notebook_circuiti_1

March 24, 2023

0.1 circuiti_1

[ ]:
```python
import numpy as np
import pandas as pd
import sys
from matplotlib import pyplot as plt
from scipy.optimize import curve_fit
import scipy.stats as stats
sys.path.append("D:/Progetti/LabProgram")
from Routine import Routine
from Funnel import Funnel
from Funnel import FunnelSingle
from functions import linear_fit
import lab_utilities as lu
```

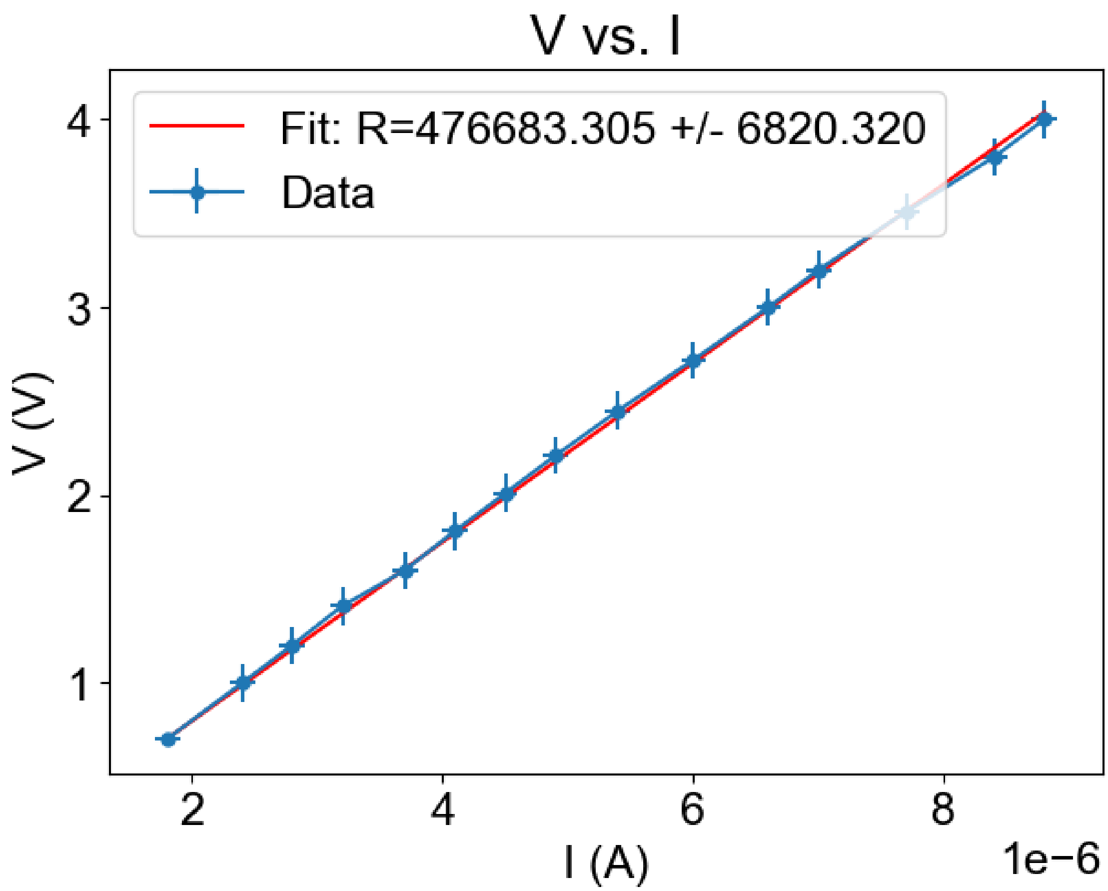
[ ]:
```python
#Impost style
lu.setDefaultGraphStyle()
```

0.1.1 Parte uno

misura resistenza interna voltometro

[ ]:
```python
R_usata = 2.999e6
sigma_R_usata = 0.001e6
datauno = pd.read_csv("data/parte_uno/vmisura_res_volmetro.csv")

V = datauno["V[V]"].values
I = datauno["I[muA]"].values / 1000000
sigma_V = datauno["sigma_V[V]"].values
sigma_I = datauno["sigma_I[muA]"].values / 1000000 # Convert microamps to amps


popt, pcov = curve_fit(linear_fit, I, V, sigma=sigma_V, absolute_sigma=True)

R_eq = popt[0]
delta_R = pcov[0, 0]**0.5
intercept = popt[1]
```

```
fit_line = linear_fit(I, R_eq, intercept)

plt.errorbar(I, V, xerr=sigma_I, yerr=sigma_V, fmt="o-", markeredgewidth=0,␣
↪label="Data")
plt.plot(I, fit_line, color="red", label=f"Fit: R={R_eq:.3f} +/- {delta_R:.3f}")
plt.xlabel("I (A)")
plt.ylabel("V (V)")
plt.title("V vs. I")
plt.legend()
plt.show()

print(f"R={R_eq:.3f}")
```




```
R=476683.305
```

[ ]:
```
#Resistenza Generatore
#R_V = 1/(1/R_eq - 1/R_usata)
R_V = (R_eq * R_usata) / (R_usata - R_eq)
print(f"R Voltometro={R_V/1000:.3f} kOhm")
```

```
R Voltometro=566.770 kOhm
```

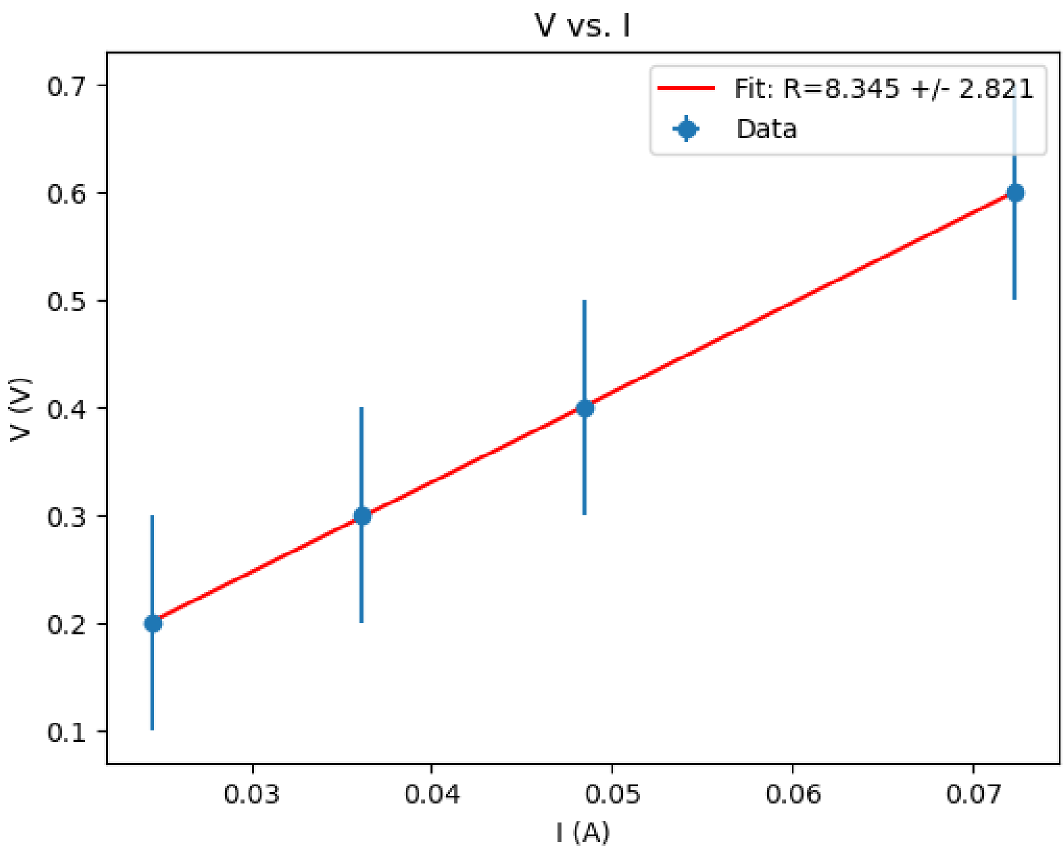
[ ]:
```python
#Calcolo giusto con solo un dato
R_usata_2 = 1.400e6
V_misurato = 2.864
sigma_V_misurato = 0.005
I_misurata = 2.6e-6
sigma_I_misurata = 0.5e-6
R_Vrut = Routine("V/I")
R_vFunnel = FunnelSingle(([['V', 'I'],[V_misurato, I_misurata],['s_V',␣
 ↪'s_I'],[sigma_V_misurato, sigma_I_misurata]), R_Vrut)
R_vFunnel.prepare_data()
R_Volt, R_Volt_error, R_Volt_error_formula = R_vFunnel.run_routine()

test = Routine('(R_e * R_u) / (R_u - R_e)')
test_funnel = FunnelSingle([['R_e', 'R_u'], [R_Volt, R_usata_2], ['s_R_u',␣
 ↪'s_R_e'], [0.01e6, R_Volt_error]], test)
test_funnel.prepare_data()
a,b,c = test_funnel.run_routine()
print(f"R Voltometro={a/1000:.3f} +- {b/1000:.3f}kOhm")
print(c)
```

```
R Voltometro=5167.010 +- 380.836kOhm
\sigma_{R_eR_e}*(R_e**2*R_u**2/(R_e**4 - 4*R_e**3*R_u + 6*R_e**2*R_u**2 -
4*R_e*R_u**3 + R_u**4) + 2*R_e*R_u**2/(-R_e**3 + 3*R_e**2*R_u - 3*R_e*R_u**2 +
R_u**3) + R_u**2/(R_e**2 - 2*R_e*R_u + R_u**2)) +
\sigma_{R_uR_u}*(R_e**2*R_u**2/(R_e**4 - 4*R_e**3*R_u + 6*R_e**2*R_u**2 -
4*R_e*R_u**3 + R_u**4) - 2*R_e**2*R_u/(-R_e**3 + 3*R_e**2*R_u - 3*R_e*R_u**2 +
R_u**3) + R_e**2/(R_e**2 - 2*R_e*R_u + R_u**2))
```

Misura resistenza interna Amperometro

[ ]:
```python
R_2 = 2.7
sigma_R_2 = 0.2

datauno_2 = pd.read_csv("data/parte_uno/misura_res_amperometro.csv")

V = datauno_2["V[V]"].values
I = datauno_2["I[mA]"].values / 1000
sigma_V = datauno_2["sigma_V[V]"].values
sigma_I = datauno_2["sigma_I[mA]"].values / 1000 # Convert microamps to amps


popt, pcov = curve_fit(linear_fit, I, V, sigma=sigma_V, absolute_sigma=True)

R_eq_2 = popt[0]
delta_R_2 = pcov[0, 0]**0.5
intercept_2 = popt[1]
```

```
fit_line = linear_fit(I, R_eq_2, intercept_2)

plt.errorbar(I, V, xerr=sigma_I, yerr=sigma_V, fmt="o", label="Data")
plt.plot(I, fit_line, color="red", label=f"Fit: R={R_eq_2:.3f} +/- {delta_R_2:.
↪3f}")
plt.xlabel("I (A)")
plt.ylabel("V (V)")
plt.title("V vs. I")
plt.legend()
plt.show()

print(f"R={R_eq_2:.3f}")
```



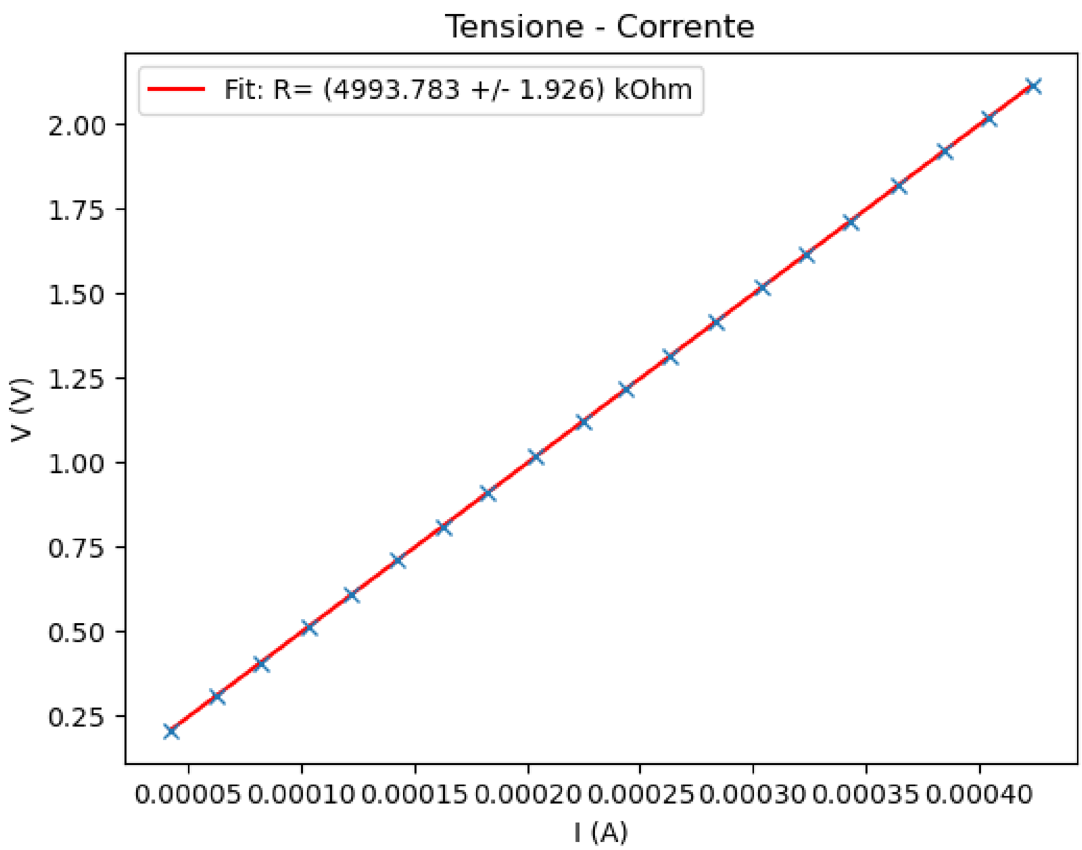

```
R=8.345
```

[ ]:
```
#Calcolo R amperometro
R_amp = R_eq_2 - R_2
print(R_amp)
```

```
5.644541631821553
```

0.1.2 Verifica legge di Ohm

```
[ ]: R_misurata = 4.991e3
sigma_R_mis = 0.002

datauno_3 = pd.read_csv("data/parte_uno/verifica_ohm.csv")

V_3 = datauno_3["V[V]"].values
I_3 = datauno_3["I[muA]"].values / 1000000
sigma_V_3 = datauno_3["sigma_V[V]"].values
sigma_I_3 = datauno_3["sigma_I[muA]"].values / 1000000 # Convert microamps to␣
↪amps


popt_3, pcov_3 = curve_fit(linear_fit, I_3, V_3, sigma=sigma_V_3,␣
↪absolute_sigma=True)

R_eq_3 = popt_3[0]
delta_R_3 = pcov_3[0, 0]**0.5
intercept_3 = popt_3[1]

fit_line_3 = linear_fit(I_3, R_eq_3, intercept_3)

dof_ohm = len(V_3)-2
chi_sq_ohm , prob_ohm = lu.chi2_fit_test(fit_line_3, V_3, sigma_V_3, dof_ohm)

plt.errorbar(I_3, V_3, xerr=sigma_I_3, yerr=sigma_V_3, fmt="x")
plt.plot(I_3, fit_line_3, color="red", label=f"Fit: R= ({R_eq_3:.3f} +/-␣
↪{delta_R_3:.3f}) kOhm")
plt.xlabel("I (A)")
plt.ylabel("V (V)")
plt.title("Tensione - Corrente")
plt.legend()
plt.show()

print(f"R={R_eq_3:.3f}")
print(f"Chi2={chi_sq_ohm:.3f}")
print(f"Prob={prob_ohm*100:.3f}%")
```



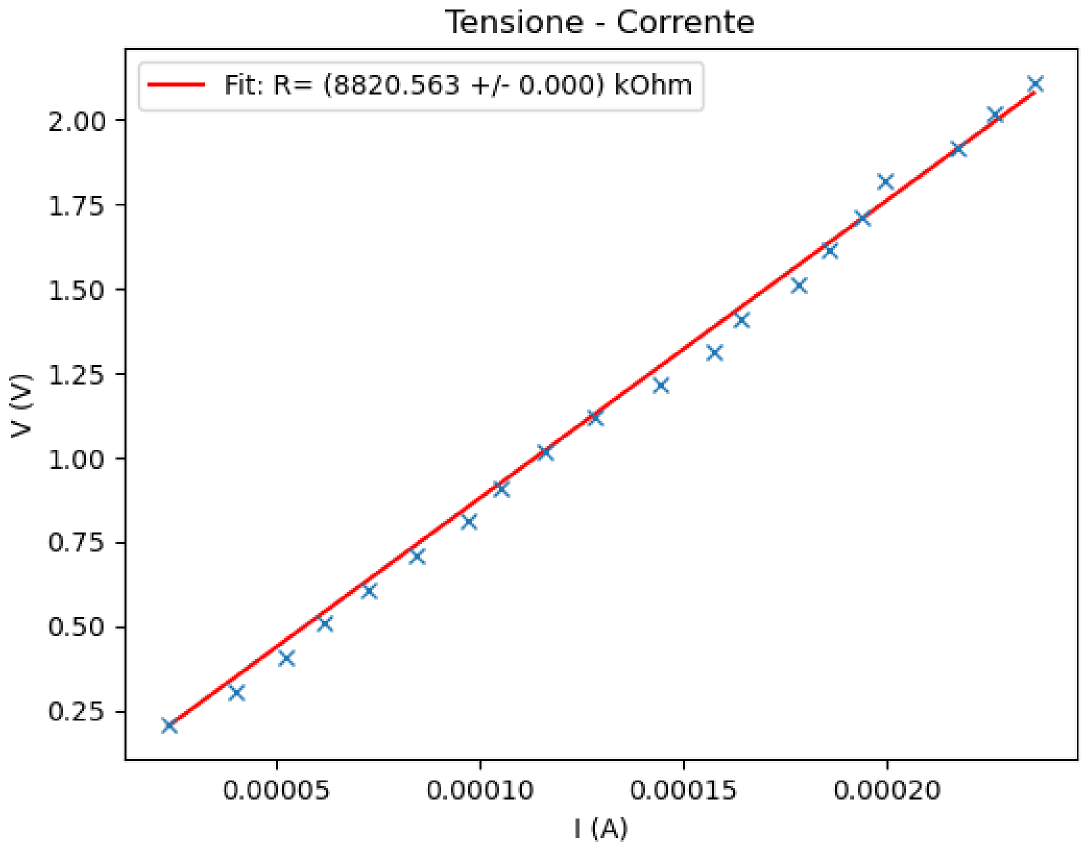

```
R=4993.783
Chi2=8.816
Prob=94.535%
```

0.1.3 Resistenze in serie e parallelo

Parallelo

[ ]:
```
R_1 = 21.75
R_2 = 14.81
sigma_Rs = 0.01

#Fare fit e confrontare con valore atteso (in parallelo)
data_parallelo = pd.read_csv("data/parte_uno/resistenze_parallelo.csv")

V_p = data_parallelo["V[V]"].values
I_p = data_parallelo["I[muA]"].values / 1000000
sigma_V_p = data_parallelo["sigma_V[V]"].values
sigma_I_p = data_parallelo["sigma_I[muA]"].values / 1000000 # Convert microamps␣
↪to amps
```

```
popt_p, pcov_p = curve_fit(linear_fit, I_p, V_p, sigma=sigma_I_p,␣
 ↪absolute_sigma=True)

R_eq_p = popt_p[0]
delta_R_p = pcov_p[0, 0]**0.5
intercept_p = popt_p[1]

fit_line_p = linear_fit(I_p, R_eq_p, intercept_3)

dof_ohm_p = len(V_p)-2
chi_sq_ohm_p , prob_ohm_p = lu.chi2_fit_test(fit_line_p, V_p, sigma_V_p,␣
 ↪dof_ohm_p)

plt.errorbar(I_p, V_3, xerr=sigma_I_p, yerr=sigma_V_p, fmt="x")
plt.plot(I_p, fit_line_p, color="red", label=f"Fit: R= ({R_eq_p:.3f} +/-␣
 ↪{delta_R_p:.3f}) kOhm")
plt.xlabel("I (A)")
plt.ylabel("V (V)")
plt.title("Tensione - Corrente")
plt.legend()
plt.show()

print(f"Chi2={chi_sq_ohm_p:.3f}")
print(f"Prob={prob_ohm_p*100:.3f}%")
```




```
Chi2=8.780
Prob=94.658%
```

Serie

[ ]:
```
#Fare fit e confrontare con valore atteso (in Serie)
```

0.2 Parte due

[ ]:
```
R_load_1 = 468.2e3
R_load_2 = 466.0e3
```

0.3 Parte tre

[ ]:
```
def shockley_fun(V, I_0, g, T):
    q=1.6e-19
    k=1.38e-23
    return I_0 * (np.exp((q*V)/(k*g*T))-1)
```

[ ]:
```python
def dummy_shockley_fun(V, I_0, g):
    q=1.6e-19
    k=1.38e-23
    T = 300
    return I_0 * (np.exp((q*V)/(k*g*T))-1)
```

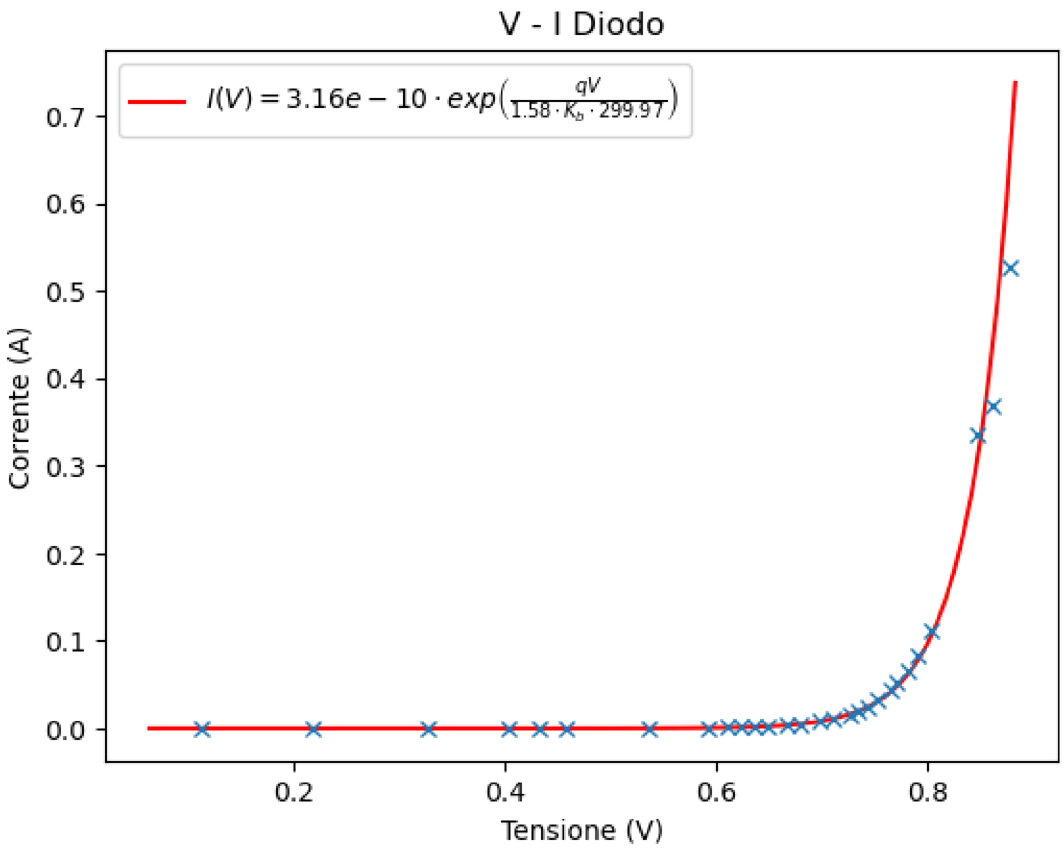
[ ]:
```python
#Calcola derivate tra coppie valori per trovare resistenza diodo in␣
 ↪quell'intervallo
dati_diodo = pd.read_csv("data/parte_tre/misure_diodo.csv")
V_ds = dati_diodo['V[V]'].to_list()
V_ds_error = dati_diodo['sigma_V[V]'].to_list()
I_ds = dati_diodo['I[muA]'].to_list()
I_ds = [i_d / 1000000 for i_d in I_ds]
I_ds_error = dati_diodo['sigma_I[muA]'].to_list()
I_ds_error = [I_ds_err / 1000000 for I_ds_err in I_ds_error]

R_diodo = [(V_ds[i+1]-V_ds[i]) / (I_ds[i+1] - I_ds[i]) for i in range(6,␣
 ↪len(V_ds)-1)]
```

[ ]:
```python
#dummy fit with T set as 300k to find initial guess values for I_0 and g
dummy_popt_d, dummy_pcov_d = curve_fit(dummy_shockley_fun, V_ds, I_ds,␣
 ↪sigma=I_ds_error, absolute_sigma=True, maxfev=5000, p0=[0.1, 1])
initial_I0, initial_g = dummy_popt_d
```

[ ]:
```python
#Fit
p0 = [initial_I0, initial_g , 300] #Initial parameter guess
popt_d, pcov_d = curve_fit(shockley_fun, V_ds, I_ds, sigma=I_ds_error,␣
 ↪absolute_sigma=True, maxfev=5000, p0=p0)

I_0 = popt_d[0]
g = popt_d[1]
T = popt_d[2]
print(I_0,g, T)

V_Shockley = np.linspace(min(V_ds)-0.05, max(V_ds)+0.005, 100)
I_Shockley = shockley_fun(V_Shockley, I_0, g, T)

plt.errorbar(V_ds, I_ds, xerr=V_ds_error, yerr=I_ds_error, fmt="x")
shockley_lable = r'$I(V) = ' + str("{:.2e}".format(I_0)) + r'\cdot␣
 ↪exp\left(\frac{qV}{' + str(round(g,2)) + r'\cdot K_b \cdot' +␣
 ↪str(round(T,2)) + r'}\right)$'
plt.plot(V_Shockley, I_Shockley, color="red", label=shockley_lable)
plt.title("V - I Diodo")
plt.xlabel("Tensione (V)")
plt.ylabel("Corrente (A)")
plt.legend()
plt.savefig('imgs/shockley_fit.png')
```

```
print(R_diodo)
```

```
3.1642257241280173e-10 1.5840697797371497 299.9700689132184
[136.6906474820142, 49.350649350649405, 36.92307692307695, 29.545454545454582,
19.11764705882354, 14.9122807017544, 8.695652173913052, 6.614785992217861,
3.921568627450984, 3.5634743875278434, 1.6509433962264164, 2.1951219512195146,
1.2500000000000016, 0.9523809523809529, 0.7643312101910839, 0.748299319727892,
0.5142857142857147, 0.45936395759717347, 0.1973094170403584, 0.441176470588236,
0.1012658227848102]
```



Ora proviamo a fittare linearmente le ultime parti del grafico

```
[ ]: def plot_linear_fits(current, voltage, current_err, voltage_err, N, m, stop):
         fig, ax = plt.subplots()

         # plot the data points
         ax.errorbar(current[10::], voltage[10::], xerr=current_err[10::],␣
      ↪yerr=voltage_err[10::], fmt='.', color='blue')
```

```
    # iterate through the data starting from N and incrementing by m
    for i in range(N, stop, m):
        x_fit = current[i:] # use data starting from index i
        y_fit = voltage[i:]
        x_err = current_err[i:]
        y_err = voltage_err[i:]

        # perform a linear fit on the data using curve_fit from scipy
        fit_params, _ = curve_fit(linear_fit, x_fit, y_fit, sigma=y_err,␣
↪absolute_sigma=True)

        # plot the fitted line
        x_plot = np.linspace(x_fit[0]-0.01, x_fit[-1]+0.01, num=100)
        ax.plot(x_plot, linear_fit(x_plot, fit_params[0], fit_params[1]),␣
↪label=f'i={i}')

    ax.set_xlabel('Corrente (A)')
    ax.set_ylabel('Voltaggio (V)')
    ax.legend()
    plt.show()
```

[ ]:
```
plot_linear_fits(V_ds, I_ds, V_ds_error, I_ds_error, 15, 1, len(V_ds) - 5)
```