How to connect the strain gauge force sensor

A standard strain gauge force or torque sensor is connected as an electrical resistance bridge (Wheatstone bridge). A simplified circuit diagram is shown in Fig. 1, resistors R1 ... R4 represent strain gauges. The Exc+ and Exc- terminals receive the excitation voltage (positive voltage for terminal Exc+, negative voltage for terminal Exc-), the output voltage is drawn at the terminals Sig+ and Sig-. What is important here is the difference of these voltages Us = (Sig+ – Sig-), not their absolute value. However, the sensor can also be supplied with AC voltage, and then the polarity of the Exc+ and Exc- terminals does not matter.

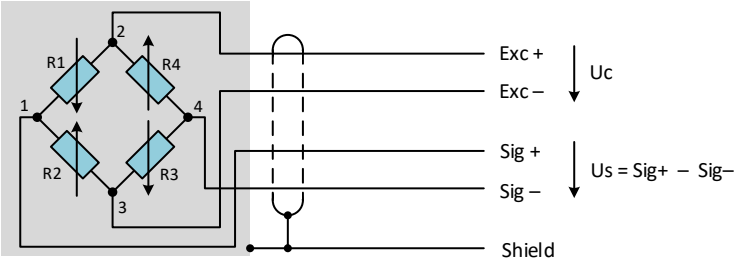


Fig. 1. Electrical connection of strain gauge force sensor

The sensor is designed in such a way that the opposing resistors change equally under mechanical load, i.e. they either increase or decrease. Suppose e.g. that when the sensor is loaded in the compression direction, resistors R1 and R3 will decrease and resistors R2 and R4 will increase. In this case, the voltage in node 1 will increase (compared to node 3) and in node 4 will decrease. The output voltage of the Us sensor will rise. When loaded in the tension direction, the ratios reverse, the voltage will drop. The characteristic is shown in Fig. 2 (Fn is nominal force, Cn is nominal sensor sensitivity).

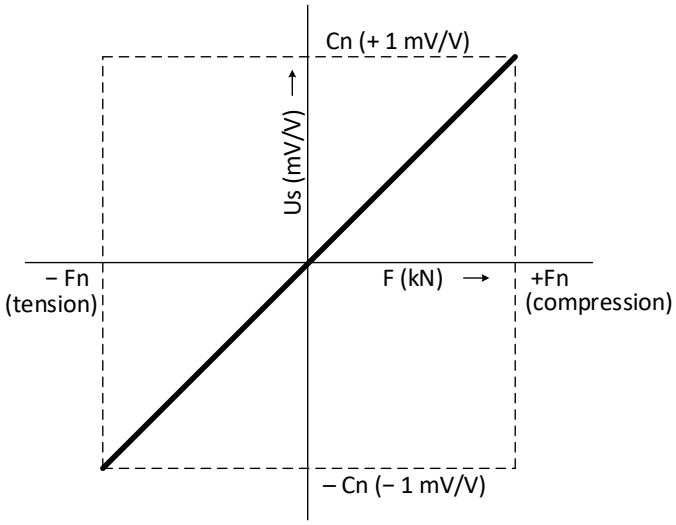


Fig. 2. Output sensor characteristic

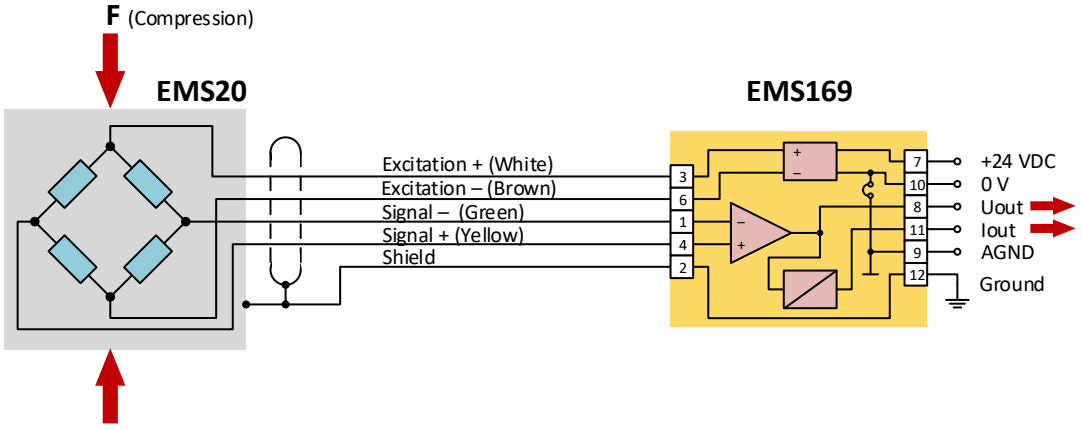
All EMSYST strain gauges force sensors are designed so that when the load is applied in the direction of COMPRESSION, the voltage Us increases, and when the load is applied in the direction of TENSION, the voltage Us decreases (Fig. 2). The force in the COMPRESSION direction is considered positive, in the TENSION direction is negative.

This must be taken into account when connecting the sensor. Usually the sensor is connected to a display or control unit (PC, PLC, panel display, etc.) which has a factory-defined input. The input is either voltage or current and can handle either one (usually positive) or both (positive and negative) polarity of signals. A problem may occur if e.g. the sensor is loaded under tension, i.e. it outputs a negative voltage, while the input of the electronic unit can only handle the positive voltage. If this happens, the signal wires must be reversed.

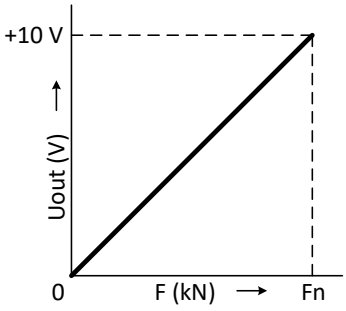
Below are the most commonly used sensor wirings with signal conditioner. As an example, the EMS20 sensor can be used (it can work in tension and compression) and the EMS169 converter. Refer to the signal conditioner documentation for details on the settings.

1. The sensor is loaded in the COMPRESSION direction, a positive output voltage is required 0...+10 V (or current 4...20 mA)

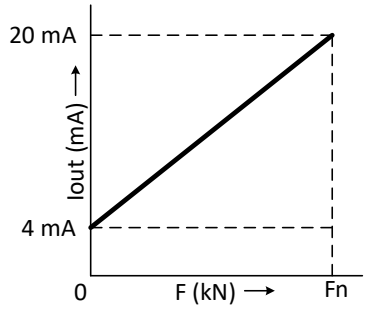
This is a standard wiring. With a compression load in the range of 0 ... Fn, the sensor output is 0 ... 10.5 mV (the sensor sensitivity is 1.5 mV/V, the signal conditioner EMS169 excitation voltage is 7 V, therefore it outputs 1.5 * 7 = 10.5 mV at nominal load). The EMS169 is configured in range -10 ... +10 V, however, since input is only positive voltage, there will also be only positive voltage in the range 0 ... +10 V in output. With this configuration, the current output provides a current in the range of 4 ... 20 mA.



Wiring diagram



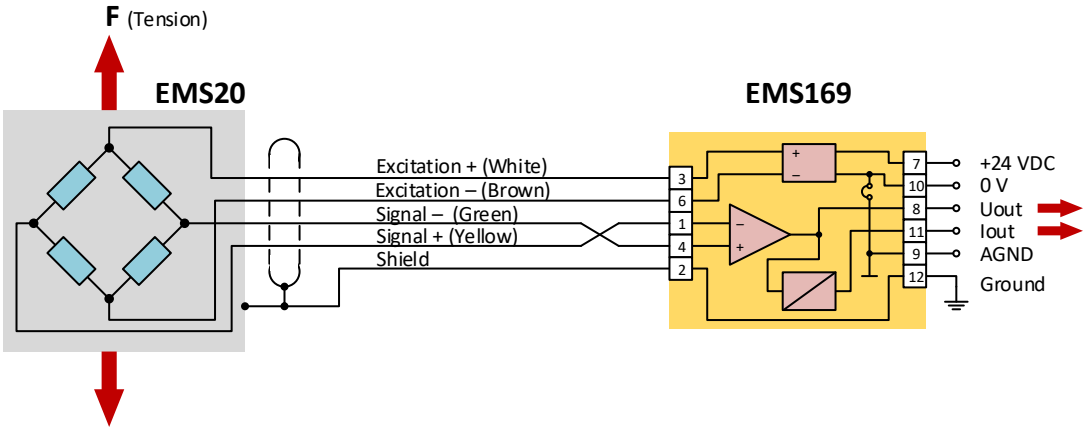
Voltage output characteristic



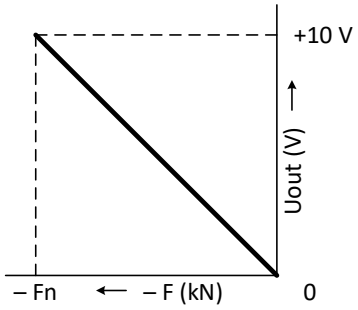
Current output characteristic

2. The sensor is loaded in the TENSION direction, a positive output voltage 0 ... +10 V (or current 4 ... 20 mA) is required

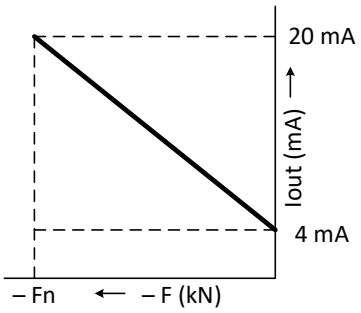
Since the sensor is loaded in the tension direction, it outputs a negative voltage in the range of 0 ... - 10.5 mV. In order to get a positive voltage at the output of the signal conditioner, the signal inputs must be reversed - see wiring diagram.



Wiring diagram



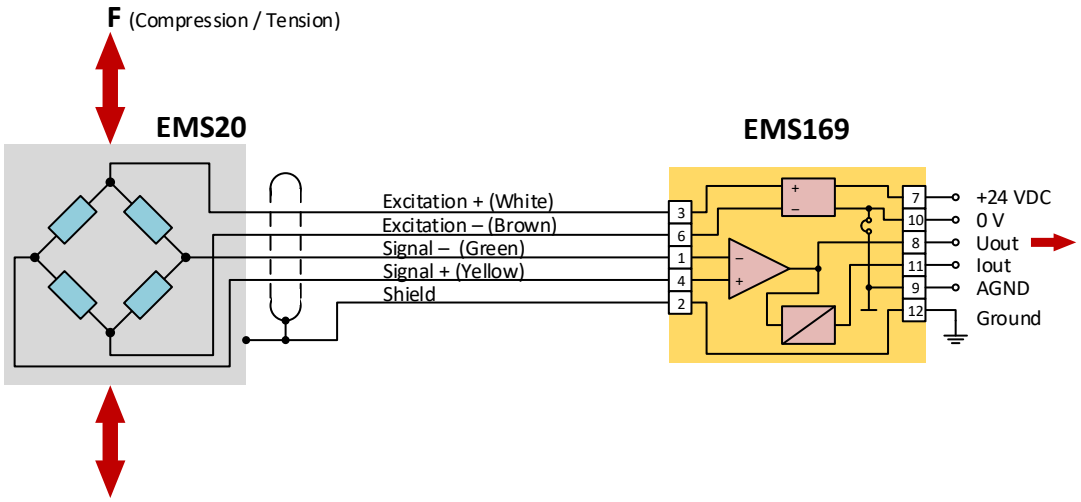
Voltage output characteristic



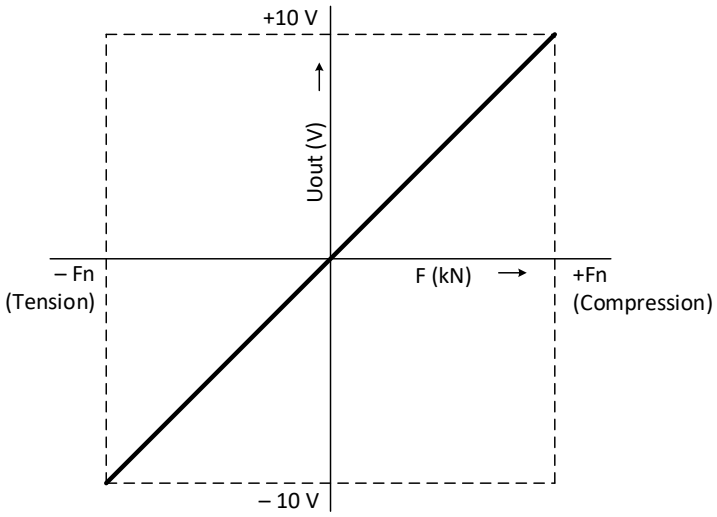
Current output characteristic

3. The sensor is loaded alternately in the COMPRESSION and TENSION directions, +10 V ... 0 ... -10 V output is required

The wiring diagram is the same as in the first case. Since the EMS169 processes both polarity signals at the input, a positive voltage is also output at the positive input voltage and a negative voltage at the negative input voltage. However, the current output does not work in the negative area and therefore cannot be used in this case.



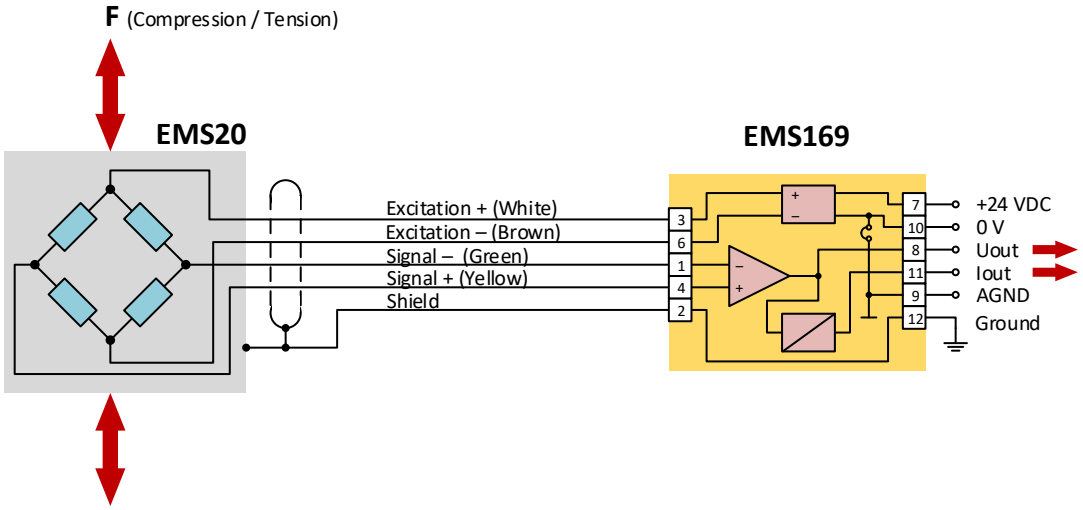
Wiring diagram



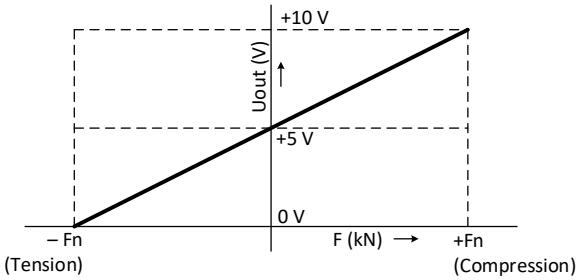
Output characteristic (voltage)

4. The sensor is loaded in COMPRESSION and TENSION directions, only positive output 0 ... +10 V (current 4 ... 20 mA) is required

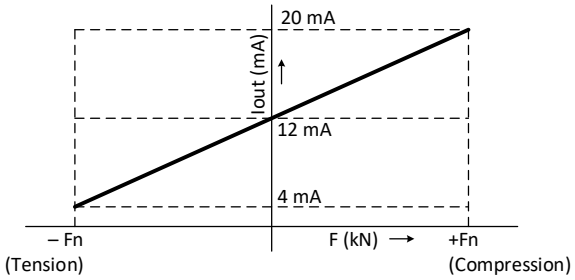
This case occurs when the sensor is loaded in both directions but the input of the electronic unit, e.g. the ADC can only process positive voltage (current). The problem can be solved by reducing the gain of the EMS169 signal conditioner so that the input voltage (sensor output) 0 ... ± 10.5 mV corresponds to the output 0 ... ± 5 V. At the same time, the signal conditioner offset is shifted to +5 V. With this configuration, it will output +5 V at zero load. Under load in compression direction the voltage will rise up to +10 V, under load in tension direction it will decrease to 0 V. Similarly, the current output will be shifted to 12 ± 8 mA.



Wiring diagram



Voltage output characteristic



Current output characteristic