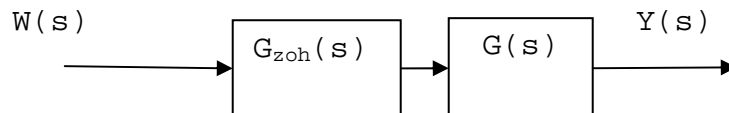


You may use Matlab/simulink wherever applicable

1. Consider the signal $x(t) = 8\sin\pi t$ volts and a 3-bit A-to-D converter (ADC)

- According to the Nyquist Sampling Theorem, what is the largest sampling time, T_s , we could use on this signal and still recover the signal?
 - Sketch the result of sampling this particular signal at exactly the Nyquist sampling rate. Look at the result and state whether we can recover this particular signal if we sample exactly at the Nyquist rate.
 - What would be a typical sampling time for a control system with this Nyquist sampling frequency?
 - In the **Time Domain**, sketch both the original signal and the output of a zero order hold (ZOH) of the signal at a sampling time of 2 times the Nyquist Rate.
 - In the time domain, sketch the original signal then sketch the results of quantizing the signal if we have an $n=3$ bit ADC
 - What is the mean-square-error (MSE) due to quantizing for our 3-bit A/D converter and our signal?
 - Devise the most logical encoding scheme to encodes the quantized signal into a 3-bit integer number (i.e., find an expression for X_{encoded} as a function of the quantized value, $X_{\text{quantized}}$)
 - Use your answer to find both $X_{\text{quantized}}$ and X_{encoded} if the value of the sample of the original signal is 5.68 volts
 - Finally, using your encoding and quantizing scheme in reverse (i.e., D/A conversion), what voltage would the encoded number 011 produce?
2. Consider the Bode plot on the following page of $G_{\text{ZOH}} G(j\omega)$

- Use this Bode plot to predict what the open-loop steady-state response will be if the input is $100\sin 10t$
- What type # is the system?
- If the break point at $j\omega = 10$ rad/sec is due to a zero-order sample and hold circuit, find T_s
- Now find $G(s)$
- Input a unit step into the open-loop system shown below. Can the open-loop system follow a step? What is the steady-state error (i.e., the difference between the input and the output in steady-state)



- Now find the open-loop unit-impulse response. Using this as a starting point, think of an input that would make the open-loop output go to one (which is what we wanted the step input to go to)
- Does the input you specified above exist in the real world? What if we have a disturbance, is an open-loop design a robust design?
- Now use simulink to close the loop on your system using unity feedback as shown. What is the steady-state error due to a step input now?

