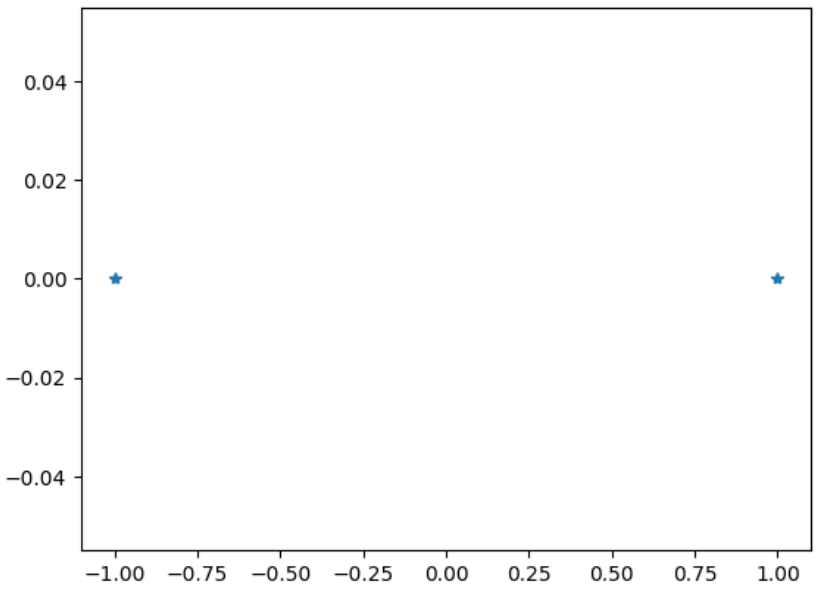
```
import numpy as np      #for numerical computing
import matplotlib.pyplot as plt            #for plotting functions
from scipy.special import erfc             #erfc/Q function


#---------Input Fields------------------------
nSym = 10**5 # Number of symbols to transmit
EbN0dBs = np.arange(start=-4,stop = 13, step = 2)          # Eb/N0 range in dB for simulation
BER_sim = np.zeros(len(EbN0dBs))                # simulated Bit error rates

M=2        #Number of points in BPSK constellation
m = np.arange(0,M)              #all possible input symbols
A = 1;                    #amplitude
constellation = A*np.cos(m/M*2*np.pi)            #reference constellation for BPSK



#------------ Transmitter----------------
inputSyms = np.random.randint(low=0, high = M, size=nSym)       #Random 1's and 0's as input
to BPSK modulator
s = constellation[inputSyms]               #modulated symbols

fig, ax1 = plt.subplots(nrows=1,ncols = 1)
ax1.plot(np.real(constellation),np.imag(constellation),'*')
```



Singnal space representation of BPSK

```
#---------- Channel ----------
#Compute power in modulatedSyms and add AWGN noise for given SNRs
for j,EbN0dB in enumerate(EbN0dBs):
    gamma = 10**(EbN0dB/10)                    #SNRs to linear scale
    P=sum(abs(s)**2)/len(s)                #Actual power in the vector
    N0=P/gamma                  # Find the noise spectral density
    n = np.sqrt(N0/2)*np.random.standard_normal(s.shape)             # computed noise vector
    r = s + n # received signal


#---------- Receiver ------------
    detectedSyms = (r <= 0).astype(int)              #thresolding at value 0
    BER_sim[j] = np.sum(detectedSyms != inputSyms)/nSym         #calculate BER

BER_theory = 0.5*erfc(np.sqrt(10**(EbN0dBs/10)))
fig, ax = plt.subplots(nrows=1,ncols = 1)
ax.semilogy(EbN0dBs,BER_sim,color='r',marker='o',linestyle='',label='BPSK Sim')
ax.semilogy(EbN0dBs,BER_theory,marker='',linestyle='-',label='BPSK Theory')
ax.set_xlabel('$E_b/N_0(dB)$');
ax.set_ylabel('BER ($P_b$)')
ax.set_title('Probability of Bit Error for BPSK over AWGN channel')
ax.set_xlim(-5,13);ax.grid(True);
ax.legend();
plt.show()
```