Electronics
Wheatstone Bridge Circuits

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Wheatstone bridges

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Balancing a Wheatstone Bridge
Wheatstone bridge options
Wheatstone bridge current limit

\[ R_1 \quad R_2 \quad R_3 \quad R_4 \]

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\[ V_{in} \]

\[ R_1 \]

\[ R_2 \]

\[ R_3 \]

\[ R_4 \]
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\[ V_{in} \]

\[ R_1 \quad R_2 \]

\[ R_3 \quad R_4 \]

\[ V_{out} \]
This is a Wheatstone bridge.
Here it’s redrawn to show the two voltage dividers.
Here’s one voltage divider.
Here’s the other voltage divider.
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The circuit is very sensitive to small changes in the variable resistor.
The variable resistor could be in any of the four positions; this is one example.
Balancing a Wheatstone Bridge

When the bridge is "balanced", $V_o = 0$ or $V_A = V_B$. (This will happen when $R_1R_2 = R_vR_4$.)

For our diagram $R_1 \rightarrow R_2$ is the reference branch, and $R_v \rightarrow R_4$ is the evaluation branch.

If $R_v$ increases, $V_B$ will decrease, and vice versa.

For optimum performance, all resistors should be of the same order of magnitude.

If using a resistive sensor, use a meter to measure resistance of sensor to get a correct order of magnitude.
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- If $R_v$ increases, $V_B$ will decrease, and vice versa.
- For optimum performance, all resistors should be of the same order of magnitude.
- If using a resistive sensor, use a meter to measure resistance of sensor to get a correct order of magnitude.
If resistors are chosen to be equal, except for $R_v$, then the output voltage will vary with changes in $R_v$. 

$R_v = R + \Delta R$
Specifically,
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\[ V_B = V \frac{R}{2R+\Delta R} = V \frac{R+\Delta R/2-\Delta R/2}{2R+\Delta R} = \frac{V}{2} - V \frac{\Delta R/2}{2R+\Delta R} \approx \]

If no current flows between \( A \) and \( B \) then

\[ V_A - V_B \approx V \frac{\Delta R}{4R} \]

which can be rearranged to give

\[ \Delta R \approx \left( V_A - V_B \right) \frac{V}{4R} \]

So we can determine \( \Delta R \).

(This approximation is true as long as \( \Delta R \ll R \).)
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Wheatstone bridge options

- Lead wire compensation
Wheatstone bridge options

- Lead wire compensation
- Temperature compensation

Instrumentation amplifiers
differential op amp circuit with voltage followers on the inputs
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  differential op amp circuit with voltage followers on the inputs
Lead wire compensation

Uncompensated

long leads; unknown resistance
Lead wire compensation

No current flows in measurement lead; similar resistance in both other leads
Temperature compensation
Temperature compensation
Temperature compensation

![Wheatstone Bridge Circuit Diagram](attachment:Wheatstone_Bridge_Circuit.png)

- **Active**

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Temperature compensation

[Temperature compensation diagram]
Temperature compensation

Temperature response of non-active sensor similar to active sensor
Doubling sensitivity
Doubling sensitivity
Doubling sensitivity

Sensors in diagonal positions produce opposite responses.
Wheatstone bridge current limit

- Put resistor in series with bridge
Wheatstone bridge current limit

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- Choose $R_s \gg R_t$
Wheatstone bridge current limit

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thus current controlled by $R_s$ (fixed) rather than $R_t$ (variable).
Reducing current
Reducing current

\[ R_s \]
Reducing current

This is useful if the voltage supply is fixed.