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Project Report: Digital Communication Lab (EC383)

Frequency Modulation in MATLAB GUI

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MATLAB GUI based Frequency Modulation

Frequency Modulation Basics

Frequency modulation (**FM**) is the encoding of information in a carrier wave by varying the instantaneous frequency of the wave. In analog signal applications, the difference between the instantaneous and the base frequency of the carrier is directly proportional to the instantaneous value of the input-signal amplitude.

If the message signal is given by the equation

$$x(t) = V_m \cos(2\pi f_m t) \quad \text{...(1.1)}$$

& the carrier signal by the equation

$$c(t) = V_c \cos(2\pi f_c t) \quad \text{...(1.2)}$$

Then, the Frequency Modulated signal is given by

$$S_{FM}(t) = V_c \cos\left(2\pi f_c t + K_f \int_0^t \mathrm{V_m} \cos(2\pi f_m t)\, dt\right) \quad \text{...(1.3)}$$

$$S_{FM}(t) = V_c \cos\left(2\pi f_c t + \beta \int_0^t \cos(2\pi f_m t)\, dt\right) \quad \text{...(1.4)}$$

Where K_f is modulation sensitivity, and β is the modulation index.

And, the two are related as

$$\beta = \frac{V_m K_f}{2\pi f_m}$$

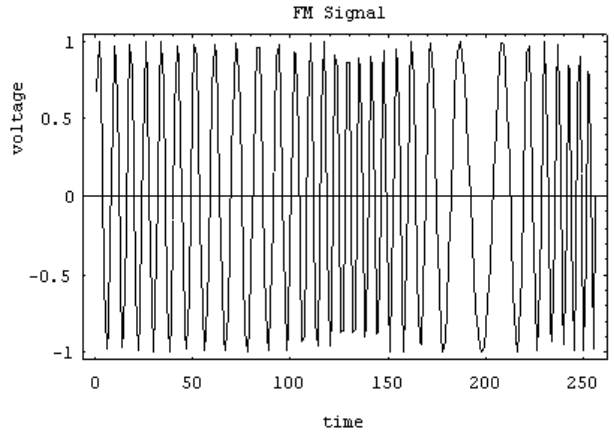


Fig. General FM output

Frequency Modulation Types

Depending on β, FM is of two types :-

1. Narrowband FM – The FM signals generated for small values of K_f are known as narrowband FM. They are known as narrowband as their bandwidth is small. They are generated using equations (1.3) & (1.4).

2. Wideband FM – The FM signals generated for high values of K_f are known as wideband FM. Their bandwidth is quite large & in their frequency spectrum large no. of sidebands are produced. They are generated using the following equation

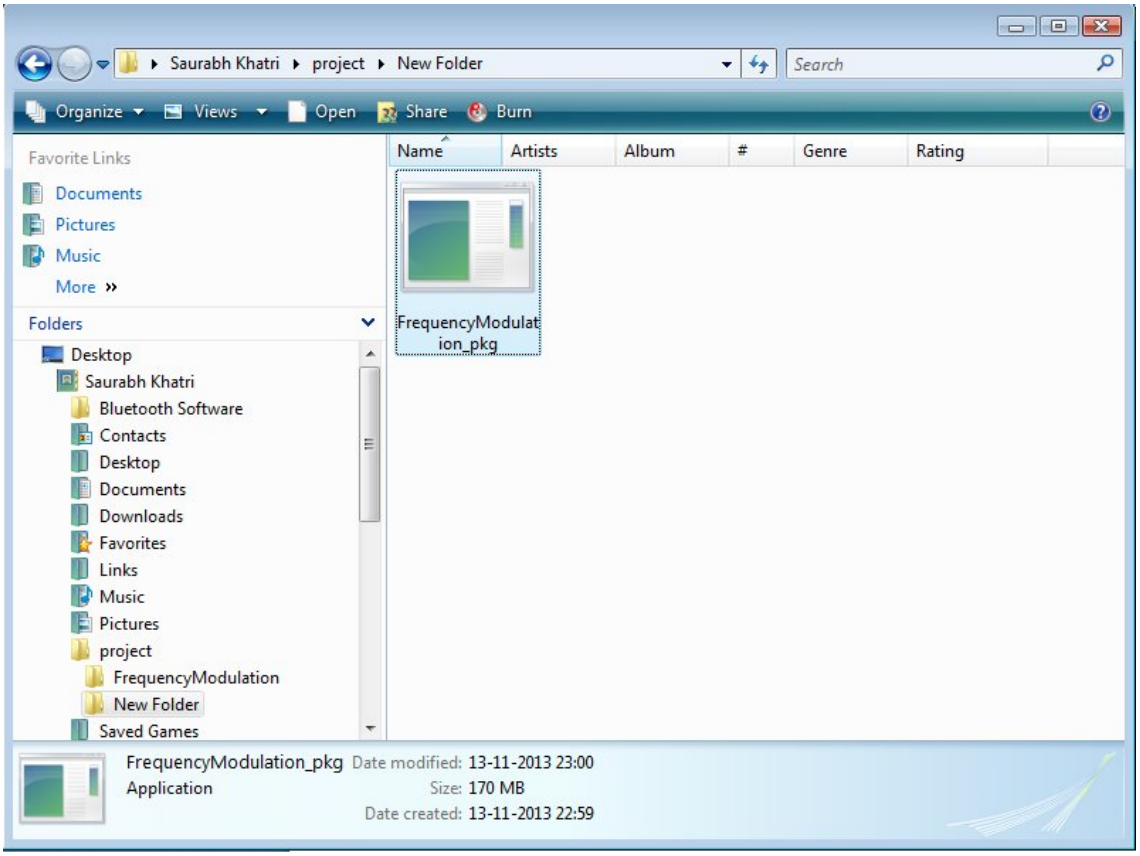
$$s(t) = V_c \sum_{n=-inf}^{inf} J_n(\beta)\cos((\omega_c + n\omega_c)t) \quad \text{...(1.5)}$$

Where J_n is the n^{th} order Bessel function

Getting started

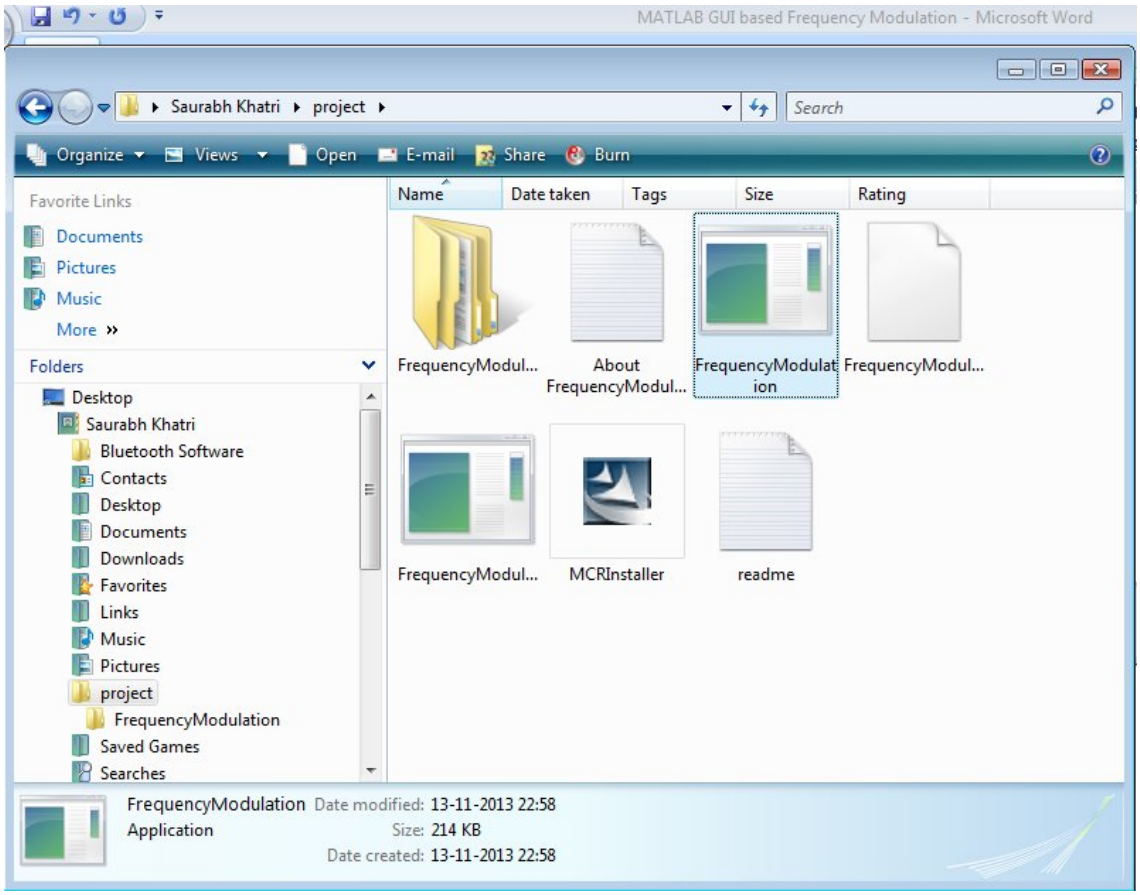
For first time users

1. Double-click on the **FrequencyModulation_pkg** file to open it.
2. Install the **MATLAB Runtime Compiler**, if it is not installed.
3. Double-click on the **FrequencyModulation.exe** start the software.



For users with MCR installed & package executed

Double-click on the **FrequencyModulation.exe** start the software.



Getting familiar with the interface

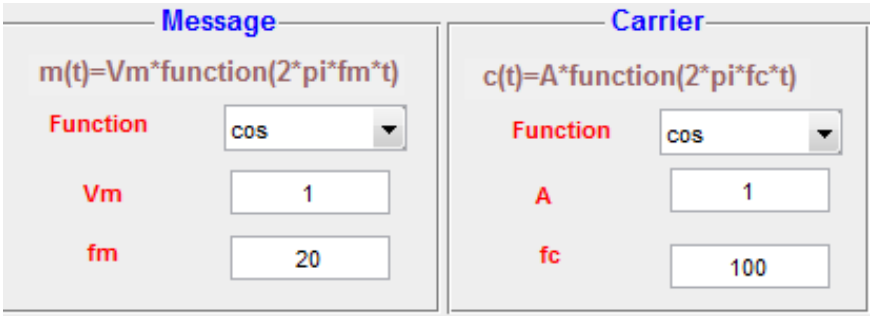


Fig. Message & Carrier panels

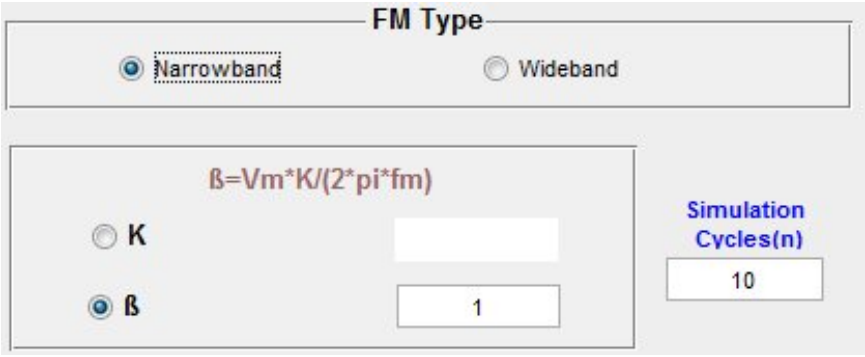


Fig. FM type panel, K-β panel & Simulation Cycles edit box

Fig. Analysis panel, Generate button & output signal equation

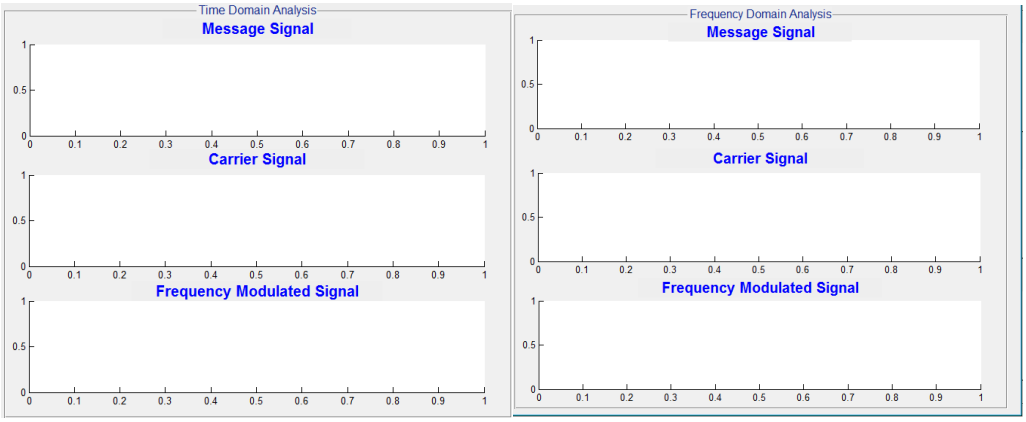


Fig. Time Domain & Frequency Domain analysis panels, changed using Analysis radio buttons

Fig. Data Cursor, Zoom Out & Zoom In buttons

Working with the software

Experiment 1

Observing the Narrowband FM waveform & its frequency spectrum

1. Set the parameters like function, amplitude & frequency for the Message signal using the respective dropdown menu & the text boxes in the **Message** panel.
2. Set the parameters like function, amplitude & frequency for the carrier signal using the respective dropdown menu & the text boxes in the **Carrier** panel.
3. Select **Narrowband** radio button in the **FM Type** panel.
4. If the effect of K_f is to be observed, select **K** radio button in the panel & type the value in the corresponding edit box.
   OR
5. If the effect of β is to be observed, select **β** radio button in the panel & type the value in the corresponding edit box.
6. Set the no. of cycles to be observed in the **Simulation Cycles** edit box.
7. Click on **Generate** button. All the plots will be generated in some time.
8. Select **Time Domain** radio button in the **Analysis** panel to observe the time domain waveform.

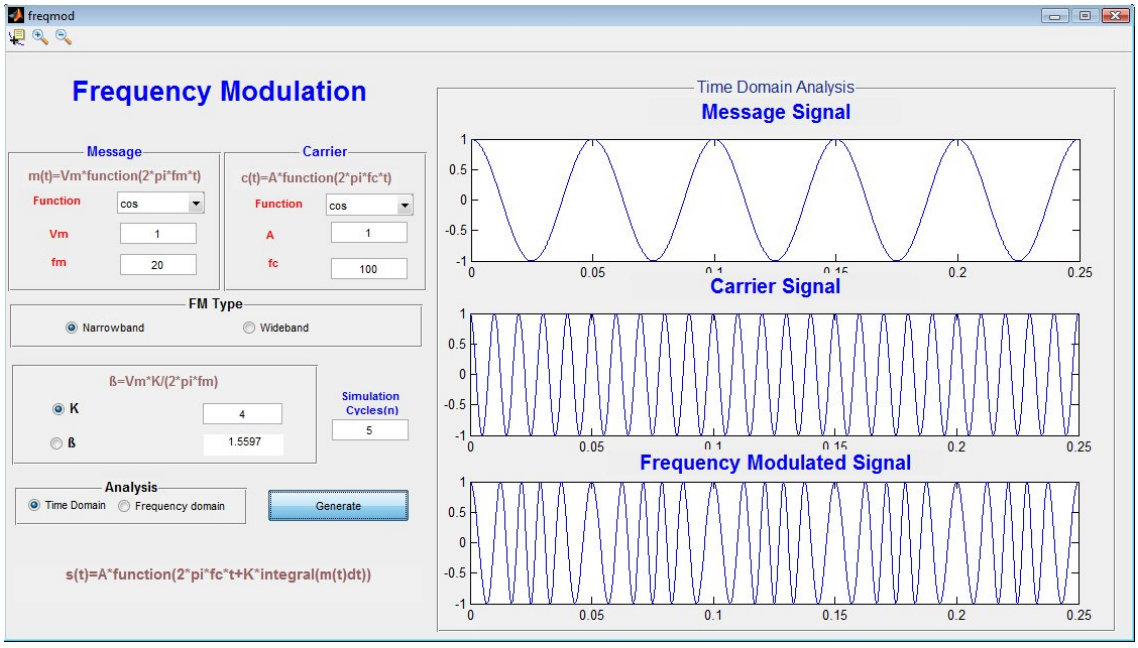


Fig. Time Domain Analysis plot

9. Select **Frequency Domain** radio button in the **Analysis** panel to observe the frequency spectrum.

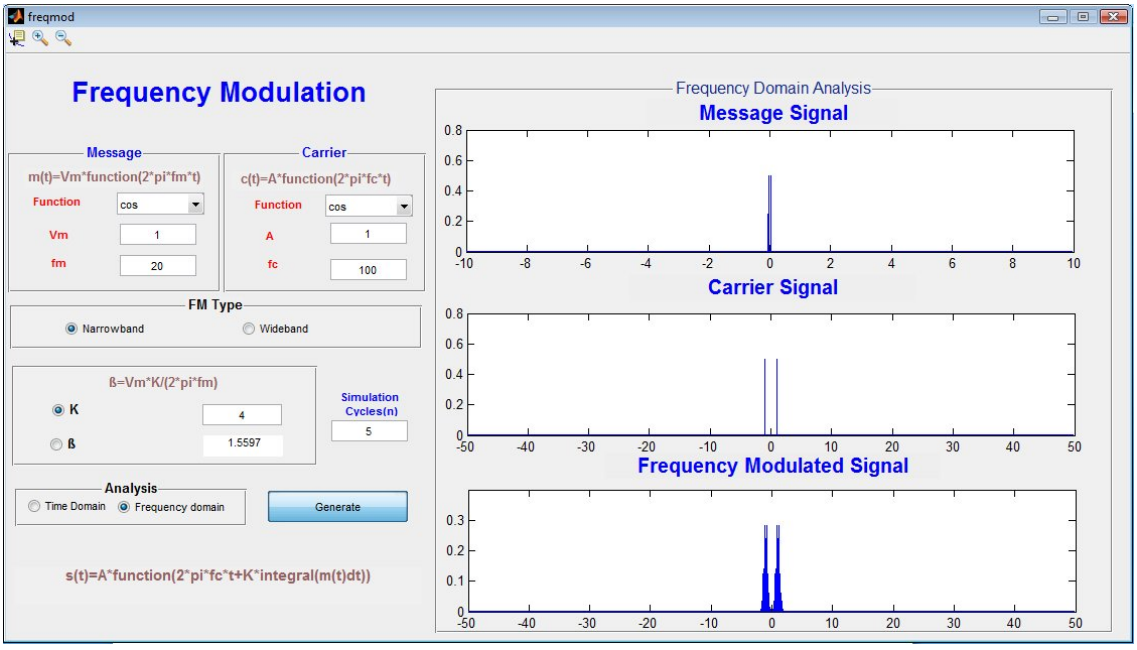


Fig. Frequency Spectrum plot

10. To calculate the bandwidth, use the data cursor. Click on one peak to get coordinates of one peak. To get the coordinates of second peak, **Alt+Click** on the second peak. The difference of X coordinates gives the bandwidth.

Fig. Data cursor

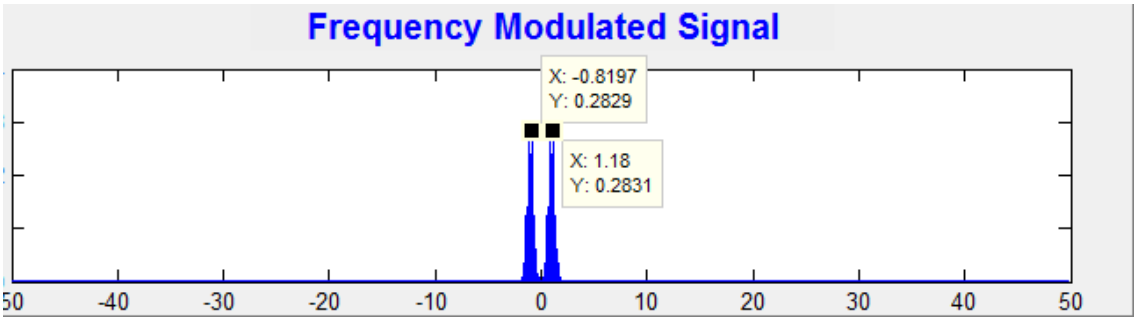


Fig. Markers for bandwidth calculation

Experiment 2

Observing the Wideband FM waveform & its frequency spectrum

1. Set the parameters like function, amplitude & frequency for the Message signal using the respective dropdown menu & the text boxes in the **Message** panel.
2. Set the parameters like function, amplitude & frequency for the carrier signal using the respective dropdown menu & the text boxes in the **Carrier** panel.
3. Select **Wideband** radio button in the **FM Type** panel.
4. If the effect of K_f is to be observed, select **K** radio button in the panel & type the value in the corresponding edit box.
   OR
5. If the effect of β is to be observed, select **β** radio button in the panel & type the value in the corresponding edit box.
6. Set the no. of cycles to be observed in the **Simulation Cycles** edit box.
7. Click on **Generate** button. All the plots will be generated in some time.
8. Select **Time Domain** radio button in the **Analysis** panel to observe the time domain waveform.

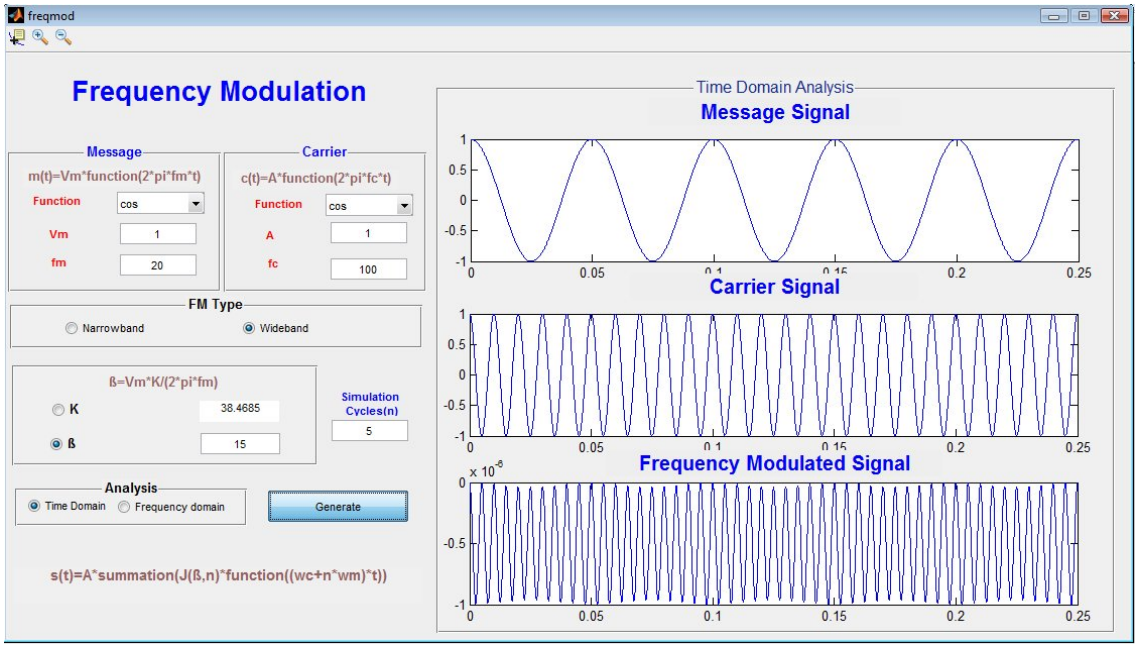


Fig. Time Domain Analysis plot

9. Select **Frequency Domain** radio button in the **Analysis** panel to observe the frequency spectrum.

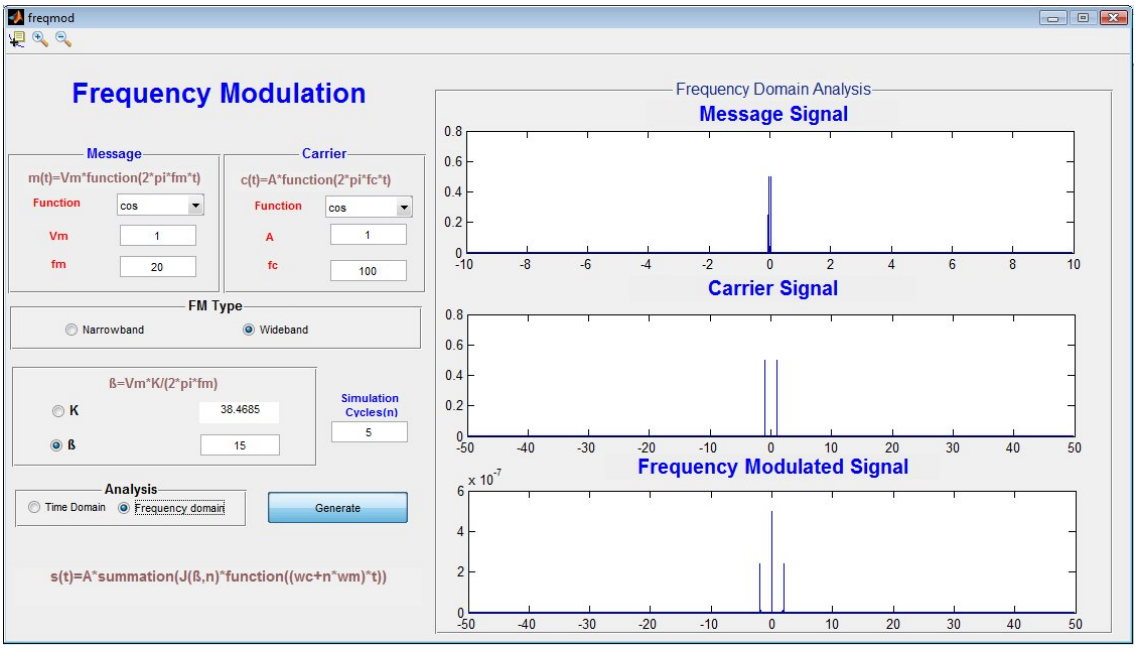


Fig. Frequency Spectrum plot

11. To calculate the bandwidth, use the data cursor. Click on one peak to get coordinates of one peak. To get the coordinates of second peak, **Alt+Click** on the second peak. The difference of X coordinates gives the bandwidth.

Fig. Data cursor

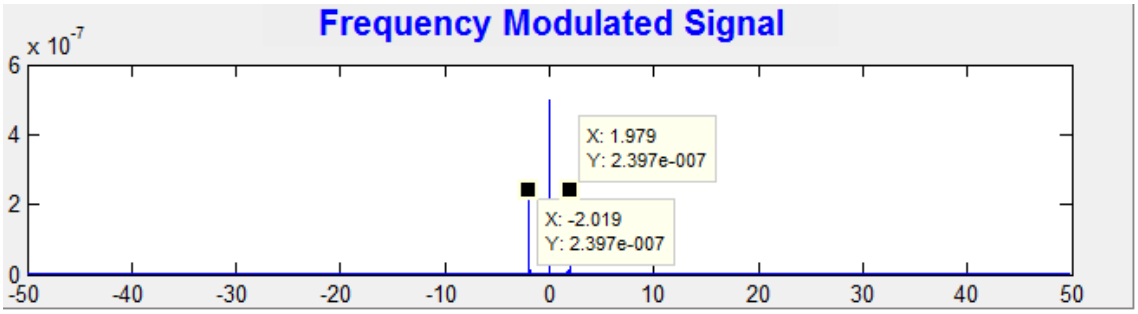


Fig. Markers for bandwidth calculation