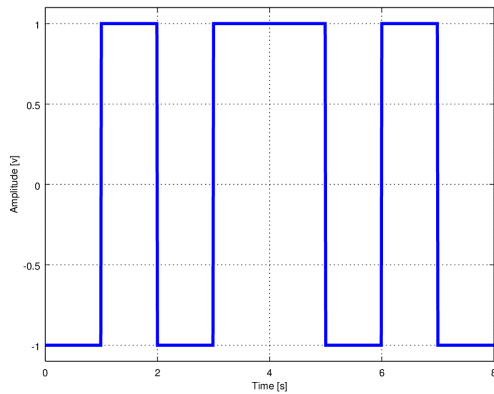


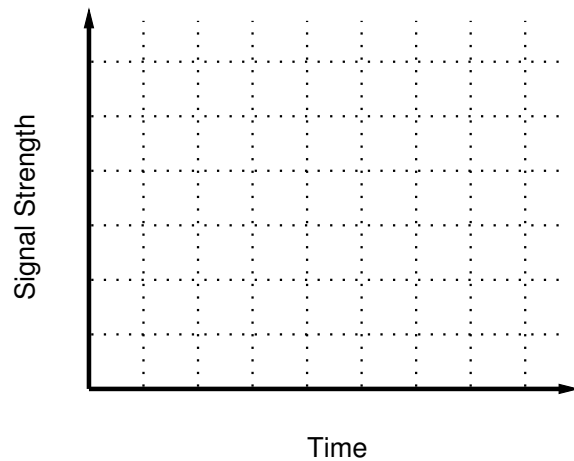
# ITS323/CSS331 – Communication Signal Examples

## 1 Representing Data in Signals



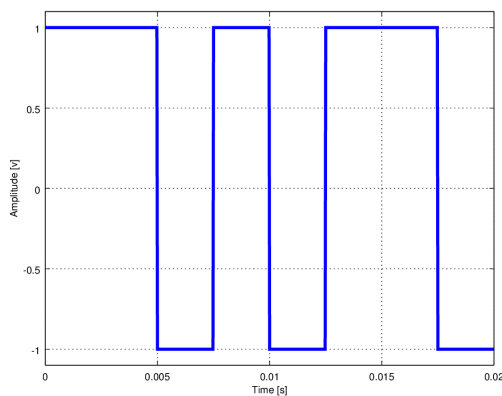
Data =  
 Signal element duration =  
 Data rate =

(a)



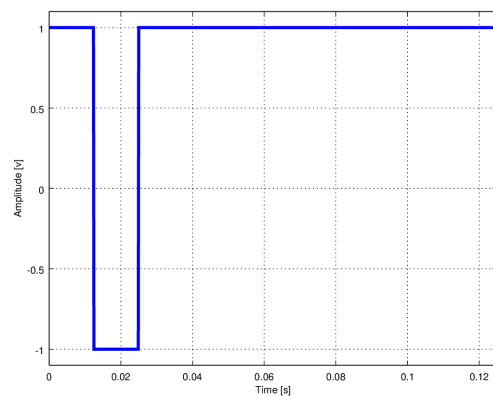
Data = 11010001  
 Signal element duration =  
 Data rate = 20 b/s

(b)



Data =  
 Signal element duration =  
 Data rate =

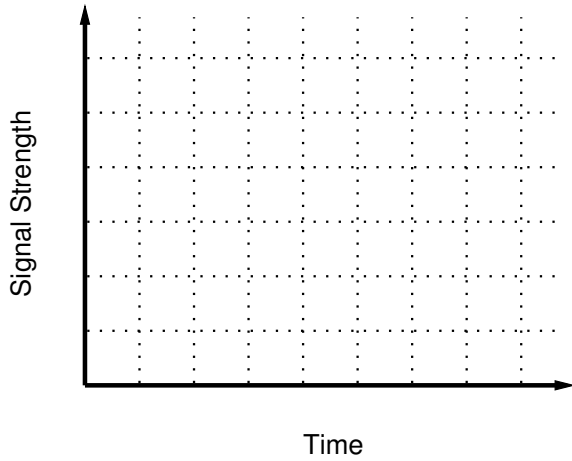
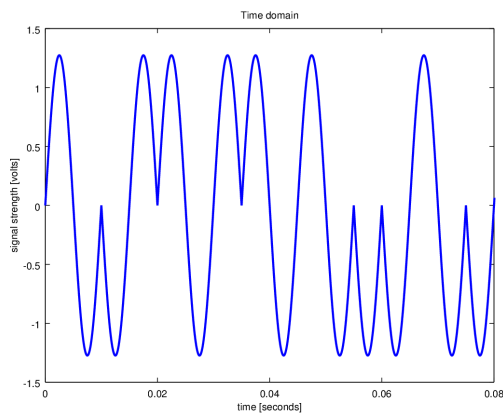
(c)



Data =  
 Signal element duration =  
 Data rate =

(d)

Figure 1: Digital data with digital signals

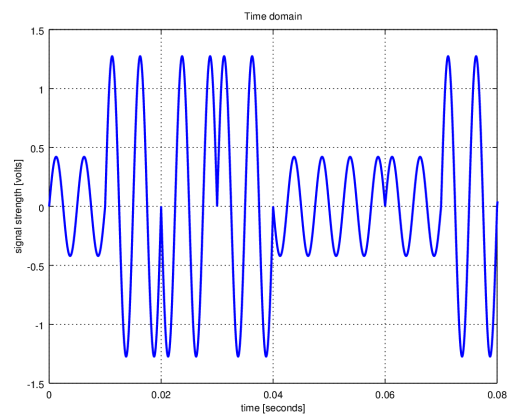
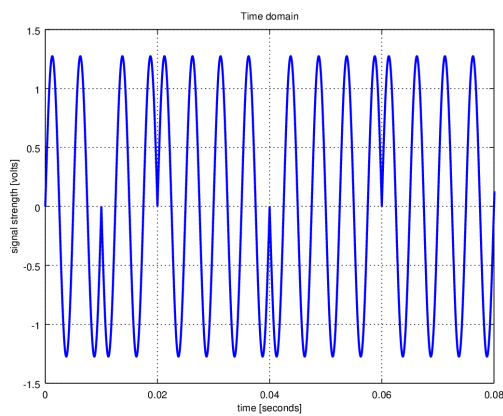


Data =  
 Frequency =  
 Signal element duration =  
 Data rate =

Data = 0010  
 Frequency =  
 Signal element duration = 0.025 s  
 Data rate =

(a)

(b)



Data =  
 Frequency =  
 Signal element duration = 0.01 s  
 Data rate =

Data =  
 Frequency =  
 Signal element duration = 0.01 s  
 Data rate =

(c)

(d)

Figure 2: Digital data with analog signals

## 2 Signals in Time and Frequency Domain

Write the equation for each signal, then determine the fundamental frequency and bandwidth and plot the signal in the frequency domain.

$$s_{1a}(t) =$$

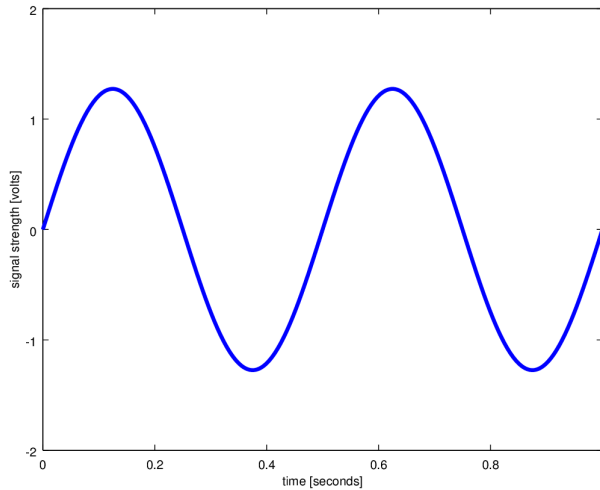


Figure 3: Signal  $s_{1a}$  in time domain

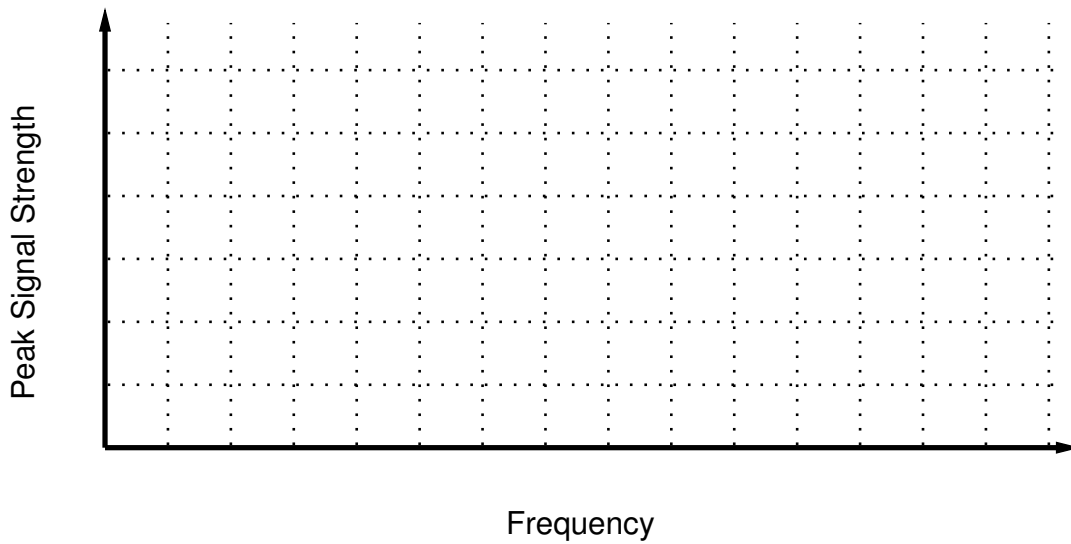
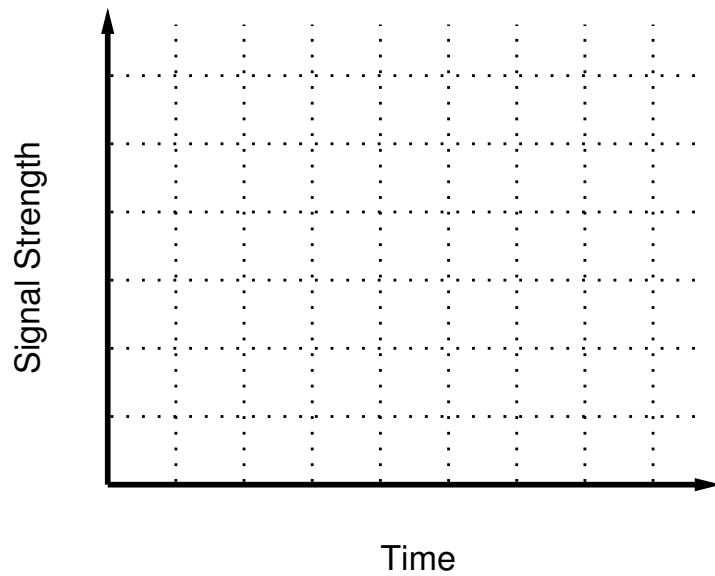
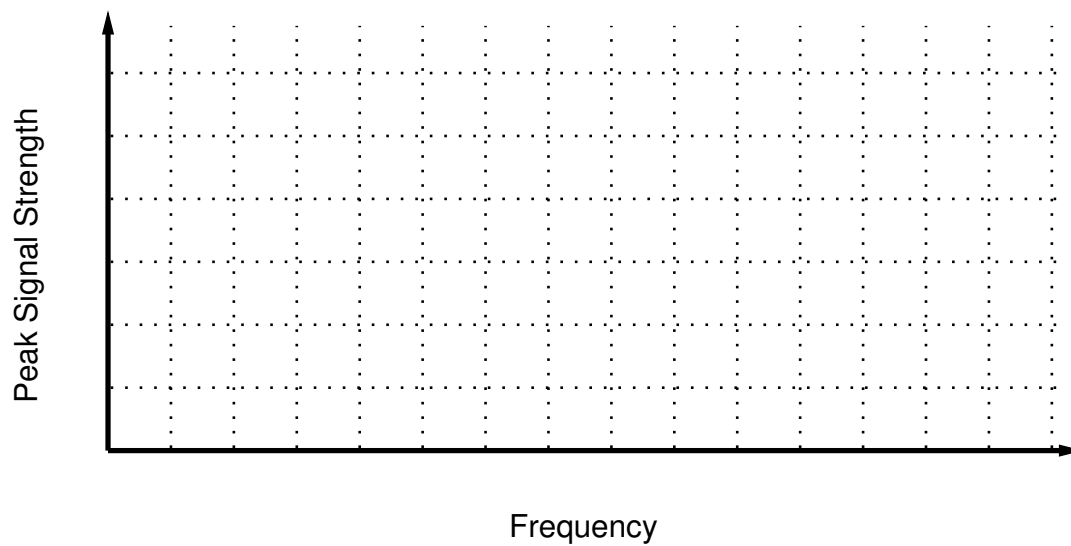


Figure 4: Signal  $s_{1a}$  in frequency domain

$$s_{1b}(t) = \frac{4}{\pi} \left[ \frac{1}{3} \sin(12\pi t) \right]$$

Figure 5: Signal  $s_{1b}$  in time domainFigure 6: Signal  $s_{1b}$  in frequency domain

$$s_2(t) =$$

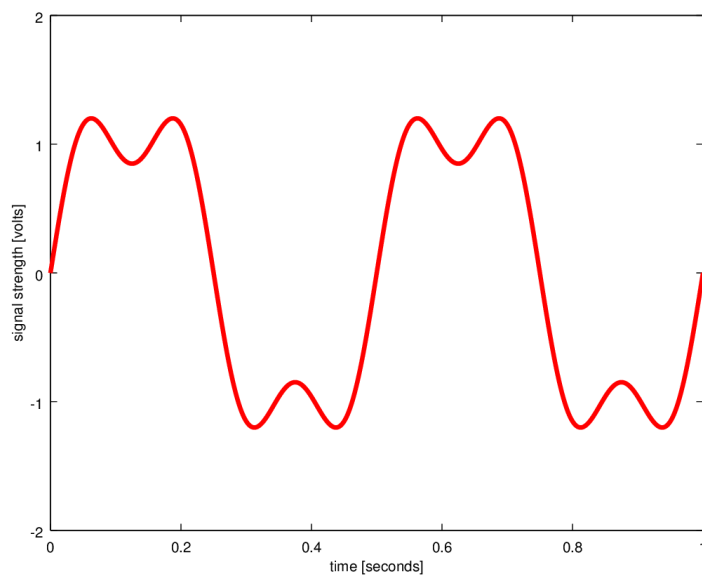


Figure 7: Signal  $s_2$  in time domain

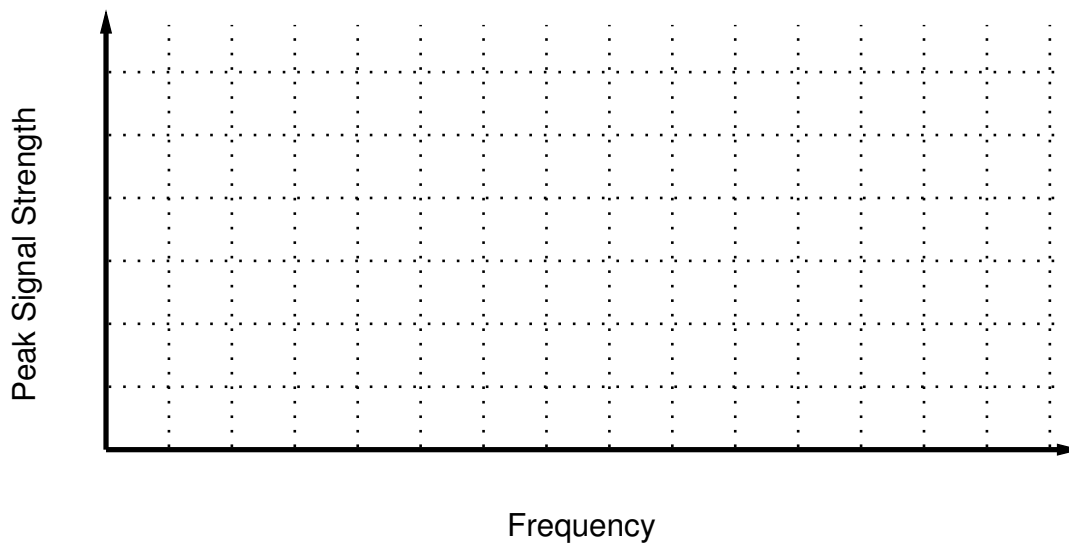


Figure 8: Signal  $s_2$  in frequency domain

$$s_3(t) =$$

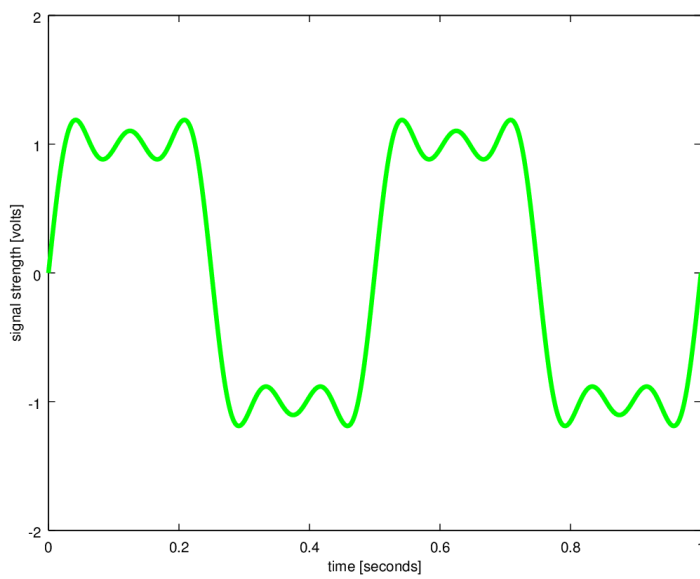


Figure 9: Signal  $s_3$  in time domain

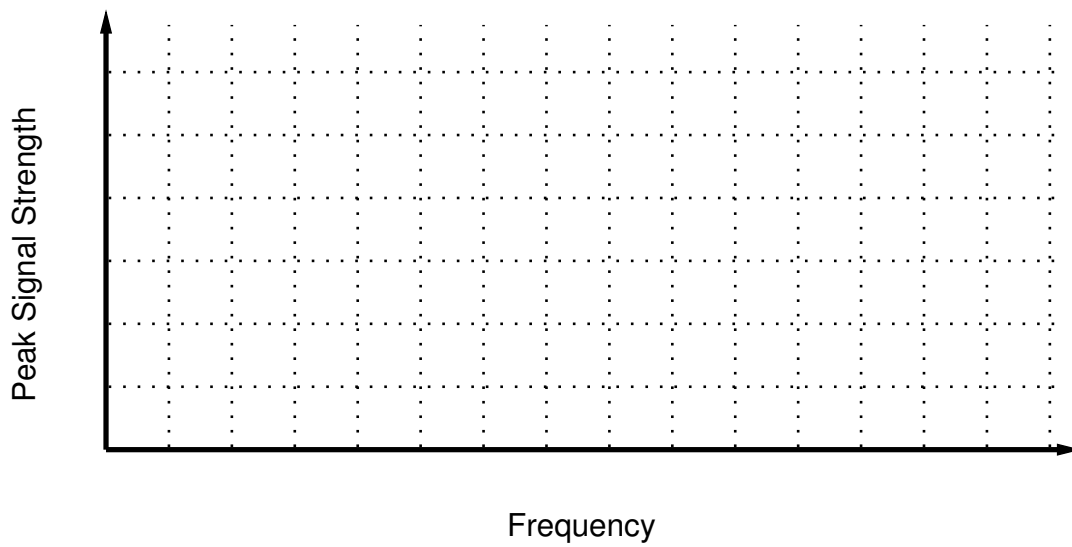


Figure 10: Signal  $s_3$  in frequency domain

$$s_4(t) =$$

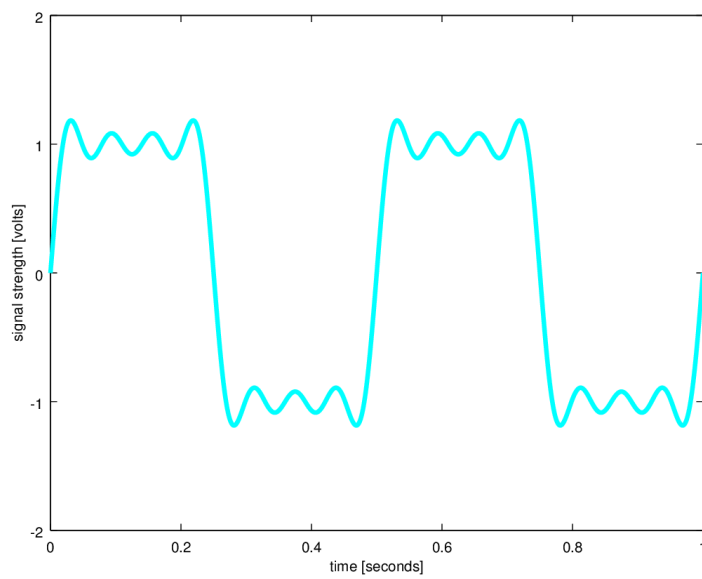


Figure 11: Signal  $s_4$  in time domain

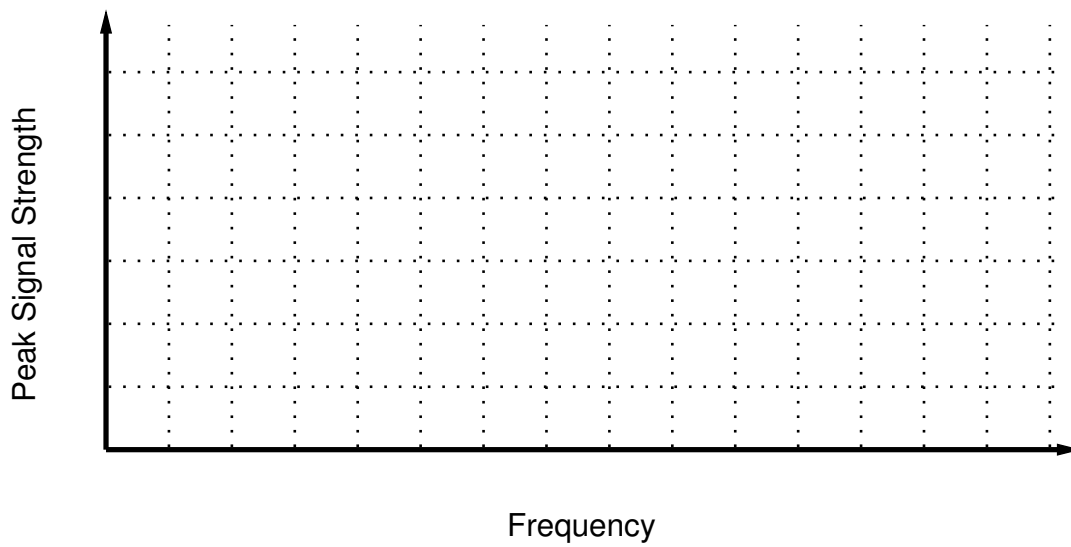


Figure 12: Signal  $s_4$  in frequency domain

$$s_{30}(t) =$$

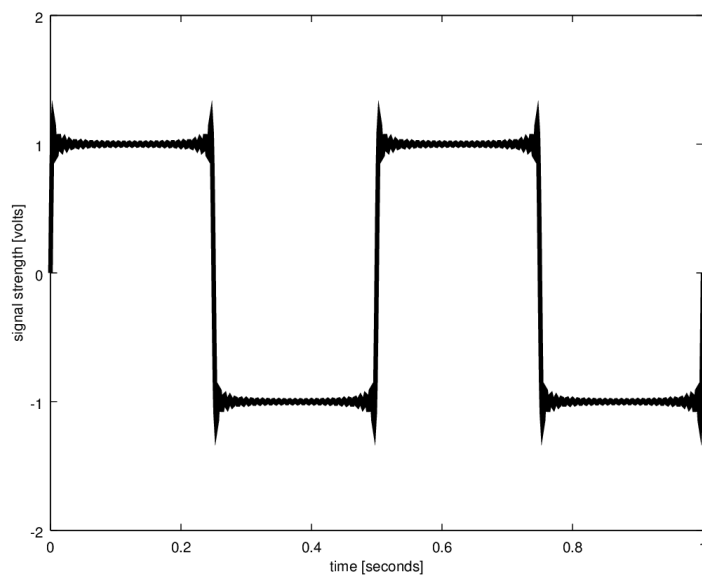


Figure 13: Signal  $s_{30}$  in time domain

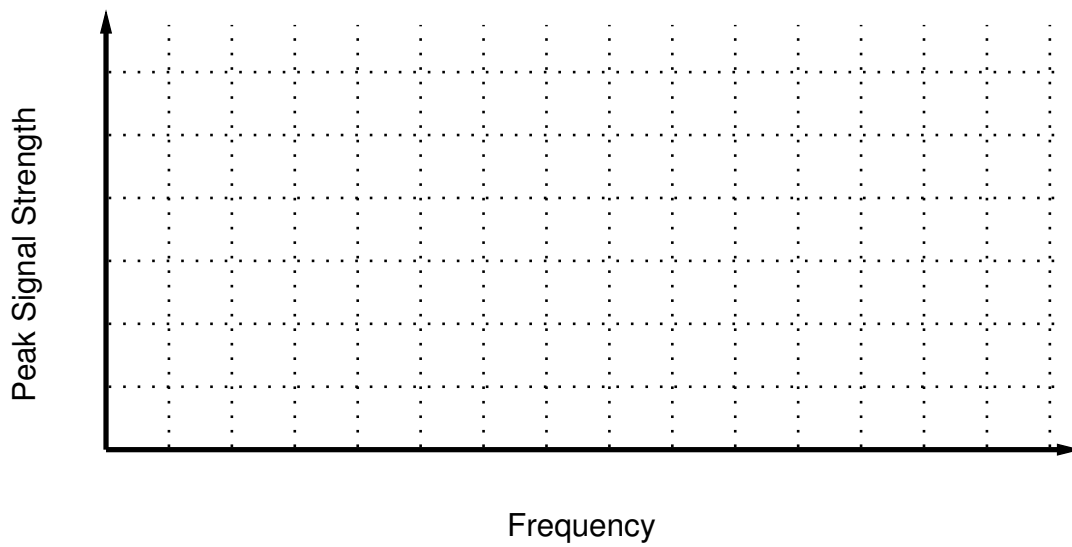


Figure 14: Signal  $s_{30}$  in frequency domain



### 3 Bandwidth Limited Signals

Transmitting a signal with bandwidth larger than  $B$  through a medium that is bandwidth limited to  $B$  (as shown in Figure 15) will result in the received signal being different from the transmitted signal (ignoring other impairments such as attenuation and noise). The challenge for the communications system designer is to ensure the receiver can still accurately interpret the received data.

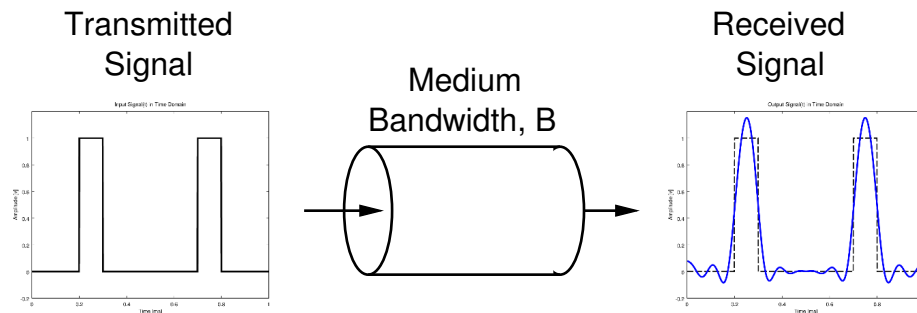


Figure 15: Transmitting a signal through bandwidth limited medium

Figure 16 shows an example signal to be transmitted. It is a digital signal containing 10 bits, sending at a rate of 1000 bit per second. The bandwidth of a digital signal is in theory infinite. The frequency domain plot shows the signal components only up until 100 kHz (the plot doesn't show precise impulses because of the way the software calculates them).

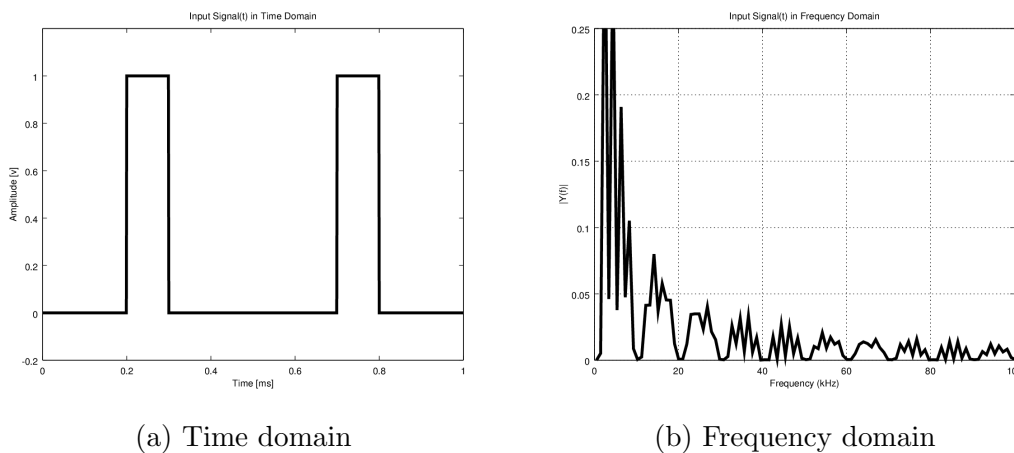


Figure 16: Transmitted signal

Now consider transmitting the above signal through a medium with bandwidth  $B$ . The next page illustrates the received signal (in time and frequency domain) for different values of  $B$ : 4, 8, 12, 16 and 20 kHz. The point to notice: the larger the medium bandwidth, the more accurate the received signal represents the transmitted signal (and hence the less chance errors will occur at the receiver, especially in the presence of noise).

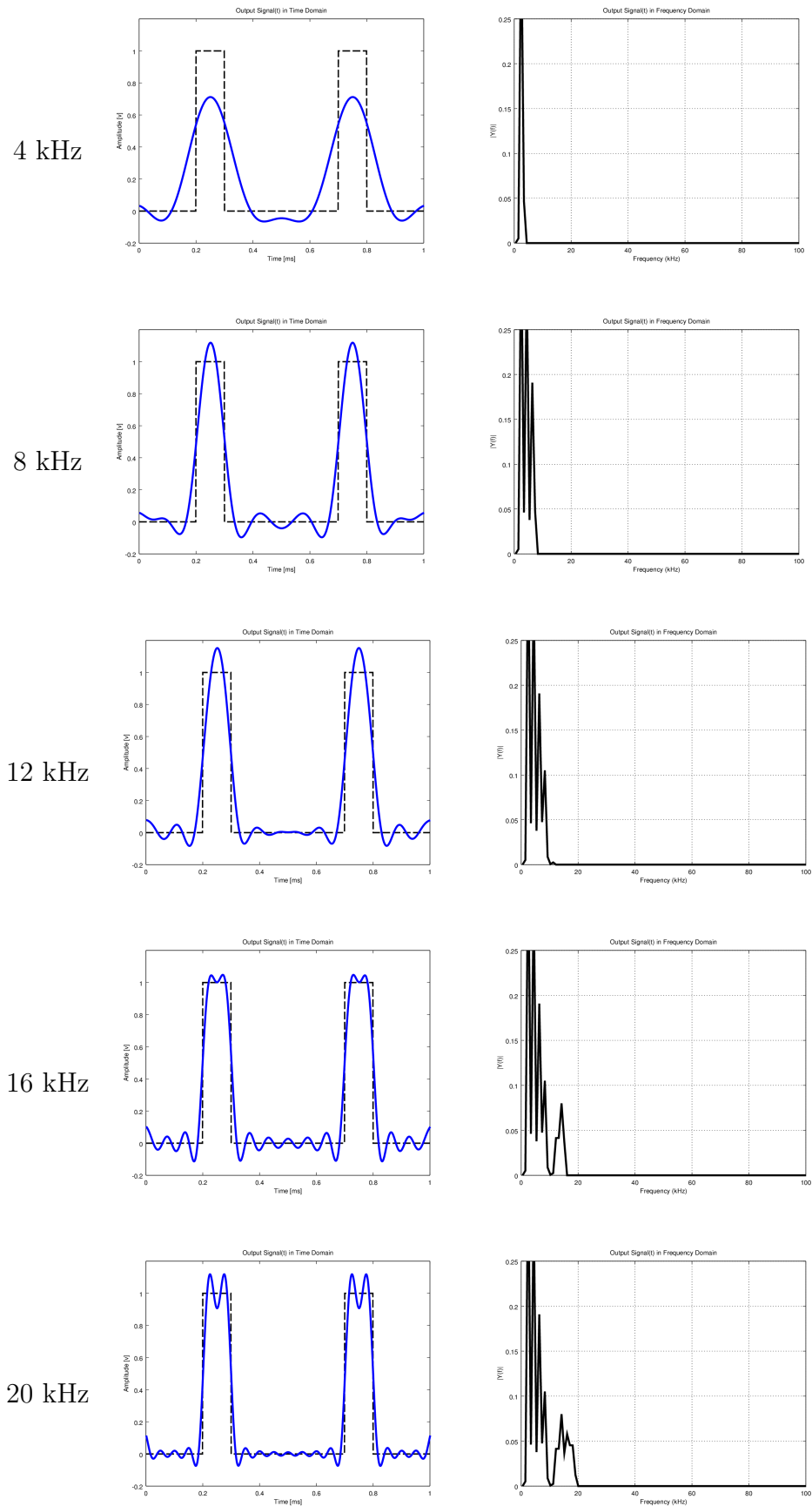


Figure 17: Received signal for different bandwidth limits