Sensors and Actuators-I

Internet of Things, Lecture-9

Rahul Shandilya

Sensors

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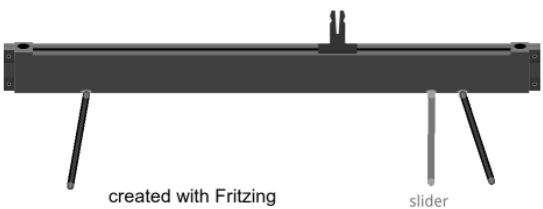
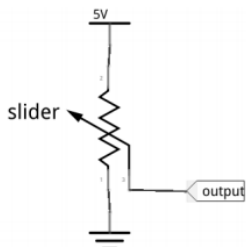
  3. Current-based sensors.

Potentiometer

A potentiometer is a variable resistor where a slider moves up and down a resistance and shortens the distance of one end point to the slider, thereby reducing the resistance between two terminals. The distance between the slider and the other end point lengthens, causing the resistance between the slider and the other terminal to increase correspondingly.





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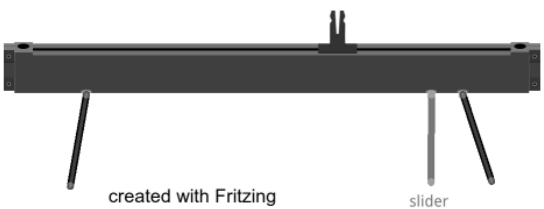
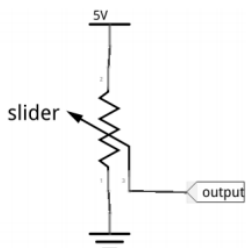
A variation of the potentiometer is a *joystick*, which is based on two orthogonally mounted potentiometers, controlled by a small stick.





light-dependent resistor or LDR

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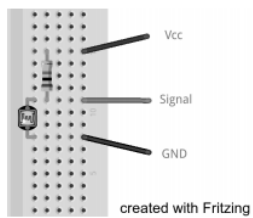

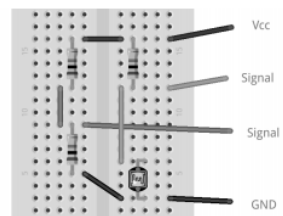

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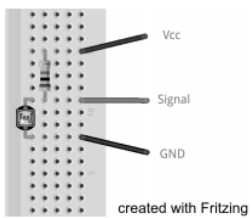

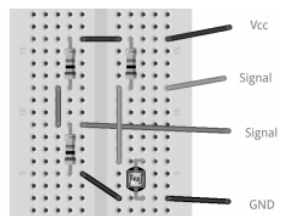

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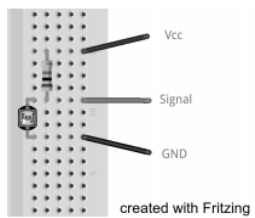

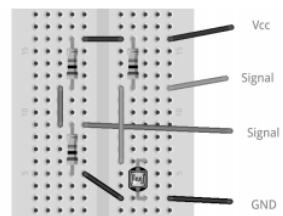

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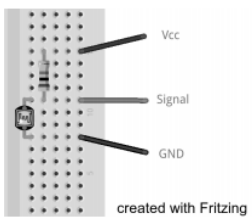
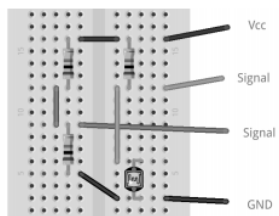
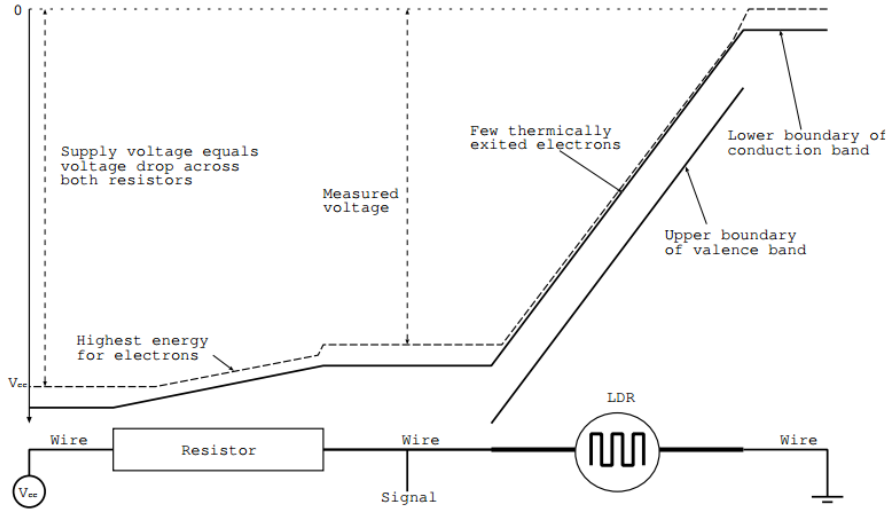
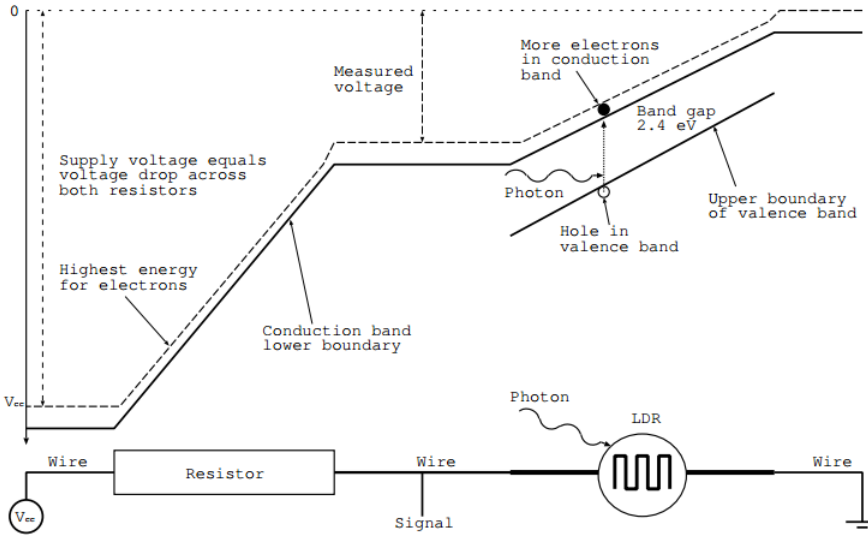
- This energy equals that of photons of green light with a wavelength of about 500 nm. Therefore, green photons can elevate electrons from the valence to the conduction band and thus create electron-hole pairs.






0
Supply voltage equals
voltage drop across
both resistors
Measured
voltage
Few thermically
exited electrons
Lower boundary of
conduction band
Upper boundary
of valence band
Highest energy
for electrons
Vcc
LDR
Wire
Resistor
Wire
Wire
Vcc
Signal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Photon
Upper boundary of valence band
Hole in valence band
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- The PT100 sensors are connected to a calibrated current source and the voltage drop across the sensor is measured with a volt meter, just as any other resistance measurement.

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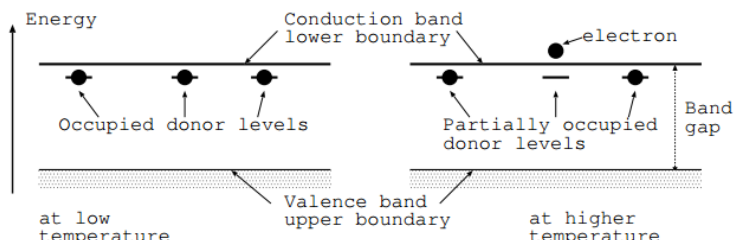

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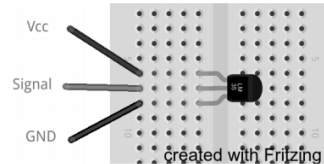

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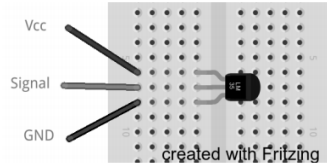

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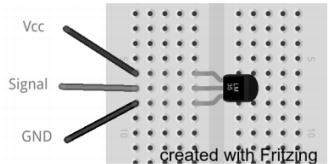
- The voltage difference is proportional to the temperature which can be understand using diode junction potential equation.

$$j_n = A(T)\left[e^{(eV_{BE,n}-E_g)/\kappa T} - 1\right]$$

where $E_g = 1.2$ V is the bandgap energy of silicon, k is the Boltzmann constant.



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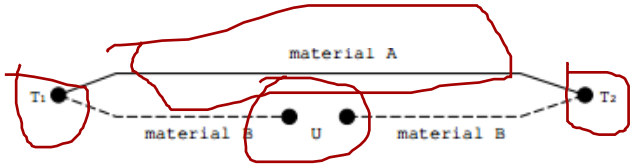
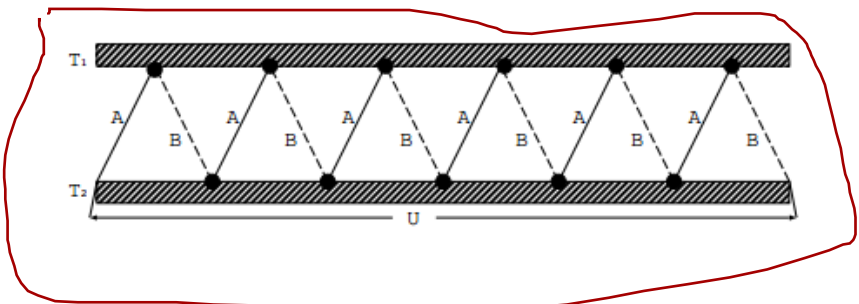
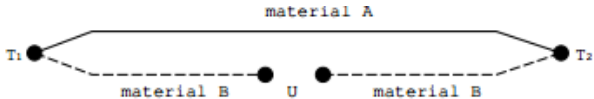
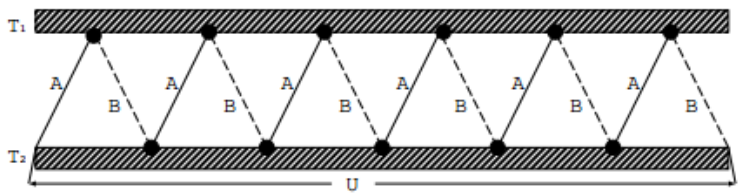
- And finally, joining the two junctions and the wires causes a current to circulate, provided the loop is closed. This is called the Seebeck effect.
- If the loop is open, as shown at the top left of, a voltage U develops at the end terminals as a consequence of the Peltier, Thomson, and Seebeck effects.

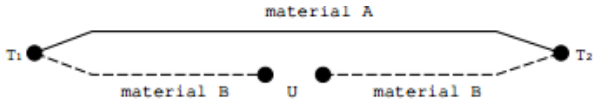

material A
T1
T2
material B
U
material B

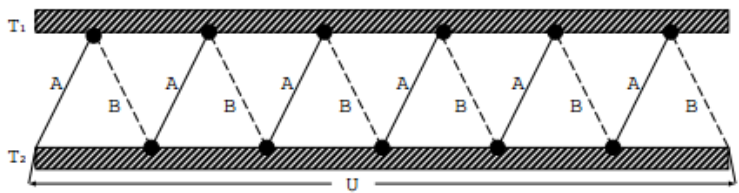

T1
A
B
A
B
A
B
A
B
A
B
A
B
T2
U





- In a thermopile a number of wire segments of materials A and B are connected in series.





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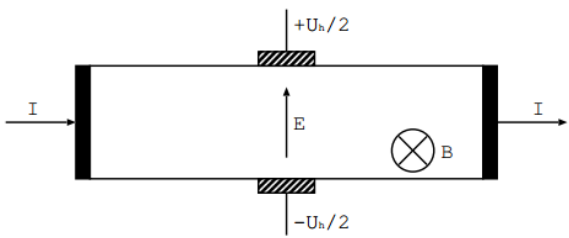
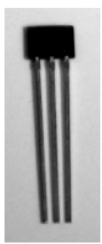
- Thermopiles are often found in devices sensing heat and infrared radiation, such as thermal imaging devices or contact-free thermometers.

Hall Effect

- Hall sensors produce a voltage that is proportional to the magnetic induction B.





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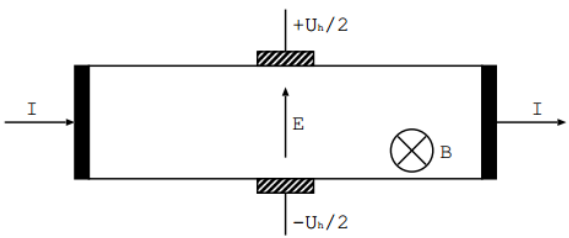

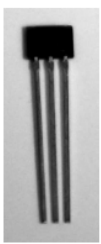

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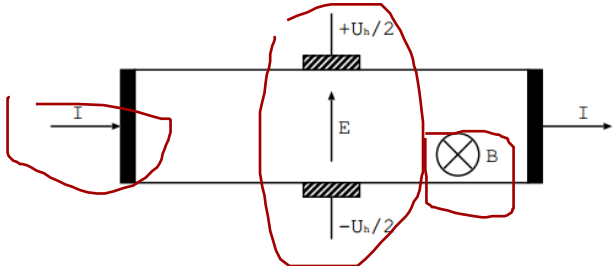
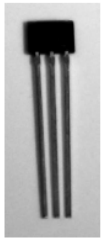
- In the presence of a magnetic field, the Lorentz force deflects the charge carriers|electrons and holes|towards perpendicularly mounted electrodes.
- This creates a potential difference (a voltage) between the electrodes, which causes a transverse electric field that counteracts the deflection from the Lorentz force such that the following charge carriers can move towards the exit electrode undeflected.





Hall Effect

- Hall sensors produce a voltage that is proportional to the magnetic induction B.
- In the presence of a magnetic field, the Lorentz force deflects the charge carriers|electrons and holes|towards perpendicularly mounted electrodes.
- This creates a potential difference (a voltage) between the electrodes, which causes a transverse electric field that counteracts the deflection from the Lorentz force such that the following charge carriers can move towards the exit electrode undeflected.
- The A1324 Hall sensor has signal-conditioning circuitry on board and only needs three pins for ground, supply voltage, and output voltage. The latter is proportional to the magnetic field, with a sensitivity of 50 mV/mT centered at 2.5 V when no field is present.