

# Module 1 - Quiz 2024 Solutions

## Question 1

Not yet answered

Marked out of 10

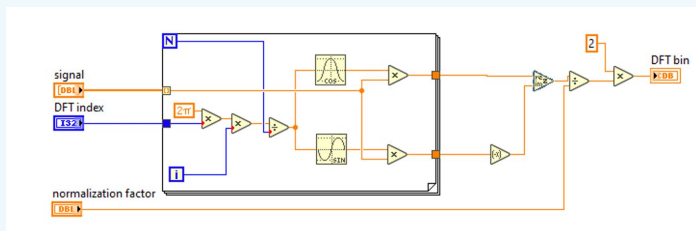
The DFT for a frequency bin  $k$  can be expressed as follows:

$$X(k) = \frac{2}{B} \sum_{n=0}^{N-1} w(n) \cdot x(n) \cdot e^{-j2\pi kn/N}, \quad k \in [0, N-1]$$

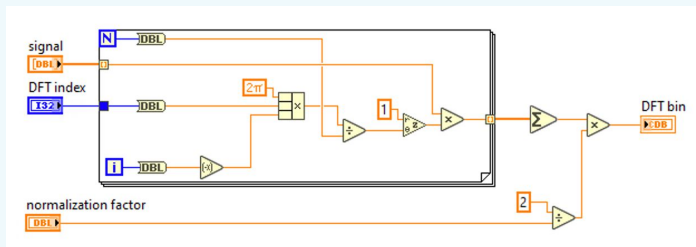
where  $x(n)$  is the sampled signal under analysis,  $w(n)$  is the discrete windowing function,  $k$  and  $n$  are the indexes of the frequency bins and time-domain samples, respectively,  $B$  is the normalization factor.

Which of the following two code examples is correctly computing this DFT bin (the input "signal" refers to the windowed signal, i.e.,  $w(n) \cdot x(n)$ )?

1.



2.



Choose the correct statement:

- ☐ a. Only 1. is correct.
- ☐ b. None is correct.
- ☐ c. Both are correct.
- ☒ d. Only 2. is correct.

**Question 2**

Not yet answered

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Assume a PMU is equipped with a synchrophasor estimation algorithm characterized by a window length of 60 ms and a reporting rate of 50 frames per second (fps). A fault occurs in the substation that is continuously monitored by the PMU. The fault lasts for 30 ms. How many synchrophasor estimates are affected by the transient?

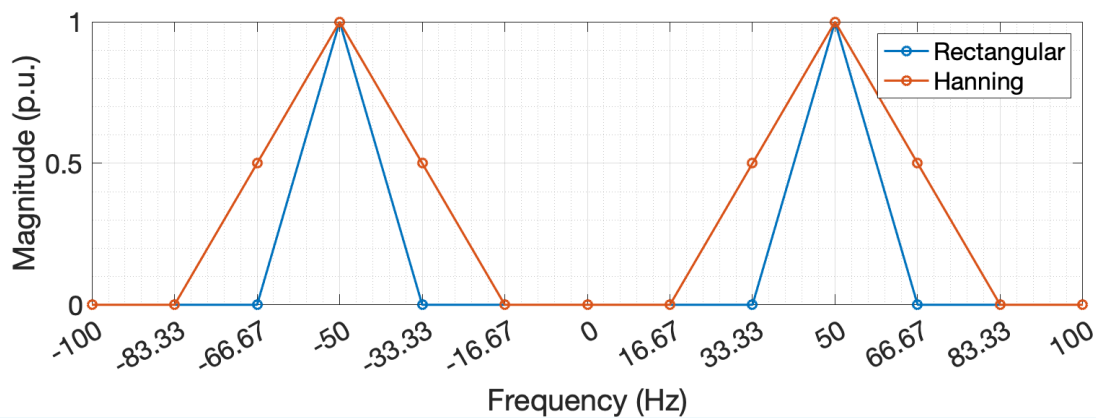
Select one:

- ☐ a. 1
- ☐ b. 2
- ☐ c. 3
- ☒ d. 4 or more

**Question 3**

Not yet answered

Marked out of 10



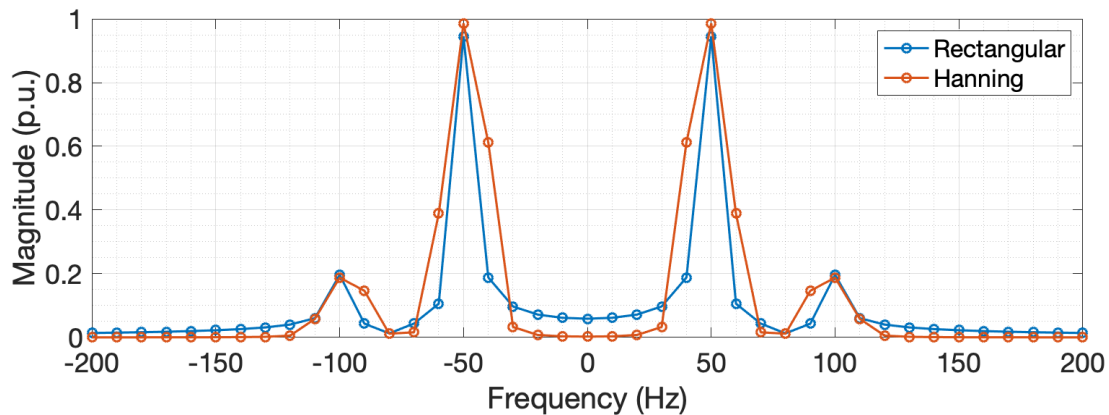
We can deduce the following parameters from the above spectrum:

- ☐ a. Signal frequency  $f_0 = 50$  Hz with a phase  $\varphi = \pi/4$  rad.
- ☐ b. Signal frequency  $f_0 = 50$  Hz, window length  $T_w = 100$  ms, sampling frequency  $T_s = 5$  kHz.
- ☒ c. Signal frequency  $f_0 = 50$  Hz, window length  $T_w = 60$  ms.
- ☐ d. Signal frequency  $f_0 = 50$  Hz, window length  $T_w = 60$  ms, sampling frequency  $T_s = 500$  Hz.

**Question 4**

Not yet answered

Marked out of 10



Select the correct statement concerning the above spectrum.

- ☒ a. The tails of the negative image leak into the positive DFT bins. This phenomenon is less evident with the Hanning window.
- ☐ b. The signal is incoherently sampled and no spectral leakage can be observed for the Hanning window.
- ☐ c. The main tone is only affected by spectral leakage from the interfering tone.
- ☐ d. The Rectangular window is better in suppressing the spectral leakage that occurs due to incoherent sampling.

**Question 5**

Not yet answered

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Suppose you need to compute the IpDFT of a single-tone sinusoidal signal at 52 Hz, sampled at 5kHz, windowed with a Hanning function characterized by a window length of 60 ms. Select the **incorrect** statement:

Select one:

- ☒ a. The correction term delta is negative.
- ☐ b. The spectrum peak lies between bins  $k=3$  and  $k=4$ .
- ☐ c. All the bins exhibit non-zero projections on the entire DFT basis set but the majority of the energy is concentrated around the third bin.
- ☐ d. The continuous spectrum peak does not correspond to the DFT bin characterized by the highest magnitude.

**Question 6**

Not yet answered

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A PMU is programmed to have a reporting rate of 50 fps, a window length of 60 ms and a sampling frequency of 5 kHz. The PMU is estimating a frequency of 50.5 Hz and a constant phase.

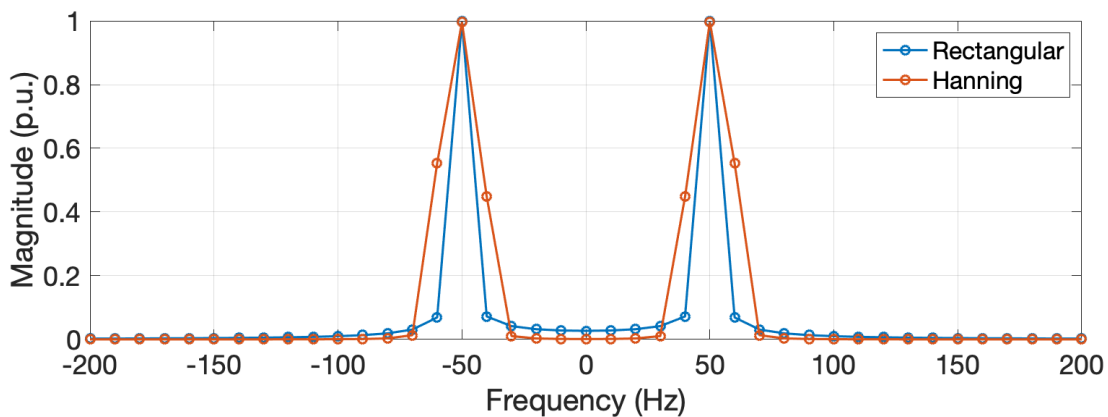
Select the **incorrect** statement.

- ☐ a. The actual sampling frequency of the PMU is less than the one that is used in the IpDFT.
- ☐ b. The reported window includes more than 3 periods of the measured signal.
- ☒ c. The PMU has a constant time synchronization error which results in a constant phase shift.
- ☐ d. The phase is constant since the actual frequency of the measured signal is synchronized to the reporting rate.

**Question 7**

Not yet answered

Marked out of 10



Assume an interpolated DFT (IpDFT) is performed on the spectrum above. Select the **correct** statement.

- ☐ a. The DFT bins used to perform the interpolation are only generated by the positive image of the tone under analysis.
- ☐ b. The TVE of the Rectangular window should be smaller than the one of the Hanning, because the two tones are very close.
- ☐ c. The Hanning window should be chosen over the Rectangular window because it better meets the Nyquist theorem.
- ☒ d. The correction factor  $\epsilon$  used in the IpDFT algorithm is positive.

### Question 8

Not yet answered

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A PMU uses GPS to synchronize to UTC time. However, there is a time delay on the GPS chip, which is not compensated for in the PMU synchronization. Which metric would be **unaffected** by this mistake?

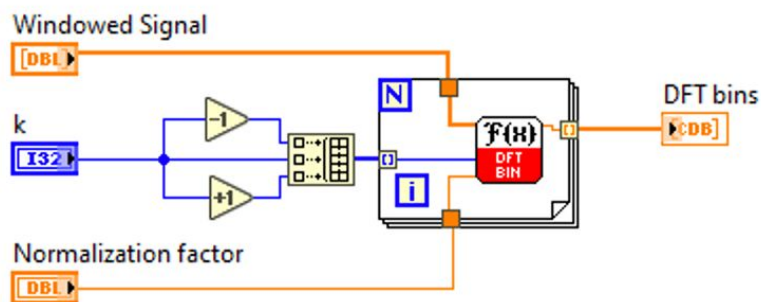
Select one:

- ☐ a. Phase error.
- ☒ b. Frequency error.
- ☐ c. TVE.
- ☐ d. All error metrics would be affected.

### Question 9

Not yet answered

Marked out of 10



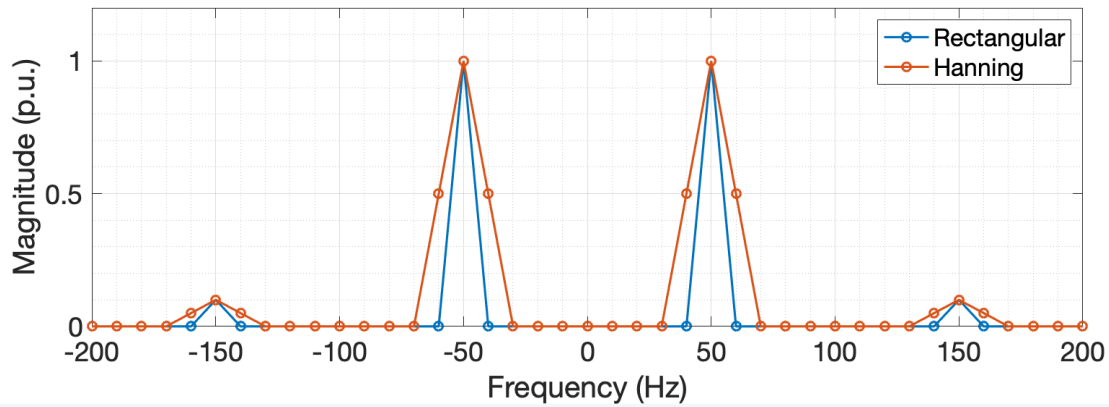
Assuming a nominal frequency of 50 Hz, select the **correct** statement concerning the code above.

- ☒ a. Given a window length of 600 samples at a sampling frequency of 10 kHz,  $k = 3$ .
- ☐ b. Given a window length of 60 ms and a sampling frequency of 10 kHz,  $k = 0 \dots 999$ .
- ☐ c. Given a window length of 1000 samples at a sampling frequency of 10 kHz,  $k = 3$ .
- ☐ d. When analyzing a signal with a frequency of 51 Hz, using a window length of 100 ms,  $k = 6$ .

**Question 10**

Not yet answered

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Select the **correct** statement concerning the above spectrum:

- ☒ a. The actual signal is composed of a 50 Hz and a 350 Hz component, and the sampling frequency of the DFT is 500 Hz.
- ☐ b. The actual signal is composed of a 50 Hz and a 150 Hz component, and aliasing occurs.
- ☐ c. The actual signal is composed of a 50 Hz and a 400 Hz component, and the sampling frequency of the DFT is 500 Hz.
- ☐ d. The actual signal is composed of a 50 Hz and a 100 Hz component, and the sampling frequency of the DFT is bigger than 800 Hz.