Thermoelektrische Wandler

Manuel Maringolo | The Fundamentals of IoT | SS2021

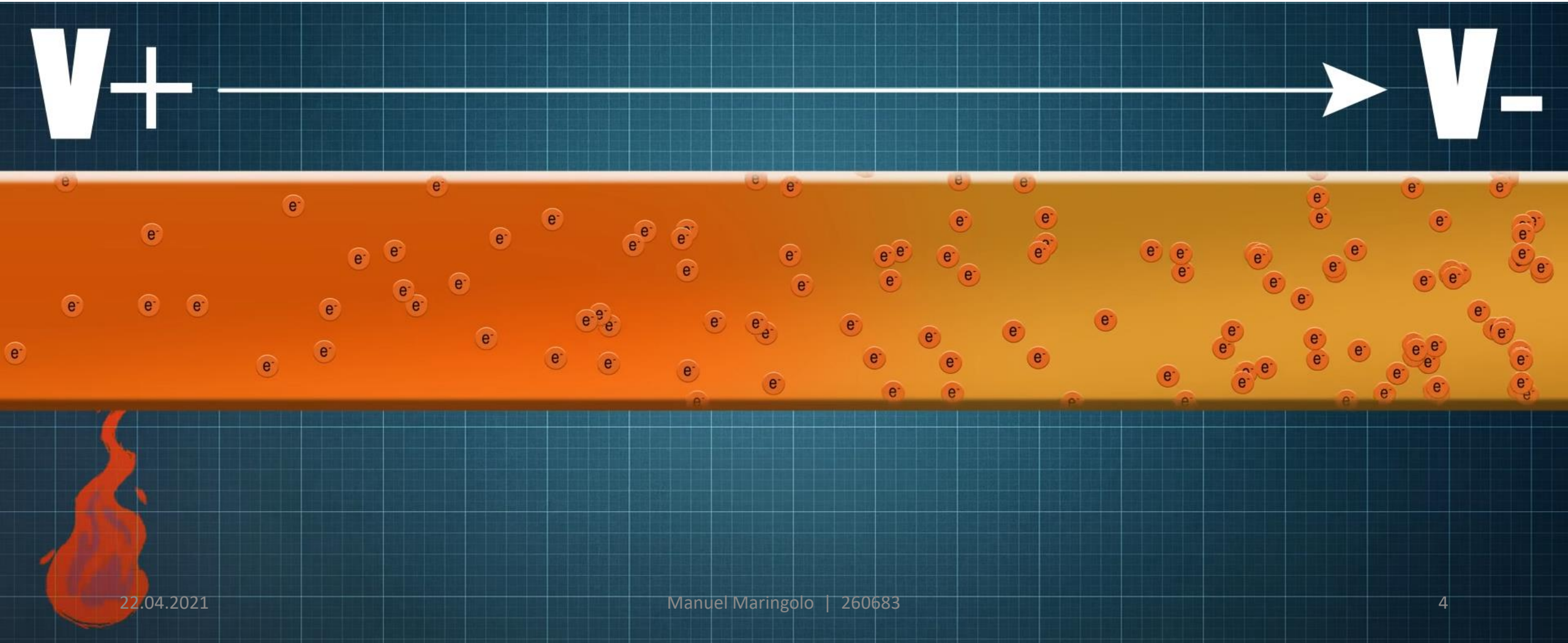
Agenda




Theorie

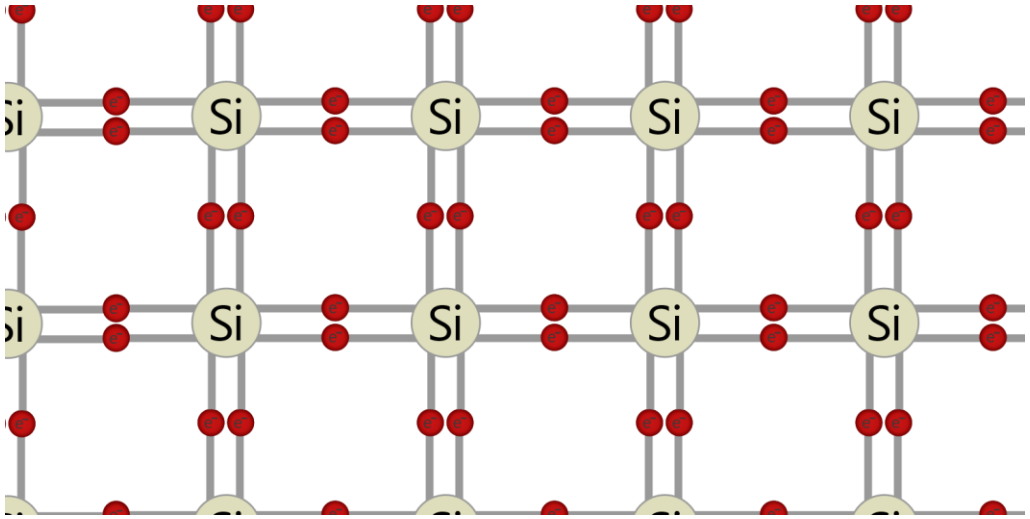
Theorie

Elektronenverhalten bei Wärme



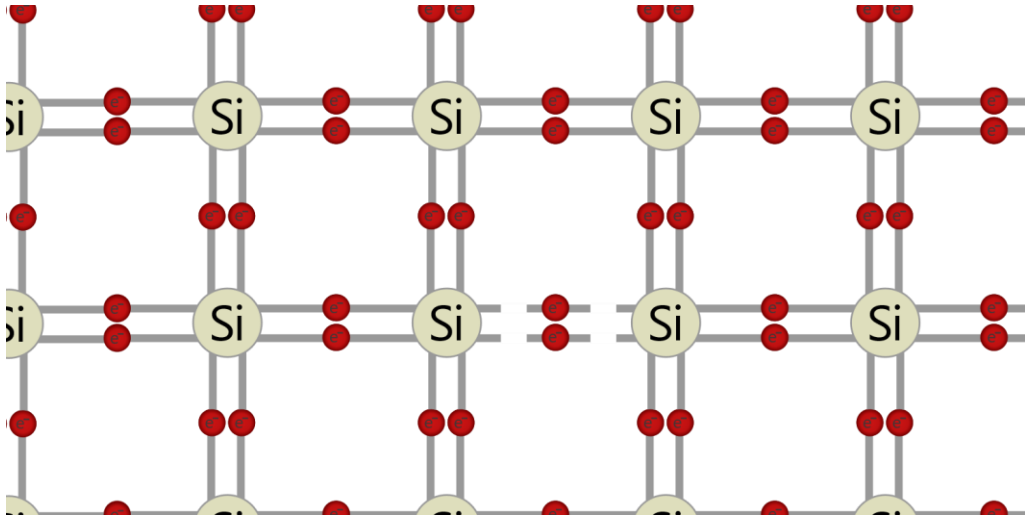
Theorie

Halbleiter



Eigene Darstellung

Kalt

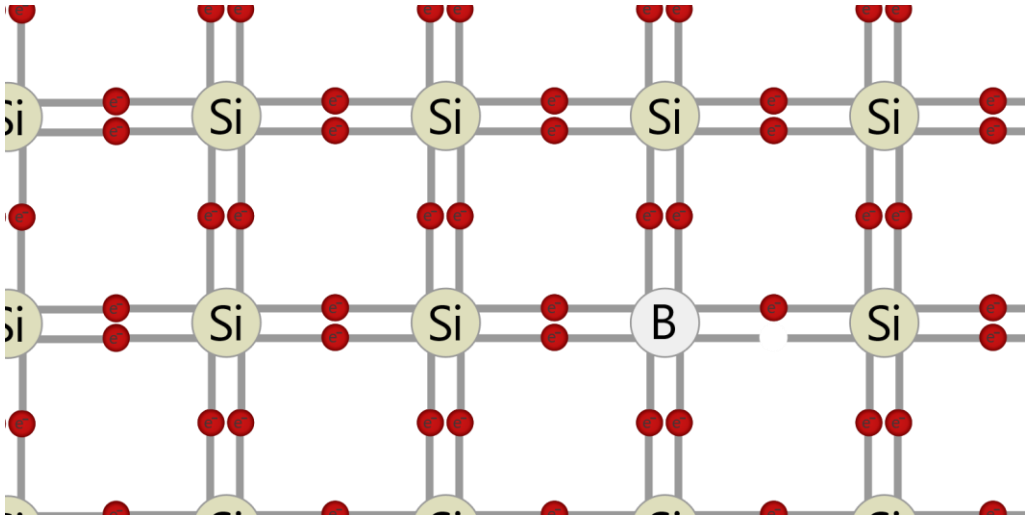


Eigene Darstellung

Warm

Theorie

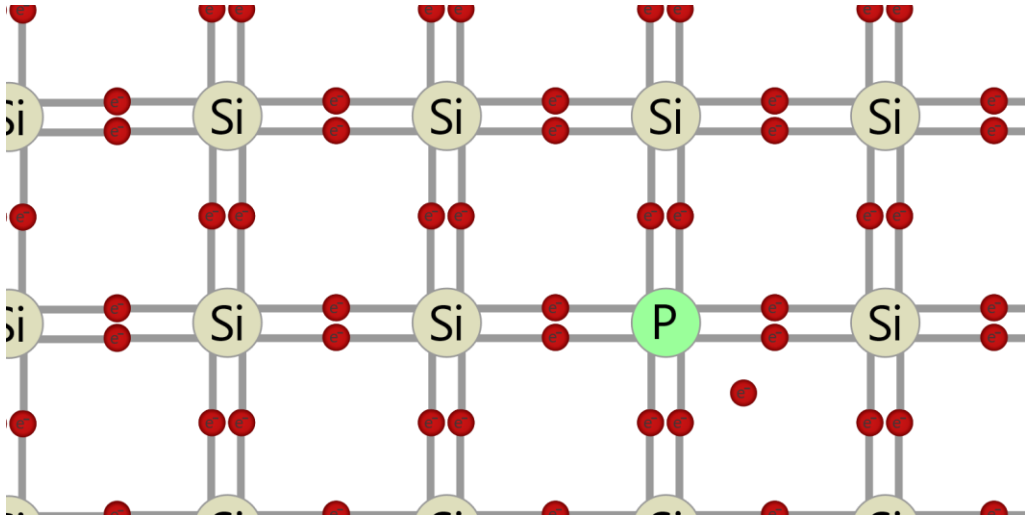
Halbleiter



Eigene Darstellung

P-Halbleiter

Positive Ladung

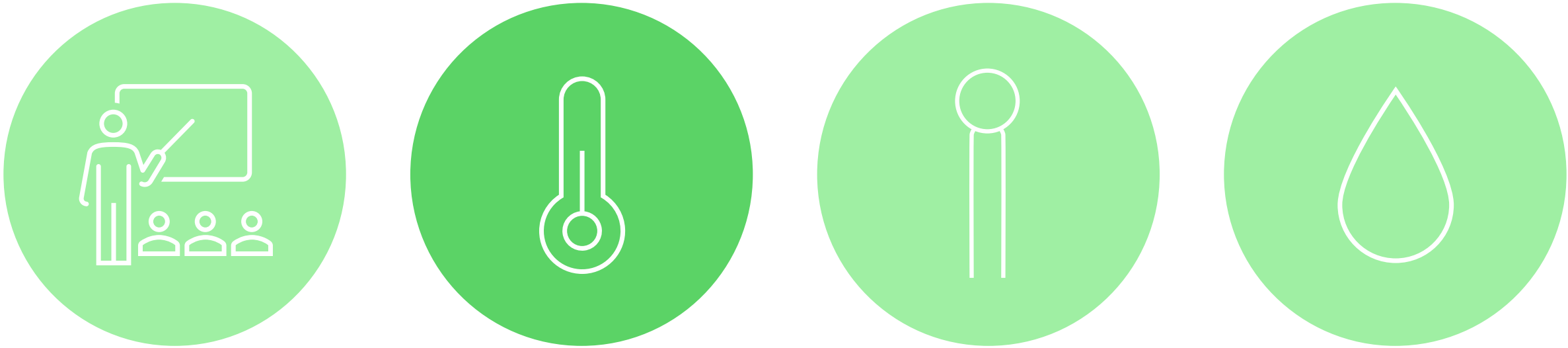


Eigene Darstellung

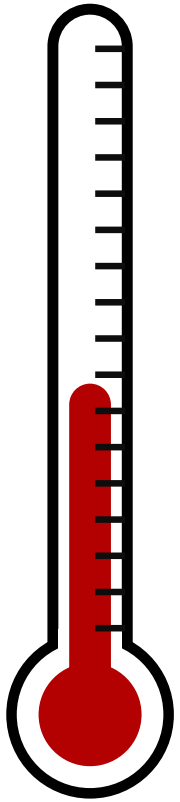
N-Halbleiter

Negative Ladung

Thermoelektrik

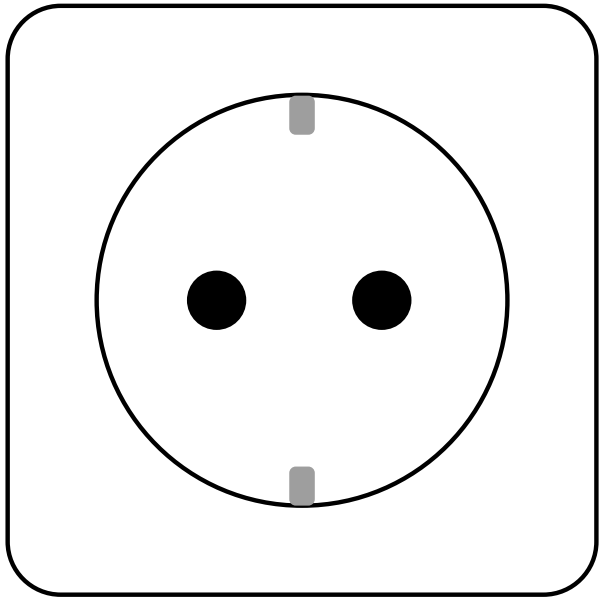


Thermoelektrik



Seebeck Effekt

Peltier Effekt



Eigene Darstellung

Thermoelektrik

Praxisbeispiele

http://pngimg.com/uploads/thermometer/thermometer_PNG76.png

Seebeck Effekt

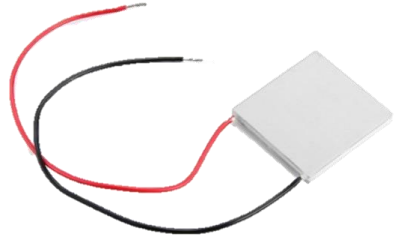
Thermopaar

https://www.fuehlersysteme.de/media/catalog/product/cache/1/image/9df78eab33525d08d6e5fb8d27136e95/t/p/tpk_e_web_00.jpg

https://www.cool-mania.net/mini/w-980/data/product/47/82f2151a301b9ba1118f52042d8fed.JPG

Perltier-Effekt

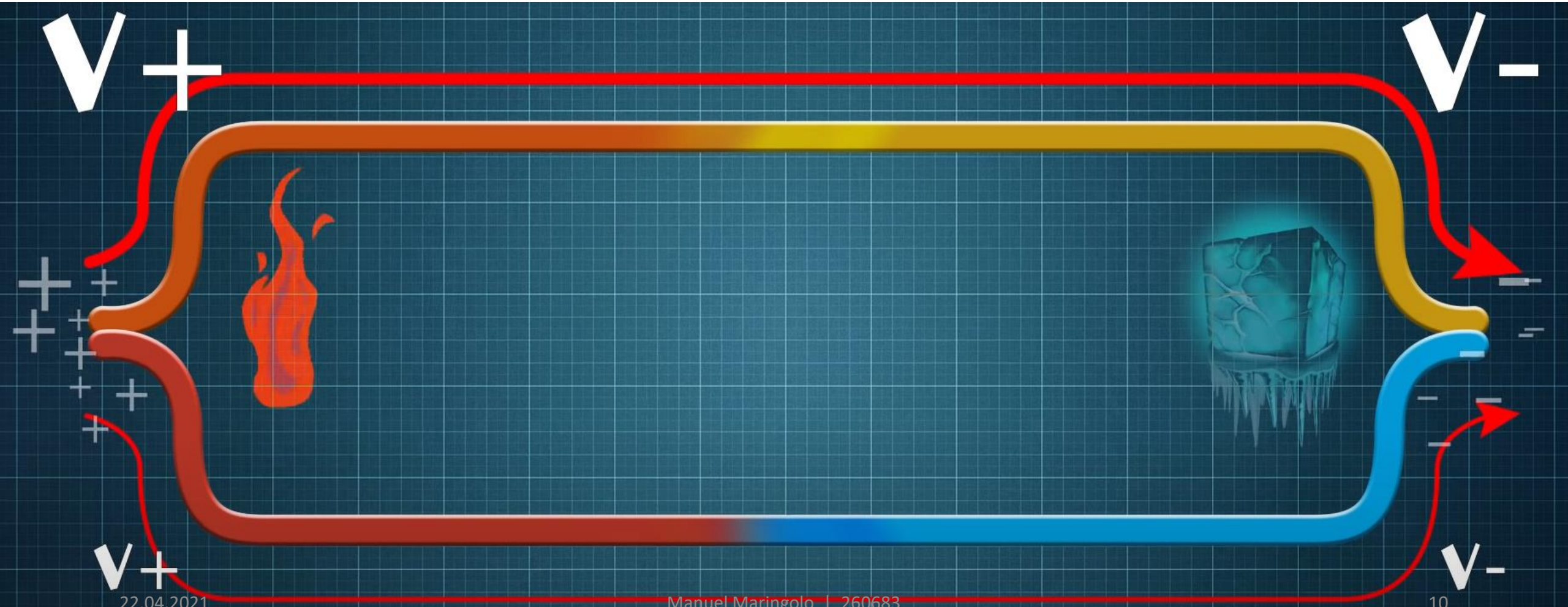
Peltier-Element



https://www.cool-mania.net/mini/w-980/data/product/47/82f2151a301b9ba1118f52042d8fed.JPG

Thermoelektrik

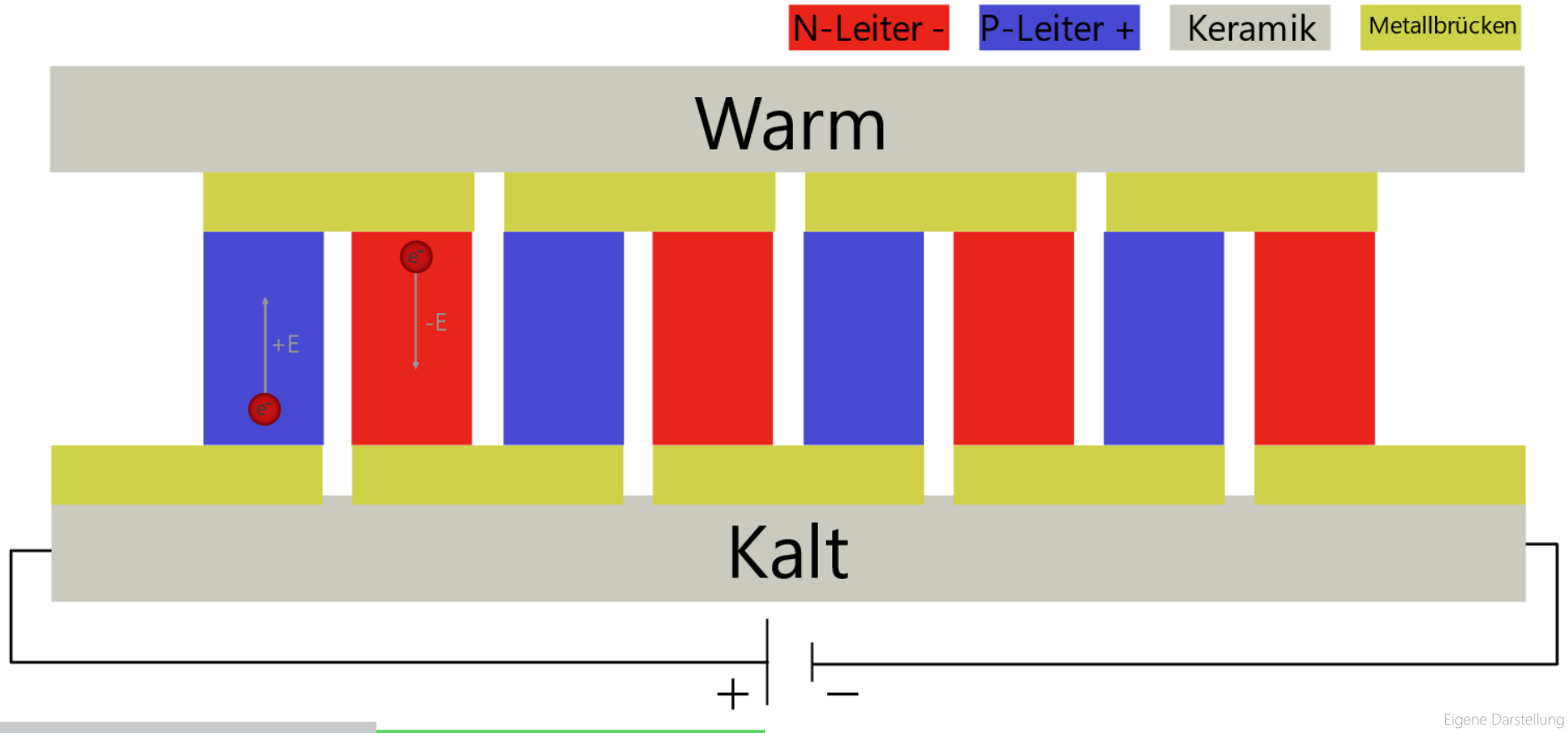
Thermopaar



https://www.youtube.com/watch?v=PccE4WcfnAw 9:39

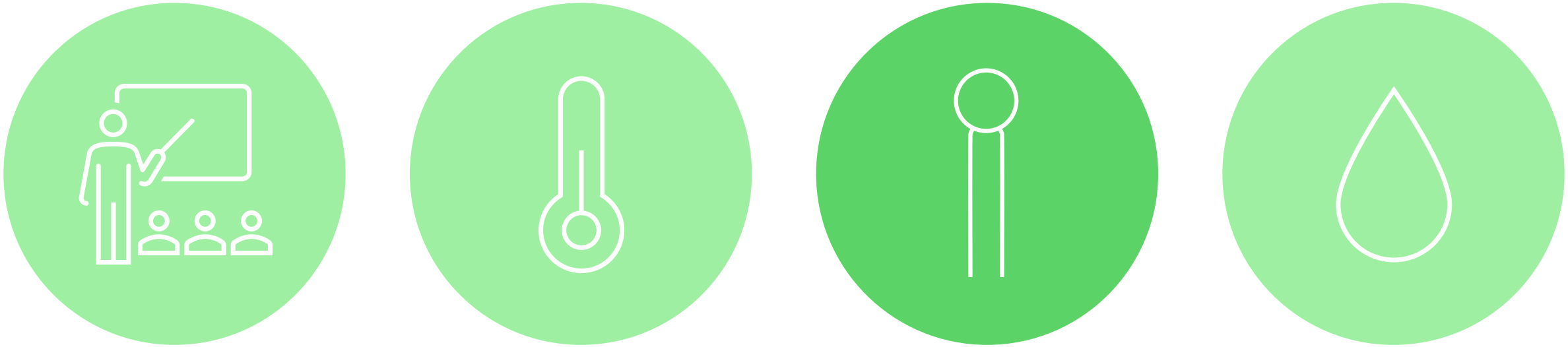
Thermoelektrik

Peltier-Element



Eigene Darstellung

Thermistor



Thermistor

https://www.voelkner.de/products/54445/TDK-B57237-S109-M-Heissleiter-S237-1.html

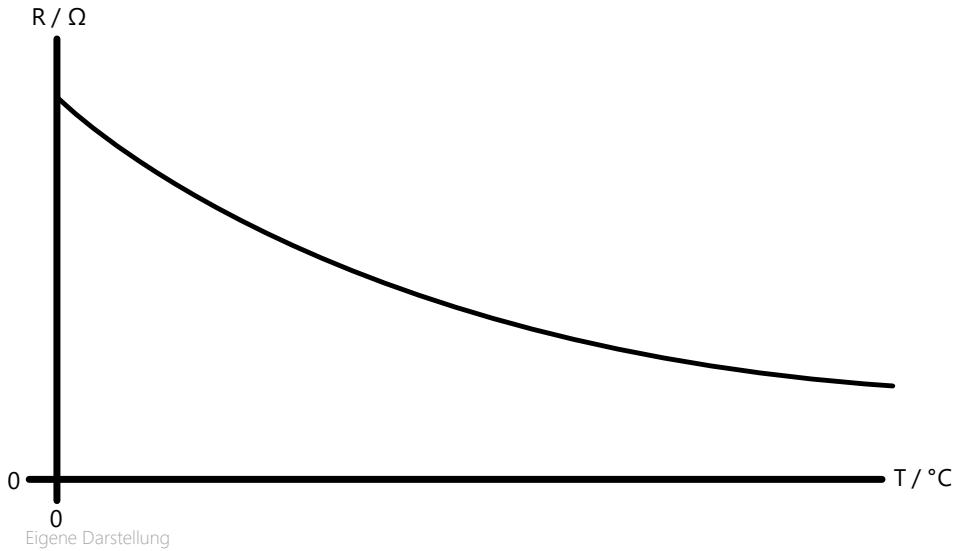
Temperaturabhängiger Widerstand

Thermistor

Kennlinie

NTC - Heißleiter

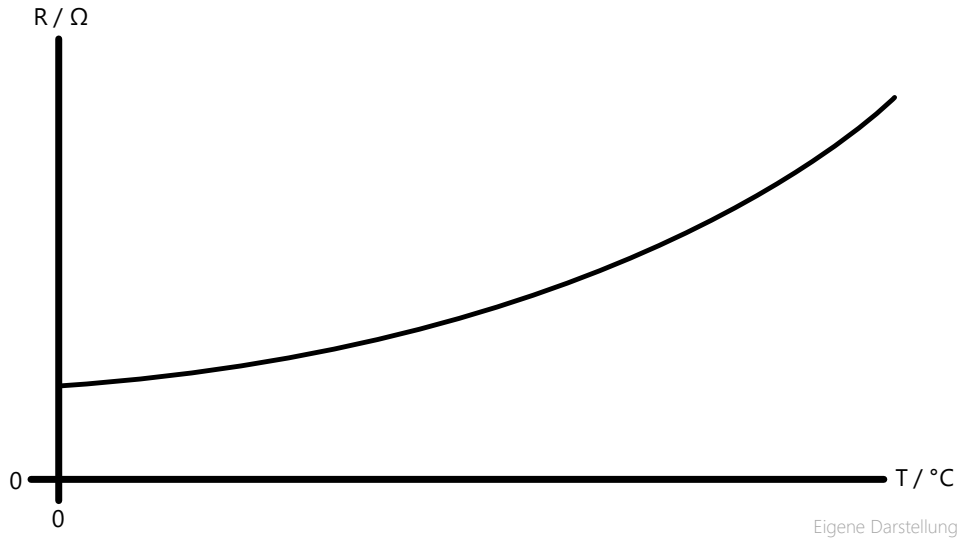
Negative Temperature Coeffizient



Eigene Darstellung

PTC - Kaltleiter

Positive Temperature Coeffizient



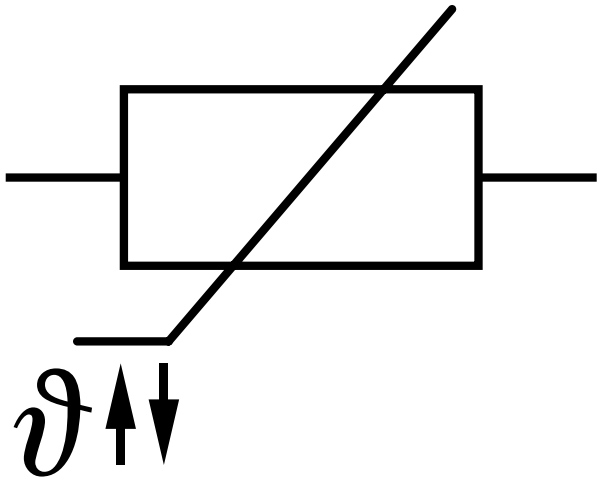
Eigene Darstellung

Thermistor

Schaltzeichen

NTC - Heißleiter

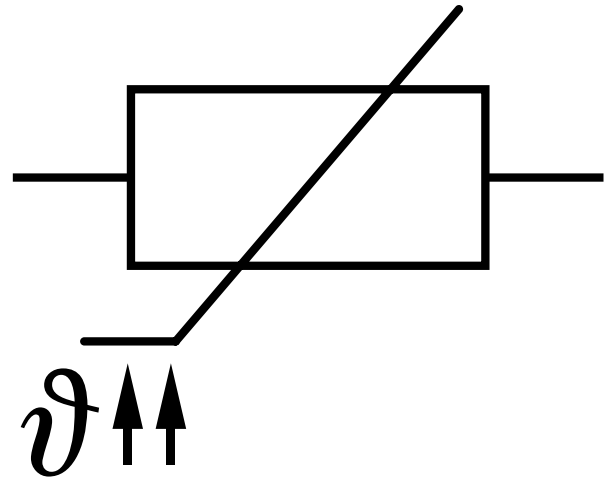
Negative Temperature Coeffizient



https://upload.wikimedia.org/wikipedia/commons/e/ea/Widerstand_NTC_DIN-EN.svg

PTC - Kaltleiter

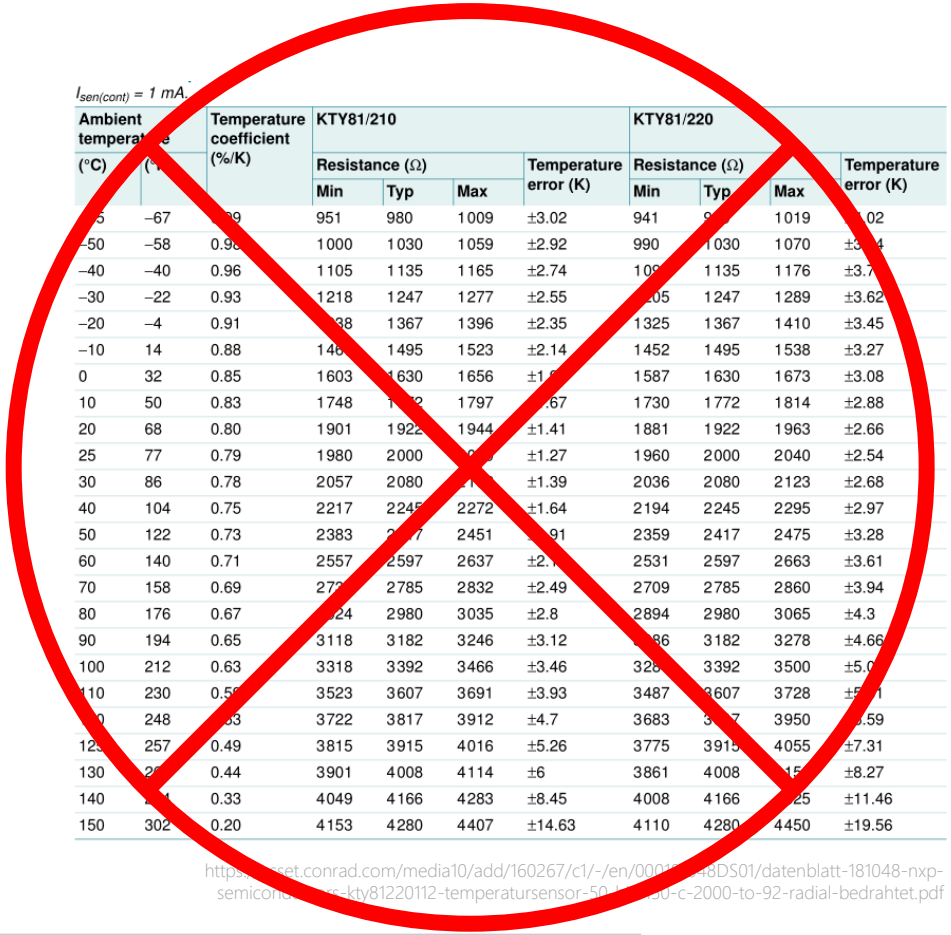
Positive Temperature Coeffizient



https://upload.wikimedia.org/wikipedia/commons/e/ee/Widerstand_PTC_DIN-EN.svg

Thermistor

Steinhart-Hart Gleichung



$I_{sen(cont)}$ = 1 mA.

Ambient temperature		Temperature coefficient (%/K)	KTY81/210				KTY81/220			
(°C)	(°F)		Resistance (Ω)			Temperature error (K)	Resistance (Ω)			Temperature error (K)
			Min	Typ	Max		Min	Typ	Max	
–55	–67	0.99	951	980	1009	±3.02	941	9[illegible]	1019	[illegible]02
–50	–58	0.98	1000	1030	1059	±2.92	990	1030	1070	±3[illegible]4
–40	–40	0.96	1105	1135	1165	±2.74	10[illegible]	1135	1176	±3.7[illegible]
–30	–22	0.93	1218	1247	1277	±2.55	[illegible]05	1247	1289	±3.62
–20	–4	0.91	[illegible]38	1367	1396	±2.35	1325	1367	1410	±3.45
–10	14	0.88	146[illegible]	1495	1523	±2.14	1452	1495	1538	±3.27
0	32	0.85	1603	1630	1656	±1.[illegible]	1587	1630	1673	±3.08
10	50	0.83	1748	1[illegible]72	1797	[illegible].67	1730	1772	1814	±2.88
20	68	0.80	1901	1922	1944	±1.41	1881	1922	1963	±2.66
25	77	0.79	1980	2000	[illegible]	±1.27	1960	2000	2040	±2.54
30	86	0.78	2057	2080	[illegible]	±1.39	2036	2080	2123	±2.68
40	104	0.75	2217	2245	2272	±1.64	2194	2245	2295	±2.97
50	122	0.73	2383	[illegible]417	2451	[illegible].91	2359	2417	2475	±3.28
60	140	0.71	2557	2597	2637	±2.1[illegible]	2531	2597	2663	±3.61
70	158	0.69	27[illegible]	2785	2832	±2.49	2709	2785	2860	±3.94
80	176	0.67	[illegible]24	2980	3035	±2.8	2894	2980	3065	±4.3
90	194	0.65	3118	3182	3246	±3.12	[illegible]86	3182	3278	±4.66
100	212	0.63	3318	3392	3466	±3.46	328[illegible]	3392	3500	±5.0[illegible]
110	230	0.5[illegible]	3523	3607	3691	±3.93	3487	3607	3728	±5[illegible]1
[illegible]0	248	[illegible]3	3722	3817	3912	±4.7	3683	3[illegible]7	3950	[illegible].59
12[illegible]	257	0.49	3815	3915	4016	±5.26	3775	3915	4055	±7.31
130	2[illegible]	0.44	3901	4008	4114	±6	3861	4008	15[illegible]	±8.27
140	[illegible]84	0.33	4049	4166	4283	±8.45	4008	4166	[illegible]25	±11.46
150	302	0.20	4153	4280	4407	±14.63	4110	4280	4450	±19.56

https[illegible]set.conrad.com/media10/add/160267/c1/-/en/000[illegible]48DS01/datenblatt-181048-nxp-semicond[illegible]ss-kty81220112-temperatursensor-50-[illegible]50-c-2000-to-92-radial-bedrahtet.pdf

$$T = \frac{1}{A + B \cdot \ln(R) + C \cdot \ln^3(R)}$$

T: Temperatur → [T] = K

A, B & C: Steinhart-Hart-Koeffizienten

R: Widerstand bei Temperatur T → [R] = Ω

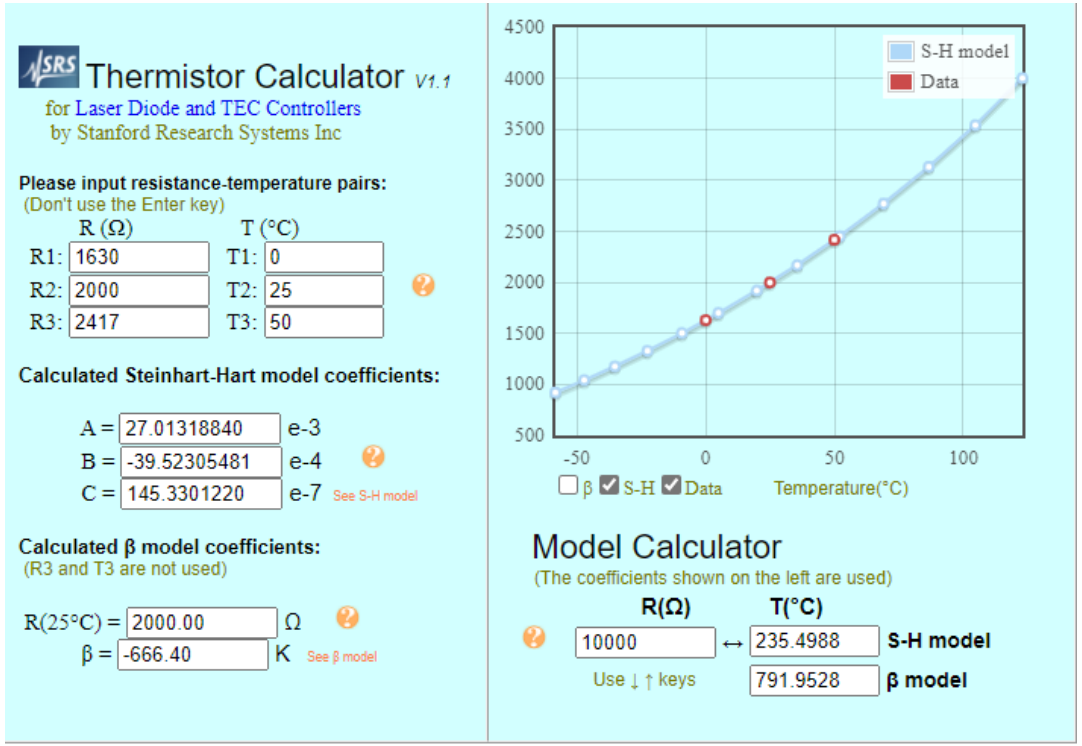
Thermistor

Steinhart-Hart Gleichung

$I_{sen(cont)}$ = 1 mA.

Ambient temperature		Temperature coefficient (%/K)	KTY81/210				KTY81/220			
(°C)	(°F)		Resistance (Ω)			Temperature error (K)	Resistance (Ω)			Temperature error (K)
			Min	Typ	Max		Min	Typ	Max	
–55	–67	0.99	951	980	1009	±3.02	941	980	1019	±4.02
–50	–58	0.98	1000	1030	1059	±2.92	990	1030	1070	±3.94
–40	–40	0.96	1105	1135	1165	±2.74	1094	1135	1176	±3.78
–30	–22	0.93	1218	1247	1277	±2.55	1205	1247	1289	±3.62
–20	–4	0.91	1338	1367	1396	±2.35	1325	1367	1410	±3.45
–10	14	0.88	1467	1495	1523	±2.14	1452	1495	1538	±3.27
0	32	0.85	1603	1630	1656	±1.91	1587	1630	1673	±3.08
10	50	0.83	1748	1772	1797	±1.67	1730	1772	1814	±2.88
20	68	0.80	1901	1922	1944	±1.44	1881	1922	1963	±2.69
25	77	0.79	1980	2000	2020	±1.27	1960	2000	2040	±2.54
30	86	0.78	2057	2080	2102	±1.39	2036	2080	2123	±2.68
40	104	0.75	2217	2245	2272	±1.64	2194	2245	2295	±2.97
50	122	0.73	2383	2417	2451	±1.91	2359	2417	2475	±3.28
60	140	0.71	2557	2597	2637	±2.19	2531	2597	2663	±3.61
70	158	0.69	2737	2785	2832	±2.49	2709	2785	2860	±3.94
80	176	0.67	2924	2980	3035	±2.8	2894	2980	3065	±4.3
90	194	0.65	3118	3182	3246	±3.12	3086	3182	3278	±4.66
100	212	0.63	3318	3392	3466	±3.46	3284	3392	3500	±5.05
110	230	0.59	3523	3607	3691	±3.93	3487	3607	3728	±5.61
120	248	0.53	3722	3817	3912	±4.7	3683	3817	3950	±6.59
125	257	0.49	3815	3915	4016	±5.26	3775	3915	4055	±7.31
130	266	0.44	3901	4008	4114	±6	3861	4008	4154	±8.27
140	284	0.33	4049	4166	4283	±8.45	4008	4166	4325	±11.46
150	302	0.20	4153	4280	4407	±14.63	4110	4280	4450	±19.56

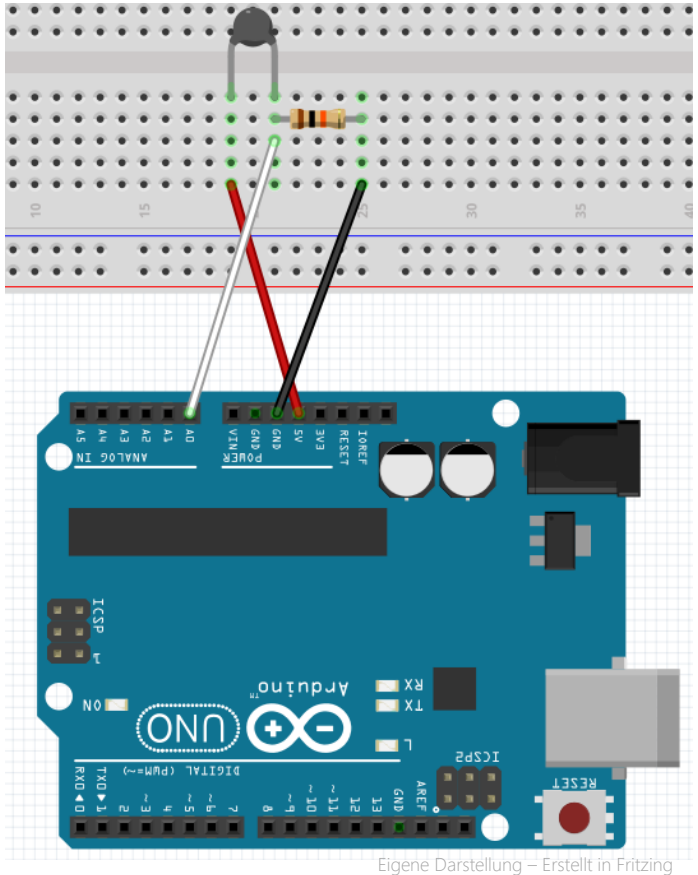
https://asset.conrad.com/media10/add/160267/c1/-/en/000181048DS01/datenblatt-181048-nxp-semiconductors-kty81220112-temperatursensor-50-bis-150-c-2000-to-92-radial-bedrahtet.pdf



https://www.thinksrs.com/downloads/programs/therm%20calc/ntccalibrator/ntccalculator.html

Thermistor

Beispiel



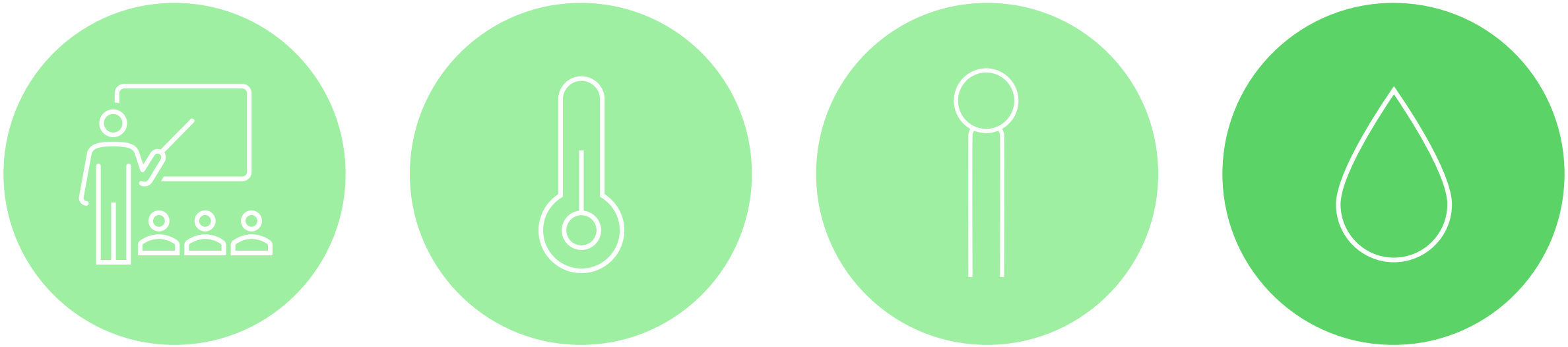
Eigene Darstellung – Erstellt in Fritzing

Thermistor

Beispiel

```
/*****************************************************************
 * Codebeispiel zur Berechnung der Temperatur mit Hilfe eines    *
 * NTC Heißleiter Thermisor                                      *
 * ***************************************************************/

#include <Arduino.h>


/*****************************************************************
 *          Hier müssen Variablen ndividuell angepasst werden    *
 *****************************************************************/

#define powerPin 21 //Pin für Strom
#define thermistorInputPin 26 //Analoger Input Pin des Temperatursensors

#define maxAnalogOutput 4095 //Maximaler Wert den der Thermistor ausgeben kann (Achtung: kein Ohm! Muss erst in Ohm umgerechnet werden)

#define referenceResistor 2700 //Wert des statischen Widerstands in Ohm(sollte gleich zu R_25 sein, sonst gibt es kiene genauen Werte)

#define T_25 25 //Raumtemperatur (sind bei dieser Berechnung immer 25°C)
#define R_25 2000 //Widerstand des Temperatursensors bei 25°C (Aus Datenblatt des Sensors zu entnehmen)


/*****************************************************************************************
 * Werte im Steinhart-Hart Koeffizienten Rechner berechnen                               *
 * und hier eintragen                                                                    *
 * https://www.thinksrs.com/downloads/programs/therm%20calc/ntccalibrator/ntccalculator.html *
 *****************************************************************************************/
#define scA 0.02592894
#define scB -0.00373536
#define scC 1.3247E-05 //e-5 entspricht 10^-5


/*****************************************************************
 *                          Setup                                *
 *                Ab hier muss nichts mehr verändert werden      *
 *****************************************************************/
void setup(void) {
  Serial.begin(115200);
```

Feuchtigkeitssensor



Feuchtigkeitssensoren

Messverfahren

Kapazitive Messung

Feuchtigkeitsänderung

↓

Veränderung der Kapazität

Elektrische Leitfähigkeit

Feuchtigkeitsänderung

↓

Veränderung des Widerstandes

Beispiel eines Temperatur- und Feuchtigkeissensors an einem Arduino

Vielen Dank!

Noch Fragen?