デジタル信号処理　第 13 回宿題

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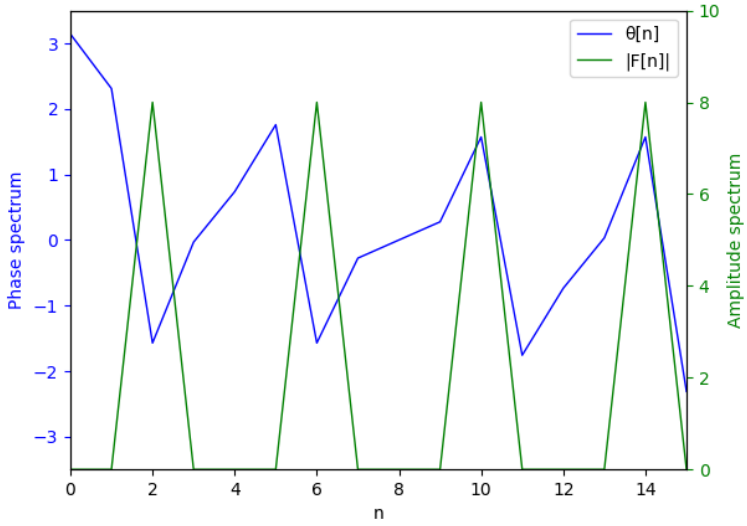
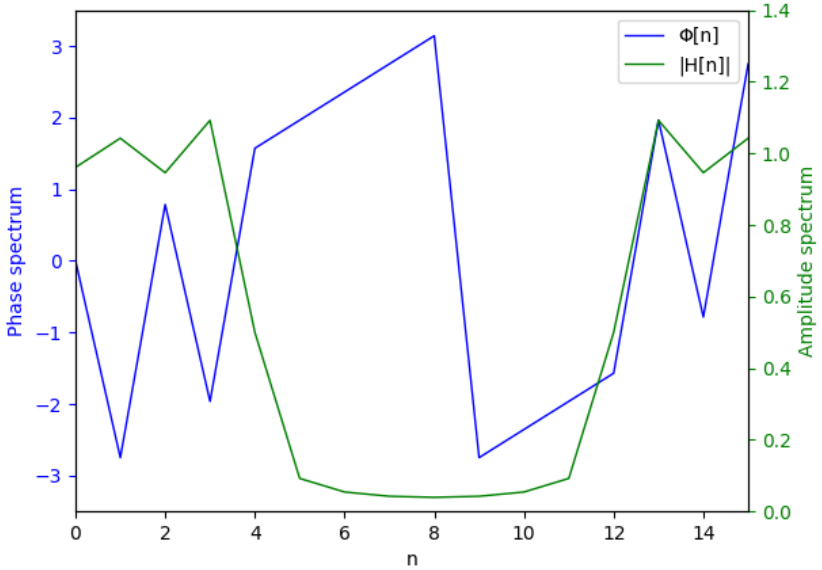
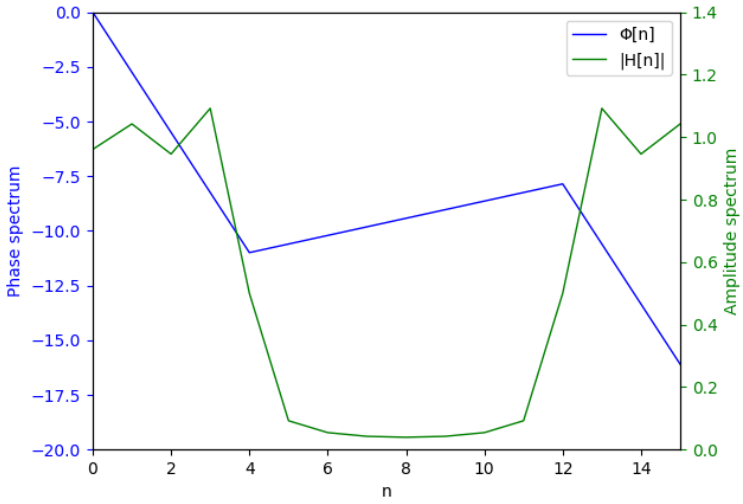
結果







ソースコード

```
import numpy as np
import matplotlib.pyplot as plt

T = 1
w1 = 0.25 * np.pi / T
w2 = 0.75 * np.pi / T
wc = 0.50 * np.pi / T
L = 7
N = 15
M = 16
k1 = np.arange(start=-L, stop=N - L, step=1)  # h[k]のとる範囲
k2 = np.arange(start=0, stop=N + 1, step=1)  # f[k]のとる範囲(1 つ目の plot のとる範囲)
f = np.sin(w1 * k2 * T) + np.sin(w2 * k2 * T)
h = (wc / np.pi) * np.sinc(wc * k1 * T / np.pi)

# DFT 行列を計算
F = np.fft.fft(f, n=M)
H = np.fft.fft(h, n=M)
F[0] = -F[0]
# 絶対値で振幅スペクトル|F[n]|を計算
F_amp = np.abs(F)
e = F / F_amp
```

```
theta1 = np.arctan2(e.imag, e.real)

H_amp = np.abs(H)
e2 = H / H_amp
theta2 = np.arctan2(e2.imag, e2.real)
unwrapped = np.unwrap(theta2)

fig, ax1 = plt.subplots()
# ax1 に f[k]を描画
ax1.plot(k2, theta1, color="b", linewidth=1, label="θ[n]")
ax1.set_xlabel("n")
ax1.set_ylabel("Phase spectrum", color="b")
ax1.tick_params("y", colors="b")
ax1.set_ylim(-3.5, 3.5)
ax1.set_xlim(0, N)

# ax2 に θ を描画
ax2 = ax1.twinx()
ax2.plot(k2, F_amp, color="g", linewidth=1, label="|F[n]|")
ax2.set_ylabel("Amplitude spectrum", color="g")
ax2.tick_params("y", colors="g")
ax2.set_ylim(0, 10)

# 凡例
lines = ax1.get_lines() + ax2.get_lines()
labels = [line.get_label() for line in lines]
ax1.legend(lines, labels, loc="upper right")

plt.show()


fig, ax1 = plt.subplots()
# ax1 に f[k]を描画
ax1.plot(k2, theta2, color="b", linewidth=1, label="Φ[n]")
ax1.set_xlabel("n")
ax1.set_ylabel("Phase spectrum", color="b")
ax1.tick_params("y", colors="b")
```

```
ax1.set_ylim(-3.5, 3.5)
ax1.set_xlim(0, N)

# ax2 に θ を描画
ax2 = ax1.twinx()
ax2.plot(k2, H_amp, color="g", linewidth=1, label="|H[n]|")
ax2.set_ylabel("Amplitude spectrum", color="g")
ax2.tick_params("y", colors="g")
ax2.set_ylim(0, 1.4)

# 凡例
lines = ax1.get_lines() + ax2.get_lines()
labels = [line.get_label() for line in lines]
ax1.legend(lines, labels, loc="upper right")

plt.show()


fig, ax1 = plt.subplots()
# ax1 に f[k]を描画
ax1.plot(k2, unwrapped, color="b", linewidth=1, label="Φ[n]")
ax1.set_xlabel("n")
ax1.set_ylabel("Phase spectrum", color="b")
ax1.tick_params("y", colors="b")
ax1.set_ylim(-20, 0)
ax1.set_xlim(0, N)

# ax2 に θ を描画
ax2 = ax1.twinx()
ax2.plot(k2, H_amp, color="g", linewidth=1, label="|H[n]|")
ax2.set_ylabel("Amplitude spectrum", color="g")
ax2.tick_params("y", colors="g")
ax2.set_ylim(0, 1.4)

# 凡例
lines = ax1.get_lines() + ax2.get_lines()
labels = [line.get_label() for line in lines]
```

```
ax1.legend(lines, labels, loc="upper right")

plt.show()
```