Best Practices in **Electrical Integration** of the FlexiForce™ Sensor

Thin, customizable FlexiForce sensors measure normal compressive forces in your device. While every application is unique, there are some universal considerations and general best practices to consider to achieve optimal performance of the FlexiForce™ sensor in your application.

This document is intended to illustrate electrical design concepts to consider while integrating FlexiForce sensors into a product or device. Refer to the "FlexiForce Integration Guide" for more detailed information, and contact Tekscan for recommendations on electrical design specific to your application.

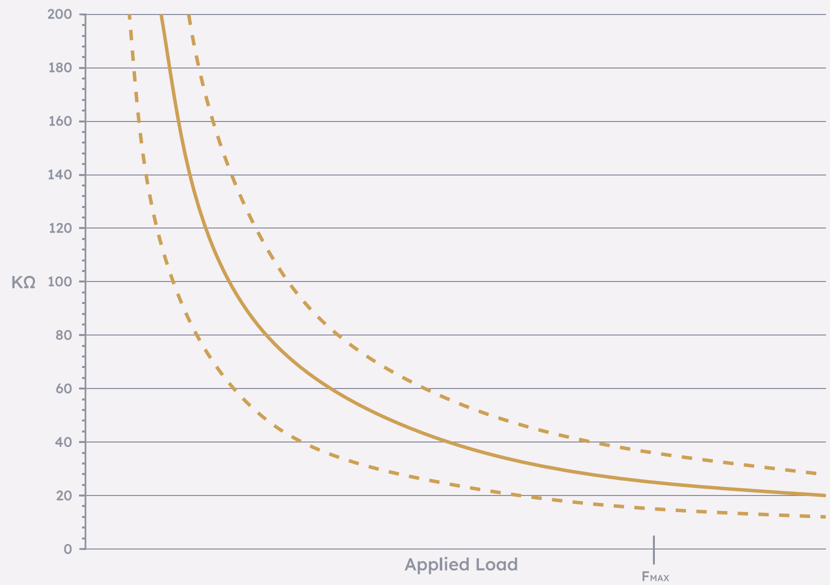
Note: The specific circuits in this document are not the only circuit designs that can be used with FlexiForce sensors. We encourage you to engage with our Applications Engineering team early in your process.

Contents

1 Fundamentals of a Flexiforce™ Sensor

A FlexiForce sensor behaves as a variable resister greater than 2 MΩ when unloaded and dropping about 25KΩ when it is subjected to its peak measurement load.

The solid line represents the target force to resistance correlation. The two dotted lines represent the potential variance of this relationship. The F_{MAX} location represents the range of resistance values where the curve of a sensor may land.



This document will cover some recommended circuits and settings to drive repeatable linear output from FlexiForce Sensors.

Additional Recommendations

- Mechanical design heavily influences sensor behavior and should be completed before finalizing circuit design. Consult the **"Mechanical Best Practices Guide"** documentation regarding effects of:

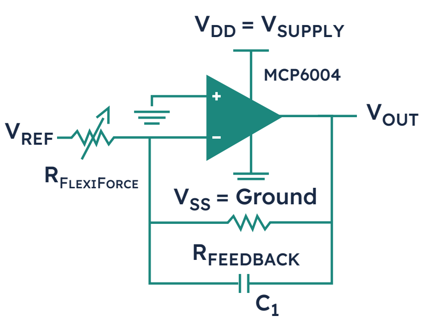
    Interface material
    Load concentration
    Environment

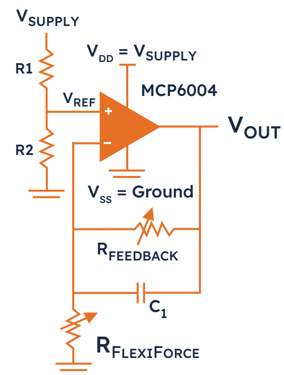
- Lower reference voltages (0.25-0.75V) reduce power consumption, provide more force range and resolution adjustability

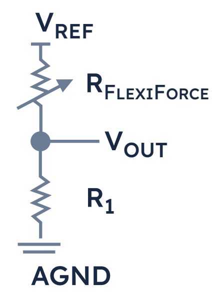
2

Circuit Selection

Tekscan recommends choosing from one of three circuits to operate FlexiForce sensors.

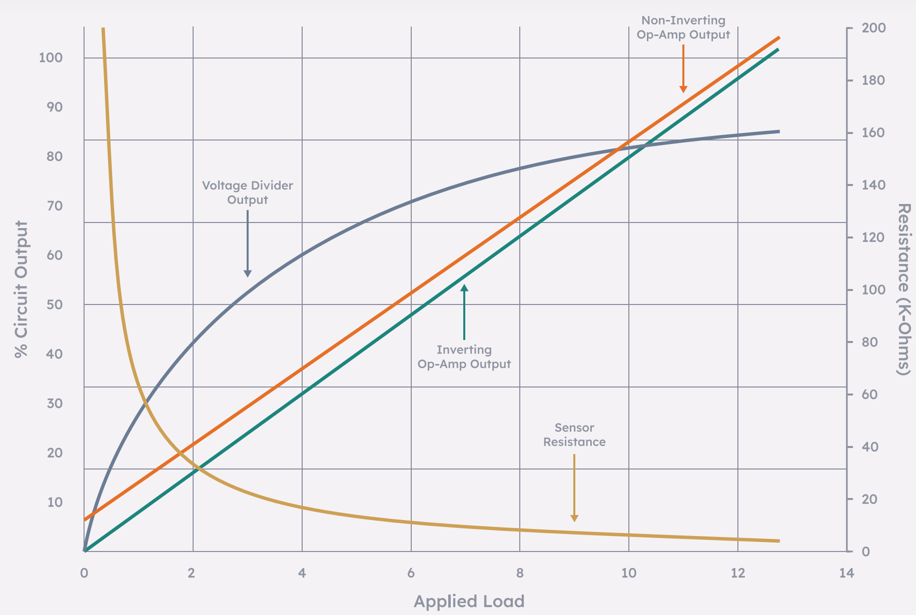






	Inverting Op-Amp Circuit	Non-Inverting Op-Amp Circuit	Voltage Divider
Usage	Best for measuring wide dynamic ranges	Good for measuring smaller dynamic ranges	Best for basic applications measuring threshold value
Linearity	●	●	○
Dynamic Range	●	◕	◔
Noise Suppression	◕	◒	◔
# of Power Supplies	2	1	1
Cost	$$$	$$	$>
Performance Notes	Very linear through origin	Very linear through offset, less dynamic range than Inv. Op-Amp	Not linear. Output will decrease at higher loads

Digital output of 3 circuits under same load conditions

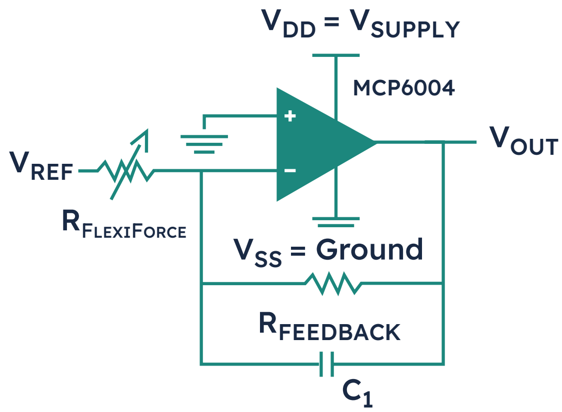


Inverting Op-Amp Circuit

$R_{FEEDBACK}$ = 20KΩ
(100KΩ Potentiometer can be used for adjustable sensitivity)

C_1=47pF

Note: Potentiometer and Capacitor values are general recommendations. Testing should be performed to determine optimal settings.



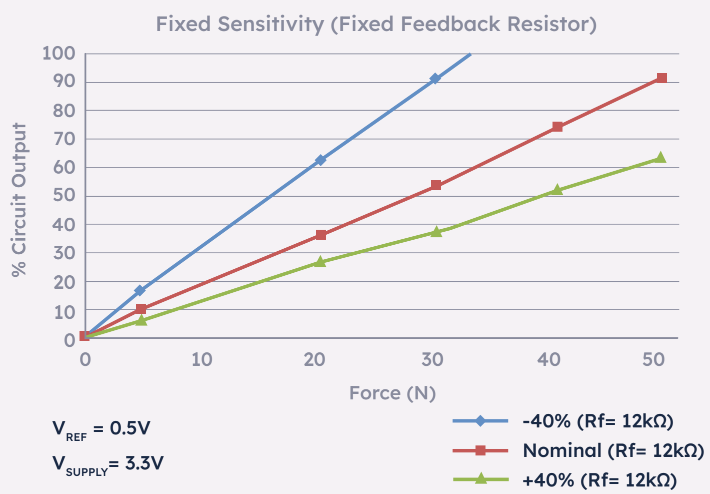
Reference Voltages

	Duty Cycle	DC
Notes	Ideal for sensor performance and reduced power consumption	Can stress sensor over time – not recommended for continuous load applications
V_{REF} Max	5V	1V
V_{REF} Ideal	0.25-0.75V	
Max Duty Cycle	20%	N/A
Max Current	2.5mA	

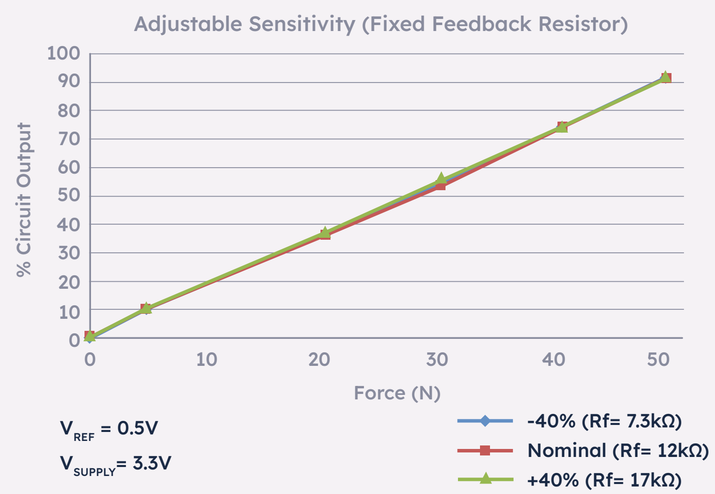
Adjusting Force Sensitivity

To address sensor variance, the output to load correlation can be adjusted by:

- The feedback resister can be configured with an analog or digital potentiometer
- The reference voltage can be adjusted with a voltage divider or Digital to Analog Converter (DAC)



More sensitive sensors saturate before max force.



All sensors operate within dynamic force range.

Unlike a Non-Inverting Op-Amp, this will NOT affect the dynamic Range

Consult the “FlexiForce Integration Guide” for more models and Graphs

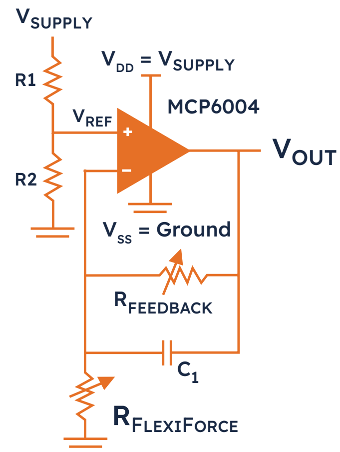
Download

Non-Inverting Op-Amp Circuit

$R_{FEEDBACK}$ = 80Ω
(100KΩ Potentiometer can be used for adjustable sensitivity)

C_1=47pF **R_1**=20K Ω **R_2**=80K Ω

Note: Potentiometer and Capacitor values are general recommendations. Testing should be performed to determine optimal settings.



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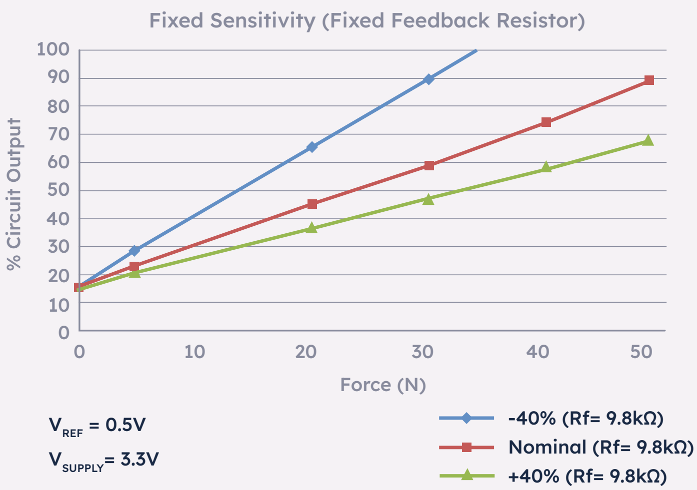

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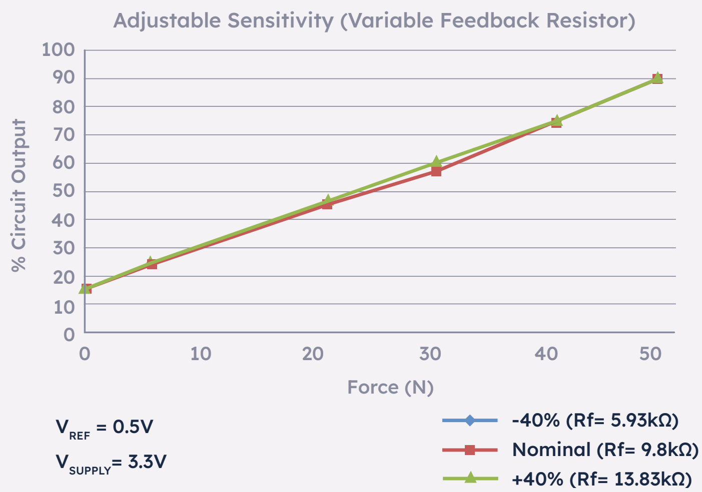


All sensors operate within dynamic force range.

Increasing V_{REF} on a Non-Inverting Op-Amp will reduce the dynamic range of the system

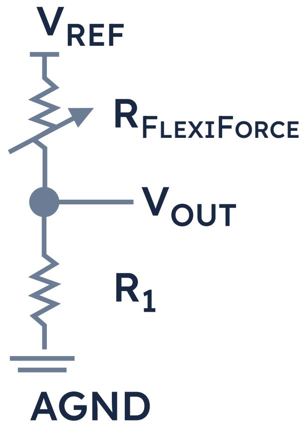
Consult the "FlexiForce Integration Guide" for more models and Graphs

Download

Voltage Divider

R_1 = 100K Ω
(100KΩ Potentiometer can be used for adjustable sensitivity)

Note: Potentiometer value is a general recommendation. Testing should be performed to determine optimal settings



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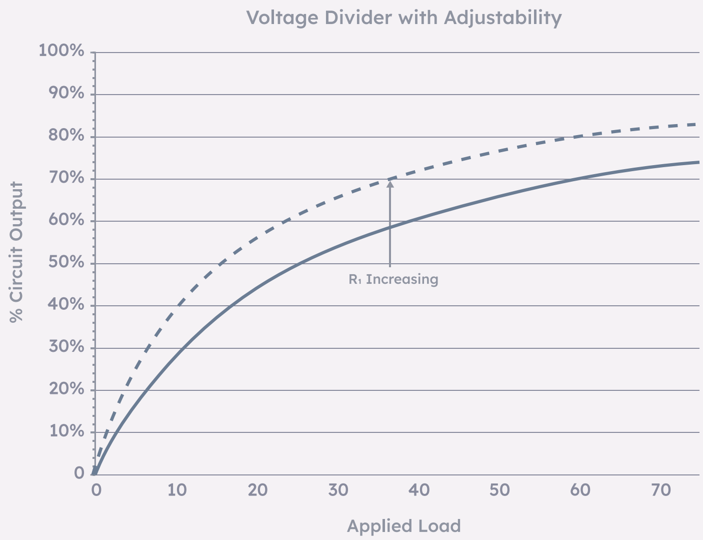


Consult the "FlexiForce Integration Guide" for more models and Graphs

Download

3 Develop Sensitivity Adjustment and Calibration Procedure

Sensitivity adjustment:

Use the circuit's sensitivity adjustment method to set the output of the circuit to 80%-90% of full-scale at maximum applied force.

Calibration

Apply known force to the sensor to correlate voltage output to engineering units (lbs, N, psi, etc). Because of the inherent part-to-part variation in FlexiForce sensors, independent/individual sensor calibration is crucial for achieving accurate results.

Before Calibration

1. Fully assemble device to be in the same state or as similar as possible, to when it will used in the field
2. If possible, condition the sensor. We generally recommend loading the sensor to 120% of maximum expected force and cycling 3-5 times for 10 seconds at a time
3. Adjusting the sensitivity of the circuit to max output at 120% max load, or 80-90% output at 100% load allows some overhead for spikes in force/pressure. This process ensures that the circuit does not saturate before your maximum expected force. Using one of the circuits and a circuit design process previously described in Sections 1 & 2 will help ensure the circuit sensitivity can be properly adjusted throughout the range of possible sensor resistances.

During Calibration

Use Completed Assembly, Or As Close to Completed As Possbile

Use Force Levels Within The Expected Application Force Range

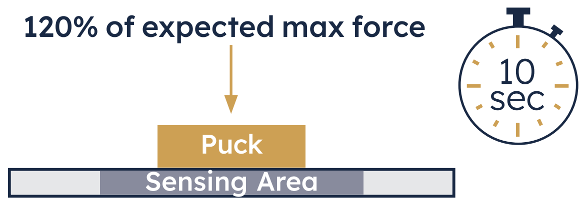
Use The Same Load Duration As Expected During The Application

4 Calibration Walk-Through Example

Condition The Sensor (Recommended)

Conditioning is only required prior to factory calibration.

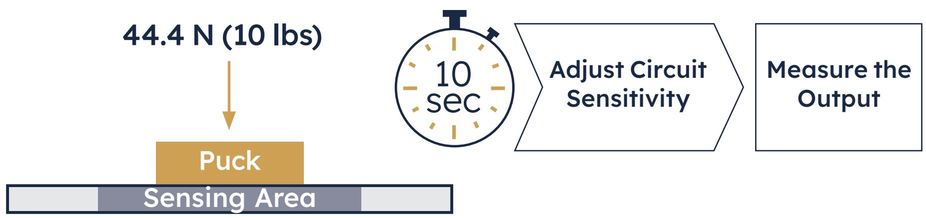
Apply & remove force at 120% of the expected max force 3-5 times, 10 seconds each time.



Adjust Circuit Sensitivity To 90% Of Circuit's Max Output

Apply max expected force. Adjust sensitivity so that output is 90% of the circuit's maximum output. Remove force

Refer to Section 2 of this document, or the "FlexiForce Integration Guide" for sensitivity adjustment methods.



Note: In this example, the circuit saturates at 3.3V. Max expected load is 44.4 N (10 lbs).

Plot Force VS Recorded Output

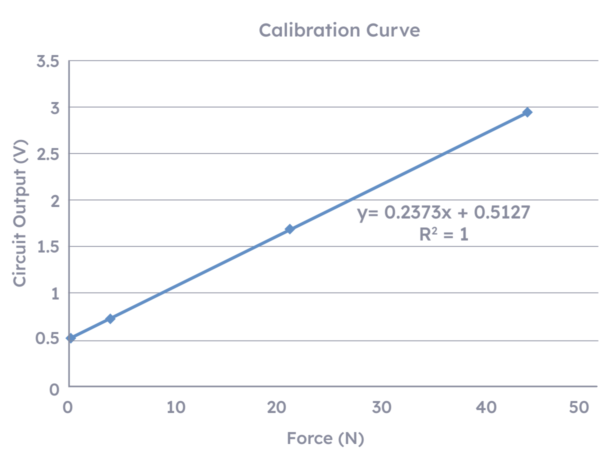
We generally recommend a two-to-three point calibration. First record the circuit output with the sensor unloaded, then:

1. Apply a low calibration point of 10% max load
2. (Optional) Apply a mid calibration point at 50% max load, if desired
3. Apply a high calibration point at 100% of max load

Record circuit output at each load.

In this example, we are recording circuit output with the sensor unloaded, then applying 4.4 N, 22.2 N, and 44.4 N (1 lb, 5 lbs, and 10 lbs, respectively) sequentially at the expected loading time interval.

Force (N (lbs))	Circuit Output (V)
0 (0)	0.51
4.4 (1)	0.75
22.2 (5)	1.70
44.4 (10)	2.96



Note: Calibration can also be carried out as a function of ADC counts if ADC is being used.

5

Additional Resources

Best Practices in Mechanical Integration

The complete **"Best Practices in Mechanical Integration"** guide provides key recommendations to consider during the prototyping phase of your OEM project. This includes:

- **Applying load concentrators to ensure even loading**
- **Recommendations to minimize shear force and preserve sensor sensitivity**
- **Methods for mounting the sensor, and more!**

Download

FlexiForce Integration Guide

For in-depth OEM integration recommendations, download the complete "**FlexiForce Integration Guide**." This guide is intended to help you optimize design, reduce costs, and streamline the overall sensor design & embedding process from prototype to production.

The "FlexiForce Integration Guide" includes additional mechanical considerations to help with your OEM project, including:

- **Characterizing sensor performance**
- **Soldering**
- **Effects of temperature on circuit and calibration**
- **Sensor/circuit duty cycle**
- **Design walk-thru examples, and more!**

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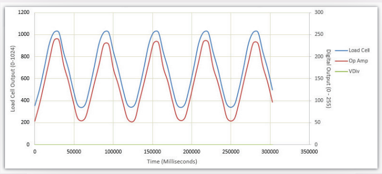
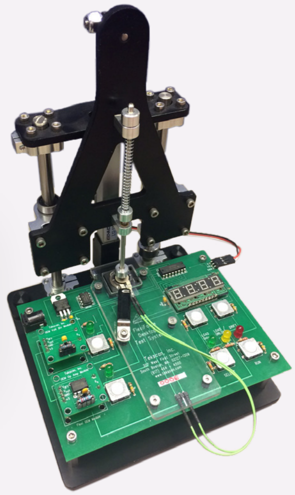
6 FlexiForce OEM Development Products

Tekscan offers two FlexiForce Integration Kits to help engineers test and evaluate FlexiForce Sensors for their embedded product or device. These include:

The FlexiForce Sensor Characterization Kit

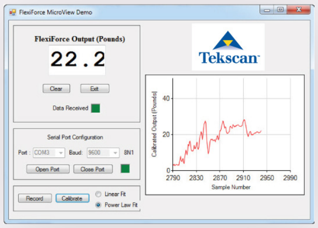


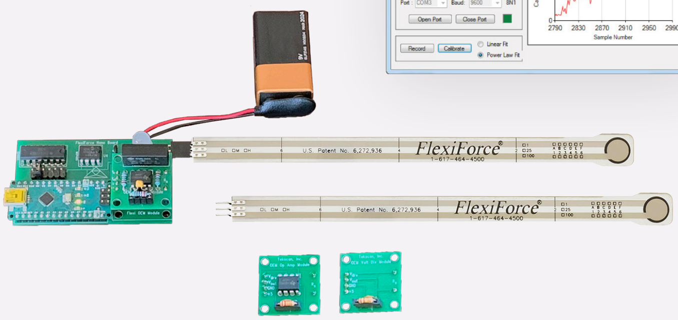


- An all-in-one testing fixture to help collect baseline sensor performance in a controlled loading environment
- Test interfacing materials with pre-programmed loading profiles in open-source software:
  - Linearity
  - Hysterisis
  - Drift
  - Repeatability
- Use with any FlexiForce Standard Sensor model, except the A101

Learn More

The FlexiForce Prototyping Kit





- A compact, plug & play kit to help engineers and designers progress smoothly through later integration phases
  - Begin collecting data in minutes!
- Test with different circuitry and make sensitivity adjustments with ease
- Use with any FlexiForce Standard Sensor model, except the A101

Learn More

What's Next?

Are you considering embedding a FlexiForce sensor into your product? Contact our Application Engineering team today to help bring your OEM project to life.

Tekscan

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