FLEXIFORCE® STARTER KIT MANUAL

A Guide to Building Circuits for FlexiForce Sensors

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FLEXIFORCE STARTER KIT MANUAL

A Guide to Building Circuits for FlexiForce Sensors

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INTRODUCTION

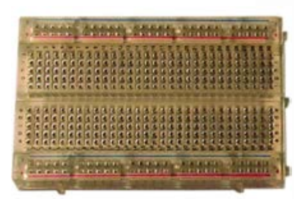
The purpose of the FlexiForce® Starter Kit is to provide a simple and cost effective method of integrating a FlexiForce sensor with Tekscan's recommended drive circuitry. Without the recommended circuitry, the sensor will output a non-linear analog resistance signal, but when used with the recommended circuitry, the FlexiForce sensor will output an analog voltage output that increases linearly with respect to applied force. This analog voltage signal can then be read by a simple multimeter, or it can be used as an input to a third party Data Acquisition System.

Three different circuit configurations that serve a variety of applications are presented in this document:

1. Single Source Circuit: Provides excellent linearity while also being easy to implement. This circuit is a good way to get started with FlexiForce sensors, and is also a good solution for using FlexiForce sensors in battery and low powered devices.
2. Dual Source Circuit: Also provides excellent linearity, and though more challenging to assemble, it provides the most versatility in terms of force range adjustment. With this circuit, the user can effectively change the force range of the same FlexiForce sensor from under 1 lb to over 1000 lb.
3. Voltage Divider Circuit: The simplest and easiest circuit configuration to implement with FlexiForce sensors. The output is very non-linear, however, which typically limits this circuit to applications requiring less accuracy (i.e. occupancy detection and switch-type applications).

Detailed instructions for component and wire connections are provided in the Connection Instructions section. These are only suggested layouts, and circuit schematics and pin-out diagrams are also included for advanced users who prefer to construct their own layouts.

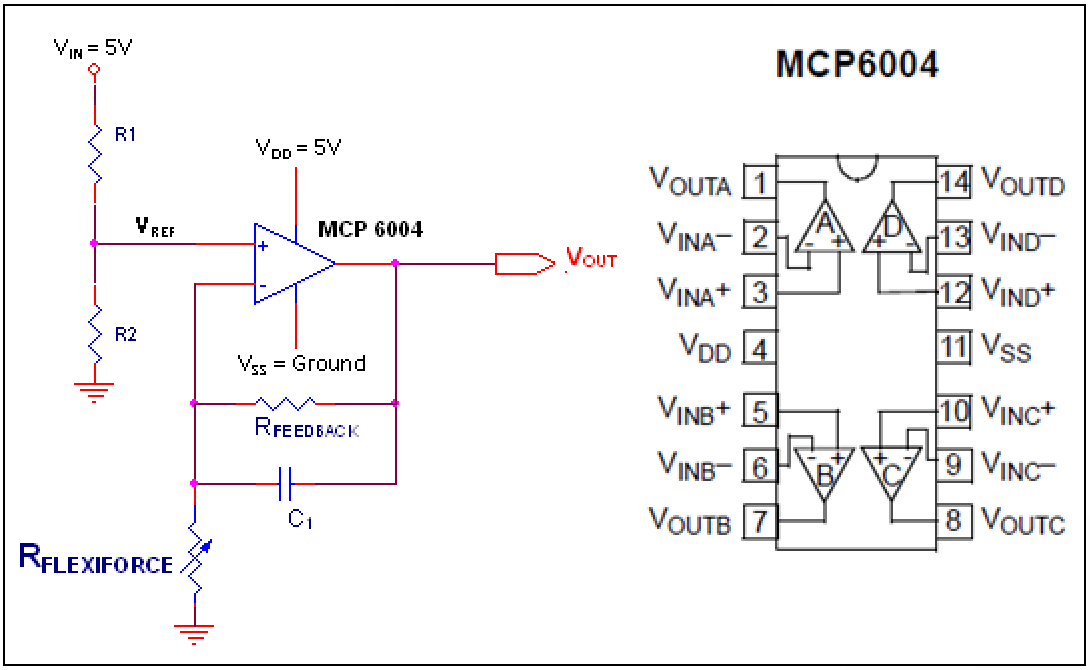
COMPONENTS CHECKLIST

Quantity	***Part Description***	***Part Image***
2	FlexiForce A201 Sensors	
1	Prototyping Board (solderless breadboard)	
1	Jumper wire kit	

1	220 pF Capacitor	
1	Op Amp Chip (MCP 6004)	
1	100kΩ Trim Pot (3362 Top Turn Screw)	
1	1kΩ Trim Pot (3362 Side Turn Screw)	
1	Pack of Resistors	
2	9V battery clips (batteries not included)	
2	5V Voltage Regulators (7805)	

CIRCUIT ONE – SINGLE SOURCE

The Single Source Circuit provides excellent voltage vs. force linearity while also being easy to implement. This circuit is a good way to get started with FlexiForce sensors, and it is also a good solution for using FlexiForce sensors in battery and low powered devices.



$$V_{OUT} = V_{REF} * (1 + (R_{FEEDBACK} / R_{FLEXIFORCE}))$$

Figure 1 - Single Source circuit schematic (left); MCP6004 Quad Op-Amp chip pin-out diagram (right)

Connection Instructions

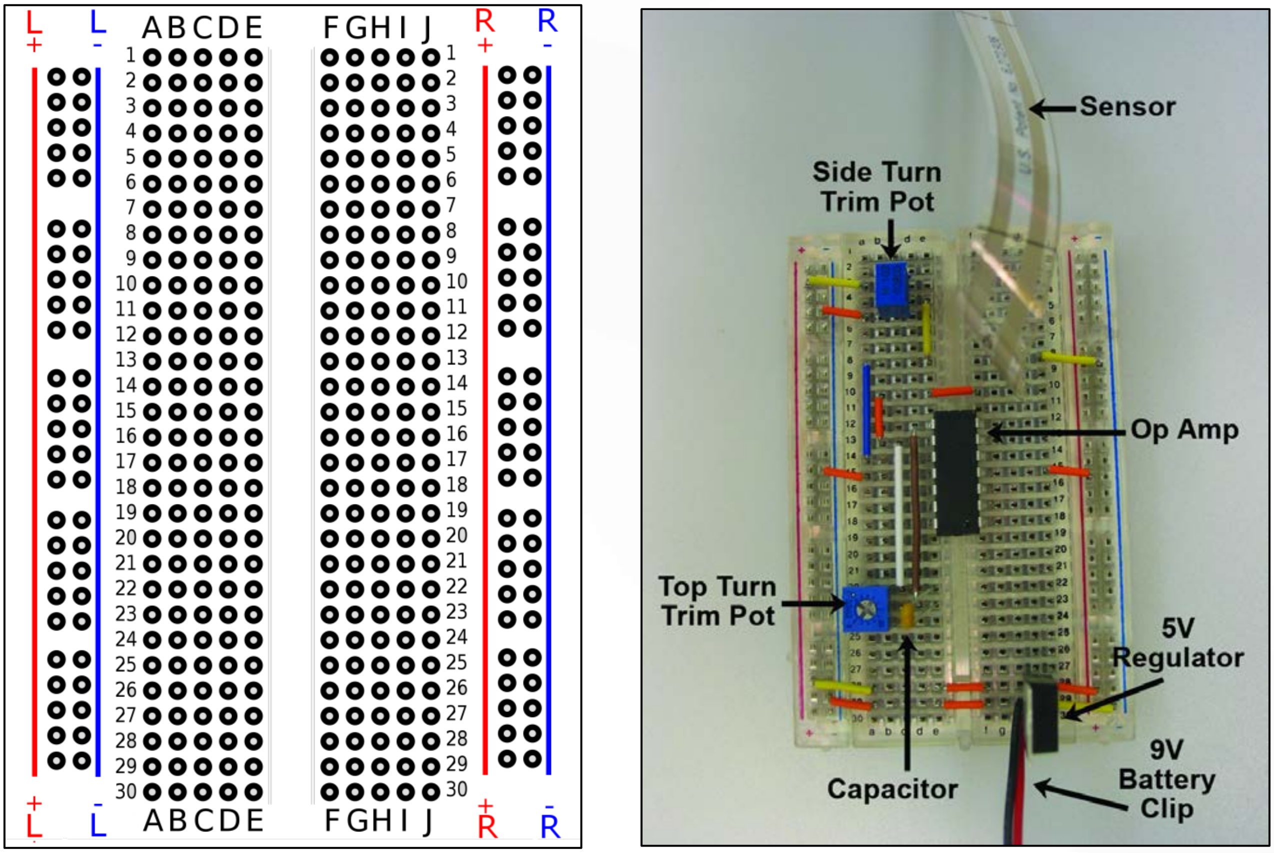


Figure 2 - Breadboard diagram (left); Assembled Single Source circuit (right)

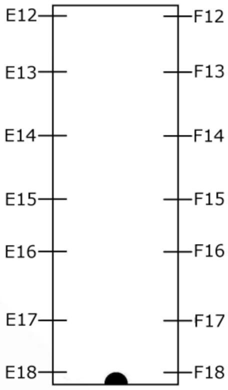
Below are instructions for placing the components and jumper wires on the breadboard to construct the single source circuit. This is only a suggested layout, and advanced users may skip this section and construct their own layout if preferred. The pin positions are designated by a letter (a-j) followed by a number (1-30). The letters a-j correspond to the columns on the breadboard from left to right, and the numbers 1-30 correspond to the rows on the breadboard from top to bottom. These rows and columns are labeled on the breadboard itself. The power rails on the left side of the breadboard are designated as L+ and L-, and the power rails on the right side of the breadboard are designated as R+ and R- (*see figure 2).*

Note: The order in which you make connections does not matter, but make sure to connect the batteries (or external power supply, if available) after all components and wires are properly placed. Take special care that the regulator is oriented correctly and the battery leads are connected to the correct locations.

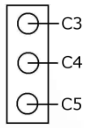
Component Connections

Note: Assume orientation/polarity of components is reversible unless stated otherwise.

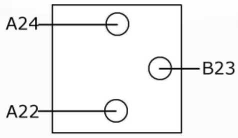
1. **Op Amp Chip** (MCP 6004)
    - Semicircle indentation on chip should be oriented towards bottom of board (towards row 30)
    - Connect left side pins to **e12 – e18**
    - Connect right side pins to **f12 – f18**



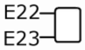
2. **Trim Pot** (part 3362 **Side Turn** Screw) for varying sensor drive voltage, V_{REF}
    - Connect pins to **c3 – c5**



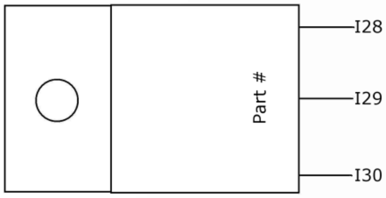
3. **Trim Pot** (part 3362 **Top Turn** Screw) for varying feedback resistor, $R_{FEEDBACK}$
    - Connect middle pin to **b23**
    - Connect outer pins to **a22** and **a24**



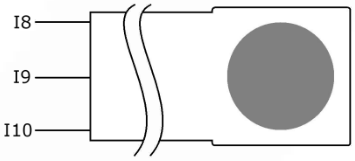
4. **Capacitor** (220 pF)
    - Connect pins to **e22** and **e23**



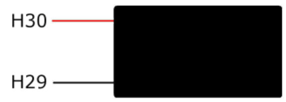
5. **Regulator** (7805)
    - Metal tab on back of regulator should be oriented towards middle of board
    - Connect pins to **i28 – i30**



6. **Sensor**
    - Connect pins to **i8 – i10**



7. **9V Battery Clip (or alternative power supply if available)**

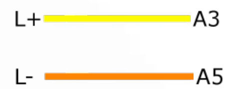


- Connect **positive** lead (red wire) to **h30**
- Connect **negative** lead (black wire) to **h29**

  Tip: For a firmer connection to breadboard, you can solder a short length of jumper wire to the end of each lead of the battery clip. Then plug the larger jumper wires into the breadboard locations specified above.

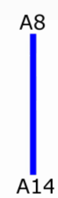
Jumper Wire Connections

1. **V_{REF} Trim Pot to Positive Op Amp Input**



- Connect **L+** to **a3**
- Connect **L-** to **a5**

- Connect **e4** to **e8**



- Connect **a8** to **a14**

2. **Sensor Output to Negative Op Amp Input**

- Connect **b10** to **b13**
- Connect **e10** to **f10**

- Connect **j8** to **R-**

3. **Op Amp V_{SS} rail**
   - Connect **L-** to **a15**

4. **Op Amp V_{DD} rail**
   - Connect **j15** to **R+**

5. **$R_{FEEDBACK}$ Trim Pot**
   - Connect **c13** to **c22**

   - Connect **d12** to **d23**

6. **Regulator**
   - Connect **L+** to **a28**

   - Connect **e28** to **f28**

   - Connect **j28** to **R+**

   - Connect **L-** to **a29**

   - Connect **e29** to **f29**

   - Connect **j29** to **R-**

Taking Measurements

Checking Circuit Functionality

Before you start taking measurements, you first want to make sure that all connections have been made correctly and the circuit is functioning properly. To ensure the circuit is functioning properly, follow these steps using your multimeter (make sure multimeter is set to read "voltage").

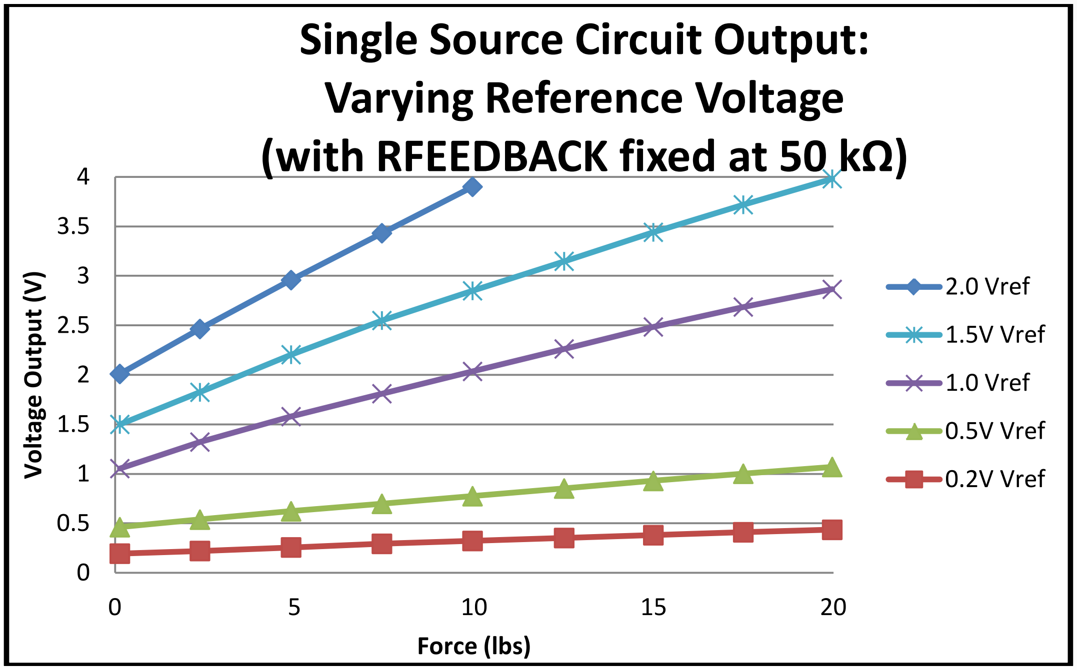
1. Plug 9V battery into battery clip.

2. Connect **positive lead** of multimeter to **L+** and **negative lead** to **L-** and check that the output is approximately +5V. If the output is not +5V, then you have made an improper circuit or multimeter connection on the breadboard.

3. Repeat step 2 for **R+** and **R-**.

4. To read $\mathbf{V_{OUT}}$ from the circuit, connect the **negative lead** of the multimeter to **L-** or **R-** (either one), and connect the **positive lead** to location **c12**. Once you press on the sensor the voltage should increase. If the voltage does not increase at all, then you have made an improper circuit or multimeter connection on the breadboard. If it increases only a little or it immediately jumps to about 5V, then you will need to adjust the $\mathbf{V_{REF}}$ and $\mathbf{R_{FEEDBACK}}$ values using the **Trim Pots** until you have fine tuned the circuit to your desired force range (instructions below).

Adjusting full scale force range with V_{REF} Trim Pot



1. Load sensor with the maximum weight that you intend to measure.

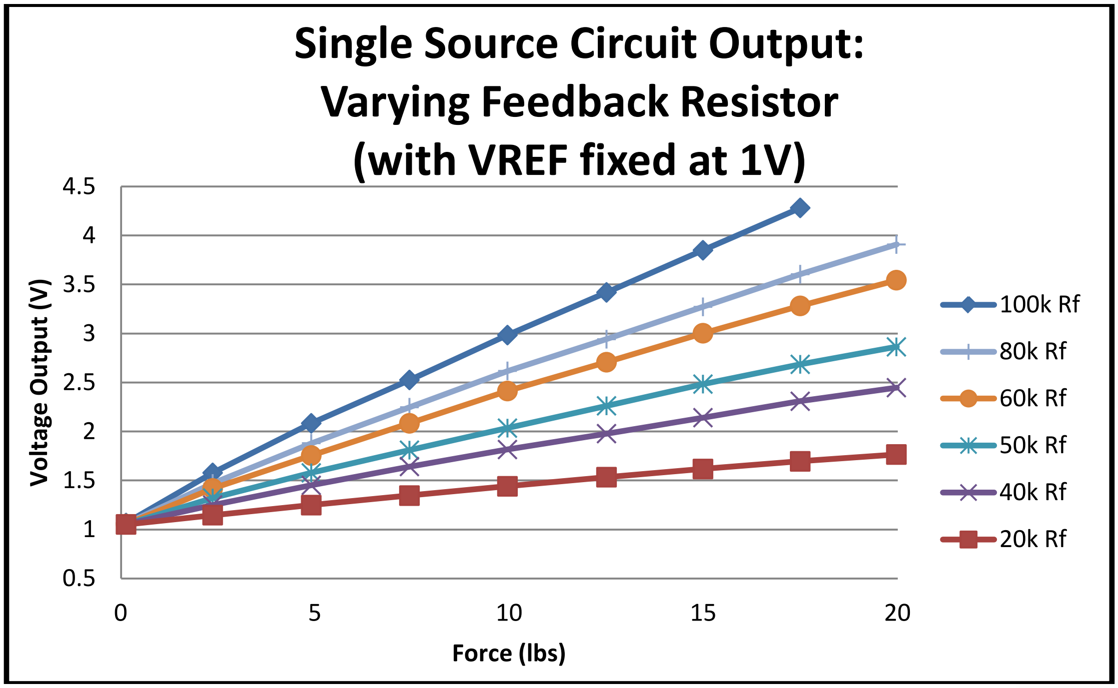
2. To read V_{OUT} from the circuit, connect the **negative lead** of the multimeter to **L-** or **R-** (either one), and connect the **positive lead** to location **c12**. Turn the multimeter on and turn it to the DC voltage setting.

3. Turn the **V_{REF} Trim Pot** adjustment screw until the multimeter reads about 4V. This ensures that you are using the full dynamic range of the circuit for your desired force range.

   Tip: You can measure the actual voltage value of **V_{REF}** by connecting the **positive lead** of multimeter to **a4** and the **negative lead** to **L-**.

4. If it is not possible to reach 4V by adjusting **V_{REF}**, further adjustment can be done by changing the value of **$R_{FEEDBACK}$** (instructions below).

Adjusting full scale force range with $R_{FEEDBACK}$ Trim Pot



1. Load sensor with the maximum weight that you intend to measure.

2. To read V_{OUT} from the circuit, connect the **negative lead** of the multimeter to **L-** or **R-** (either one), and connect the **positive lead** to location **c12**. Turn the multimeter on and turn it to the DC voltage setting.

3. Turn the **$R_{FEEDBACK}$ Trim Pot** adjustment screw until the multimeter reads about 4V. This ensures that you are using the full dynamic range of the circuit for your desired force range.

   Tip: You can measure the actual resistance value (change multimeter to read Resistance) of **$R_{FEEDBACK}$** by removing the capacitor and connecting the **positive lead** of multimeter to **e22** and the **negative lead** to **e23**. Make sure that the battery (or other power source) is unplugged when you measure the resistance.

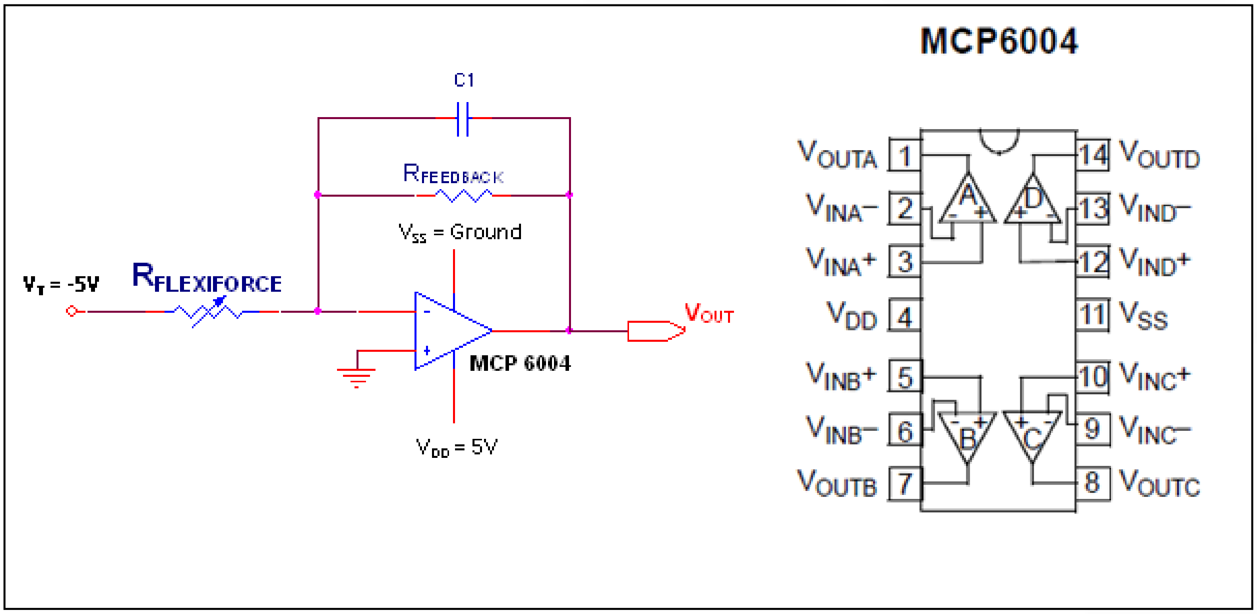
Conditioning, Calibrating, and Measuring

Now that you have successfully assembled and adjusted the single source circuit, you can now calibrate the sensors and start taking measurments! You can read the output of the circuit in the same way as described above (connecting **positive lead** of multimeter to **c12** and **negative lead** to **L-** or **R-** with multimeter set to read Voltage).

Please see the Calibration Quickstart Guide (http://www.tekscan.com/how-do-i-calibrate-my-flexiforce-sensor) and FlexiForce User Manual (http://www.tekscan.com/flexiforce-user-manual) for information about conditioning and calibrating the sensors.

CIRCUIT TWO – DUAL SOURCE

The Dual Source Circuit also provides equivalent linearity to the Single Source Circuit and a larger dynamic range. It also provides the most versatility in terms of force range adjustment. With this circuit, the user can effectively change the force range of the same FlexiForce sensor from under 1 lb to over 1000 lb.



$$V_{OUT} = -V_T * R_{FEEDBACK} / R_{FLEXIFORCE}$$

Figure 3 - Dual Source circuit schematic (left); MCP6004 Quad Op-Amp chip pin-out diagram (right)

Connection Instructions

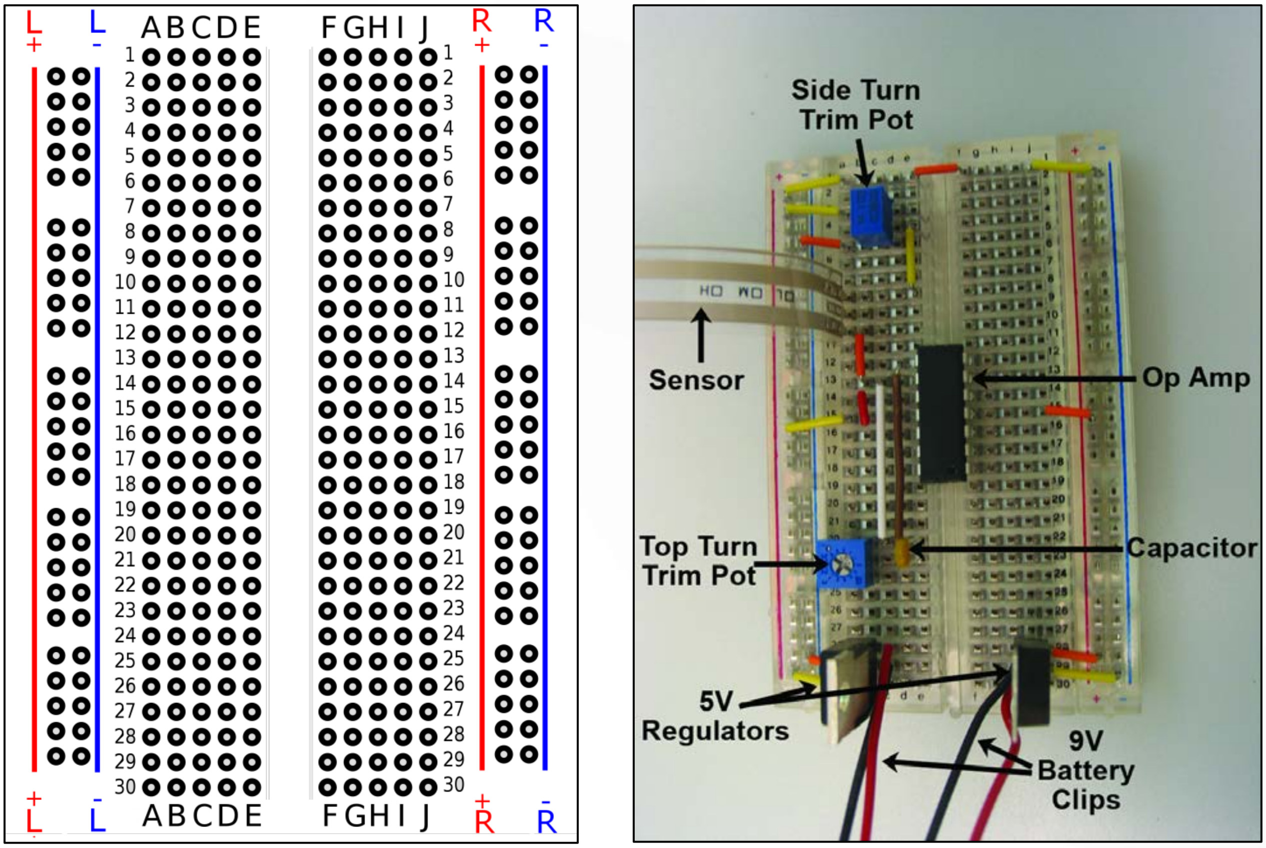


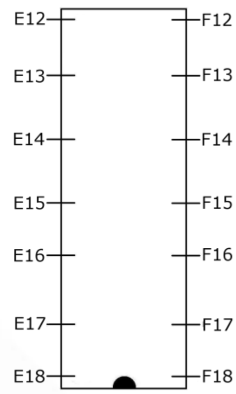
Figure 4 – Breadboard diagram (left); Assembled Dual Source circuit (right)

Below are instructions for placing the components and jumper wires on the breadboard to construct the recommended dual source circuit. This is only a suggested layout, and advanced users may skip this section and construct their own layout if preferred. The pin positions are designated by a letter (a-j) followed by a number (1-30). The letters a-j correspond to the columns on the breadboard from left to right, and the numbers 1-30 correspond to the rows on the breadboard from top to bottom. These rows and columns are labeled on the breadboard itself. The power rails on the left side of the breadboard are designated as L+ and L-, and the power rails on the right side of the breadboard are designated as R+ and R- (*see figure 4*).

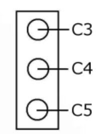
Note: The order in which you make connections does not matter, but make sure to connect the batteries (or external power supply if available) after all components and wires are properly placed. Take special care that the regulator is oriented correctly and the battery leads are connected to the correct locations.

Component Connections

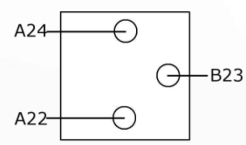
Note: Assume orientation/polarity of components is reversible unless stated otherwise.



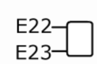
1. **Op Amp Chip** (MCP 6004)
   - Semicircle indentation on chip should be oriented towards bottom of board (towards row 30)
   - Connect left side pins to **e12 – e18**
   - Connect right side pins to **f12 – f18**



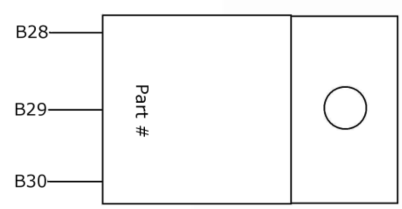
2. **Trim Pot** (part 3362 **Side Turn** Screw) for varying sensor drive voltage, V_T
   - Connect outer pins to **c3 – c5**



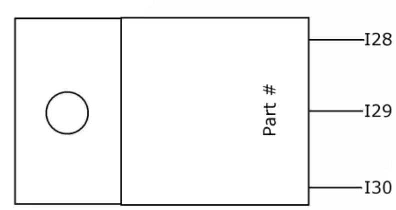
3. **Trim Pot** (part 3362 **Top Turn** Screw) for varying feedback resistor, $R_{FEEDBACK}$
   a. Connect middle pin to **b23**
   b. Connect outer pins to **a22** and **a24**



4. **Capacitor** (220 pF)
   - Connect pins to **e22** and **e23**

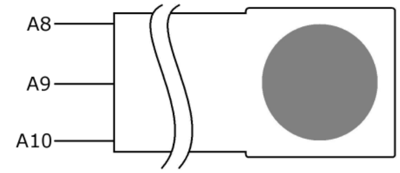


5. **Regulator** (7805)
   - Metal tab on back of regulator should be oriented towards middle of board
   - Connect pins to **b28 – b30**



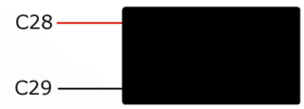
6. **Regulator** (7805)
   - Metal tab on back of regulator should be oriented towards middle of board
   - Connect pins to **i28 – i30**

7. **Sensor**



   - Connect sensor pins to **a8 – a10**

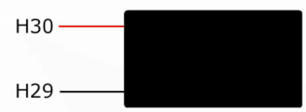
8. **9V Battery Clip (or alternative power supply if available)**



   - Connect **positive** lead (red wire) to **c28**
   - Connect **negative** lead (black wire) to **c29**

   Tip: For a firmer connection to breadboard, you can solder a short length of jumper wire to the end of each lead of the battery clip. Then plug the larger jumper wires into the breadboard locations specified above.

9. **9V Battery Clip (or alternative power supply if available)**



   - Connect **positive** lead (red wire) to **h30**
   - Connect **negative** lead (black wire) to **h29**

   Tip: For a firmer connection to breadboard, you may want to solder a short length of jumper wire to the end of each lead of the battery clip. Then plug the larger jumper wires into the breadboard locations specified above

Jumper Wire Connections

1. **L+ to R-**

   - Connect **L+** to **a1**

   - Connect **e1** to **f1**

   - Connect **j1** to **R-**

2. **V_T Trim Pot**

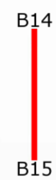
   - Connect **L+** to **a3**

- Connect **L-** to **a5**

- Connect **e4** to **e8**

3. **Sensor Output to Negative Op Amp Input**
   - Connect wire from **b10** to **b13**

4. **Positive Op Amp Input to Ground**
   - Connect **b14** to **b15**



5. **Op Amp V_{SS} rail**
   - Connect **L+** to **a15**

6. **Op Amp V_{DD} rail**
   - Connect **R+** to **j15**

7. **$R_{FEEDBACK}$ Trim Pot**
   - Connect **c13** to **c22**

   - Connect **d12** to **d23**

8. **Left Side Regulator**
   - Connect **L-** to **a29**

   - Connect **L+** to **a30**

9. **Right Side Regulator**
   - Connect **j29** to **R-**

   - Connect **j28** to **R+**

Taking Measurements

Checking Circuit Functionality

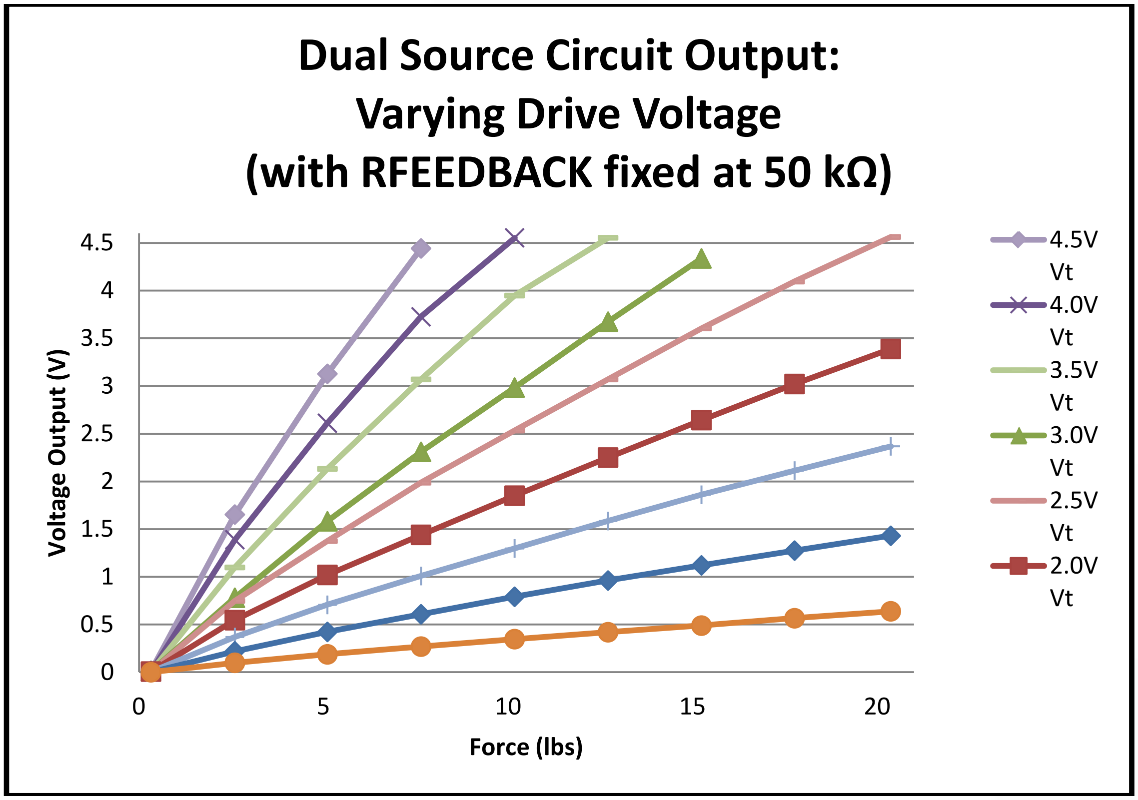
Before you start taking measurements, you first want to make sure that all connections have been made correctly and the circuit is functioning properly. To ensure the circuit is functioning properly, follow these steps using your multimeter (make sure multimeter is set to read “voltage”).

1. Connect both 9V batteries to the battery clips.

2. Connect **positive lead** of multimeter to **L+.** Connect **negative lead** of multimeter to **L-** and check that the output is approximately +5V. Then connect the **negative lead** of multimeter to **R+** and check that the output is approximately -5V. If this is not the case, then you have made an improper circuit or multimeter connection on the breadboard.

3. To read $\mathbf{V_{OUT}}$ from the circuit, connect the **negative lead** of the multimeter to **R-**, and connect the **positive lead** to location **c12**. The voltage should initially read approximately 0V. Once you press on the sensor the voltage should increase. If the voltage does not increase at all, then you have made an improper circuit or multimeter connection on the breadboard. If it increases only a little or it immediately jumps to 5V, then you will need to adjust the $\mathbf{V_T}$ and $\mathbf{R_{FEEDBACK}}$ values using the **Trim Pots** until you have fine tuned the circuit to your desired force range (instructions below).

Adjusting full scale force range with V_T Trim Pot



1. Load sensor with the maximum weight that you intend to measure.

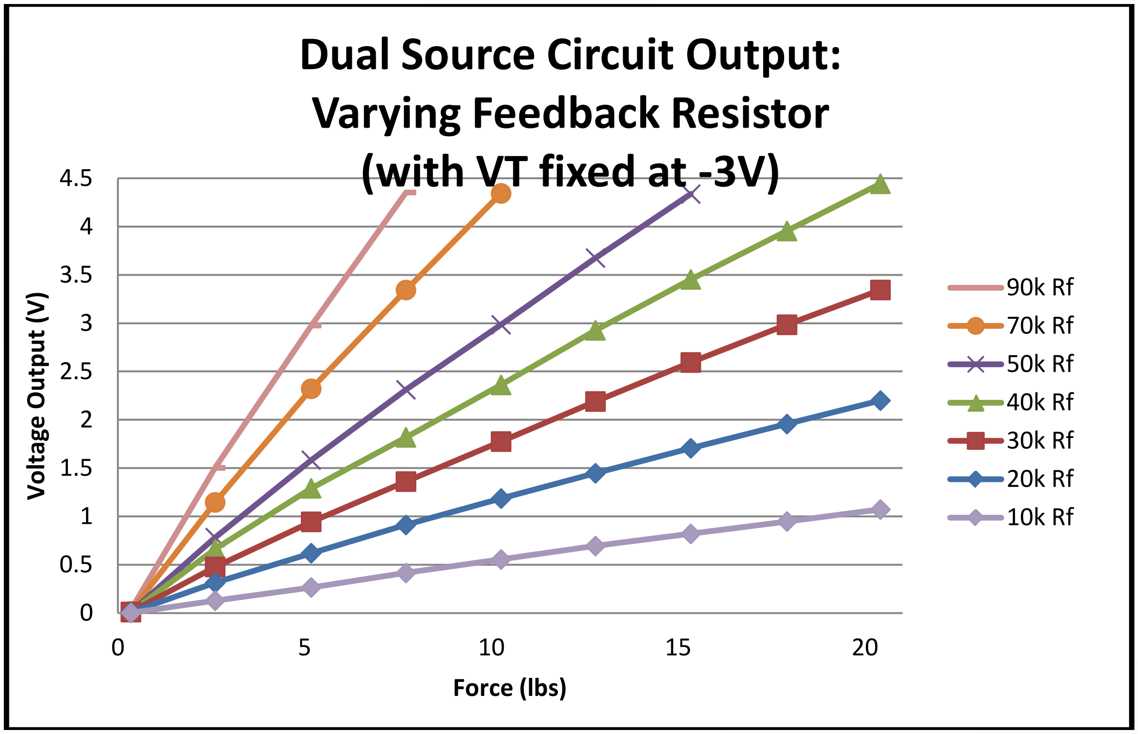
2. To read V_{OUT} from the circuit, connect the **negative lead** of the multimeter to **R-**, and connect the **positive lead** to location **c12**. Turn the multimeter on and turn it to the DC voltage setting.

3. Turn the **V_T Trim Pot** adjustment screw until the multimeter reads about 4V. This ensures that you are using the full dynamic range of the circuit for your desired force range.

   Tip: You can measure the actual voltage value of V_T by connecting the **positive lead** of multimeter to **a4** and the **negative lead** to **L-**.

4. If it is not possible to reach 4V by adjusting V_T, further adjustment can be done by changing the value of $R_{FEEDBACK}$ (instructions below).

Adjusting full scale force range with $R_{FEEDBACK}$ Trim Pot



1. Load sensor with the maximum weight that you intend to measure.

2. To read V_{OUT} from the circuit, connect the **negative lead** of the multimeter to **R-** and connect the **positive lead** to location **c12**. Turn the multimeter on and turn it to the DC voltage setting.

3. Turn the **$R_{FEEDBACK}$ Trim Pot** adjustment screw until the multimeter reads about 4V. This ensures that you are using the full dynamic range of the circuit for your desired force range.

   Tip: You can measure the actual resistance value (change multimeter to read Resistance) of **$R_{FEEDBACK}$** by removing the capacitor and connecting the **positive lead** of multimeter to **e22** and the **negative lead** to **e23**. Make sure that the battery (or other power source) is unplugged when you measure the resistance.

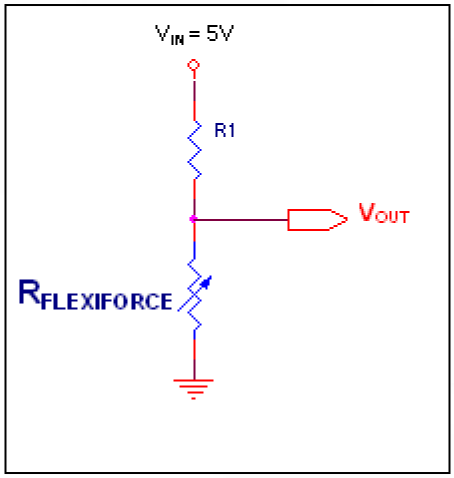
Conditioning, Calibrating, and Measuring

Now that you have successfully assembled and adjusted the dual source circuit, you can now calibrate the sensors and start taking measurments! You can read the output of the circuit in the same way as described above (connecting **positive lead** of multimeter to **c12** and **negative lead** to **R-** with multimeter set to read Voltage).

Please see the Calibration Quickstart Guide (http://www.tekscan.com/how-do-i-calibrate-my-flexiforce-sensor) and FlexiForce User Manual (http://www.tekscan.com/flexiforce-user-manual) for information about conditioning and calibrating the sensors.

CIRCUIT THREE – VOLTAGE DIVIDER

The Voltage Divider Circuit is by far the simplest and easiest circuit configuration to implement with FlexiForce sensors. The output is very non-linear, however, which typically limits this circuit to applications requiring less accuracy (i.e. occupancy detection and switch-type applications).



$$V_{OUT} = V_{IN} * R_{FLEXIFORCE} / (R_1 + R_{FLEXIFORCE})$$

Figure 5 - Voltage Divider circuit Schematic

Connection Instructions

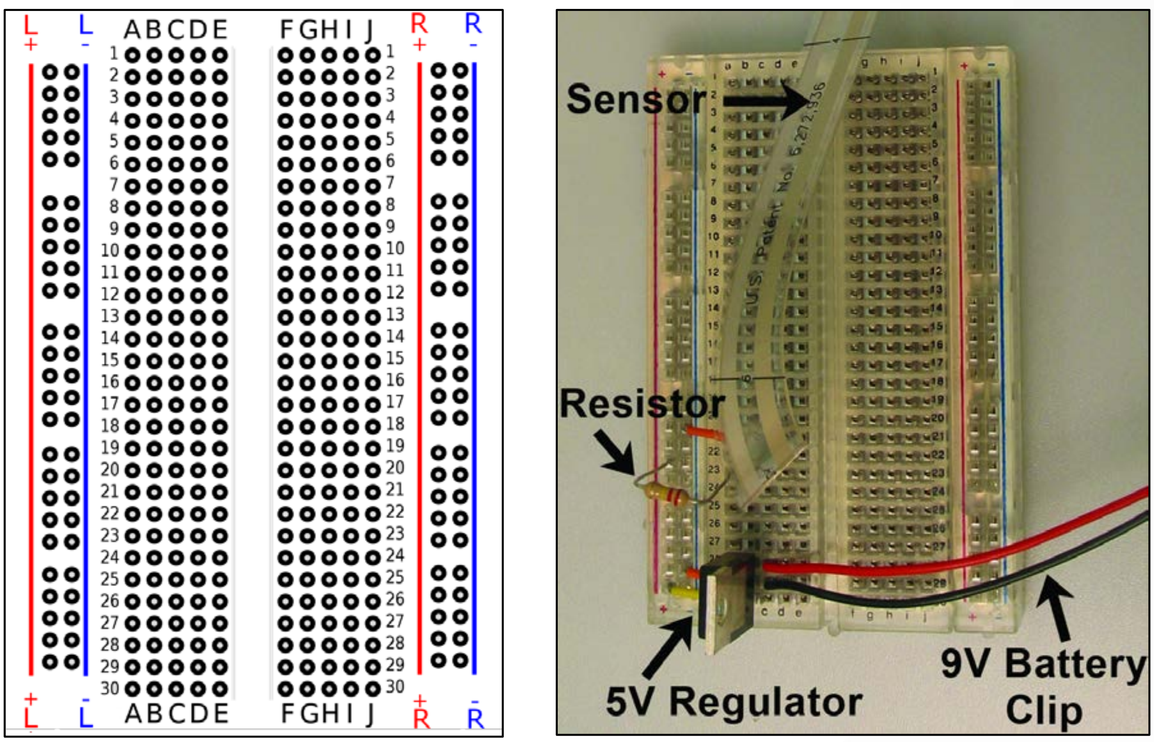


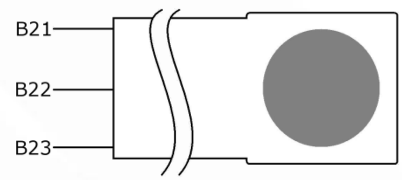
Figure 6 - Breadboard diagram (left); Assembled Voltage Divider circuit (right)

Below are instructions for placing the components and jumper wires on the breadboard to construct the voltage divider circuit. This is only a suggested layout, and advanced users may skip this section and construct their own layout if preferred. The pin positions are designated by a letter (a-j) followed by a number (1-30). The letters a-j correspond to the columns on the breadboard from left to right, and the numbers 1-30 correspond to the rows on the breadboard from top to bottom. These rows and columns are labeled on the breadboard itself. The power rails on the left side of the breadboard are designated as L+ and L-, and the power rails on the right side of the breadboard are designated as R+ and R- (*see figure 6).*

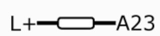
Note: The order in which you make connections does not matter, but make sure to connect the batteries (or external power supply, if available) after all components and wires are properly placed. Take special care that the regulator is oriented correctly and the battery leads are connected to the correct locations.

Component Connections

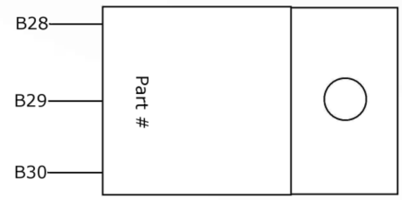
1. **Sensor**
    - Connect sensor pins to **b21 – b23**



2. **Resistor**
    - Connect to **a23** and **L+**

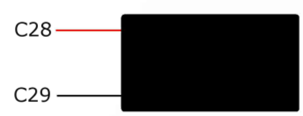


3. **Regulator**
    - Metal tab on back of regulator should be oriented towards middle of board
    - Connect pins to **b28 – b30**



4. **9V Battery Clip (or alternative power supply if available)**
    - Connect **positive** lead (red wire) to **c28**
    - Connect **negative** lead (black wire) to **c29**

    Tip: For a firmer connection to breadboard, you can solder a short length of jumper wire to the end of each lead of the battery clip. Then plug the larger jumper wires into the breadboard locations specified above.



Jumper Wire Connections

1. **V_{IN}**
   - Connect **L+** to **a30**

   - Connect **L-** to **a29**

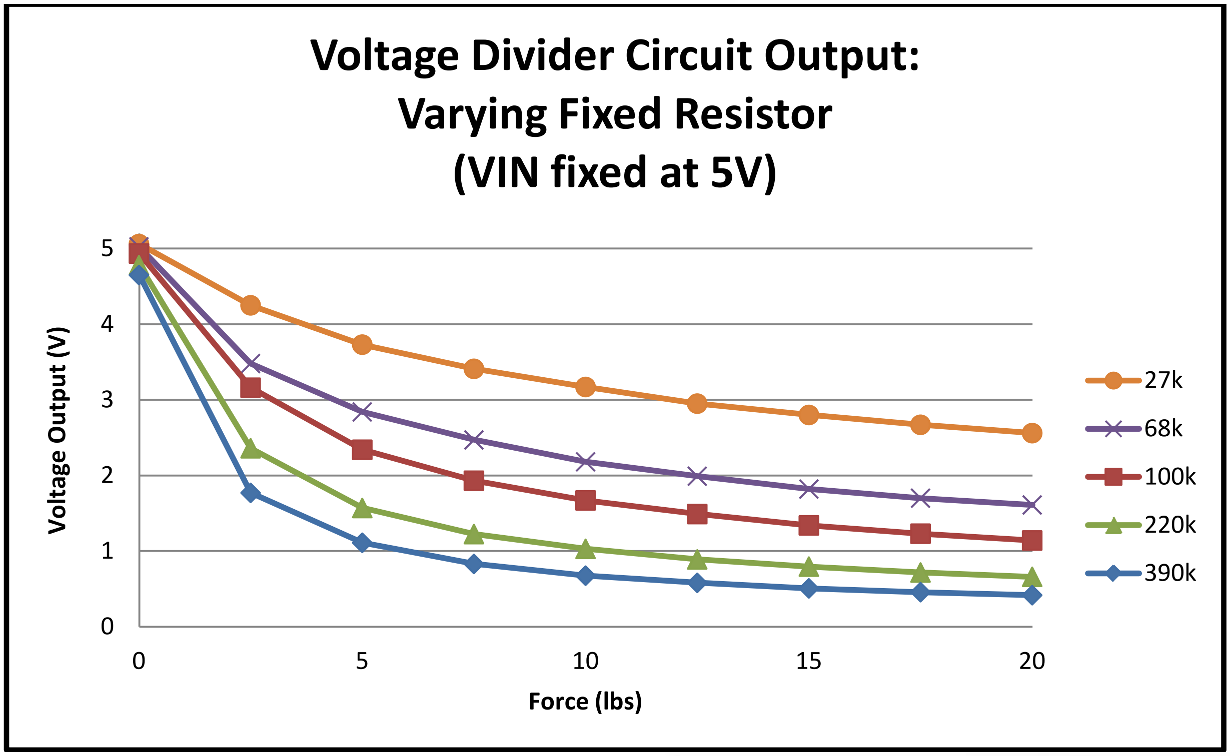
2. **Ground**
   - Connect **a21** to **L-**

Taking Measurements

Checking Circuit Functionality

Before you start taking measurements, you first want to make sure that all connections have been made correctly and the circuit is functioning properly. To ensure the circuit is functioning properly, follow these steps using your multimeter (make sure multimeter is set to read voltage):

1. Plug 9V battery into battery clip.
2. Connect **positive lead** of multimeter to **L+** and **negative lead** to **L-** and check that the output is approximately +5V. If the output is not +5V, then you have made an improper circuit or multimeter connection on the breadboard.
3. To read **V_{OUT}** from the circuit, connect the **negative lead** of the multimeter to **L-** and connect the **positive lead** to location **d23** . The voltage should initially read approximately 5V. Once you press on the sensor the voltage should decrease. If the voltage does not decrease at all, then you have made an improper circuit or multimeter connection on the breadboard.
4. Try different resistors from the provided resistor pack until you obtain the desired response from the circuit for your application and force range.



SUPPORT

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.

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