

TECH NOTE - Calculating resulting force



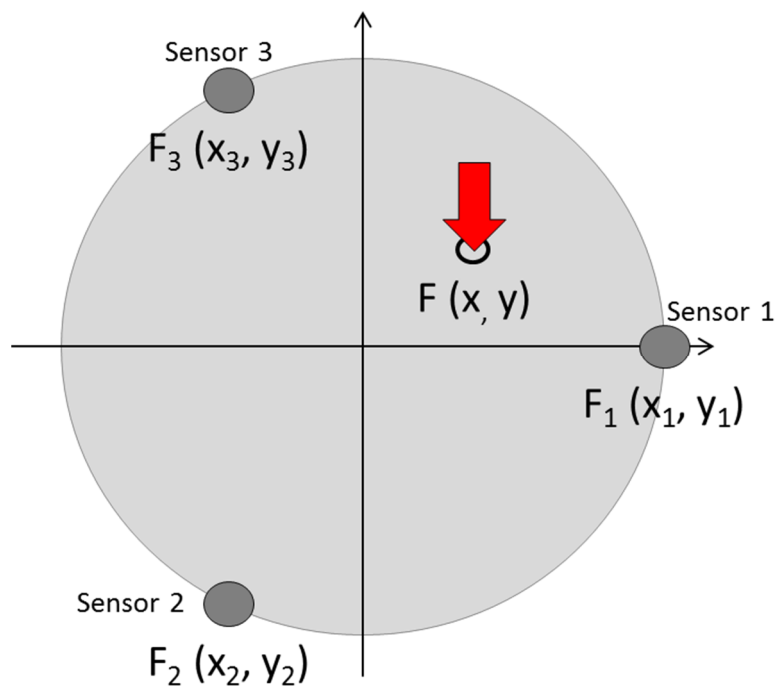
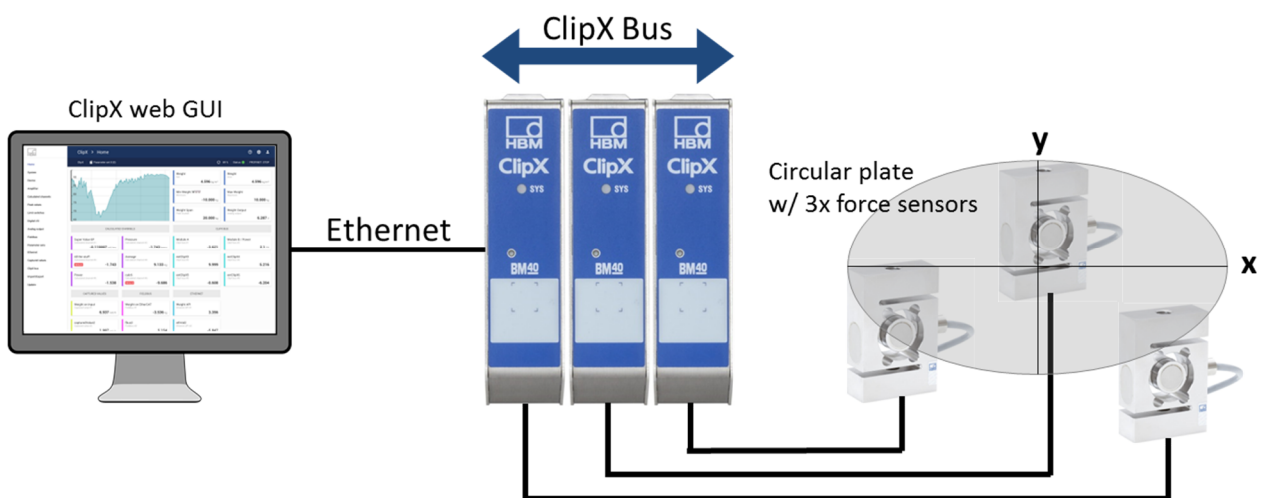
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Brief description

This application is about localizing a force and calculating its result value on a plane surface. Therefore three force sensors are mounted on the bottom of a circular plate. The raw signals from the sensors are further processed by three ClipX measurement amplifiers. Those communicate with each other through the ClipX bus technology. The devices are set up with the ClipX Web-GUI. The basic setup is shown in the figure below.



Sensor scaling

First go to the amplifier section on the left side and select the correct sensor type and physical unit.

Sensor Type
Full bridge 5mV/V (DC) ▼

Physical Unit
N

1 / 10

Then give the signal a reasonable name.

| <div style="border: 1px solid #ccc; padding: 5px;"> <p>Sensor1 Field value</p> <p style="text-align: right; font-size: 1.2em;">-0.024 mV/V</p> <table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left; font-size: 0.8em;">Name</th> <th style="text-align: left; font-size: 0.8em;">Decimal Places</th> </tr> </thead> <tbody> <tr> <td style="border-bottom: 1px solid #ccc;">Sensor1</td> <td style="border-bottom: 1px solid #ccc;">.000 ▼</td> </tr> </tbody> </table> <p style="text-align: right; font-size: 0.8em;">7 / 22</p> </div> | Name | Decimal Places | Sensor1 | .000 ▼ | <div style="border: 1px solid #ccc; padding: 5px;"> <p>F1 Gross - Zero Value: 0 N - Zero Target Value: 0 N</p> <p style="text-align: right; font-size: 1.2em;">-24.438 N</p> <table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left; font-size: 0.8em;">Name</th> <th style="text-align: left; font-size: 0.8em;">Decimal Places</th> </tr> </thead> <tbody> <tr> <td style="border-bottom: 1px solid #ccc;">F1</td> <td style="border-bottom: 1px solid #ccc;">.000 ▼</td> </tr> </tbody> </table> <p style="text-align: right; font-size: 0.8em;">2 / 22</p> </div> | Name | Decimal Places | F1 | .000 ▼ |
|--|----------------|----------------|---------|--------|---|------|----------------|----|--------|
| Name | Decimal Places | | | | | | | | |
| Sensor1 | .000 ▼ | | | | | | | | |
| Name | Decimal Places | | | | | | | | |
| F1 | .000 ▼ | | | | | | | | |

Next step is to scale the sensor according to its sensitivity. Look it up on the sensor itself or in its datasheet.

Scaling Type
Two-point Scaling ▼

| | | | |
|---------------------|------|------|----------------|
| 1. Point Electrical | 0 | mV/V | MEASURE |
| 1. Point Physical | 0 | N | |
| 2. Point Electrical | 1 | mV/V | MEASURE |
| 2. Point Physical | 1000 | N | |

Last step is to set the current value to zero. **Repeat for all three amplifiers.**

Zero Value

-24.4681

N CLEAR **ZERO**

Transmit measurement values via ClipX bus

Go to the ClipX bus section. Give the devices an address (1 to 3). Enter 3 as highest address for all devices. Select the signal that should be sent on the bus as source.

Settings

| | |
|---|----------------------|
| Own Address 1 | Highest Address 3 |
| Source F1 (Gross) ▼ | |

After giving all signals on the bus a name the result looks like this. **Repeat for all three amplifiers.**

| | |
|---|---|
| <div style="border: 1px solid #ccc; padding: 5px;"> <p>F1 ClipX bus #1 -0.024 N</p> <hr/> <p>Name F1 2 / 22</p> <hr/> <p>Decimal Places: .000 Physical Unit: N</p> </div> | <div style="border: 1px solid #ccc; padding: 5px;"> <p>F2 ClipX bus #2 0.048 N</p> <hr/> <p>Name F2 2 / 22</p> <hr/> <p>Decimal Places: .000 Physical Unit: N</p> </div> |
| <div style="border: 1px solid #ccc; padding: 5px;"> <p>F3 ClipX bus #3 -0.007 N</p> <hr/> <p>Name F3 2 / 22</p> <hr/> <p>Decimal Places: .000 Physical Unit: N</p> </div> | <div style="border: 1px solid #ccc; padding: 5px;"> <p>ClipX bus value 4 ClipX bus #4 N/A</p> <p style="text-align: center; background-color: #ccc; padding: 2px;">DISABLED</p> <hr/> <p>Name ClipX bus value 4 17 / 22</p> <hr/> <p>Decimal Places: .000 Physical Unit:</p> </div> |

Calculate the result signal and its coordinates

The equations below are needed to calculate the force and its coordinates.

The resulting force value F:
$$F = F_1 + F_2 + F_3 \quad \text{eq.1}$$

The x-coordinate of F:
$$x = \frac{F_1 \cdot x_1 + F_2 \cdot x_2 + F_3 \cdot x_3}{F} \quad \text{eq.2}$$

The y-coordinate of F:
$$y = \frac{F_1 \cdot y_1 + F_2 \cdot y_2 + F_3 \cdot y_3}{F} \quad \text{eq.3}$$

The x-coordinate of each sensor:
$$x_n = r \cdot \cos\left(\frac{360^\circ}{n_{max}} \cdot n\right) \quad \text{eq.4}$$

The y-coordinate of each sensor:
$$y_n = r \cdot \sin\left(\frac{360^\circ}{n_{max}} \cdot n\right) \quad \text{eq.5}$$

The goal is to locate and define the result force signal. First step is to calculate the summed force by using an Adder / Multiplier in the ClipX calculated channels. Simply enter equation eq.1.

#3
Adder / Multiplier

1 -0.085 ^

$$y = X_1 X_2 X_3 X_4 + X_5 X_6 + X_7 X_8 + X_9 X_{10}$$

| | | | |
|----------------|-------------------|-----------------|---|
| x ₁ | F1 (ClipX bus #1) | x ₂ | 1 |
| x ₃ | 1 | x ₄ | 1 |
| x ₅ | F2 (ClipX bus #2) | x ₆ | 1 |
| x ₇ | F3 (ClipX bus #3) | x ₈ | 1 |
| x ₉ | 0 | x ₁₀ | 0 |

| | |
|---|----------------------|
| y | Calculated Channel 1 |
|---|----------------------|

↑ UP
↓ DOWN

DELETE

Then finally we want to know where exactly the result force F is coming from. To get the x-coordinate of F equation eq.2 can be entered in a Divider. To get the multiplier constants equation eq.4 has to be calculated before with a pocket calculator. Alternatively, the distances can be measured. **The constants have to be entered on the bottom of the calculated channel page before they can be used.**

#1
Divider

2 -0.283 ^

$$y = (X_1 X_2 + X_3 X_4 + X_5 X_6) / (X_7 + X_8 + X_9)$$

| | | | |
|----------------|-----------------------|----------------|-------------------|
| x ₁ | 9.8 (User defined 1) | x ₂ | F1 (ClipX bus #1) |
| x ₃ | -4.9 (User defined 2) | x ₄ | F2 (ClipX bus #2) |
| x ₅ | -4.9 (User defined 2) | x ₆ | F3 (ClipX bus #3) |
| x ₇ | F1 (ClipX bus #1) | x ₈ | F2 (ClipX bus #2) |
| x ₉ | F3 (ClipX bus #3) | | |

| | |
|---|----------------------|
| y | Calculated Channel 2 |
|---|----------------------|

↓ DOWN

DELETE

Analog to the x-coordinate the y-coordinate is calculated by using equation eq.3 and eq.5.

#2 Divider
3 -0.016

$$y = (x_1 x_2 + x_3 x_4 + x_5 x_6) / (x_7 + x_8 + x_9)$$

| | |
|--|----------------------------------|
| x ₁ 0 | x ₂ F1 (ClipX bus #1) |
| x ₃ -8.487 (User defined 3) | x ₄ F2 (ClipX bus #2) |
| x ₅ 8.487 (User defined 4) | x ₆ F3 (ClipX bus #3) |
| x ₇ F1 (ClipX bus #1) | x ₈ F2 (ClipX bus #2) |
| x ₉ F3 (ClipX bus #3) | |

| | |
|---|----------------------|
| y | Calculated Channel 3 |
|---|----------------------|

↑ UP ↓ DOWN
DELETE

The result looks like this.

| | |
|--|---|
| <div style="border-bottom: 1px solid #ccc; padding-bottom: 5px;"> <h3>F result</h3> <p>Calculated Channel Flag 1</p> <p style="text-align: right; font-size: 24px; font-weight: bold;">5.431</p> </div> <div style="padding: 5px;"> <p>Name: F result 8 / 22</p> <hr/> <p>Decimal Places: .000 Physical Unit: 0 / 10</p> </div> | <div style="border-bottom: 1px solid #ccc; padding-bottom: 5px;"> <h3>x coordinate</h3> <p>Calculated Channel Flag 2</p> <p style="text-align: right; font-size: 24px; font-weight: bold;">0.010</p> </div> <div style="padding: 5px;"> <p>Name: x coordinate 12 / 22</p> <hr/> <p>Decimal Places: .000 Physical Unit: 0 / 10</p> </div> |
| <div style="border-bottom: 1px solid #ccc; padding-bottom: 5px;"> <h3>y coordinate</h3> <p>Calculated Channel Flag 3</p> <p style="text-align: right; font-size: 24px; font-weight: bold;">-0.191</p> </div> <div style="padding: 5px;"> <p>Name: y coordinate 12 / 22</p> <hr/> <p>Decimal Places: .000 Physical Unit: 0 / 10</p> </div> | <div style="border-bottom: 1px solid #ccc; padding-bottom: 5px;"> <h3>Calculated value 4</h3> <p>Calculated Channel Flag 4</p> <p style="text-align: right; font-size: 24px; font-weight: bold;">0.000</p> </div> <div style="padding: 5px;"> <p>Name: Calculated value 4 18 / 22</p> <hr/> <p>Decimal Places: .000 Physical Unit: 0 / 10</p> </div> |

Note: When not applying a force, the values are full of noise. See equation eq.2 and eq.3.

Disclaimer

These examples are for illustrative purposes only. They cannot be used as the basis for any warranty or liability claims.