LAB 02 - Digitalne komunikacije

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1 Question 2.1

Some Wi-Fi communication systems are based on the IEEE wireless LAN standards 802.11 and 802.11b, which operate in the 2.4 GHz ISM (industrial, scientific, and medical) unlicensed frequency band. In the 802.11 standard, an 11-chip Barker sequence is modulated and transmitted at a chip rate of 11 MHz, i.e., the chip duration is 0.909 µs. The 11-chip Barker sequence is [1, -1, 1, 1, -1, 1, 1, 1, -1, -1, -1].

Determine the values of the autocorrelation function of the above-mentioned sequence. What is the ratio of the sidelobe, when compared to the peak autocorrelation value?

Values of the autocorrelation function of the before mentioned sequence are as follows: [11, 0, -1, 0, -1, 0, -1, 0, -1, 0, -1].

Ratio of the sidelobe compared to the peak of the autocorrelation value is:

$$PSR = \frac{1}{11} = 0.0\overline{90}$$

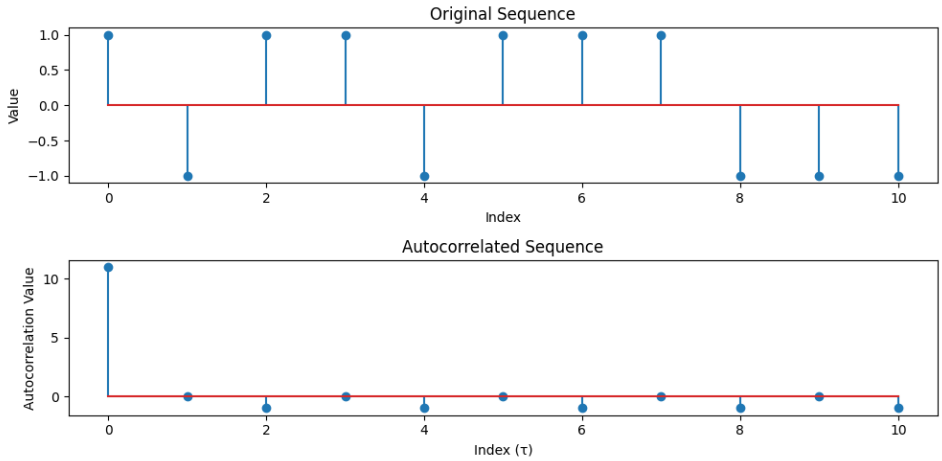

Figure 1: Original signal sequence and autocorrelated signal sequence

Source code used for generating autocorrelation values, ratio and ploting function values:

```
def autocorrelation(sequence):
    N = len(sequence)
    autocorr = []

```

```
    for tau in range(N):
        val = sum(sequence[n] * sequence[n + tau] for n in
        ↪  range(N - tau))
        autocorr.append(val)

    return autocorr

def find_peak_and_sidelobe(autocorr):
    peak = max(autocorr)
    sidelobes = [abs(val) for val in autocorr if val != peak]
    sidelobe = max(sidelobes)

    return peak, sidelobe

barker_sequence = [1, -1, 1, 1, -1, 1, 1, 1, -1, -1, -1]

autocorr_values = autocorrelation(barker_sequence)
peak_value, sidelobe_value =
↪  find_peak_and_sidelobe(autocorr_values)

ratio_sidelobe_to_peak = sidelobe_value / peak_value

print("Autocorrelation values:", autocorr_values)
print("Peak autocorrelation value:", peak_value)
print("Sidelobe value:", sidelobe_value)
print("Ratio of sidelobe to peak autocorrelation value:",
↪  ratio_sidelobe_to_peak)

plt.subplot(2, 1, 1)
plt.stem(range(len(barker_sequence)), barker_sequence,
↪  markerfmt='o')
plt.title('Original sequence')
plt.xlabel('Index')
plt.ylabel('Value')

plt.subplot(2, 1, 2)
plt.stem(range(len(autocorr_values)), autocorr_values,
↪  markerfmt='o')
plt.title('Autocorrelated sequence')
plt.xlabel('Index ()')
plt.ylabel('Autocorrelation value')
```

2 Question 2.2

A random sequence signal has a $[(sinx)/x]^2$ power spectrum. What is the peak power level of the first sidelobe compared with that of the main lobe?

Peak power of the first sidelobe is around 0.047, or more than 21 times smaller than the peak value of the main sidelobe.

What percentage of total signal power is contained in the main lobe?

$$\frac{\int_{-\pi}^{\pi}[(sinx)/x]^2\,dx}{\int_{-\infty}^{\infty}[(sinx)/x]^2\,dx} = \frac{2.8363}{3.1415} = 0.9028 = 90.28\%$$

What is the signal's 3-dB bandwidth?

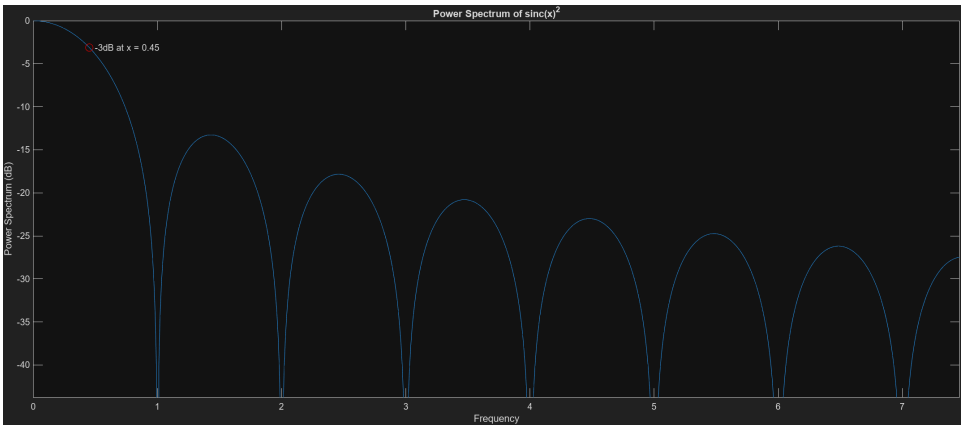

Figure 2: Plot of the power spectrum in dB/frequency with marked -3dB value

While we can make a readout from the shown plot and conlcude that 3dB bandwidth is around 0.45 Hz, built in MATLAB function gives us exact solution of 0.491 Hz