What is a Strain Gage?

Strain gages measure the tension or compression (strain) in the surface of a sub-stance. 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.

Gage Factor = $(\Delta R/R) \div (\Delta L/L)$, where R = 350Ω 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.

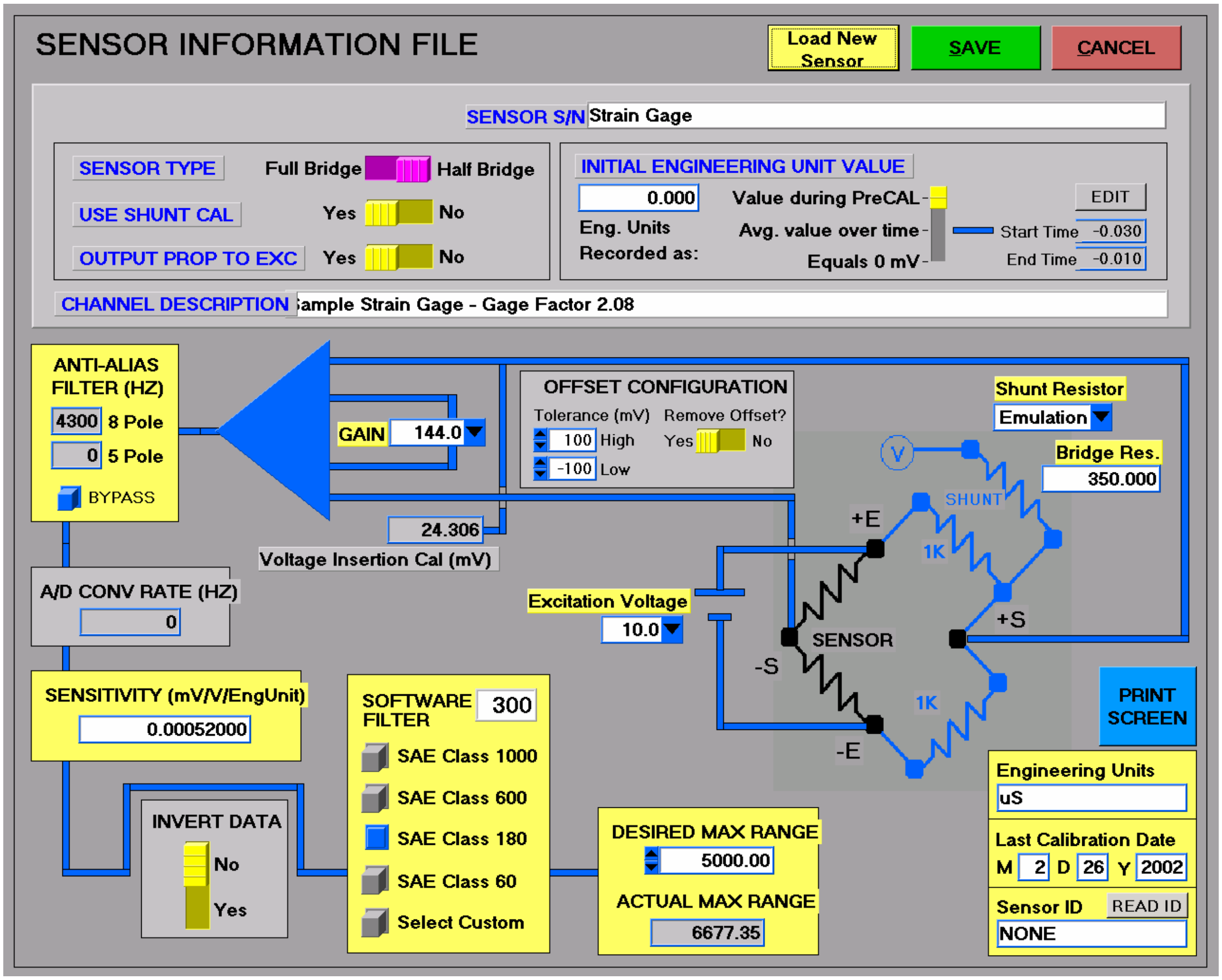
Example: 350Ω gage with a gage factor of 2.08. What is the sensitivity in μS for TDAS?

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

a. $2.08 = (\Delta R/350) \div (1/1{,}000{,}000)$
b. $(\Delta R/350) = 2.08(1/1{,}000{,}000)$, or $(\Delta R/350) = 2.08X10^{-6}$
c. **$\Delta R = 350(2.08X10^{-6})$** $= 7.28X10^{-4}\ \Omega$
   - This means that 1 μS will cause the resistance of the gage to change **0.000728Ω**

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.

$$0.5 - [350 \div (350 + (350 + \mathbf{0.000728}))] = 5.2X10^{-7}\ V/V/\mu S, \text{ or } \mathbf{0.00052\ mV/V/\mu S}$$



(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 µS, 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 µS is not possible. Real-world values are in the hundreds or thousands of µS.