FlexiForce™

Single Serial Button (SSB)

User's Guide

INTRODUCTION

This manual describes how to use FlexiForce's Single Serial Button (SSB). These sensors are ideal for designers, engineers and researchers who need to measure forces without disturbing the dynamics of their test. The FlexiForce sensors can be used to measure both static and dynamic forces (up to 1000 lbf), and are thin enough to enable non-intrusive measurement.

SSB sensors use a resistive-based technology. The application of a force to an active sensor results in a change in the resistance of the sensing element in inverse proportion to the force applied.

OVERVIEW

Sensor Construction

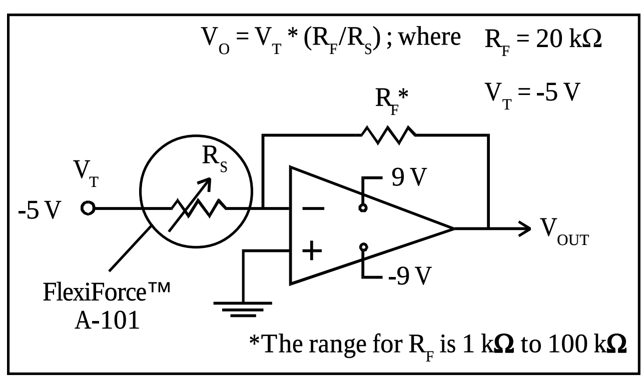
The SSB sensor is an ultra-thin (0.005"), flexible printed circuit. It is 0.55" (14 mm.) wide and 8" (203 mm.) in length, from the end of the connector to the tip of the sensor. Sensors are available with specificied maximum forces of 1, 25, 100, 500, and 1000 lbf*. The *active sensing area* is a 0.375" diameter circle at the end of the sensor. The sensors are constructed of two layers of substrate, such as a polyester film. On each layer, a conductive material (silver) is applied, followed by a layer of pressure-sensitive ink. Adhesive is then used to laminate the two layers of substrate together to form the sensor. The '*active sensing area*' is defined by the silver circle on top of the pressure-sensitive ink. Silver extends from the sensing area to the connectors at the other end of the sensor, forming the conductive leads. SSB sensors are terminated with a 3-pin Berg Clincher™ connector, which allows them to be incorporated into a circuit. The two outer pins of the connector are active and the center pin is inactive.

Application

The sensor acts as a resistor in an electrical circuit. When the sensor is unloaded, it's resistance is very high. When a force is applied to the sensor, this resistance decreases. This resistance can be read by connecting an ohmmeter to the outer two pins of the sensor connector and applying a force to the sensing area.

There are many ways to integrate the SSB sensor into an application. One way is to incorporate it into a force-to-voltage circuit. A means of calibration must then be established to convert the output into the appropriate engineering units. Depending on the setup, an adjustment could then be done to increase or decrease the sensitivity of the sensor.

An example circuit is shown to the right. In this case, it is driven by a 5 V DC excitation voltage. This circuit uses an operational amplifier arrangement to produce an analog output based on the sensor resistance and a fixed reference resistance. An analog-to-digital converter can be used to change this voltage to a digital output. In this circuit, the sensitivity of the sensor could be adjusted by changing the reference resistance (R_F); a lower reference resistance will make the sensor less sensitive, and increase it's active force range.



* When used in a circuit with a 20kΩ reference resistance. The dynamic force range of the sensor can be adjusted by changing this resistance (refer to the 'Saturation' section)

SENSOR LOADING CONSIDERATIONS

The following general sensor loading guidelines can be applied to almost any application, and will help you achieve the most accurate results from your tests. It is important that you read the '*Sensor Performance Characteristics*' section for further information on how to get the most accurate results from your sensor readings.

Sensor Loading

The entire 'sensing area' of the FlexiForce sensor is treated as a single contact point. For this reason, the applied load should be distributed evenly across the sensing area to ensure accurate and repeatable force readings. Readings may vary slightly if the load distribution changes over the sensing area. **Note that the 'sensing area' is the silver circle on the top of the sensor only.** It is also important that the sensor be loaded consistently, or in the same way each time.

If the footprint of the applied load is smaller than the sensing area, the load should not be placed near the edges of the sensing area, to ensure an even load distribution. **It is also important to ensure that the entire load path is through the sensing area, and that the load is not supported by the area outside of the sensing area.** If the footprint of the applied load is larger than the sensing area, it may be necessary to use a 'puck'. A 'puck' is a piece of rigid material (smaller than the sensing area) that is placed on the sensing area to ensure that the entire load path goes through this area. The 'puck' must not touch any of the edges of the sensing area, or these edges may support some of the load, and give an erroneous reading.

The FlexiForce sensor is intended for reading forces that are perpendicular to the sensor plane. Applications that require measuring *shear* forces are not recommended, and will reduce the life and consistency of the sensor. If the application will impart a *shear* force onto the sensor, it should be protected by covering it with a more resilient material.

Saturation

The *saturation* force is the point at which the sensor output resistance no longer varies with applied force. The *saturation* force of each sensor is the maximum application force specified by Tekscan, and this value (1, 25, 100, 500, or 1000 lbf) is printed on the system packaging or the actual sensor. In the example circuit in the 'Application' section, the saturation force (maximum force) of each sensor is related to the R_F (reference resistance), and can be altered by changing the *sensitivity*. The sensitivity of the sensor would be adjusted by changing the reference resistance (R_F); a lower reference resistance will make the system less sensitive, and increase it's active force range. ***It is important that the sensor does not become saturated during testing.***

Conditioning

Exercising, or *Conditioning* a sensor before testing is essential to acheiving accurate results. It helps to lessen the effects of drift and hysteresis, which are defined in 'Sensor Performance Characteristics'. *Conditioning* is required for new sensors, and for sensors that have not been used for a length of time.

To *condition* a sensor, place 110% of the test weight on the sensor, allow the sensor to stabilize, then remove the weight. Repeat this process four or five times. The interface between the sensor and the test subject material should be the same during conditioning as during testing.

IMPORTANT! Sensors must be properly conditioned prior to calibration and use.

Calibration

Calibration is the method by which the sensor's electrical output is related to an engineering unit, such as pounds or Newtons. To calibrate a sensor, simply apply a known force to the sensor, and equate the sensor output to this force. Repeat this step with a number of known forces, that approximate the load range to be used in testing. A linear interpolation can then be done between zero load and the known calibration loads, to determine the actual force range that matches the sensor output range.

The following guidelines should be considered when calibrating a sensor:

- Apply a calibration load that approximates the load to be applied during system use, using *dead weights* or a *testing device* (such as an MTS™ or Instron™).
- Avoid loading the sensor to near saturation when calibrating. If the sensor saturates at a lower load than desired, adjust the Sensitivity.
- Distribute the applied load evenly across the sensing area to ensure accurate force readings. Readings may vary slightly if the load distribution changes over the sensing area.
- Follow the guidelines in the 'Sensor Loading' section, concerning load distribution, when calibrating the sensor.

SENSOR PERFORMANCE CHARACTERISTICS

There are a number of characteristics of sensors which can effect your results. The following is a description of each of these conditions, and recommendations on how to lessen their effects.

Repeatability

Repeatability is the ability of the sensor to respond in the same way to a repeatedly applied force. As with most measurement devices, it is customary to exercise, or "condition" a sensor before calibrating it or using it for measurement. This is done to reduce the amount of change in the sensor response due to repeated loading and unloading. FlexiForce sensors are generally repeatable within 2.5% once they have been conditioned. A sensor is conditioned by loading it to 110% of the test weight four or five times. Follow the full procedure in the 'Conditioning Sensors' section.

Linearity

Linearity refers to the sensor's response to the applied load, over the range of the sensor. This response should ideally be linear; and any non-linearity of the sensor is the amount that it's output deviates from this line. FlexiForce sensors are linear within +/-5%.

Hysteresis

Hysteresis is the difference in the sensor output response during loading and unloading, at the same force. For static forces, and applications in which force is only increased, and not decreased, the effects of *hysteresis* are minimal. If an application includes load decreases, as well as increases, there may be error introduced by *hysteresis* that is not accounted for by calibration. For a conditioned sensor, with 50% of the full force range applied, *hysteresis* is less than 4.5 % of full scale.

Drift

Drift is the change in sensor output when a constant force is applied over a period of time. If the sensor is kept under a constant load, the resistance of the sensor will continually decrease, and the output will gradually increase. In FlexiForce sensors, drift is less than 3%/logarithmic time.

Temperature Sensitivity

To ensure accuracy, calibrate the sensor at the temperature at which it will be used in the application. The operating range for FlexiForce sensors is from 15°F (-9°C) to 140°F (60°C). FlexiForce sensor output may vary up to 0.2% per degree F (approx. 0.36% per degree C). For loads of less than 10 lb., the operating temperature can be increased to 165°F (74°C).

Sensor Life / Durability

Sensor life depends on the application in which it is used. Sensors are reusable, unless used in applications in which they are subjected to severe conditions, such as against sharp edges, or shear forces.

Rough handling of a sensor will also shorten its useful life. For example, a sensor that is repeatedly installed in a flanged joint will have a shorter life than a sensor installed in the same joint once and used to monitor loads over a prolonged period. After each installation, visually inspect your sensors for physical damage.

It is also important to keep the sensing area of the sensor clean. Any deposits on this area will create uneven loading, and will cause saturation to occur at lower applied forces.

GETTING ASSISTANCE

FlexiForce™, Inc. will provide technical assistance for any difficulties you may experience using your *Single Serial Button (SSB).* Write, call or fax us with any concerns or questions. Our knowledgeable support staff will be happy to help you. Comments and suggestions are always welcome. Custom sensor designs are available.

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