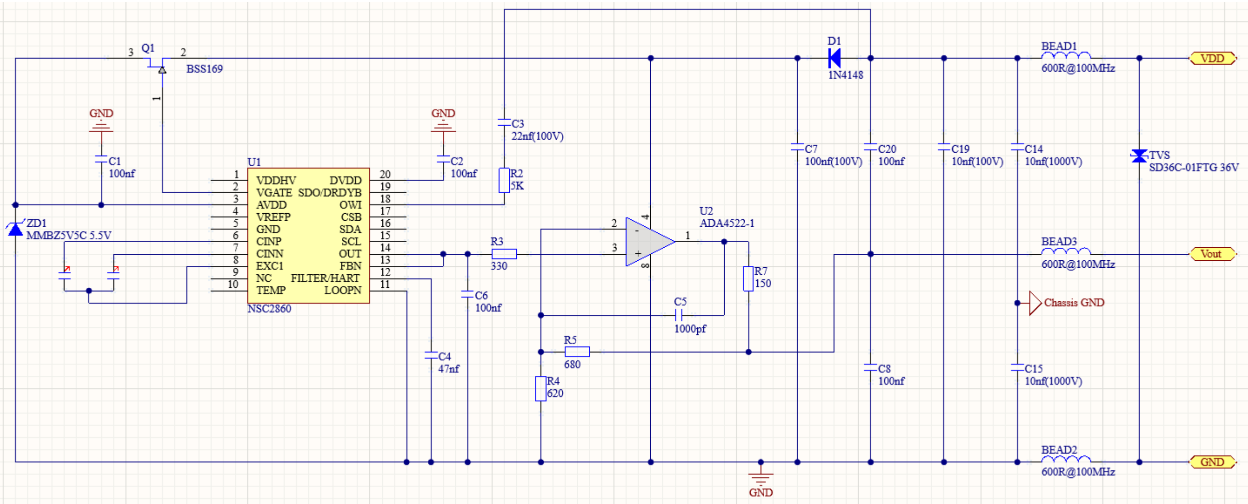

Figure 3.5 0-10V Typical Application-4

Table 3.5 0-10V Typical Application-4 Material List

Designator	Comment	Footprint	Value
BEAD1	Inductor	0603	600ohm(1MHz)
BEAD2	Inductor	0603	600ohm(1MHz)
BEAD3	Inductor	0603	600ohm(1MHz)
C1	Cap	0603	100nf
C2	Cap	0603	100nf
C3	Cap	0603	22nF(100V)
C4	Cap	0603	47nf
C5	Cap	0603	1000pf
C6	Cap	0603	100nf
C7	Cap	0603	100nf(100V)
C8	Cap	0603	100nf
C14	Cap	1206	10nf(1000V)
C15	Cap	1206	10nf(1000V)
C19	Cap	0603	10nf(100V)
C20	Cap	0603	100nf
D1	1N4148	SOD323	
Q1	BSS169N(JFET-N)	SOT23	
R2	Res	0603	5K
R3	Res	0603	330
R4	Res	0603	620
R5	Res	0603	680
R7	Res	0603	150
TVS	SD36C-01FTG	SOD323	36V
U1	NSC2860	NSC2860_SSOP16	
U2	ADA4522-1	MSOP	
ZD1	MM3Z5V5C	SOD323	5.5V

3.3.0-5V Typical Application

3.3.1.Directly power supply ,Driver mode ,internal temperature sensor

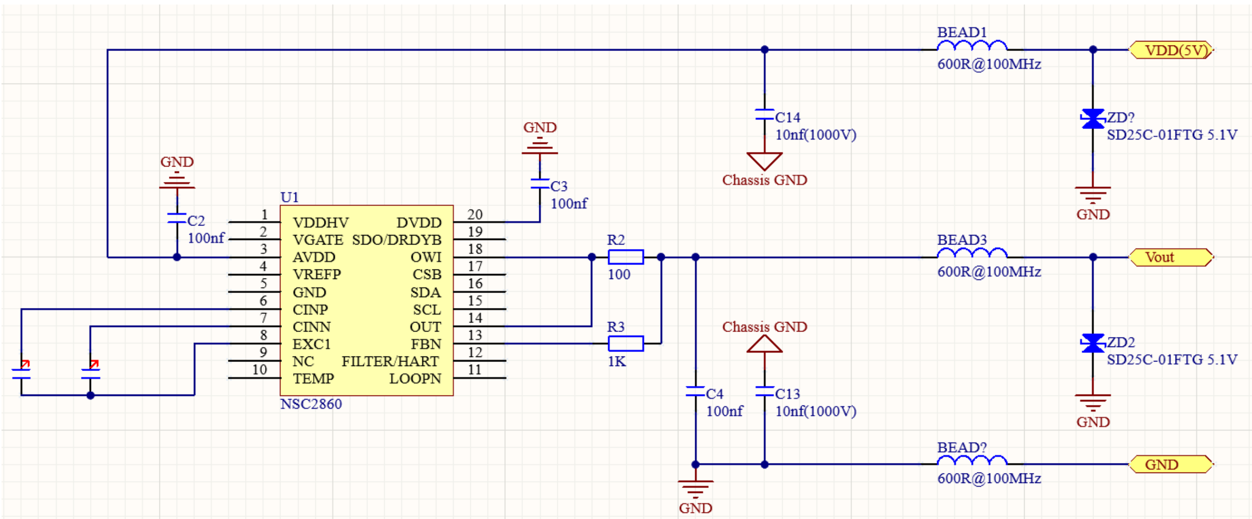

Figure 3.6 0-5V Typical Application-1

Table 3.6 0-5V Typical Application-1 Material List

Designator	Comment	Footprint	Value
BEAD1	Inductor	0603	600ohm(100MHz)
BEAD2	Inductor	0603	600ohm(100MHz)
BEAD3	Inductor	0603	600ohm(100MHz)
C2	Cap	0603	100nf
C3	Cap	0603	100nf
C4	Cap	0603	100nf
C13	Cap	1206	10nf(1000V)
C14	Cap	1206	10nf(1000V)
R2	Res	0603	100
R3	Res	0603	1K
U1	NSC2860	NSC2860_TSSOP20	
ZD1	SD05C-01FTG		5.1V
ZD2	SD05C-01FTG		5.1V

3.3.2.High voltage power Supply 0-5V output circuit, Driver mode, internal temperature sensor

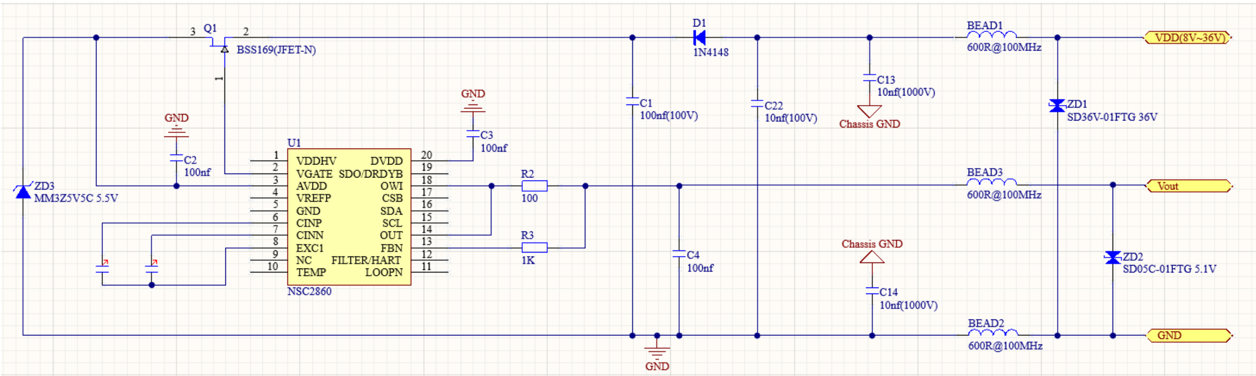

Figure 3.7 0-5V Typical Application-2

Table 3.7 0-5V Typical Application-2 Material List

Designator	Comment	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
C13	Cap	1206	10nf(1000V)
C14	Cap	1206	10nf(1000V)
C22	Cap	0603	10nf(100V)
D1	1N4148	SOD323	
Q1	BSS169N(JFET-N)	SOD23	
R2	Res	0603	100
R3	Res	0603	1V
U1	NSC2860	NSC2860_TSSOP20	
ZD1	SD36C-01FTG	SOD323	36K
ZD2	SD05C-01FTG	SOD323	5.1V
ZD3	MM3Z5V5C	SOD323	

4.Revision History

Revision	Description	Author	Date
1.0	Initial Version	Weijie Zhou	2023/09/15