

What is a Strain Gage?

Strain gages measure the tension or compression (strain) in the surface of a substance. Common gages employ various metal alloys printed onto a flexible substrate. When the gage is deformed, its resistance changes in a predictable way as described by its *gage factor*. When you bond the gage to structure, you can quantify the strain and/or stress in that component.

What is Strain?

Strain is defined as the *change in length divided by the original length*, often expressed in *millionths* of an inch per inch, or microstrain (μS). If you have a 1" cube of aluminum and you subject it to a compressive force that causes the cube to compress 1/1000 of an inch, that cube experienced 1000 μS (0.001"/1.000"). Various materials will tolerate different strain levels before yield or failure occurs.

Sometimes it makes sense to convert strain gage output to stress readings. Simply stated, stress is the *force per unit area*, often expressed in pounds per square inch (PSI). Since metals typically have strengths in the tens of thousands of PSI, it is common to record data with KPSI units.

Key Variables

Gage factor relates the change in length of a strain gage to its change in resistance. This is important because you must convert the change in resistance to a scale factor that makes sense, either in μS , KPSI, or some other engineering unit.

$$\text{Gage Factor} = (\Delta R/R) \div (\Delta L/L), \text{ where } R = 350\Omega \text{ for a typical gage}$$

Sensitivity for the DAS must be determined by calculating the expected output of a strain gage bridge for a given strain condition.

Example: 350 Ω gage with a gage factor of 2.08. What is the sensitivity in μS for TDAS?

Using **2.08 = $(\Delta R/R) \div (\Delta L/L)$** , calculate how much resistance change will occur per μS .

- $2.08 = (\Delta R/350) \div (1/1,000,000)$
- $(\Delta R/350) = 2.08(1/1,000,000)$, or $(\Delta R/350) = 2.08 \times 10^{-6}$
- $\Delta R = 350(2.08 \times 10^{-6}) = 7.28 \times 10^{-4} \Omega$**
- This means that 1 μS will cause the resistance of the gage to change **0.000728 Ω**

Since most single gages are part of a balanced bridge, you use Ohm's law to determine how much bridge output there will be, and hence the sensitivity for the DAS.

$$0.5 - [350 \div (350 + (350 + \mathbf{0.000728}))] = 5.2 \times 10^{-7} \text{ V/V}/\mu\text{S}, \text{ or } \mathbf{0.00052 \text{ mV/V}/\mu\text{S}}$$

What is a Strain Gage?

SENSOR INFORMATION FILE [Load New Sensor] [SAVE] [CANCEL]

SENSOR S/N: Strain Gage

SENSOR TYPE: Full Bridge Half Bridge

USE SHUNT CAL: Yes No

OUTPUT PROP TO EXC: Yes No

INITIAL ENGINEERING UNIT VALUE: 0.000 [EDIT]

Eng. Units: Value during PreCAL: [] Avg. value over time: []

Recorded as: Equals 0 mV Start Time: -0.030 End Time: -0.010

CHANNEL DESCRIPTION: Sample Strain Gage - Gage Factor 2.08

ANTI-ALIAS FILTER (HZ): 4300 8 Pole [] 0 5 Pole [] BYPASS

GAIN: 144.0

Voltage Insertion Cal (mV): 24.306

Excitation Voltage: 10.0

Offset Configuration: Tolerance (mV): 100 High [] -100 Low [] Remove Offset? Yes No

Shunt Resistor Emulation Bridge Res.: 350.000

A/D CONV RATE (HZ): 0

SENSITIVITY (mV/V/EngUnit): 0.00052000

INVERT DATA: No Yes

SOFTWARE FILTER: 300

SAE Class 1000 SAE Class 600 SAE Class 180 SAE Class 60 Select Custom

DESIRED MAX RANGE: 5000.00

ACTUAL MAX RANGE: 6677.35

Engineering Units: uS

Last Calibration Date: M 2 D 26 Y 2002

Sensor ID: READ ID NONE

[PRINT SCREEN]

(Note: This screen may look slightly different in various software versions.)

Stress. If you want to convert the sensitivity into units of stress (i.e., PSI), you must use the modulus of elasticity (E) of the material that you are putting the strain gages on. The E factor relates applied stress to expected strain for a given material. For aluminum, the E number below means that 10,000,000 pounds applied to a 1" cube (one square inch of force area) would produce 1,000,000 μ S, or a strain of 1.

Two of the more common E values are:

- 10,000,000 PSI for aluminum (nominal)
- 30,000,000 PSI for steel (nominal)

A strain of 1,000,000 μ S is not possible. Real-world values are in the hundreds or thousands of μ S.