

Bus Bar Theory of Operation

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ABSTRACT

Traditional bus bar current measurement techniques use closed loop current modules to accurately measure and control current. These modules usually require a large magnetic core that encloses the entire bus bar. Because the compensation current generated inside the module is proportional to the bus bar current, the power dissipation can be as high as several watts. An alternative approach is to use two DRV425 devices connected in a differential configuration and mounted on opposite sides of a printed circuit board (PCB). This board is then placed into a cutout (hole or slot) located in the center of a bus bar.

Figure 1 shows the alternate approach using two DRV425 devices. When a cutout (hole or slot) is placed in the center of the bus bar, the current is split in two equal parts. Each side of the cutout will generate magnetic field gradients that oppose one another inside the cutout. The high sensitivity and linearity of the two DRV425 devices allow small opposing magnetic fields to be sensed and the current to be measured with high-accuracy levels. The DRV425 devices are placed equidistant from the center of the cutout and oriented in opposite directions to provide a differential measurement. This differential measurement also helps to reject outside stray magnetic fields.

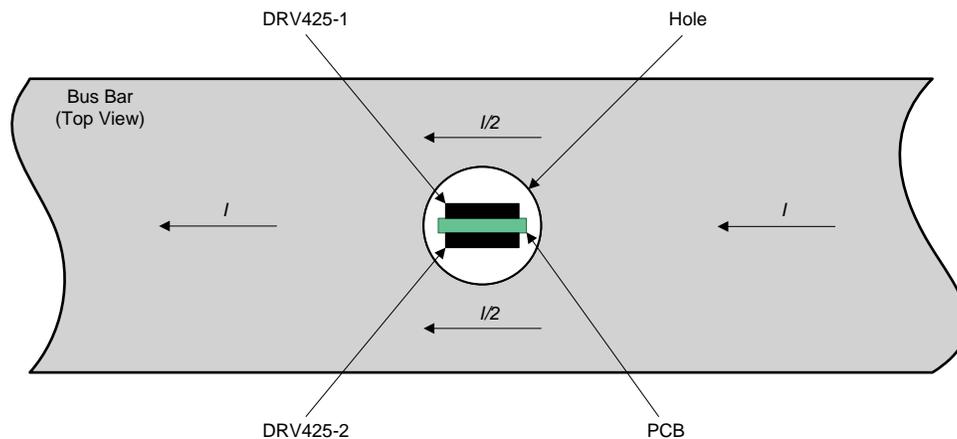


Figure 1. DRV425 Bus Bar Current Sensing Hole Configuration

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1 Magnetic Field Gradient

When current flows through a conductor it produces a magnetic field perpendicular to the flow of current. The direction of the magnetic field is determined by the right hand rule as demonstrated in Figure 2. The thumb points in the direction of the current (I) and the fingers curl in the direction of the magnetic field (B).

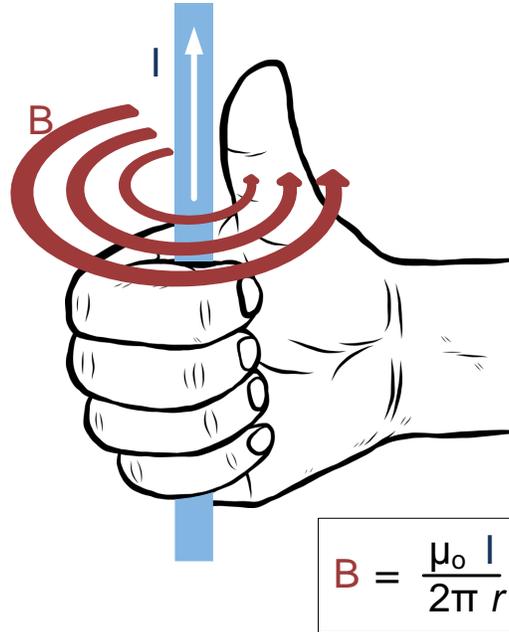


Figure 2. Right Hand Rule

The magnitude of the magnetic field (B) is proportional to the amount of current (I) flowing through the conductor and inversely proportional to the distance (r) away from the conductor. The magnetic field gradients are affected by the geometry of the conductor. For a rectangular conductor (bus bar), the corners of the conductor impact the magnetic field. At distances close to the bus bar, the magnetic fields resemble more of an ellipse as shown in Figure 3.

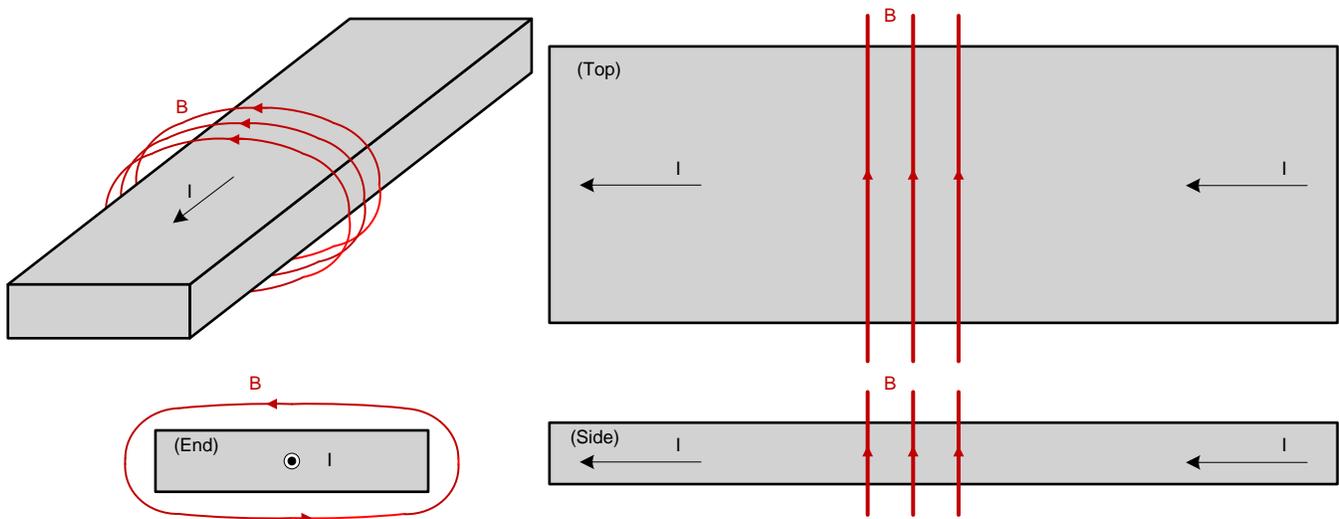


Figure 3. Magnetic Field Around Rectangular Conductor

Figure 4 shows the magnetic field gradients around a bus bar.

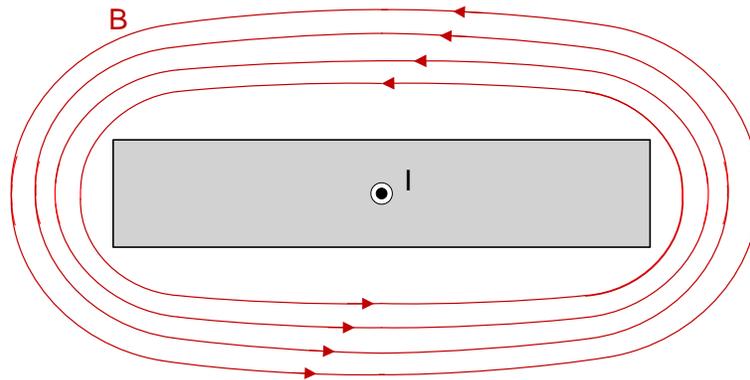


Figure 4. Magnetic Field Gradients

When a cutout (hole or slot) is placed in the center of the bus bar, the current is split in two equal parts. The magnetic fields generated by the current create opposite gradients inside the cutout as shown in Figure 5 and Figure 6. The opposing fields cancel each other out in the center of the cutout.

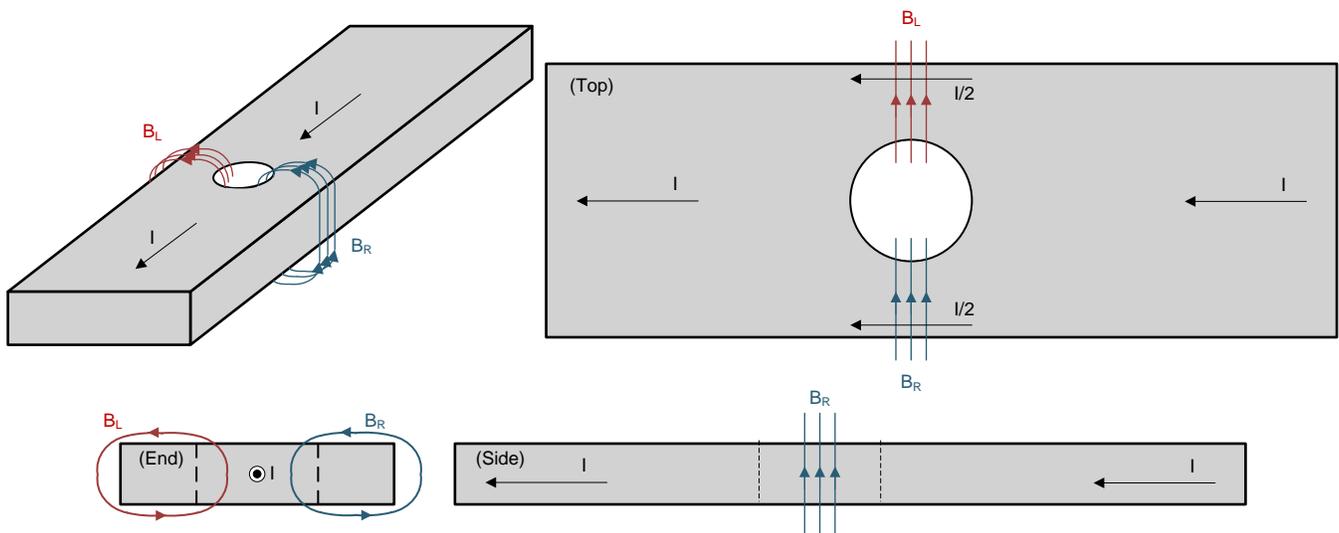


Figure 5. Magnetic Fields Inside of a Cutout in a Rectangular Conductor

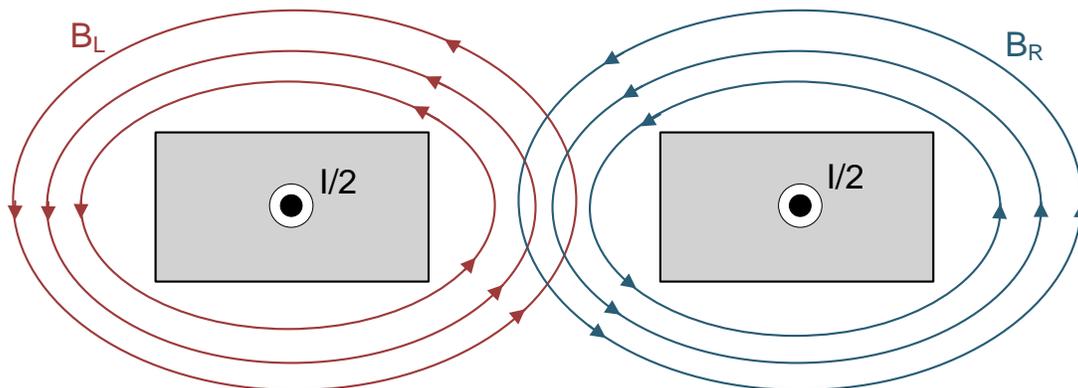


Figure 6. Magnetic Field Gradient Inside Cutout

2 DRV425 Sensor Characteristics

The internal fluxgate sensor in the DRV425 is a single-axis sensor. The DRV425 will measure magnetic fields only in its axis of sensitivity. The DRV425's axis of sensitivity is in the x-axis when looking at a top view with pin 1 in the upper left corner. The location of the fluxgate sensor in the package is shown in Figure 7.

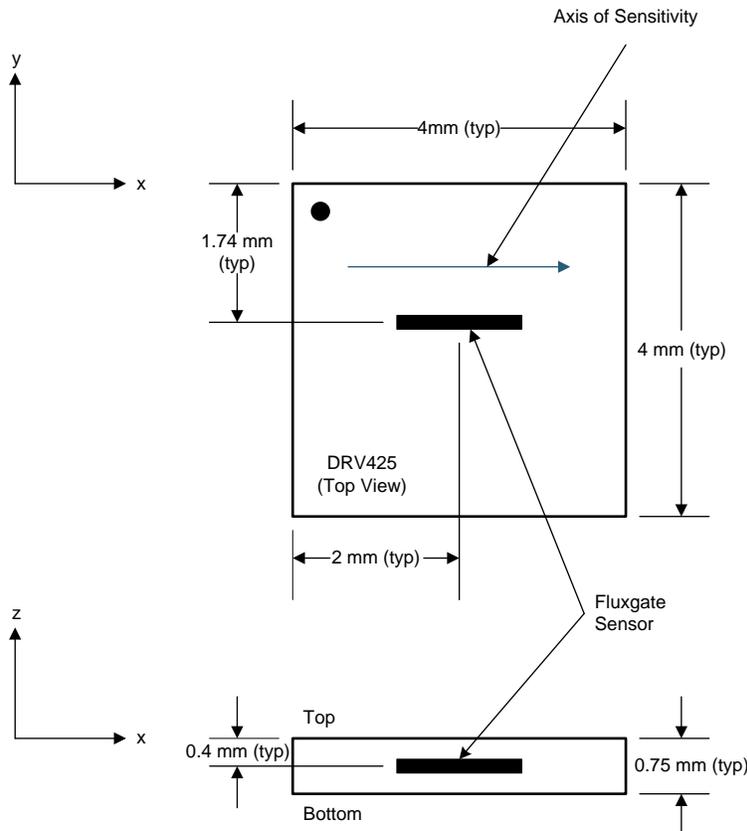


Figure 7. DRV425 Fluxgate Sensor Location

3 Bus Bar Design Requirements

In order to accurately measure the magnetic field gradient in a bus bar, two DRV425 devices are placed inside the cutout at a well-defined distance. The measurement range and resolution depends on the following factors:

- Bus bar geometry (width and height)
- Cutout configuration and size
- DRV425 PCB orientation (vertical or horizontal)
- DRV425 sensor spacing

Each of these factors can be optimized to create the desired measurement range for a specific application.

3.1 Bus Bar Geometry

The width (x) and height (y) of the bus bar are needed to accurately measure the magnetic field gradient. Figure 8 shows the bus bar geometry. A wider (larger x -dimension) and/or thicker bus bar (larger y -dimension) produces a smaller magnetic field gradient.

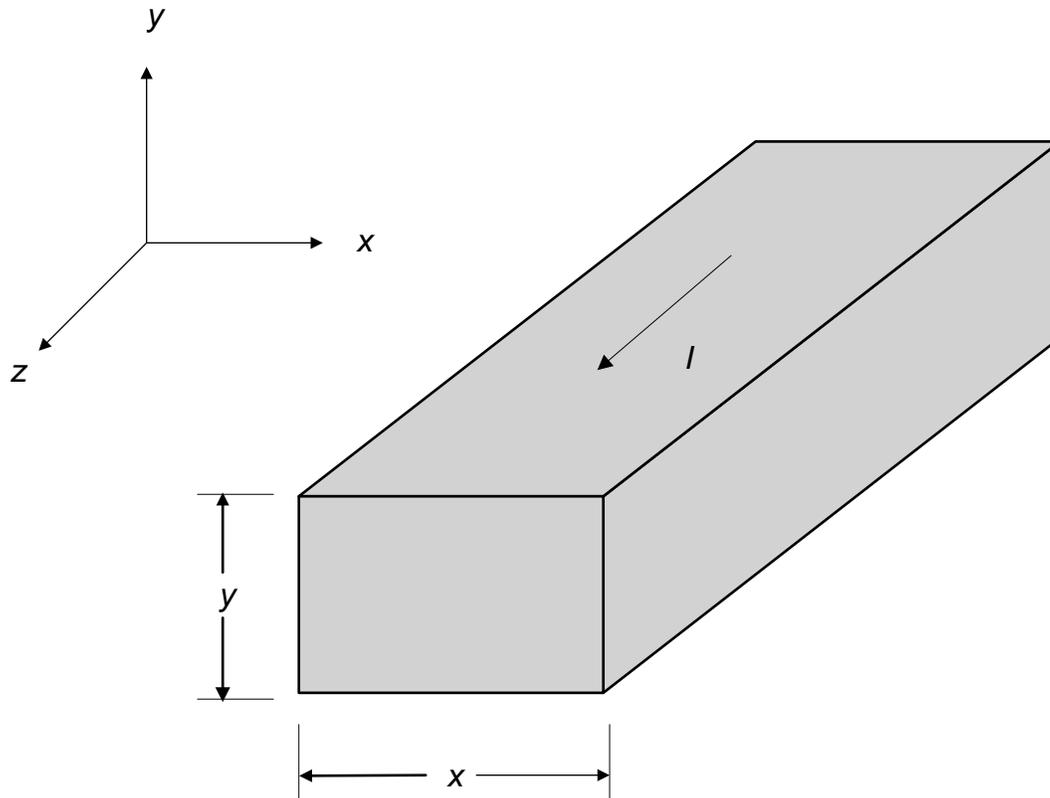


Figure 8. Bus Bar Geometry

3.2 Cutout Configuration and Size

The configuration and size of the cutout have an impact on the magnetic field located inside the cutout. The cutout in the bus bar has the largest impact on the magnetic field strength measurement. This document will describe two possible configurations: hole and slot. A smaller cutout cross section will produce a larger magnetic field strength inside the cutout. The noise level generated by stray magnetic fields is not affected by the cutout size. Therefore, a larger magnetic field strength from a smaller cutout cross section will increase the signal-to-noise ratio (SNR).

3.2.1 Hole

When a hole is placed in the center of a bus bar, the current is split as shown in [Figure 9](#). Because the magnetic field is perpendicular to the current flow, the magnetic field concentrates towards the center of the hole causing the magnetic field to have a 3-dimensional aspect. This is an advantage for this configuration because it amplifies the desired signal to be measured and increases the SNR. The smaller the hole diameter (D in [Figure 9](#)), the larger the magnetic field gradient inside the hole. The minimum hole diameter is dictated by the width of the PCB holding the two DRV425 devices ($D > \sim 6$ mm).

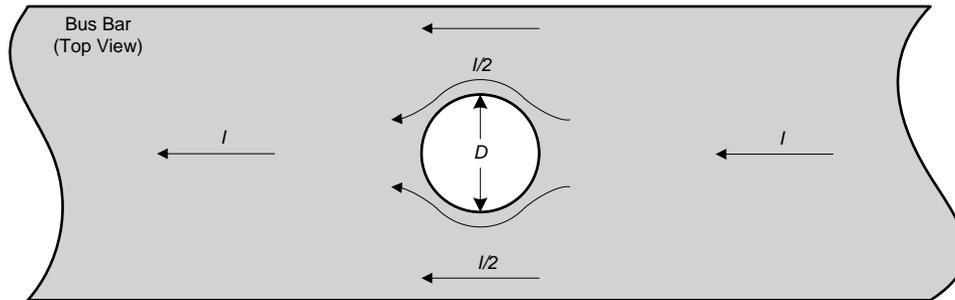


Figure 9. Hole Cutout Configuration

3.2.2 Slot

[Figure 10](#) shows a slot cutout configuration and dimensions (L and W). When a slot is placed in the center of a bus bar, the current is split evenly on both sides. The corresponding magnetic field gradients are symmetric and have a two-dimensional aspect. For maximum magnetic field inside the slot, the width (W) should be kept as small as possible. When the length (L) is less than 25.4 mm (1 in), the magnetic field gradients will be influenced by the ends of the cutout and no longer have a two-dimensional aspect.

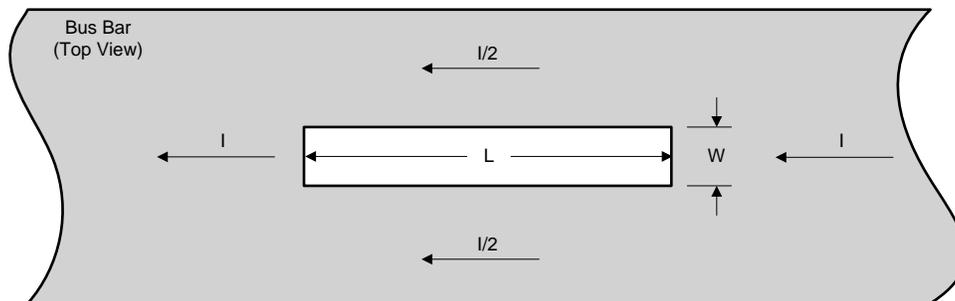


Figure 10. Slot Cutout Configuration

3.3 DRV425 PCB Layout Orientation

The dual DRV425 bus bar implementation has two PCB layout orientations (vertical and horizontal). Both layout orientations have similar noise rejection. Additionally, each layout orientation has a reduced susceptibility to saturation by stray magnetic fields.

3.3.1 Vertical PCB Layout Orientation

In the vertical PCB layout orientation each DRV425 device has its axis of sensitivity parallel to the PCB length as shown in Figure 11. Each device's axis of sensitivity is oriented in the opposite directions to provide a differential measurement.

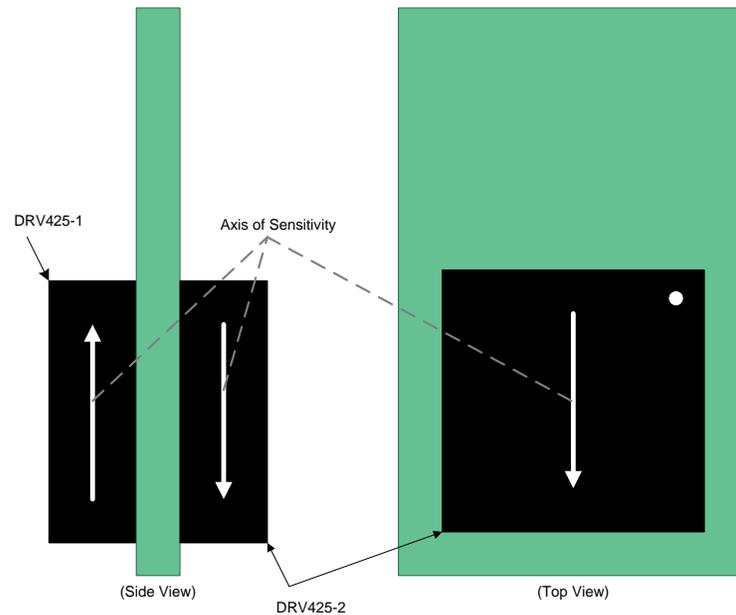


Figure 11. Vertical PCB Layout Configuration

In this orientation the PCB is placed in the center of the cutout in parallel with the current flow as shown in Figure 12. Note: Using the vertical PCB layout orientation allows for a smaller slot width because the width of the PCB is ~6 mm while the thickness of the PCB + two DRV425 devices is ~3.5 mm. Each DRV425 device will measure the difference in the magnetic fields generated from each side of the cutout.

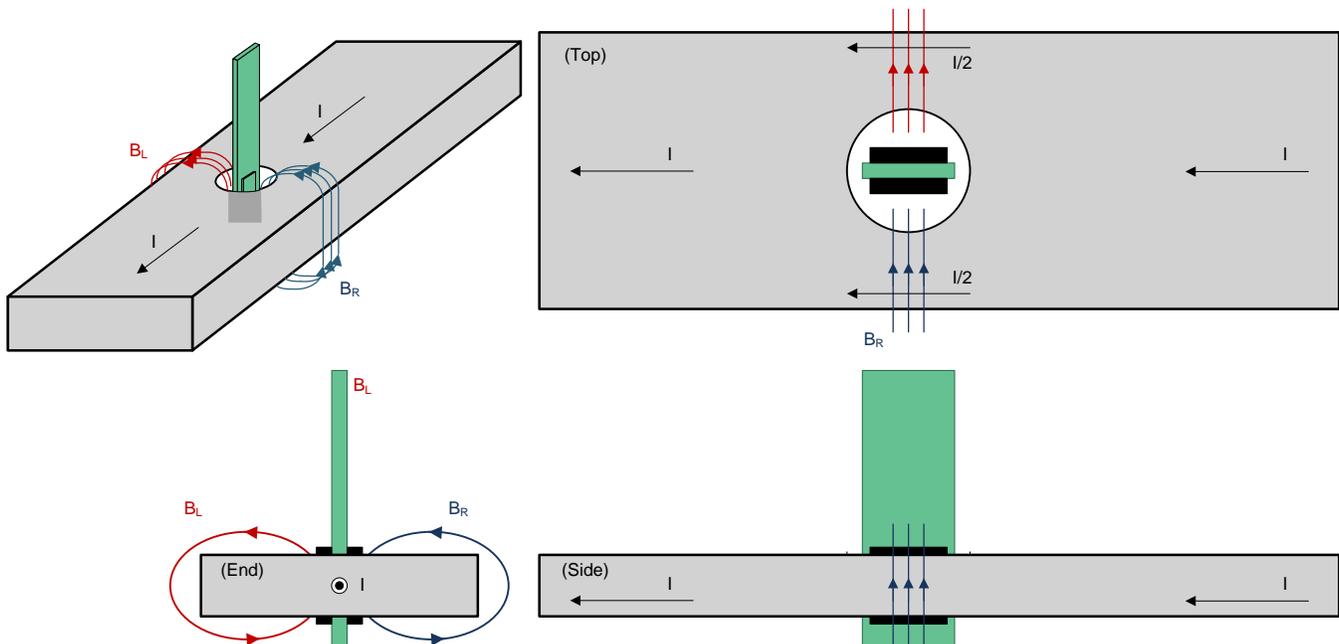


Figure 12. Vertical Layout in Bus Bar

Figure 13 shows the magnetic field gradients measurement for the vertical layout orientation. The magnetic field strength is larger and closer on the side of the cutout, and the strength decays the farther away from the side of the cutout. The axis of sensitivity for each DRV425 device needs to be oriented to match the magnetic field direction closest to its side of the cutout to generate a positive value.

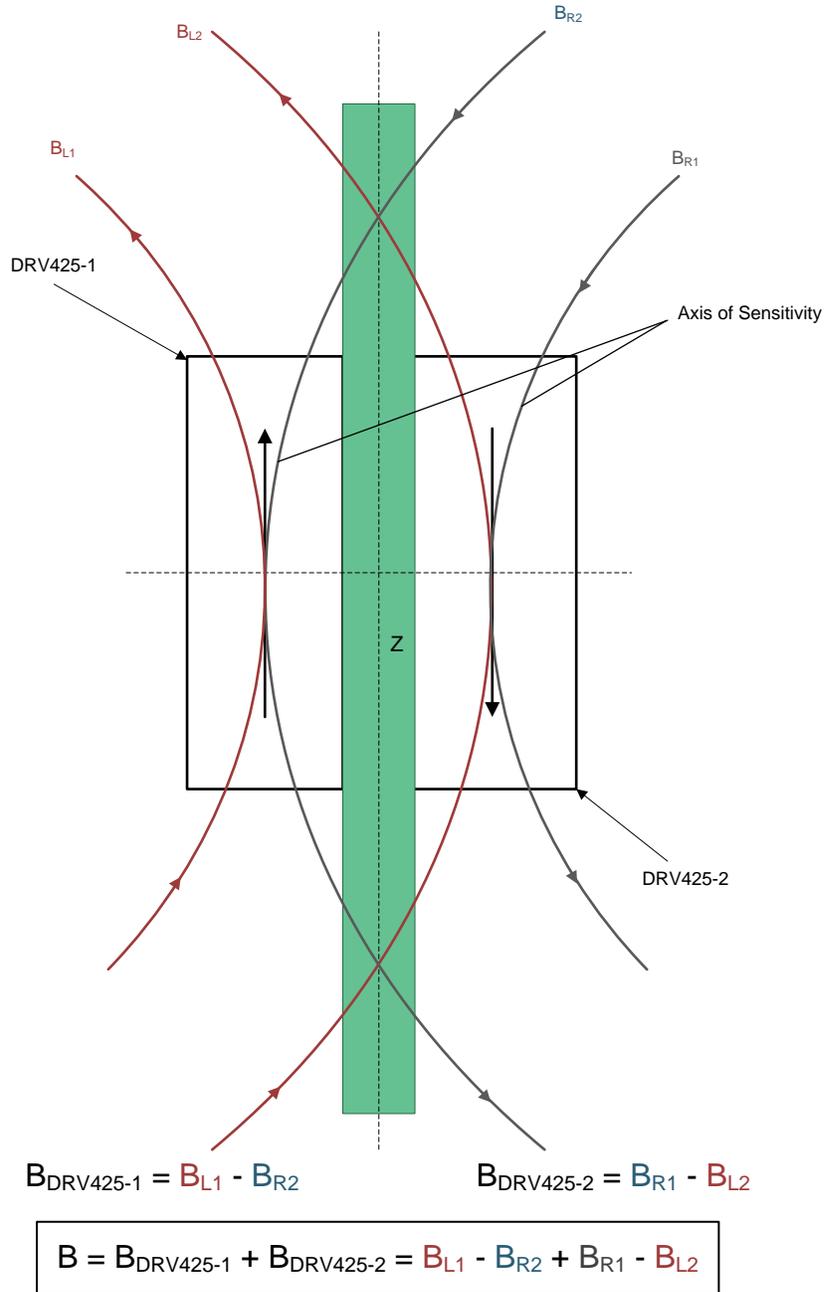


Figure 13. Vertical Layout Orientation Magnetic Field Measurement

- B_{R1} : Magnetic field strength at DRV425-2 from the right side of the cutout
- B_{R2} : Magnetic field strength at DRV425-1 from the right side of the cutout
- B_{L1} : Magnetic field strength at DRV425-1 from the left side of the cutout
- B_{L2} : Magnetic field strength at DRV425-2 from the left side of the cutout

3.3.2 Horizontal PCB Layout Orientation

In the horizontal PCB layout orientation each DRV425 device has its axis of sensitivity perpendicular to the PCB length as shown in Figure 14. Each device's axis of sensitivity is oriented in the opposite direction to provide a differential measurement.

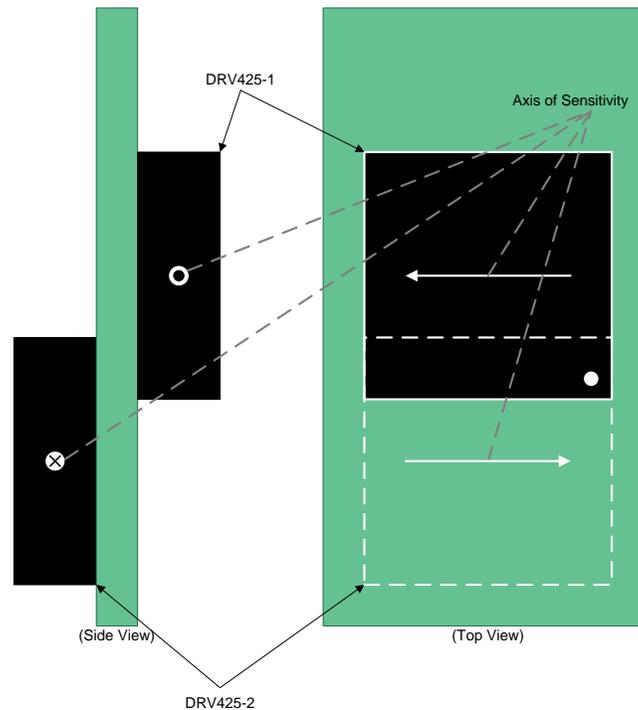


Figure 14. Horizontal PCB Layout Configuration

In this configuration the PCB is placed in the center of the cutout perpendicular with the current flow as shown in Figure 15. Each DRV425 device in this orientation measures the sum of the x-axis component of the magnetic field strength from each side of the cutout.

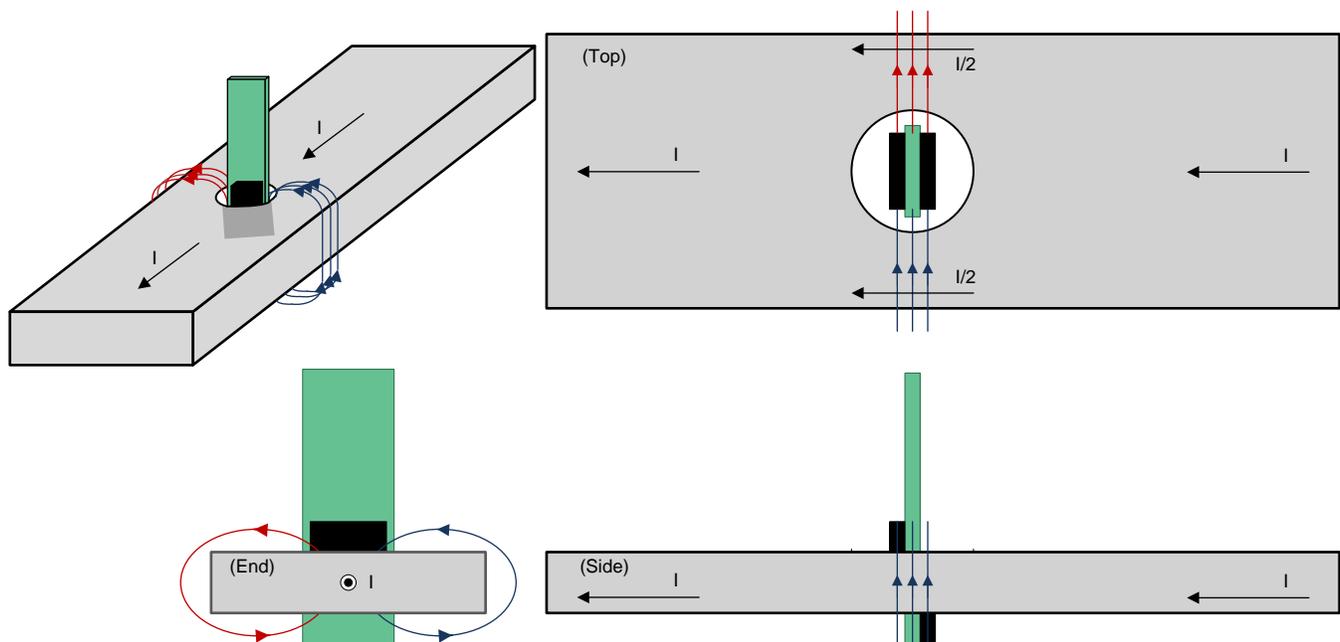


Figure 15. Horizontal Layout in Bus Bar

Because the DRV425 device's axis of sensitivity is horizontal for this orientation, each device will only measure the x-axis component of the magnetic fields. Figure 16 and Figure 17 show the magnetic fields seen by each DRV425 device. Note: Each DRV425 is drawn two times to show how each magnetic field is measured by the fluxgate sensor.

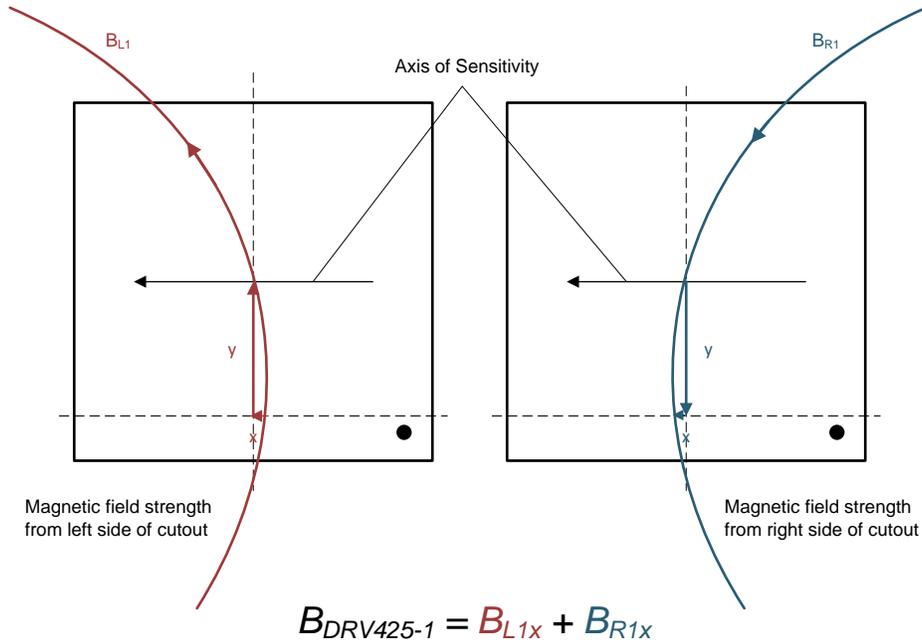


Figure 16. Magnetic Field Seen by DRV425-1

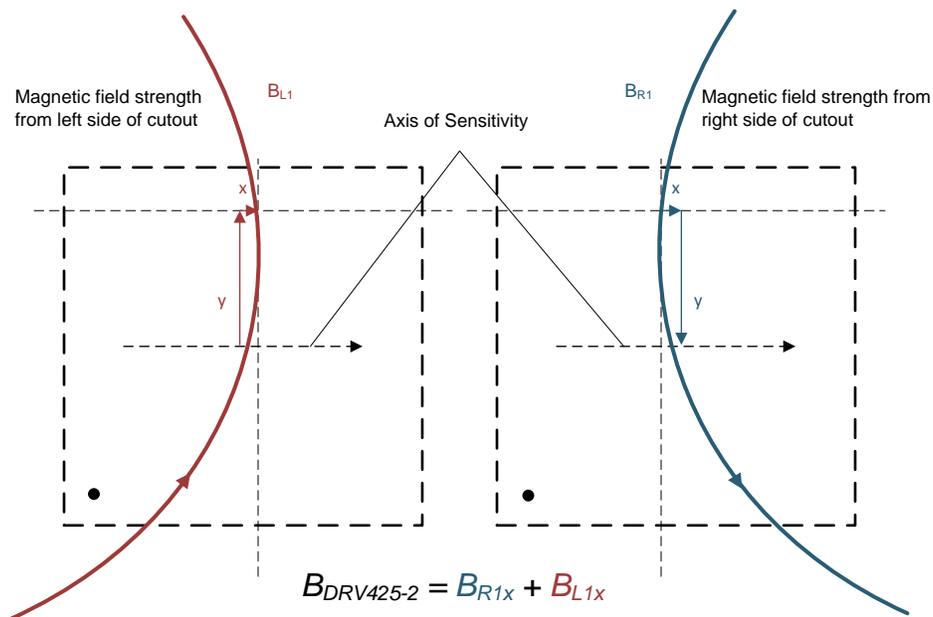


Figure 17. Magnetic Field Seen by DRV425-2

Figure 18 shows the combined DRV425 devices and the magnetic fields measured for this orientation. The axis of sensitivity for each DRV425 device needs to be oriented to match the magnetic field direction.

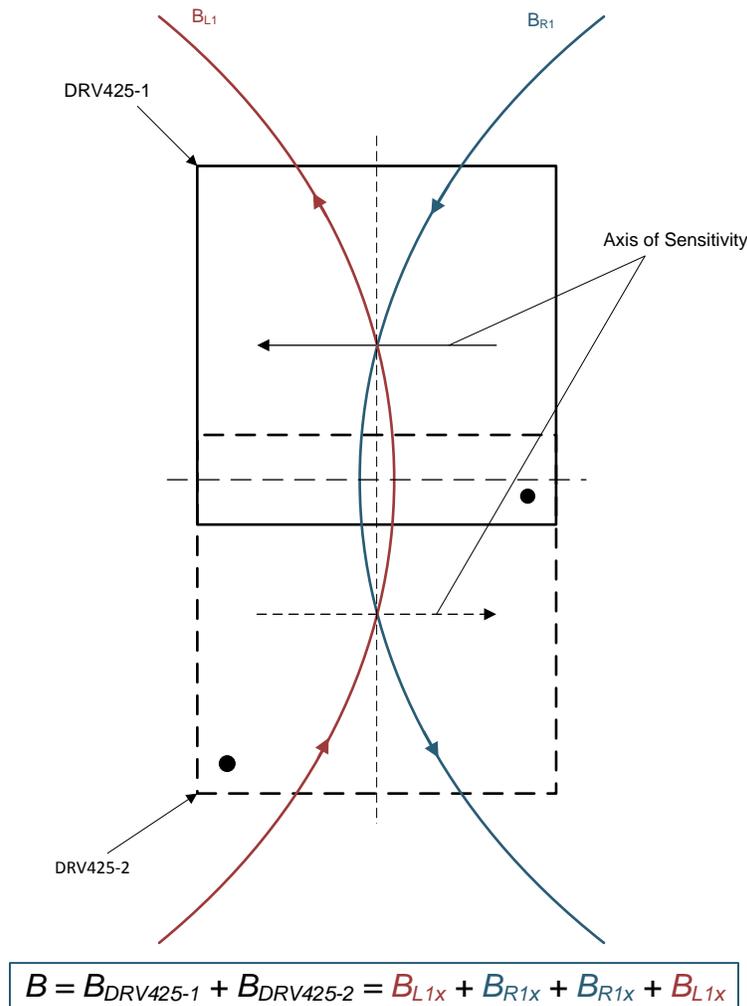


Figure 18. Horizontal Layout Magnetic Field Measurement

- B_{R1x} : Magnetic field strength at each DRV425 from the right side of the cutout in the x-axis
- B_{L1x} : Magnetic field strength at each DRV425 from the left side of the cutout in the x-axis

3.4 DRV425 Sensor Spacing

The final factor that influences the magnetic field strength in the dual DRV425 bus bar implementation is the spacing between DRV425 device sensors. The SNR of the desired measured magnetic field to unwanted stray measured magnetic field does not change with sensor spacing.

3.4.1 Vertical PCB Layout Orientation Sensor Spacing

In the vertical PCB layout orientation, the spacing of the DRV425 sensors is shown in Figure 19. A larger sensor spacing distance will produce a larger measured magnetic field differential in this orientation. For a slot configuration, smaller sensor spacing enables a thinner slot width.

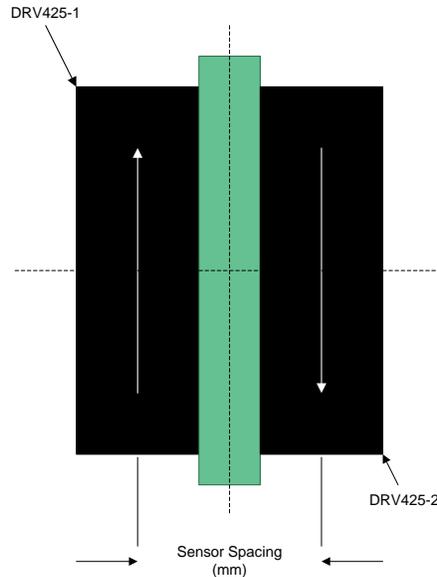


Figure 19. Vertical Layout Sensor Spacing

3.4.2 Horizontal PCB Layout Orientation Sensor Spacing

Figure 20 shows the DRV425 sensor spacing for the horizontal PCB layout orientation. A larger sensor spacing distance produces a larger measured magnetic field sum in this orientation.

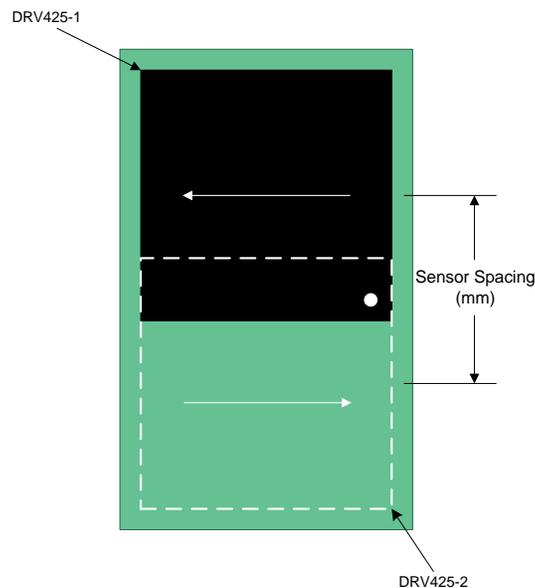


Figure 20. Horizontal Layout Sensor Spacing

3.5 Stray Field Impact

Due to the sensitivity of the DRV425, stray fields affect the measurement accuracy of the desired magnetic field. A stray field is an unwanted magnetic field that is measured by the DRV425. This measured stray magnetic field will result in an offset or error. The advantage of having a dual DRV425 orientation with each device's axis of sensitivity in an opposite direction is the effects from the stray magnetic fields will be reduced or cancelled. Figure 21 shows how the stray magnetic fields are measured by the two DRV425 devices.

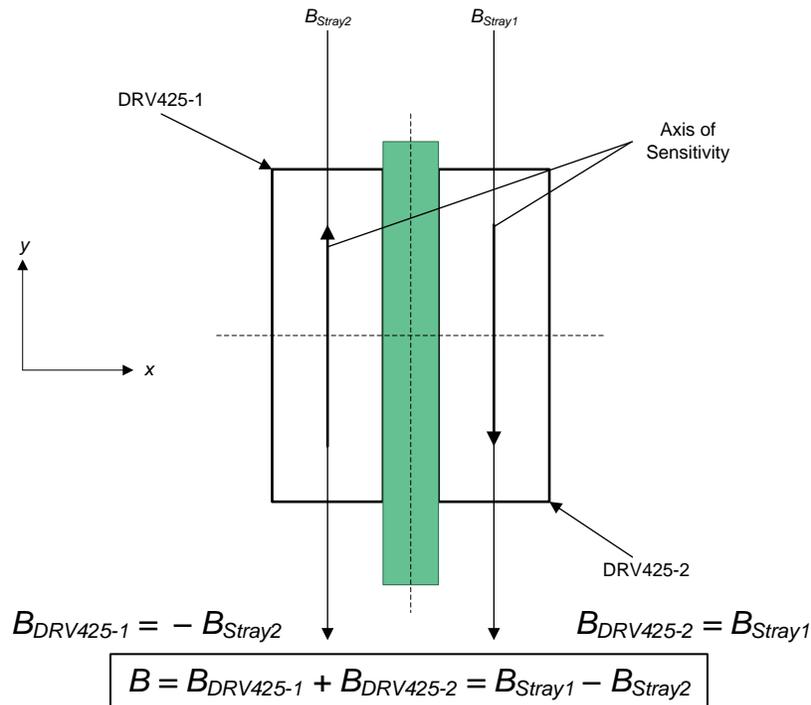


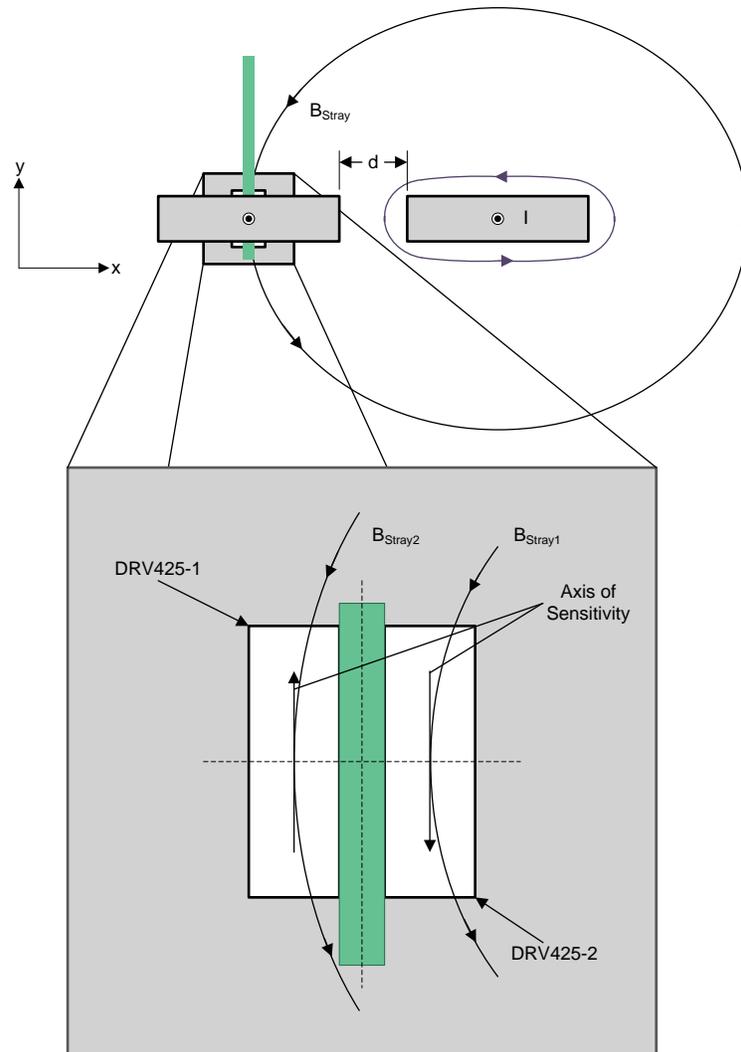
Figure 21. Stray Magnetic Field

- B_{Stray1} : Stray magnetic field strength at DRV425-2
- B_{Stray2} : Stray magnetic field strength at DRV425-1

When the magnitude of a stray magnetic field is seen by both DRV425 devices and has equal strength ($B_{Stray1} = B_{Stray2}$), the result will be an offset or error of zero. An example of this type of stray magnetic field is the Earth's magnetic field.

3.5.1 Vertical PCB Layout Orientation Stray Magnetic Field Susceptibility

The vertical PCB layout orientation is susceptible to stray magnetic fields in the vertical path (y-axis). An example of this is when two or more bus bars are placed in parallel in the x-axis as shown in Figure 22.



$$B_{\text{DRV425-1}} = -B_{\text{Stray2}}$$

$$B_{\text{DRV425-2}} = B_{\text{Stray1}}$$

$$B = B_{\text{DRV425-1}} + B_{\text{DRV425-2}} = B_{\text{Stray1}} - B_{\text{Stray2}}$$

Figure 22. Vertical Layout Stray Magnetic Field Susceptibility

- B_{Stray1} : Stray magnetic field strength at DRV425-2
- B_{Stray2} : Stray magnetic field strength at DRV425-1

In this configuration, the distance (d) between the bus bars determines the strength difference of the stray magnetic field seen as an offset or error. Table 1 provides some example errors illustrating the impact of stray magnetic fields or crosstalk in this orientation.

Conditions:

- 2 bus bars: 1.5 in (38.1 mm) x 0.09 in (2.286 mm)
- 0.5-in (12.7-mm) hole
- 0.07874-in (2-mm) sensor spacing
- 100A of current

Table 1. Vertical Stray Magnetic Field Error

| d (in) | ERROR |
|--------|-------|
| 0.25 | 5.18% |
| 0.5 | 3.77% |
| 1 | 2.28% |
| 2 | 1.11% |
| 4 | 0.44% |
| 6 | 0.23% |

This offset or error can either be left in the system or calibrated out.

Another potential issue with using the vertical PCB layout orientation when two or more bus bars are placed in parallel in the x-axis is the possibility of saturation. As discussed earlier, each DRV425 device measures the difference in the magnetic fields generated from each side of the cutout plus the stray fields from the adjacent bus bar as shown in Figure 23. If the total magnetic field of either DRV425 device is larger than 2 mT, the DRV425 will saturate and all measurements will be incorrect.

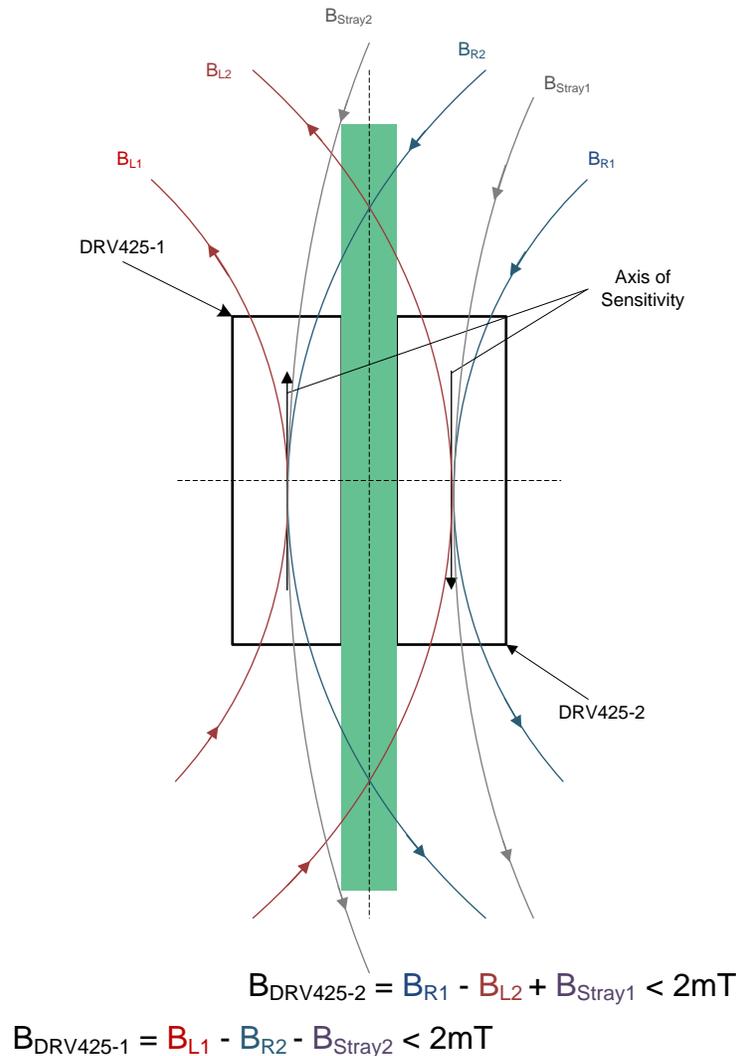


Figure 23. Possible Vertical Saturation Configuration

3.5.2 Horizontal PCB Layout Orientation Stray Magnetic Field Susceptibility

The horizontal PCB layout orientation is susceptible to stray magnetic fields in the horizontal path. An example of this is when two or more bus bars are placed in parallel in the y-axis as shown in Figure 24.

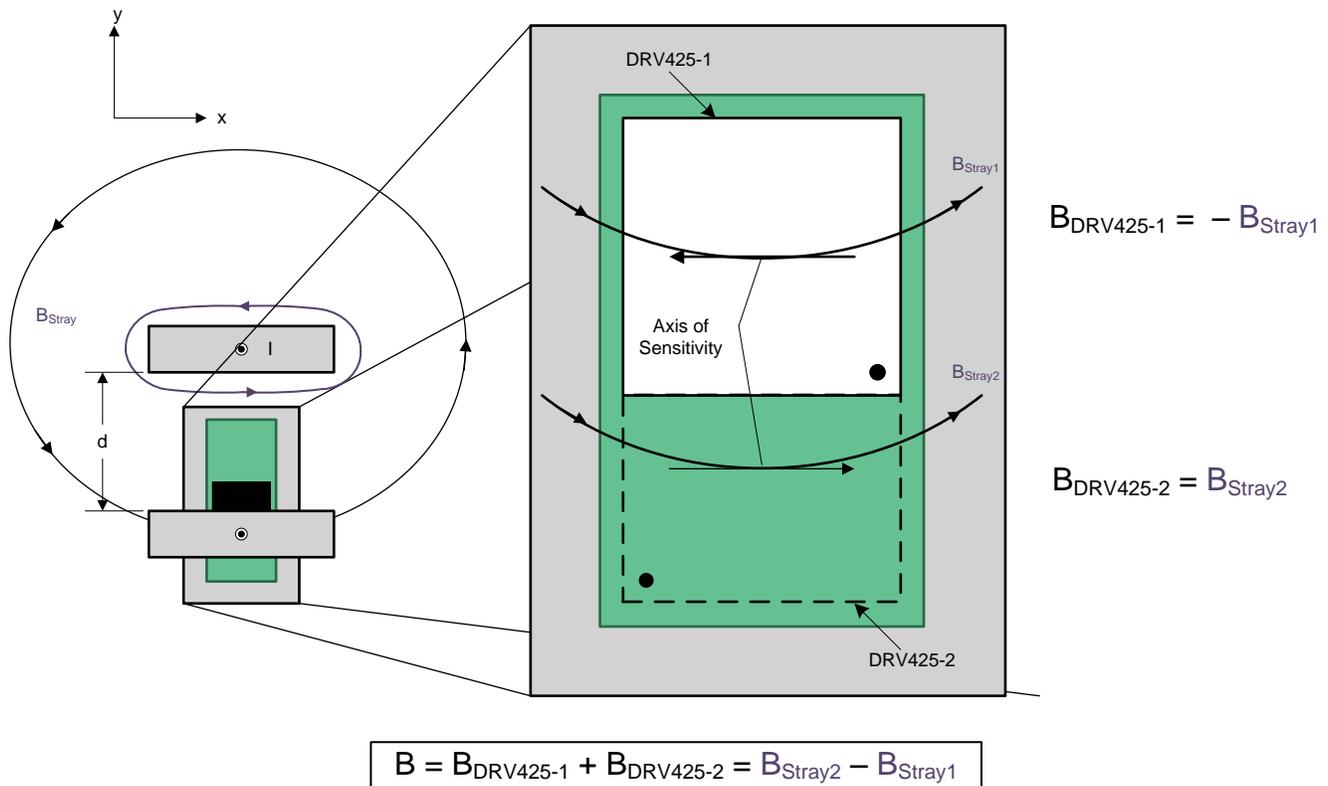


Figure 24. Horizontal Layout Stray Magnetic Field Susceptibility

- B_{Stray1} : Stray magnetic field strength at DRV425-2
- B_{Stray2} : Stray magnetic field strength at DRV425-1

In this configuration, the distance (d) between the bus bars determines the strength difference of the stray magnetic field seen as an offset or error. [Table 2](#) provides some example errors illustrating the impact of stray magnetic fields or crosstalk in this orientation.

Conditions:

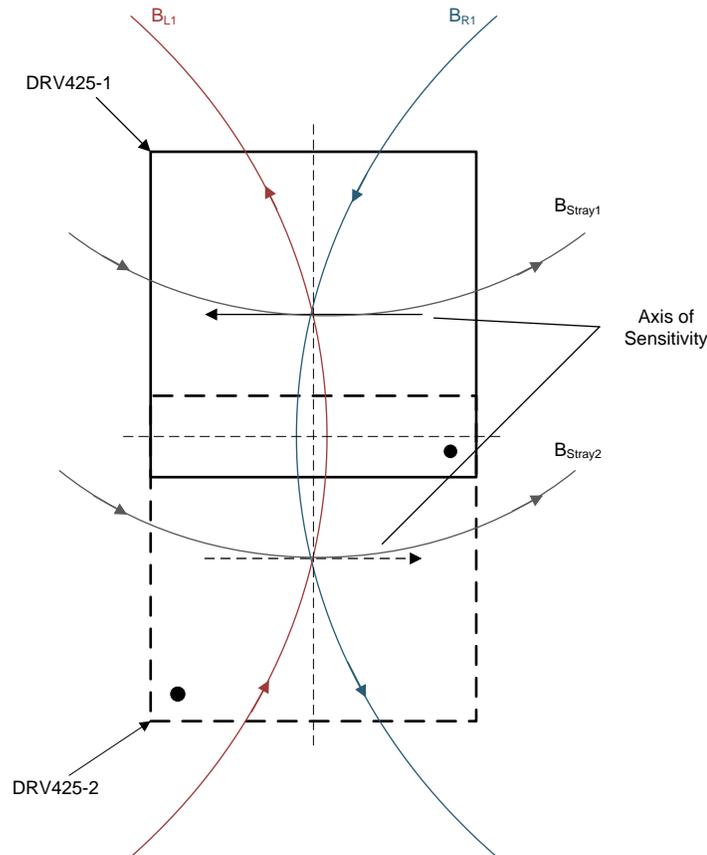
- 2 bus bars: 1.5 in (38.1 mm) x 0.09 in (2.286 mm)
- 0.5-in (12.7-mm) hole
- 0.07874-in (2-mm) sensor spacing
- 100A of current

Table 2. Horizontal Stray Magnetic Field Error

| d (in) | ERROR |
|--------|-------|
| 1 | 3.50% |
| 2 | 1.58% |
| 4 | 0.56% |
| 6 | 0.28% |
| 8 | 0.17% |

This offset or error can either be left in the system or calibrated out.

Another potential issue with using the horizontal PCB layout orientation when two or more bus bars are placed in parallel in the y-axis is the possibility of saturation. As discussed earlier, each DRV425 device will measure the sum in the magnetic fields generated from each side of the cutout plus the stray fields from the adjacent bus bar as shown in Figure 23. If the total magnetic field of either DRV425 device is larger than 2 mT, the DRV425 will be in saturation and all measurements will be incorrect.



$$B_{DRV425-1} = B_{L1x} + B_{R1x} - B_{Stray1} < 2\text{mT}$$

$$B_{DRV425-2} = B_{R1x} + B_{L1x} + B_{Stray2} < 2\text{mT}$$

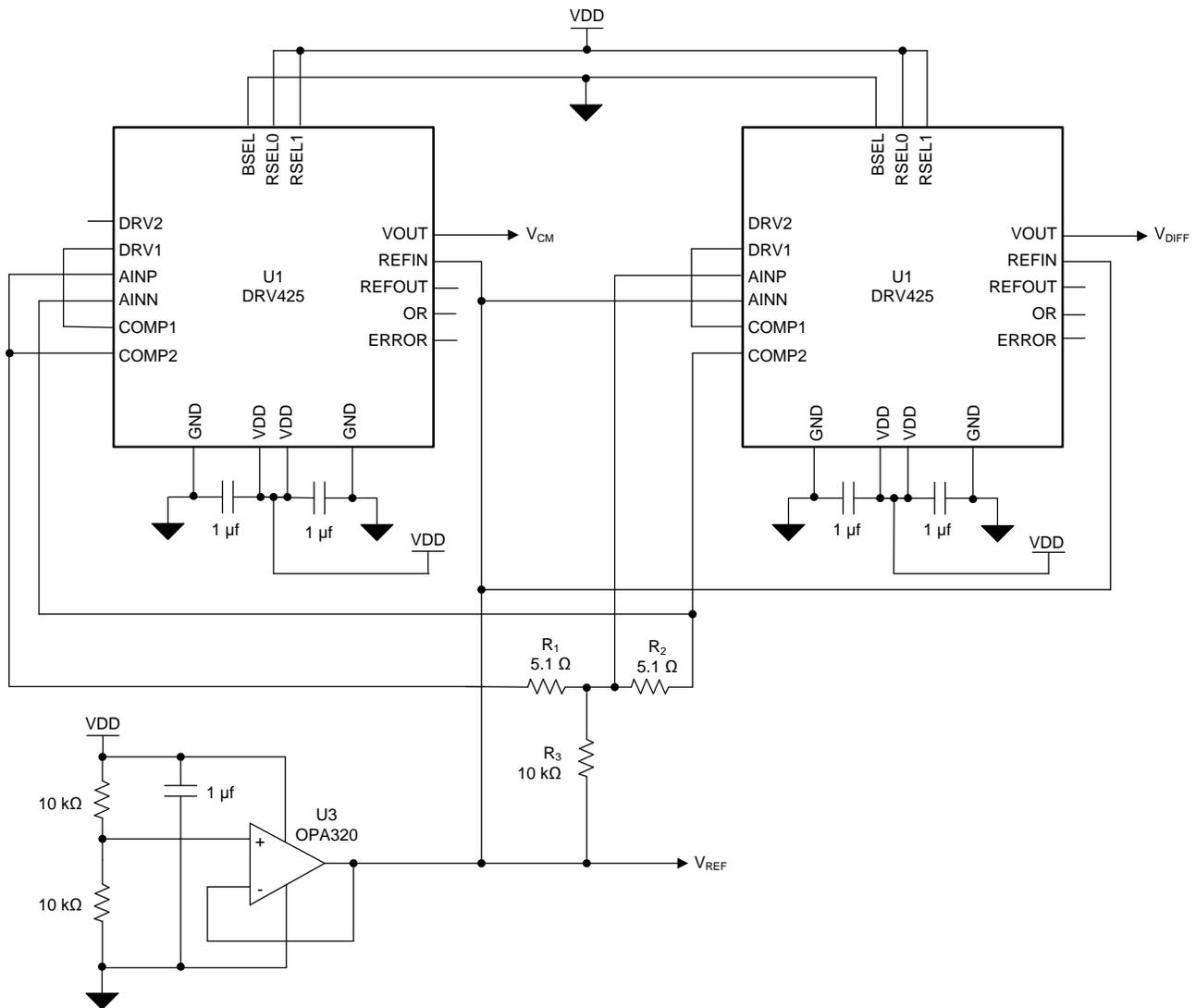
Figure 25. Possible Horizontal Saturation Configuration

3.6 Bus Bar Design Requirements Summary

The mechanical dimensions of the bus bar and PCB layout configuration all impact the magnetic field strength generated by the current flow. Of the four factors described above, the size of the cutout has the largest impact on the magnetic field strength and SNR. When choosing a PCB layout orientation, knowledge of the overall system and location of potential stray magnetic fields affects the optimal orientation.

4 Circuit Analysis Description

The circuit for the dual DRV425 bus bar implementation is orientation independent. The layout is different for each orientation due to the axis of sensitivity, but the circuit is the same, as shown in [Figure 26](#).



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Figure 26. DRV425 Bus Bar Schematic

Figure 27 shows a functional block diagram for the dual DRV425 bus bar schematic.

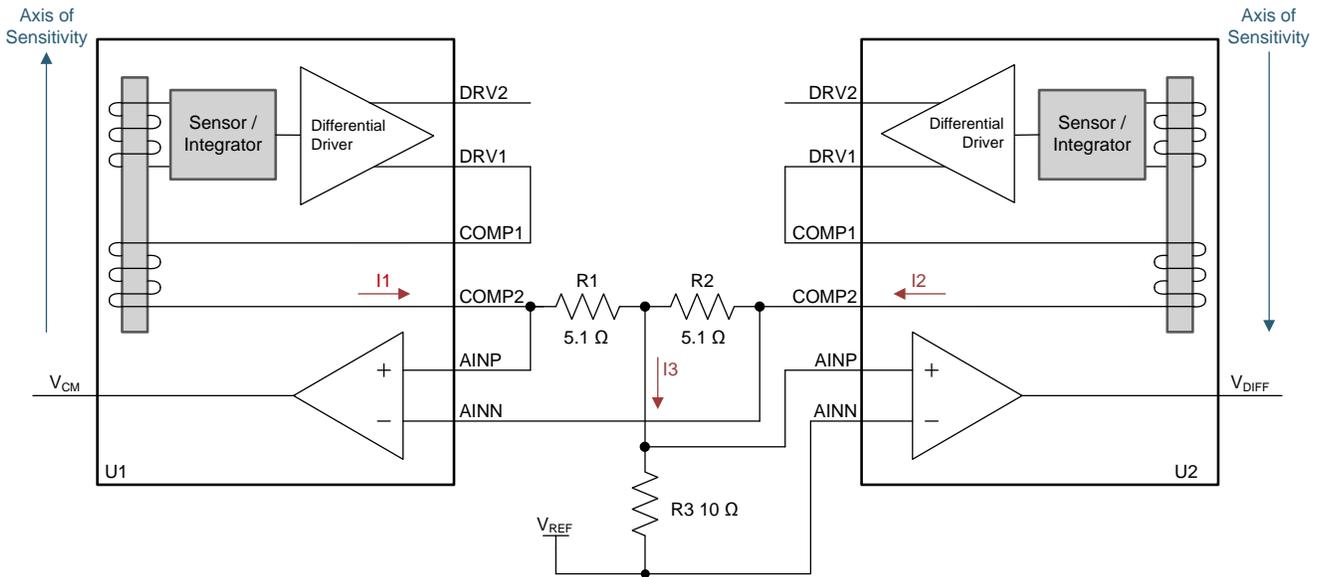
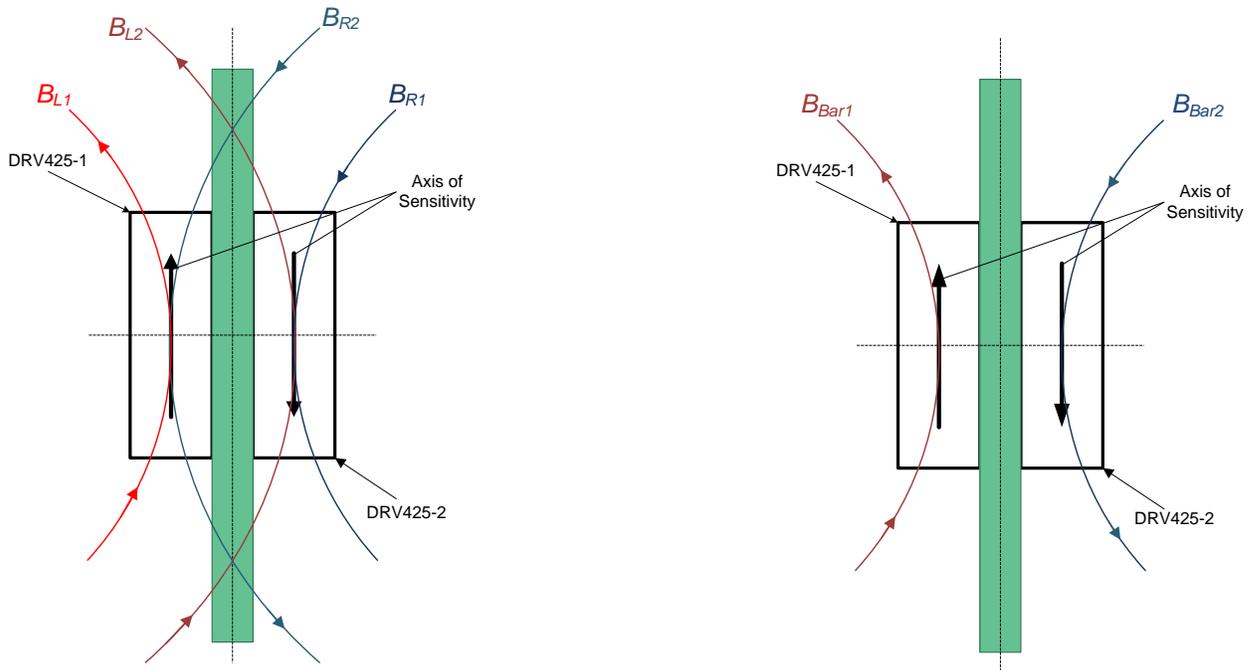


Figure 27. DRV425 Bus Bar Function Block Diagram

4.1 Circuit Analysis of the Dual DRV425 Bus Bar Application

The setup for the configuration described below will be as shown in Figure 12. The current (I) that is measured creates the magnetic fields B_R and B_L . B_R is the magnetic field created from the right side of the bus bar, and B_L is created from the left side. As previously described, B_R has a stronger influence on U_1 , and B_L has a stronger influence on U_2 . It is important to note the dominate direction of the magnetic field at each sensor location. Superposition principle can be used on magnetic fields at the location of each sensor due to the current on the bar. Figure 28 shows the combination of the field to create B_{Bar1} and B_{Bar2} . The bus bar is symmetrical; therefore, the magnitude of B_{Bar1} and B_{Bar2} are equal – only facing in opposite directions.



$$B_{DRV425-1} = B_{L1} - B_{R2}$$

$$B_{DRV425-2} = B_{R1} - B_{L2}$$

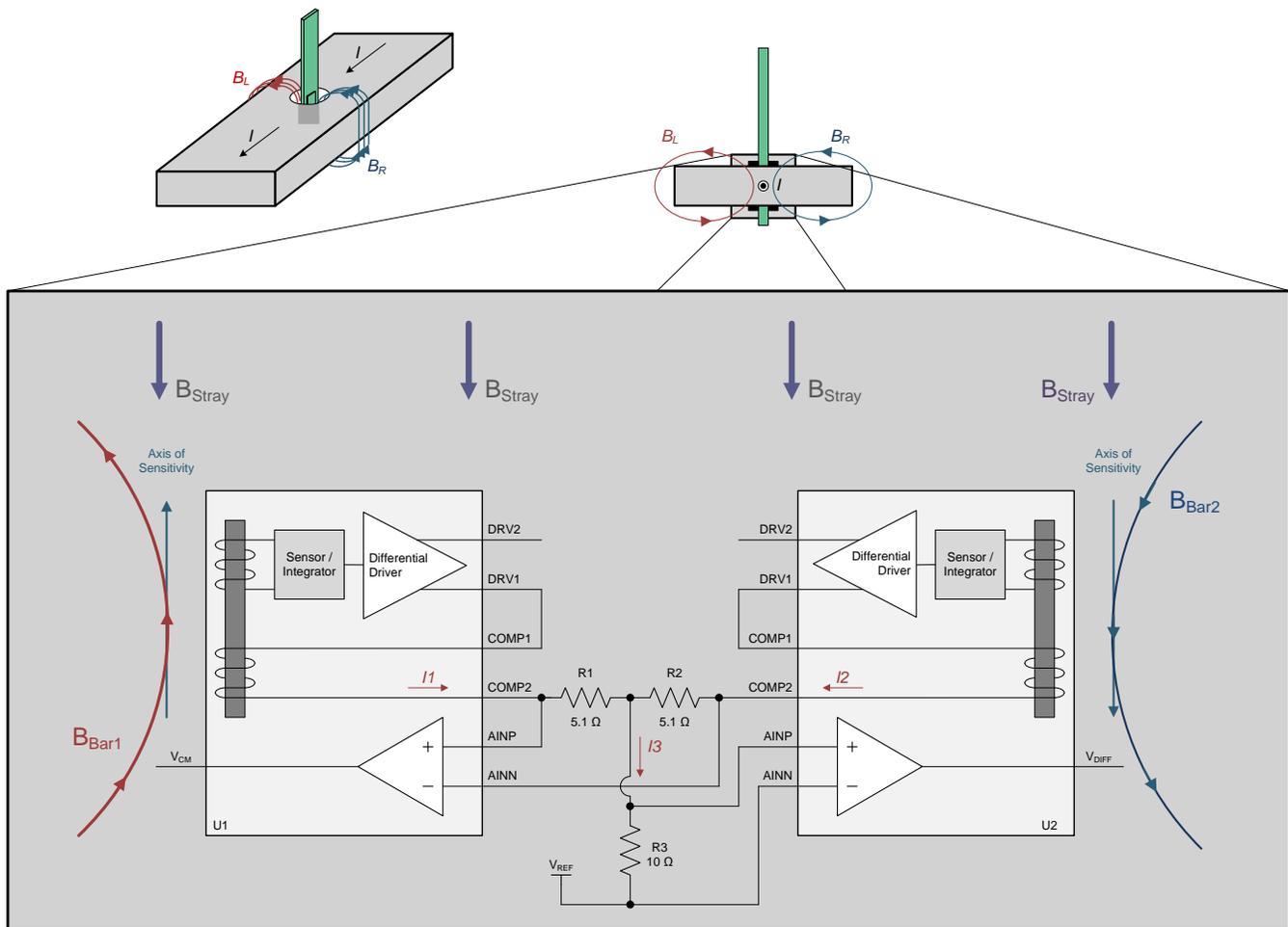
$$B_{DRV425-1} = B_{L1} - B_{R2} = B_{Bar1}$$

$$B_{DRV425-2} = B_{R1} - B_{L2} = B_{Bar2}$$

Figure 28. Combination of B_R and B_L to Create B_{Bar1} and B_{Bar2}

The DRV425 has a current output that drives the compensation coil, which is proportional to the magnetic field sensed by each DRV425 device. There is a detailed description of this in the [DRV425 Fluxgate Magnetic-Field Sensor](#) data sheet. For magnetic field strength calculation, see the [DRV425 Bus Bar Application Magnetic Field Calculator](#).

Figure 29 zooms in on the bus bar with magnetic fields and the circuit schematic. U_1 on the left drives the compensation current I_1 , and U_2 drives the compensation current I_2 . These currents combine through R_1 , R_2 and then flow through R_3 . The shunt-sense amplifiers are then connected across the resistors to give either the common mode magnetic field or the difference of the two DRV425 magnetic fields. The circuit gives two outputs V_{Diff} and V_{CM} . V_{Diff} is the differential magnetic field of the two DRV425 devices while V_{CM} is the common field seen by both DRV425. The following subsections describe four examples to show how the circuit behaves.


Figure 29. Circuit With Magnetic Field

$$I_{\text{Out}} = B * G_{\text{Flux}} \quad (1)$$

$$I_1 + I_2 = I_3 \quad (2)$$

$$V_{\text{Diff}} = I_3 * R_3 * G_{\text{amp}} \quad (3)$$

$$V_{\text{CM}} = (I_1 - I_2) * (R_1 + R_2) * G_{\text{amp}} \quad (4)$$

where:

- I_{out} : Current out of DRV425 going into Comp1 and out of Comp2
- B : Magnetic field measured at DRV425
- G_{Flux} : Gain of flux gate sensor, 12.2 mA/mT
- G_{amp} : Gain of the sense amplifier, 4 V/V
- V_{Diff} : Difference in magnetic field detected by both DRV425s
- V_{CM} : Common magnetic field detected by both DRV425s

Conditions:

- 1 bus bar: 1.5 in (38.1 mm) × 0.09 in (2.286 mm)
- 0.5-in (12.7-mm) hole
- 0.07874-in (2-mm) sensor spacing

4.1.1 Example One: No Current Flow, 50- μ T Stray Field

$$I_{\text{Bar}} = 0$$

$$B_{\text{Stray}} = 50 \mu\text{T}$$

With the stray field of $B_{\text{Stray}} = 50 \mu\text{T}$ and the current through the bus bar of $I = 0 \text{ A}$, the DRV425s only detect magnetic fields generated by the stray field, which are the same with both devices. As shown in [Figure 29](#), B_{Stray} is in the opposite direction of U_1 sensitivity, which produces a negative current. Using [Equation 1](#) with $B = -50 \mu\text{T}$ yields the result of $I_1 = -610 \mu\text{A}$. U_2 measures the same magnetic field but is in the same direction of its sensitivity, so it produces a positive $I_2 = 610 \mu\text{A}$. Through Kirchhoff's current law, [Equation 2](#) is obtained. In this condition, the calculation results yields the result of $I_3 = 0$. The output voltages can be calculated with [Equation 3](#) and [Equation 4](#). This calculation produces an output voltage of $V_{\text{Diff}} = 0 \text{ V}$ and $V_{\text{CM}} = -49.775 \text{ mV}$. All output voltages are referenced to the V_{ref} voltage and are bipolar.

4.1.2 Example Two: 100-A Current Flow, No Stray Field

$$I_{\text{Bar}} = 100 \text{ A}$$

$$B_{\text{Stray}} = 0 \mu\text{T}$$

With the stray field of $B_{\text{Stray}} = 0 \mu\text{T}$ and the current through the bus bar of $I = 100 \text{ A}$, the DRV425s only detect magnetic fields generated by the current in the bus bar. The bus bar current creates a magnetic field of $B_{\text{Bar1}} = B_{\text{Bar2}} = 239.66 \mu\text{T}$ at each DRV425. As shown in [Figure 29](#), the magnetic field generated from the bus bar on U_1 is in the same direction, which produces a positive current. Using [Equation 1](#) with $B = 239.66 \mu\text{T}$ yields the result of $I_1 = 2.924 \text{ mA}$. U_2 measures the same magnetic magnitude field and is in the same direction of its sensitivity so it also produces a positive $I_2 = 2.924 \text{ mA}$. Through [Equation 2](#), $I_3 = 5.848 \text{ mA}$. The output voltages can be calculated with [Equation 3](#) and [Equation 4](#). This calculation produces an output voltage of $V_{\text{Diff}} = 233.9 \text{ mV}$ and $V_{\text{CM}} = 0 \text{ V}$.

4.1.3 Example Three: 100-A Current Flow, 50- μ T Stray Field

$$I_{\text{Bar}} = 100 \text{ A}$$

$$B_{\text{Stray}} = 50 \mu\text{T}$$

With the stray field of $B_{\text{Stray}} = 50 \mu\text{T}$ and the current through the bus bar of $I = 100 \text{ A}$, the DRV425s detect both magnetic fields generated by the current in the bus bar and the stray field. The bus bar current creates a magnetic field of $239.66 \mu\text{T}$ at each DRV425, and the stray field is $50 \mu\text{T}$. Using the superposition principle, the magnetic field will sum at the location of the sensor. The direction and axis of sensitivity is important to determine if they should add or subtract. So U_1 will detect $239.66 \mu\text{T} + (-50 \mu\text{T}) = 189.66 \mu\text{T}$, and U_2 will detect $239.66 \mu\text{T} + 50 \mu\text{T} = 289.66 \mu\text{T}$. Using [Equation 1](#) for each DRV425, the results are $I_1 = 2.314 \text{ mA}$ and $I_2 = 3.534 \text{ mA}$. Through [Equation 2](#), $I_3 = 5.848 \text{ mA}$. Notice the I_3 value did not change from example two (see [Section 4.1.2](#)) by adding an ambient field that is constant on both DRV425. The output voltages can be calculated with [Equation 3](#) and [Equation 4](#). This calculation produces an output voltage $V_{\text{Diff}} = 233.9 \text{ mV}$ and $V_{\text{CM}} = -49.776 \text{ mV}$.

4.1.4 Example Four: 100-A Current Flow, Neighbor Current Stray Field

$I_{Bar} = 100 \text{ A}$
 $B_{Stray1} = 143.02 \mu\text{T}$
 $B_{Stray2} = 145.11 \mu\text{T}$
 Neighbor current = 100 A
 Neighbor distance (d) = 4 in (101.6 mm)

The previous examples dealt with a magnetic field constant at both DRV425 devices. A neighbor current, as seen in Figure 30, will not produce the same magnetic field at each DRV425 device due to the fact each DRV425 is a different distance from the neighboring current. The distance away from the current source determines the magnetic field strength; therefore, $B_{Stray2} > B_{Stray1}$. This difference generates an error that will be detected at the output V_{Diff} . This error is highly influenced by the distance (d) as explained in Section 3.5. In this example, the distance used is: (d) = 4 in (101.6 mm).

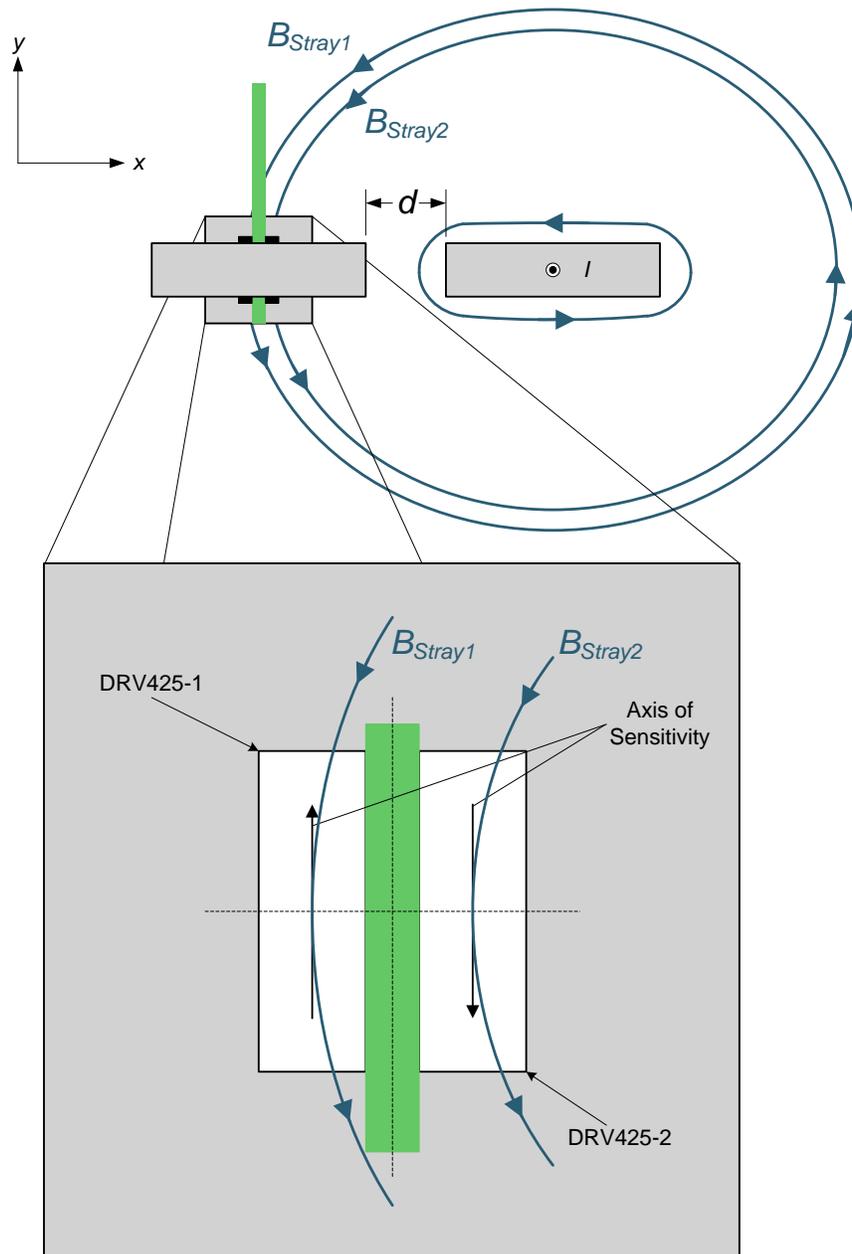


Figure 30. Stray Field Due to Neighbor Current

The stray fields are now different for each sensor. The bus bar is $I = 100$ A. The DRV425s detect both magnetic fields generated by the current in the bus bar and the stray fields generated by neighboring current. The bus bar current creates a magnetic field of $239.66 \mu\text{T}$ at each DRV425, and the neighboring current creates the fields of $B_{\text{Stray1}} = 143.02 \mu\text{T}$ and $B_{\text{Stray2}} = 145.11 \mu\text{T}$. The superposition principle and direction of the field is used again to calculate the magnetic field at the location of the sensor. So U_1 will detect $239.66 \mu\text{T} + (-143.02 \mu\text{T}) = 96.64 \mu\text{T}$, and U_2 will see $239.66 \mu\text{T} + 145.11 \mu\text{T} = 387.77 \mu\text{T}$. Using [Equation 1](#) for each DRV425, the results are $I_1 = 1.179$ mA and $I_2 = 4.694$ mA. Through [Equation 2](#), $I_3 = 5.873$ mA. Notice the I_3 value changed from example two (see [Section 4.1.2](#)) and example three (see [Section 4.1.3](#)). The output voltages can be calculated with [Equation 3](#) and [Equation 4](#). This calculation produces an output voltage $V_{\text{Diff}} = 234.9$ mV and $V_{\text{CM}} = -143.34$ mV. The stray fields from the neighbor current give a 0.428% error.

4.1.5 Circuit Design Considerations

The analysis done in examples one, two, and three were completed with a stray field constant on both devices. This constant would be something like the earth's magnetic field, which will vary insignificantly between both devices. As described in the stray field susceptibility sections of this application report, the stray fields from other sources will not be completely cancelled, and the error is shown in example four. The circuit has some tradeoff for making the differential measurement an output. The DRV425 DRV pins are limited to driving voltages to the supply rails of VDD and GND. Depending on the resistors chosen (R_1 , R_2 , R_3) and the value of the compensation coil resistance (see the [DRV425 System Parameter Calculator](#)) the sensing range will be limited. [Equation 5](#) is the limitation. Assumptions made are $V_{\text{ref}} = V_{\text{DD}}/2$ and $R_1 = R_2$.

$$\text{MAG}_{\text{diff}} * G_{\text{Flux}} * R_3 + \left(\text{MAG}_{\text{Stray}} * G_{\text{Flux}} + \frac{\text{MAG}_{\text{diff}} * G_{\text{Flux}}}{2} \right) * (R_1 + R_{\text{coil}}) < \frac{V_{\text{DD}}}{2} \quad (5)$$

where:

- MAG_{diff} : Differential magnetic field
- $\text{MAG}_{\text{Stray}}$: Common stray magnetic field
- G_{Flux} : Gain of flux gate sensor, 12.2 mA/mT
- R_{coil} : Compensation coil resistance

To avoid this limitation and get a higher range, connect each DRV425 individually to measure its own magnetic field. After the measurements are complete, apply some post processing to calculate the difference in the magnetic field.

5 Related Documentation

1. Texas Instruments, [DRV425 Bus Bar Application Magnetic Field Calculator](#), Software (SBOC480)

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