Electronics
Voltage Dividers

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Wilfrid Laurier University

May 31, 2017

Applications of Kirchhoff's Voltage Law

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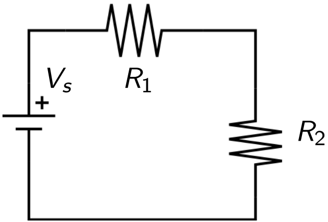
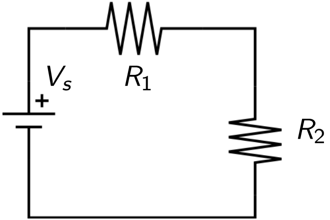
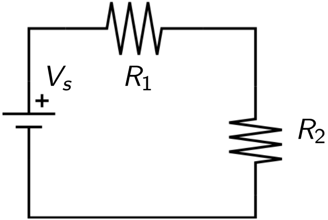
Voltage dividers

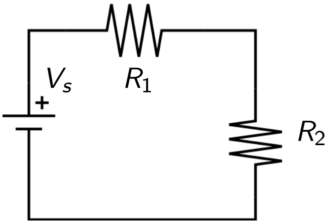

V_s
+
R_1
R_2



$$V_s = V_{R_1} + V_{R_2}$$



- A **voltage divider** “divides” the supply voltage



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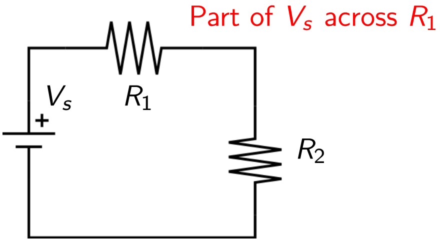
- It's useful when you need a different voltage than the supply



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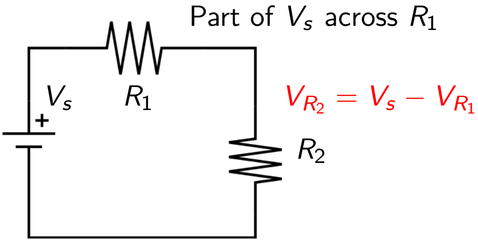

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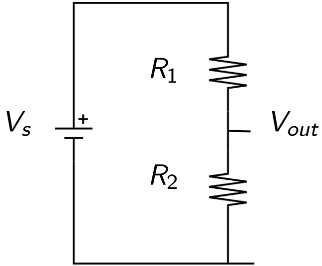
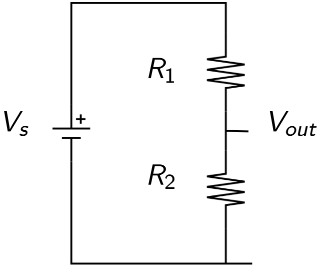
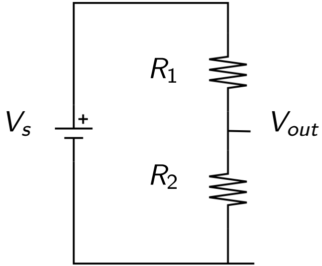

R_1
V_s
+
V_{out}
R_2

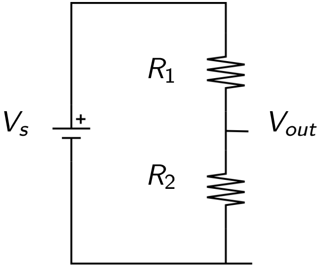


Usually a voltage divider is drawn like this so it looks like a ladder.



Usually a voltage divider is drawn like this so it looks like a ladder.

As you climb the ladder, the voltage increases.



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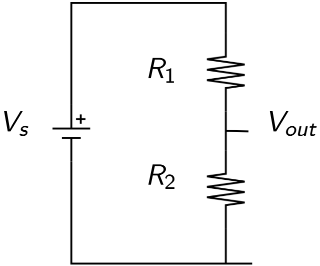
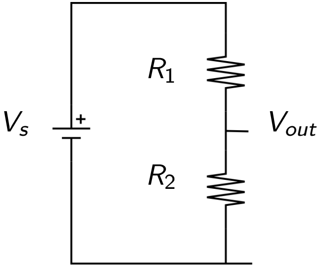


Since $I_1 = I_2$, (by Kirchhoff's current law,)



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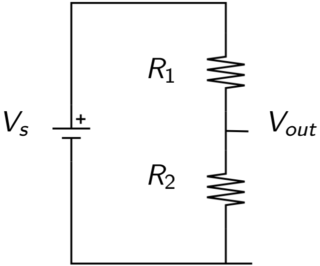

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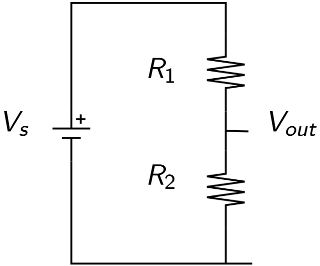

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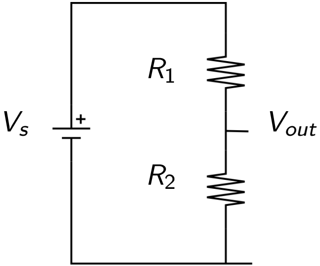

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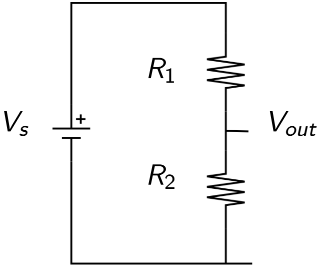

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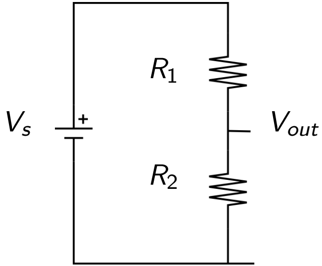
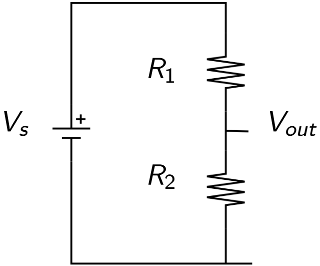
$I = \frac{V_s}{R_1+R_2}$



So $V_{out} = V_2 = IR_2$



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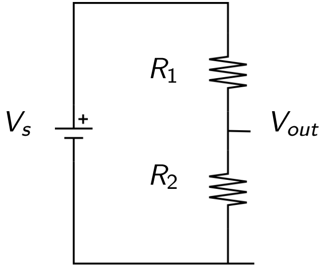
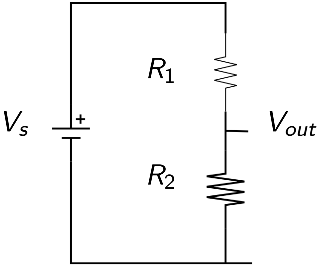


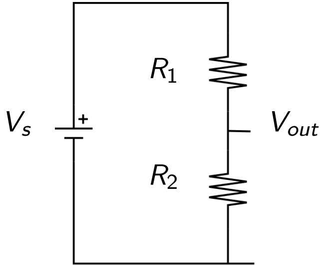
So $V_{out} = V_2 = IR_2 = \frac{V_s}{R_1+R_2} R_2$
$= V_s \left(\frac{R_2}{R_1+R_2} \right)$



If R_1 gets *smaller*, then

$V_{out} = V_s \left(\frac{R_2}{R_1+R_2}\right)$

gets *bigger*.



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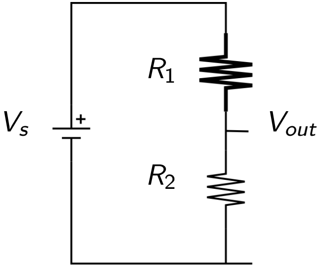

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Voltage divider (no load)

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V_{out}

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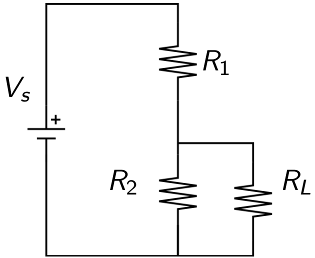
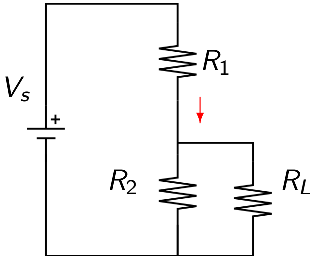
Voltage divider (with load RL)



Load will reduce the output voltage

Voltage divider (with load RL)



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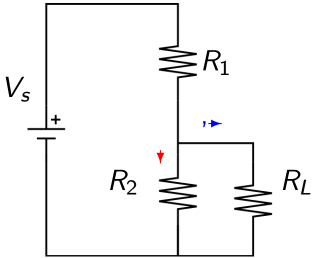

Some current goes through R_2, but some goes through R_L so the *effective* value of R_2 is reduced.

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$= 2.5V$

Variable resistors

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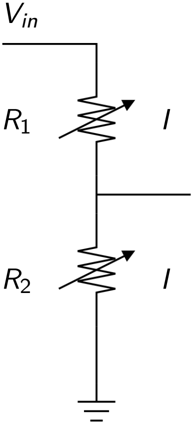
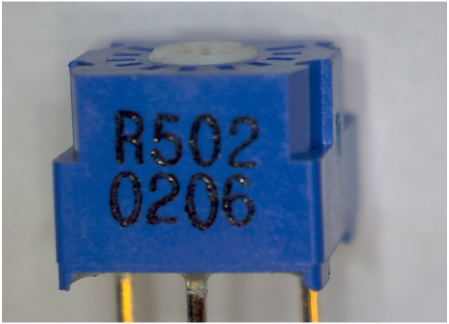
These are sometimes called **potentiometers** or **trimmers**.

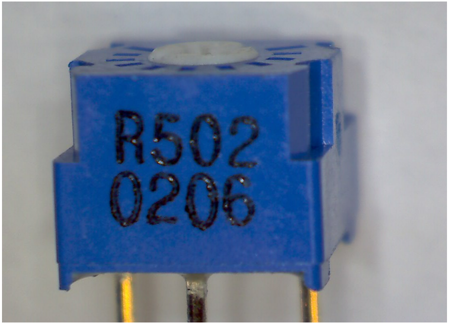


$V_{out} = V_{in}\left(\frac{R_2}{R_1+R_2}\right)$

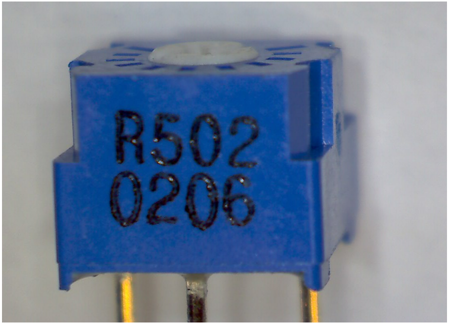
True if $I_{out} \equiv 0$

$R_1 + R_2 =$ a constant.


R502
0206



Here is a trimmer.



Here is a trimmer. The top line should look familiar.

The potentiometer has three pins.

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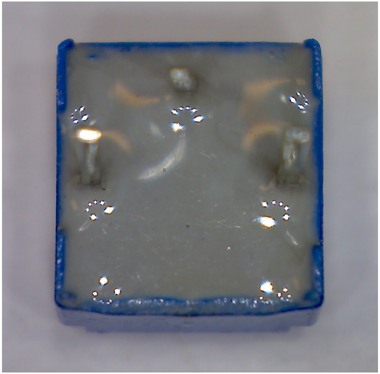
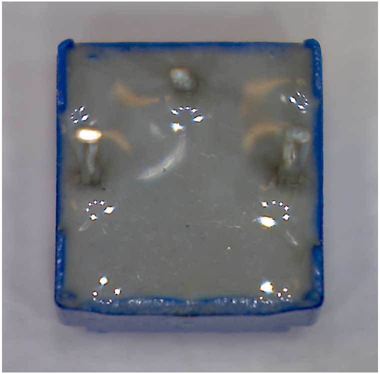
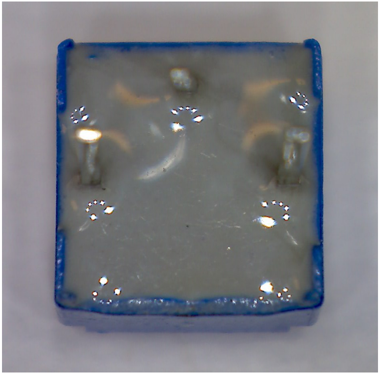
The resistance between the two end pins will be constant.

If you want a resistance which varies, just use the wiper and one end pin.

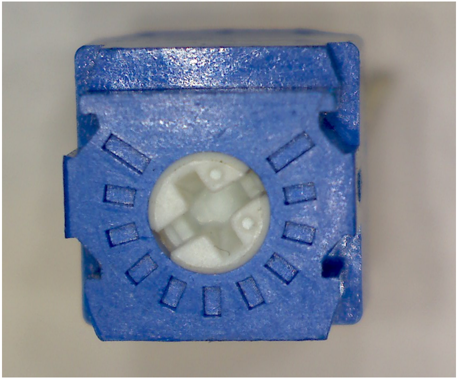


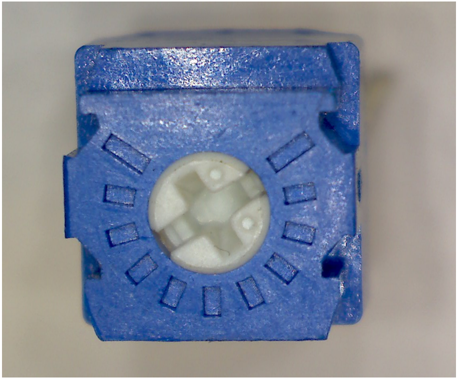


Here's a different view.

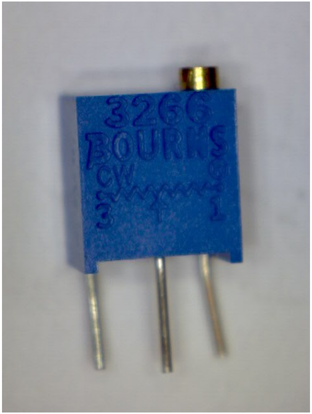


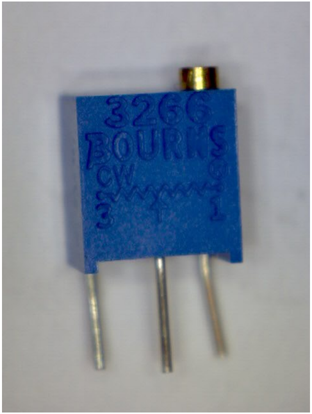
Here's a different view. The wiper is in the middle.



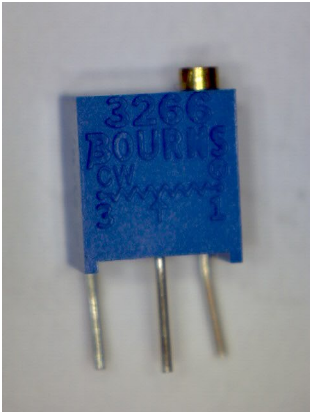


From the top, this one has 10 dashes to represent intervals of roughly $R/10$.


3266
BOURNS
CW
3
1



This is a slightly different style.



This is a slightly different style. Note the graphical indication of the wiper.

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Measure the output voltage on the wiper.

Adjusting the wiper will change the output voltage from one end of the supply to the other, or to anywhere in between.

Switches in voltage dividers

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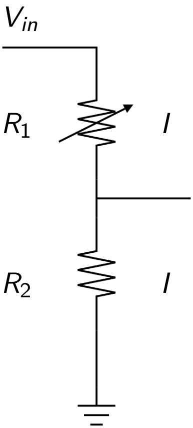
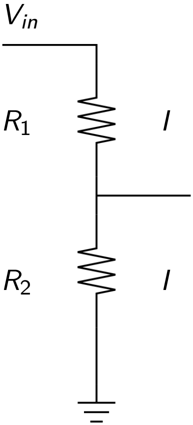
- A switch can be thought of as a resistor which can have a value of either zero or infinity.
- Following is an illustration of a voltage divider where one element is a switch.



$$V_{out} = V_{in} \left(\frac{R_2}{R_1 + R_2} \right)$$

True if $I_{out} \equiv 0$



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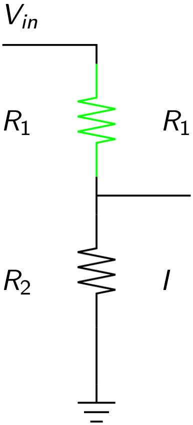
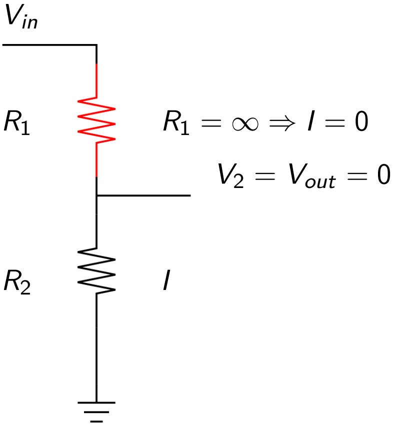
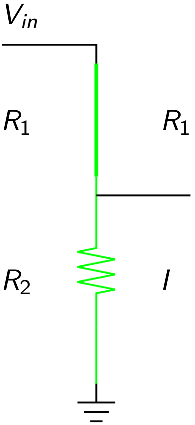


$R_1 = 0 \Rightarrow V_1 = 0$

$V_2 = V_{out} = V_{in}$


V_{in}
R_1
$R_1 = \infty \Rightarrow I = 0$
$V_2 = V_{out} = 0$
R_2
I



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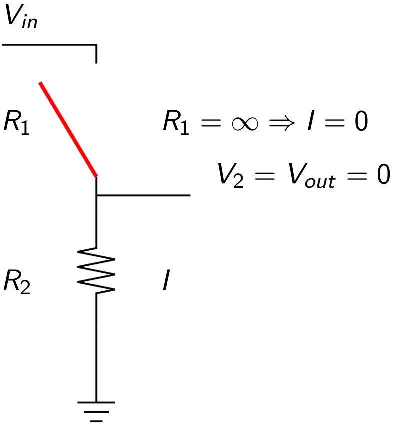
V_{in}
R_1
$R_1 = \infty \Rightarrow I = 0$
$V_2 = V_{out} = 0$
R_2
I

- So if one of the elements is a *switch*, the output varies between 0 and V_{in}.

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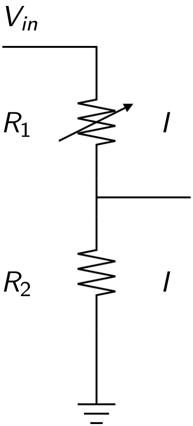
- If either resistor in a voltage divider is *variable*, then a range of output voltages is possible.

Resistive sensors in voltage dividers



$$V_{out} = V_{in}\left(\frac{R_2}{R_1+R_2}\right)$$

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  $R = \sqrt{R_{min} \times R_{max}}$