به نام خدا

دانشگاه تهران
دانشکده مهندسی برق و کامپیوتر

اصول سیستم های مخابراتی

تمرین کامپیوتری دوم

نام و نام خانوادگی	سیاوش شمس
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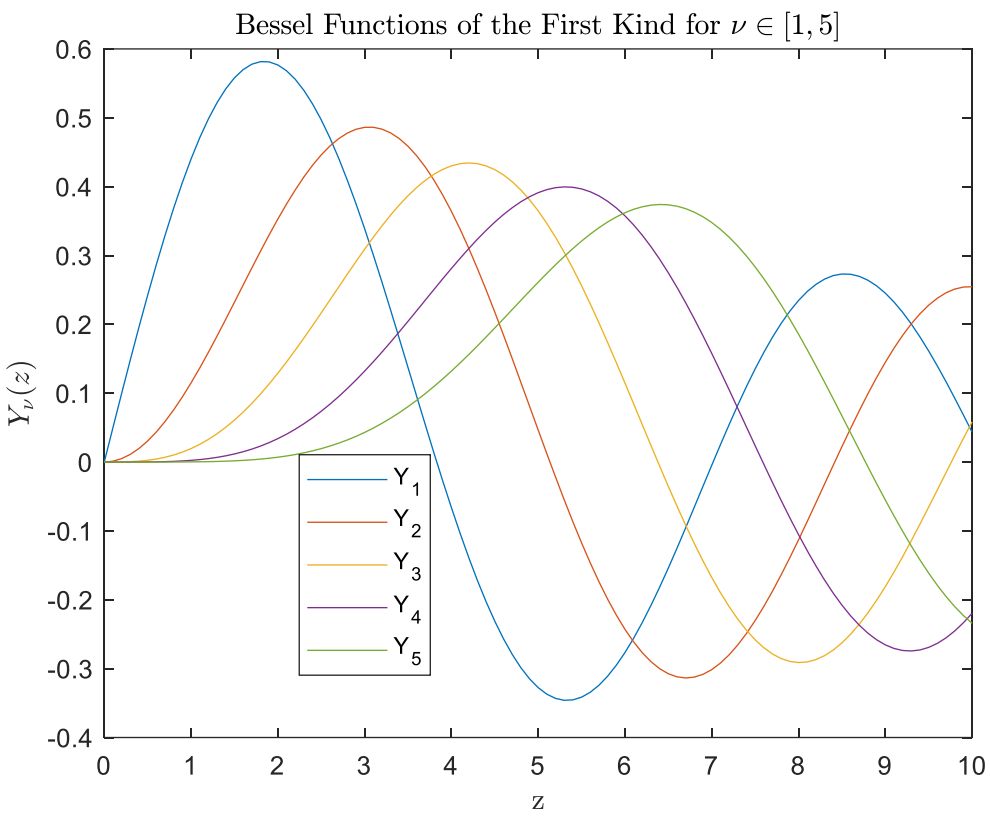
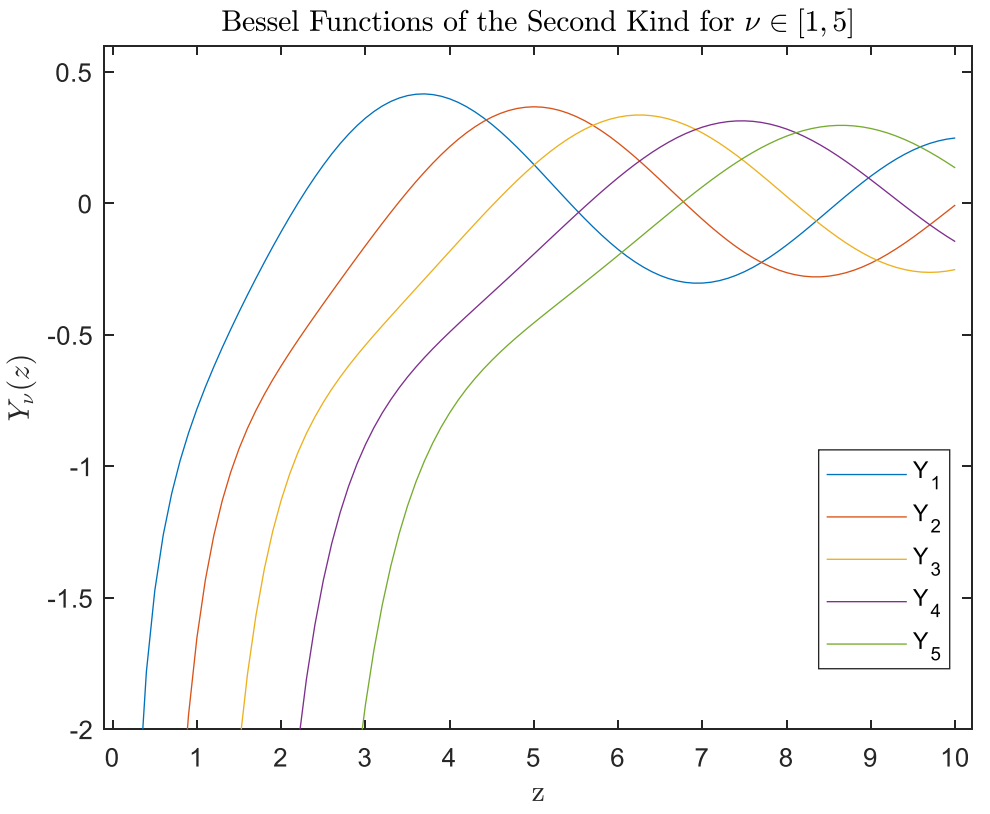
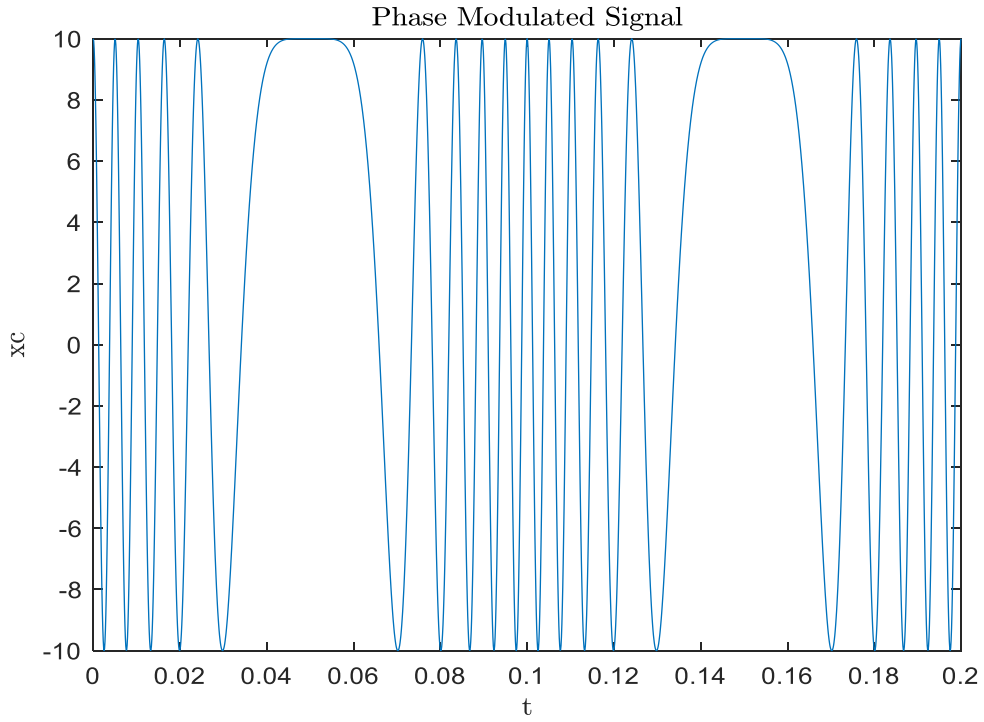
فهرست گزارش سوالات

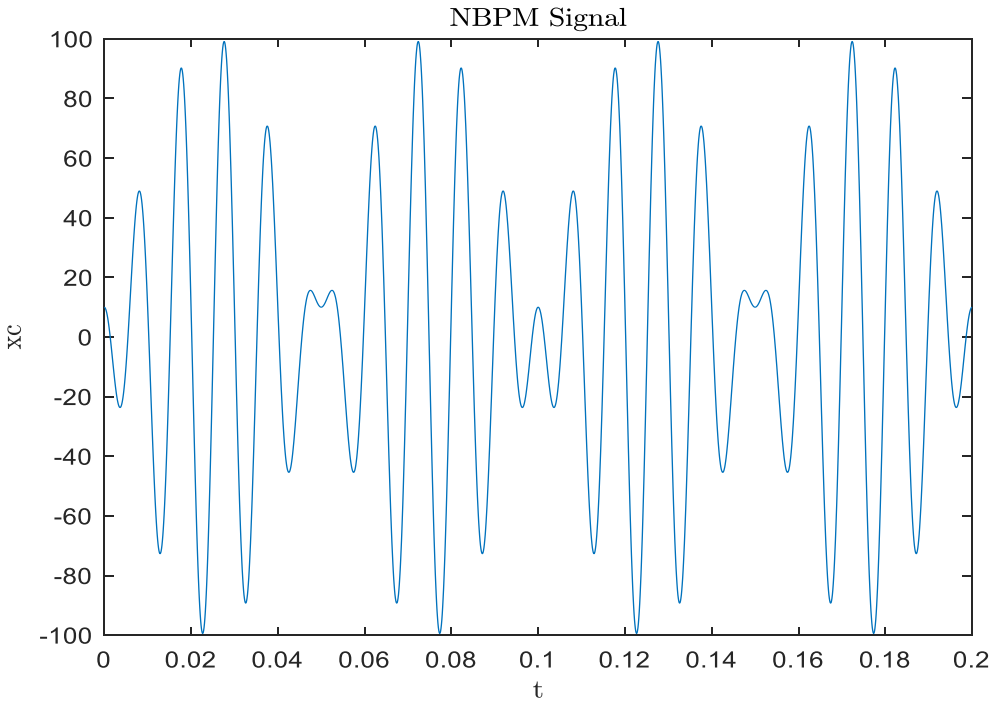
سوال ۱-Bessel functions



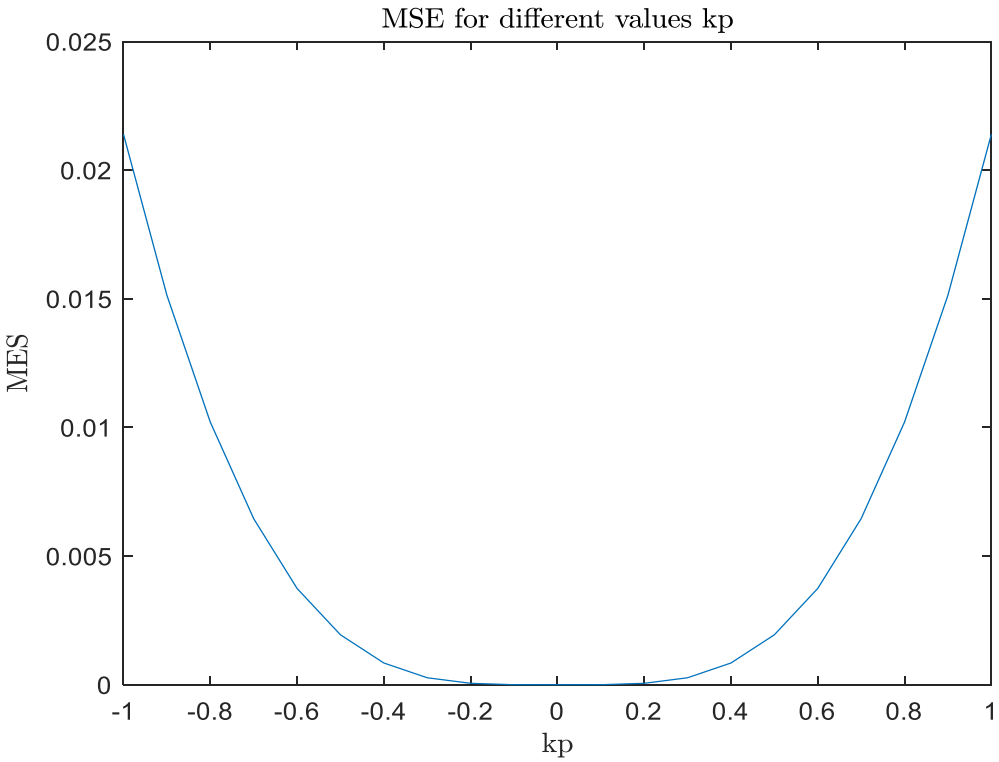


Narrow Band Modulation-۲ سوال



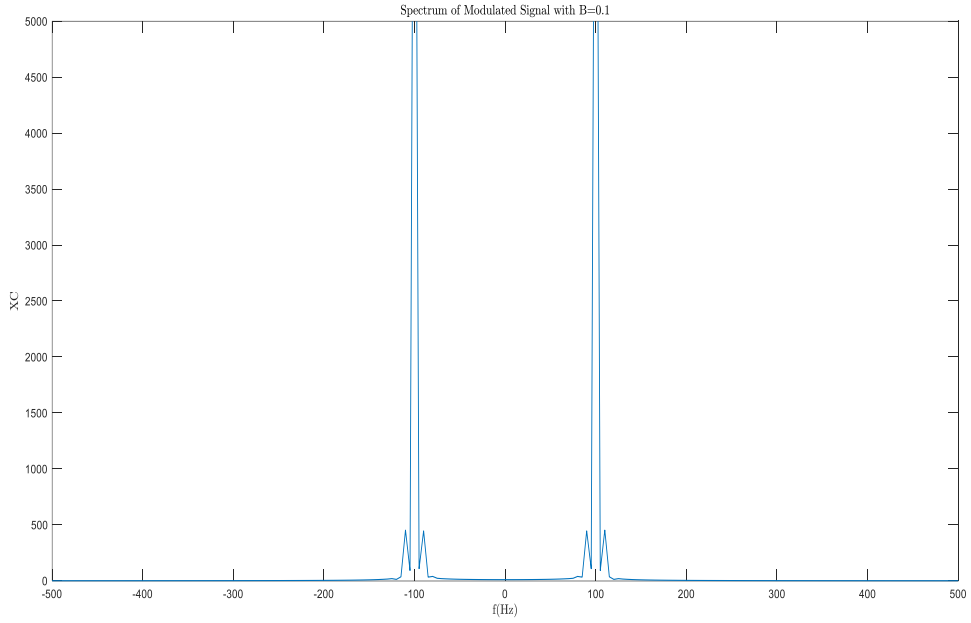


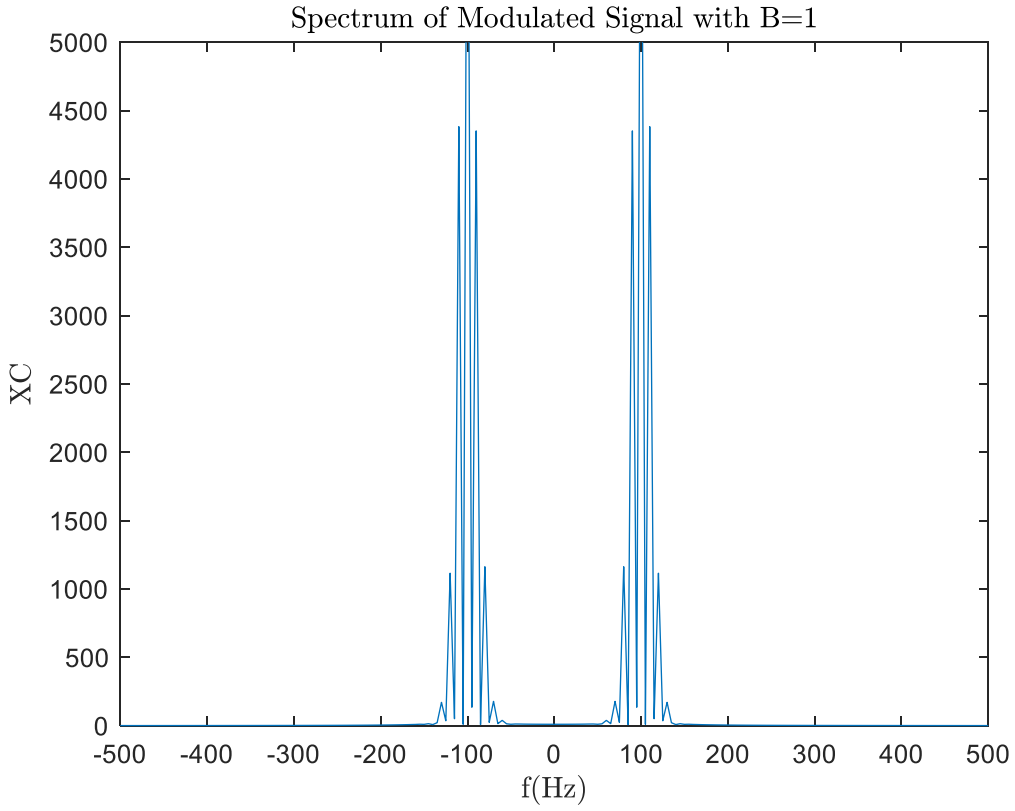
The reason that NBPM is different from Phase modulated signal is that we used approximation (first terms of Taylor's series) for calculating the NBPM though $|\varphi(t)|$ is not less than 1.

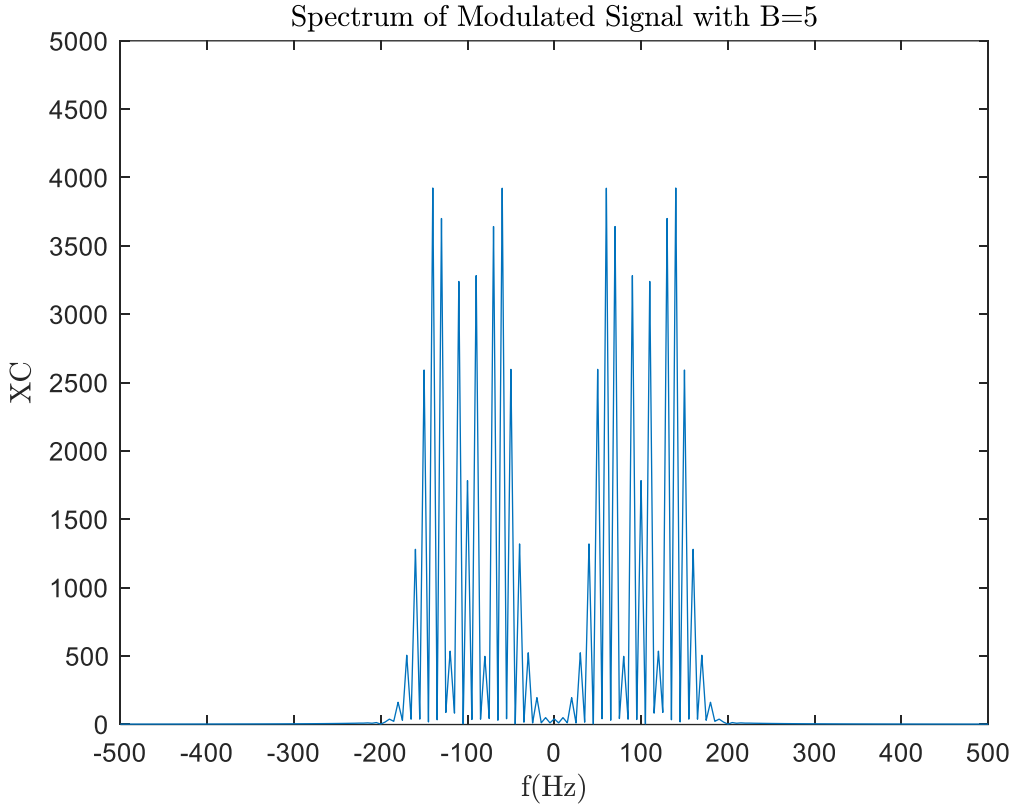


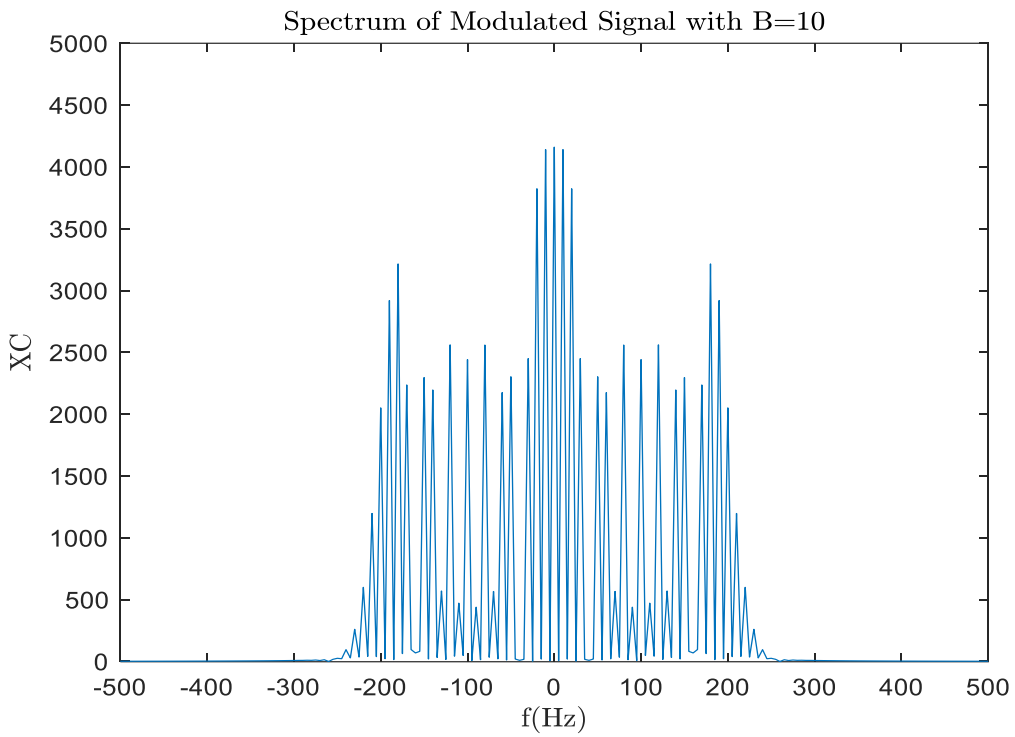
maximum value of kp for having less than 1% error is 0.7

سوال ۳- Single Tone Modulation




Spectrum of Modulated Signal with B=1
XC
f(Hz)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
-500
-400
-300
-200
-100
0
100
200
300
400
500


Spectrum of Modulated Signal with B=5
XC
f(Hz)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
-500
-400
-300
-200
-100
0
100
200
300
400
500



As we see in the above graphs, as β increases the bandwidth also increases, its due to increament of $|\varphi(t)|$, so the spectrum of the modulated signal changes in that way.

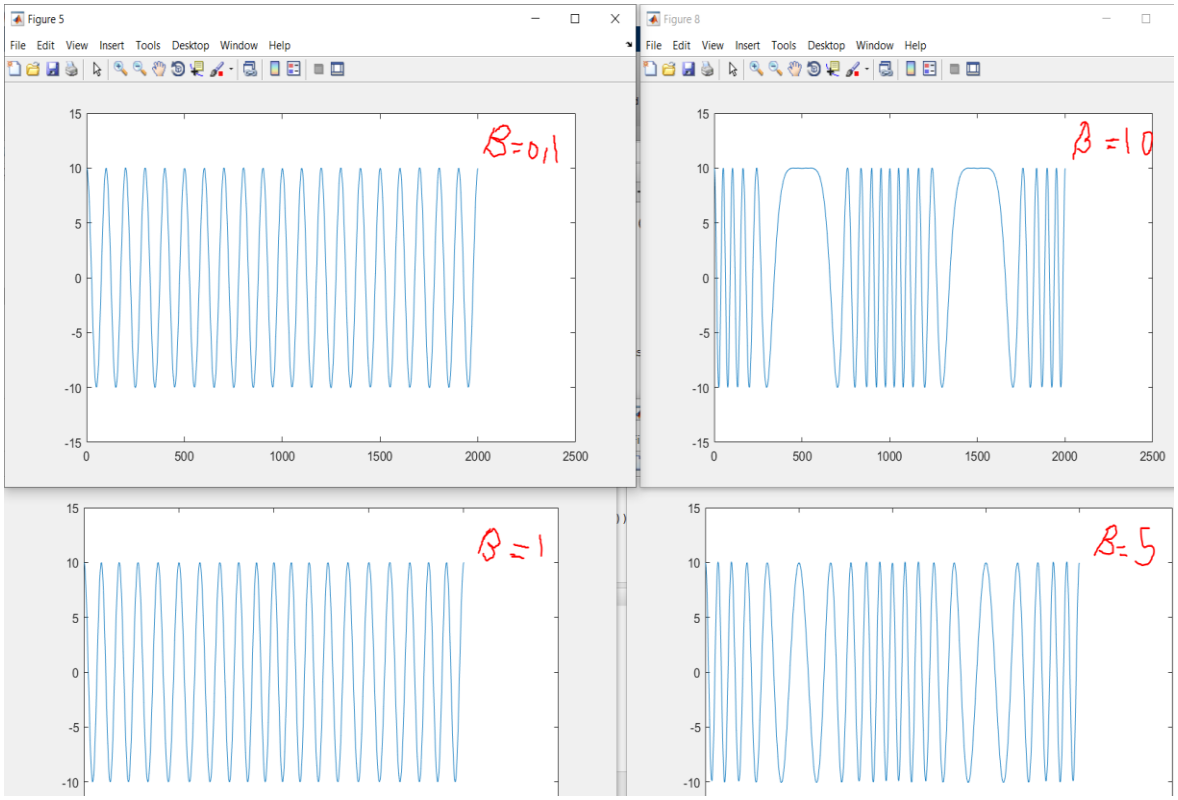
For $\beta = 0.1$ approximate bandwidth is $2(0.1+1)10 = 22\ Hz \rightarrow n = 1.1 \rightarrow N = 2$

For $\beta = 1$ approximate bandwidth is $2(1+1)10 = 40\ Hz \rightarrow n = 2 \rightarrow N = 2$

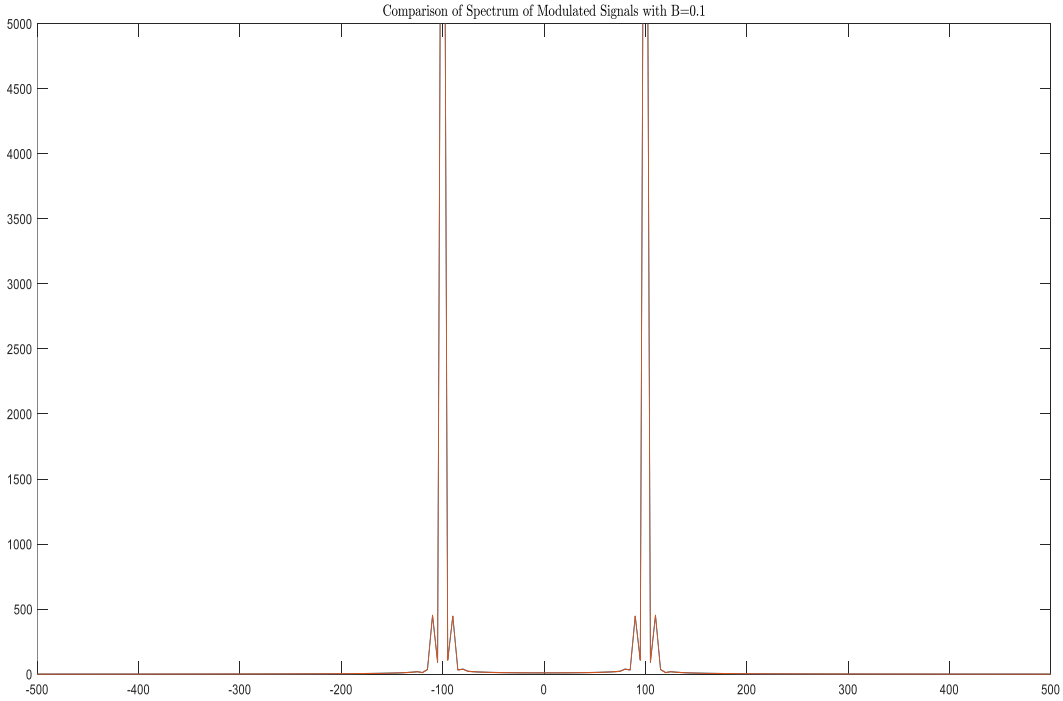
For $\beta = 5$ approximate bandwidth is $2(5+1)10 = 120\ Hz \rightarrow n = 6 \rightarrow N = 6$

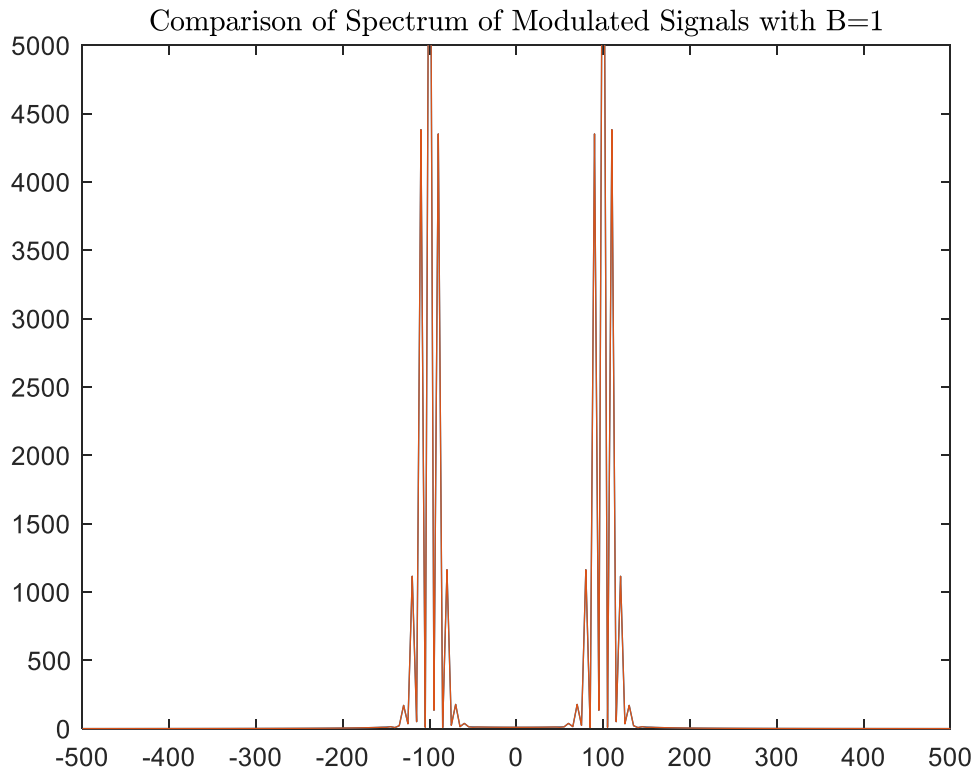
For $\beta = 10$ approximate bandwidth is $2(10+1)10 = 220\ Hz \rightarrow n = 11 \rightarrow N = 11$

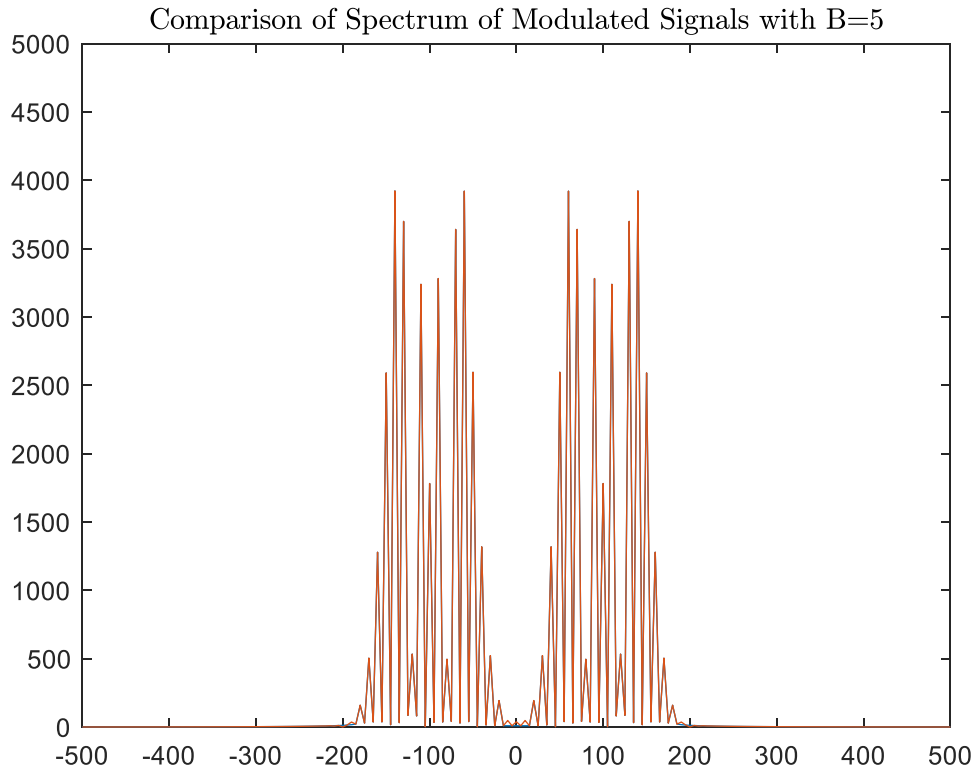
These are the calculated N's for using bessel function for modulation, but we use a value higher than these calculated N's for our simulations to have more accurate and better results.

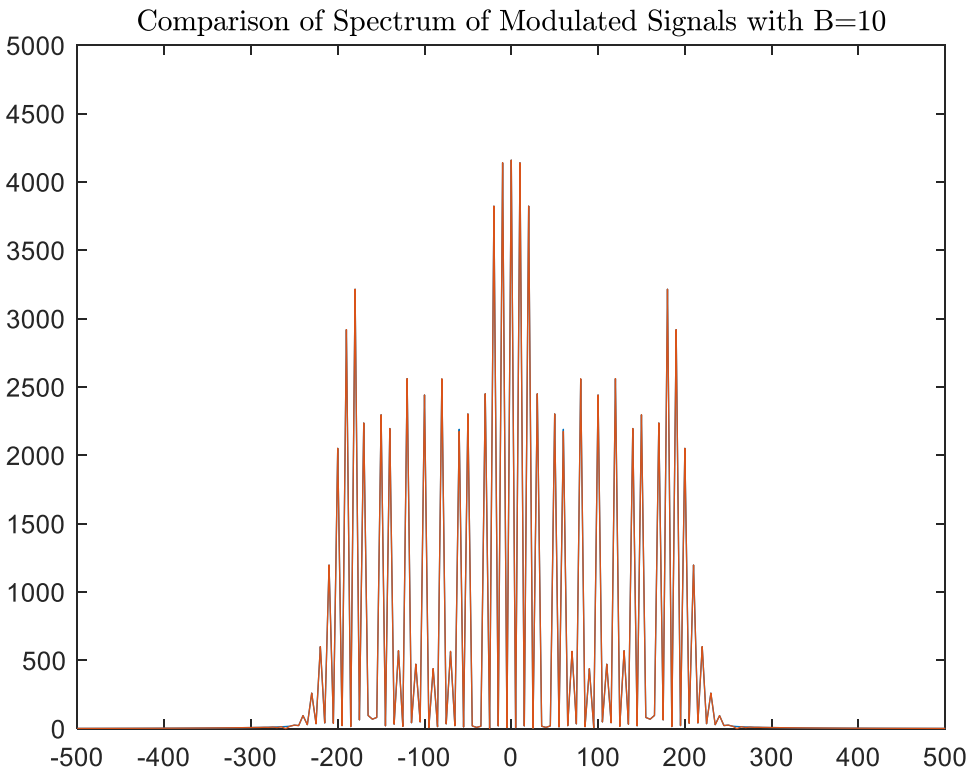


Modulated signals using Bessel's function for different values of β

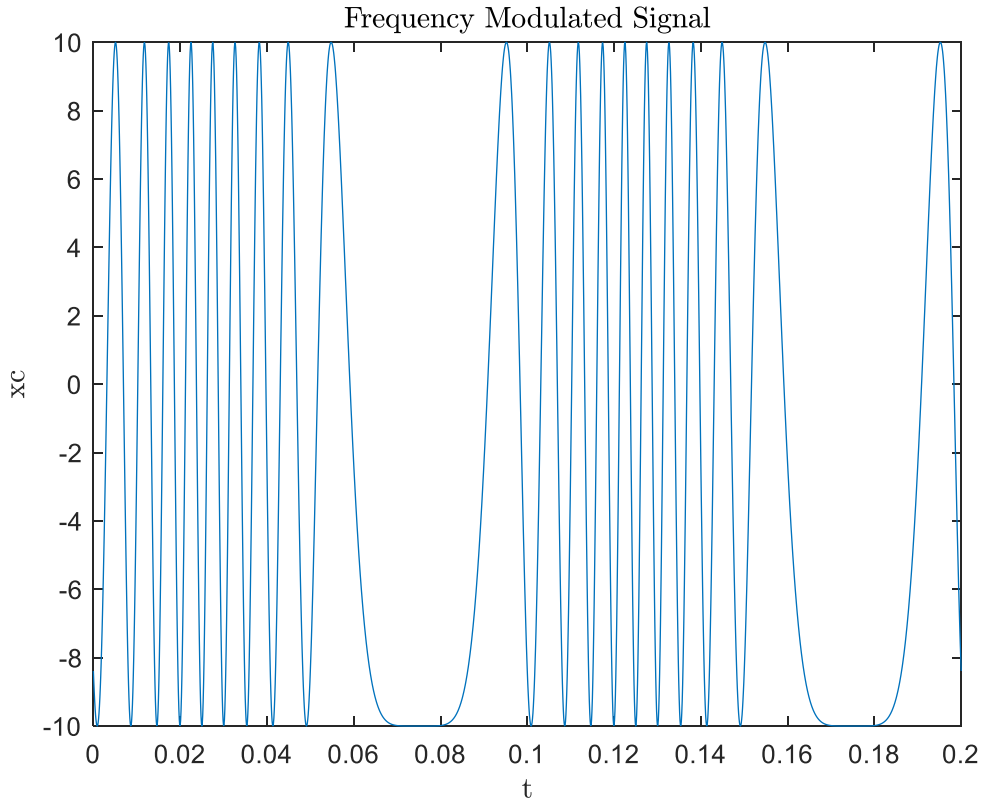



Comparison of Spectrum of Modulated Signals with B=1
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
-500
-400
-300
-200
-100
0
100
200
300
400
500


Comparison of Spectrum of Modulated Signals with B=5
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
-500
-400
-300
-200
-100
0
100
200
300
400
500


Comparison of Spectrum of Modulated Signals with B=10
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
-500
-400
-300
-200
-100
0
100
200
300
400
500

سوال ۴- FM using PM



$$\beta = \frac{kf}{fm} \rightarrow kf = 100$$

Comparing output of FM modulation and PM modulation we realize that FM modulated signal has $\frac{\pi}{2}$ phase shift and a minus sign.

Armstrong Indirect Method -۵ سوال

If we use several multipliers instead of one we will need a crystal oscillator with much less frequency so it will be cheaper. For example we want to multiply frequency by 3072 with fc=200Khz, if we use one multiplier we will need a crystal oscillator with 500 MHz frequency to put it on 100MHz but if we use two multipliers with value of 64 and 48 we will achieve this goal with only a 10.8MHz crystal oscillator.

Frequency multiplier is a non-linear device combined with BPF

Output of non-linear circuit is $y(x) = a_0 + a_1x + a_2x^2 + a_3x^3 + \cdots$

And if we choose $x = \cos(\omega t)$ the output will be

$y(x) = a_0 + a_1\cos(\omega t) + a_2\cos^2(\omega t) + a_3\cos^3(\omega t) + \cdots$

We know that: $\cos^2(\omega t) = (1 - \cos(2\omega t))$ & $\cos^3(\omega t) = \frac{1}{4}(\cos(\omega t) + \cos(3\omega t))$ & …

So we can write $y = b_0 + b_1\cos(\omega t) + b_2\cos(2\omega t) + b_3\cos(3\omega t) + \cdots$

So we can choose what multiple of the frequency of the input signal we want and then pass It through the BPF.

Frequency converter: These devices usually consist of a rectifier stage (producing direct current) which is then inverted to produce AC of the desired frequency. The inverter may use thyristors, IGCTs or IGBTs.