Lab 3: FM Simulation and USRP

Exercise 1: FM Modulator

Generalised function for FM is:

$$g(t) = A_c \cos\big(2\pi f_c t + \theta_m(t)\big), \text{ where } \theta_m(t) = 2\pi\Delta_f \int m(\tau)\mathrm{d}\tau,$$

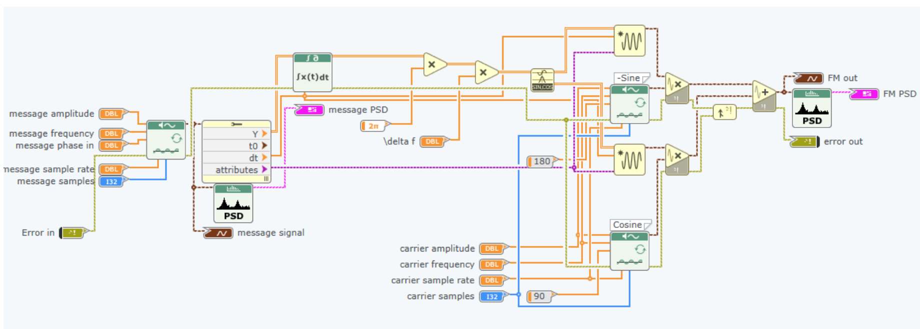
Instantaneous frequency is:

$$\omega = 2\pi f_c t + \theta_m(t)$$

Equivalent form we will be using:

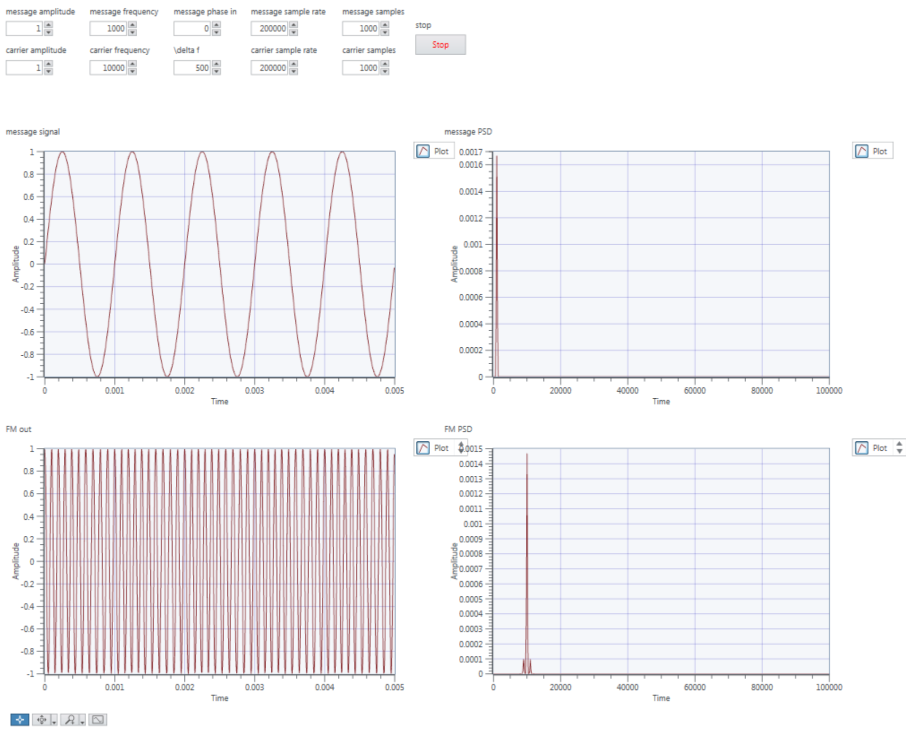
$$s(t) = A_c \cos\big(2\pi f_c t\big)\cos\big(\theta_m(t)\big) - A_c \sin\big(2\pi f_c t\big)\sin\big(\theta_m(t)\big)$$

Diagram

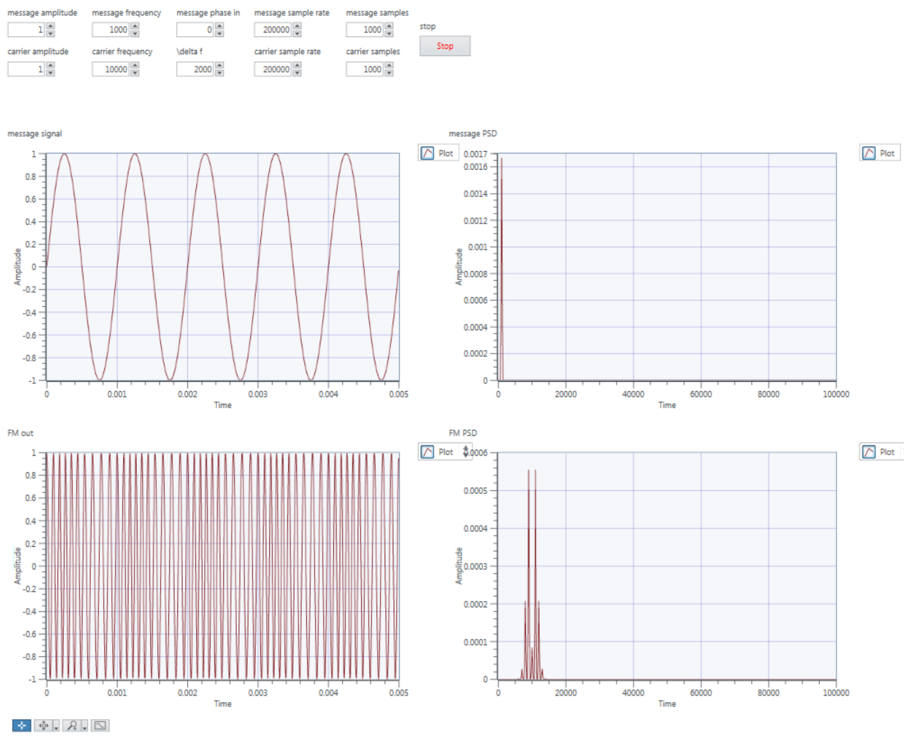


Varying *delta f*

delta f=500

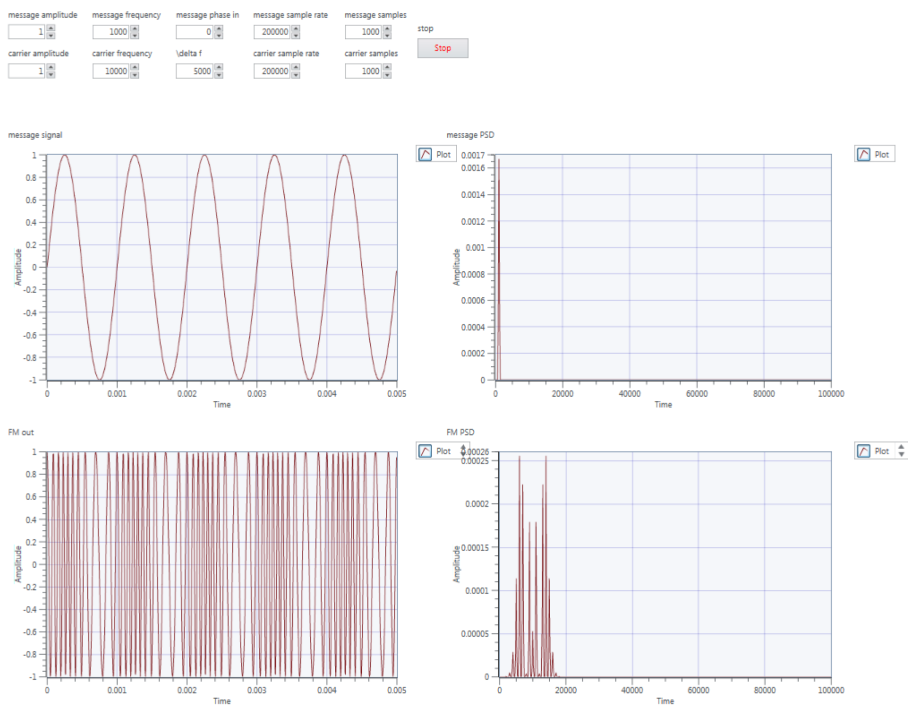


***delta f*=2000**



message amplitude
message frequency
message phase in
message sample rate
message samples
stop
Stop
carrier amplitude
carrier frequency
\delta f
carrier sample rate
carrier samples
message signal
message PSD
FM out
FM PSD
Amplitude
Time
Plot

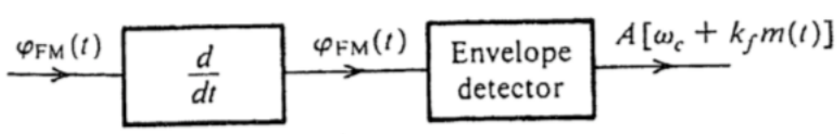
delta f=5000



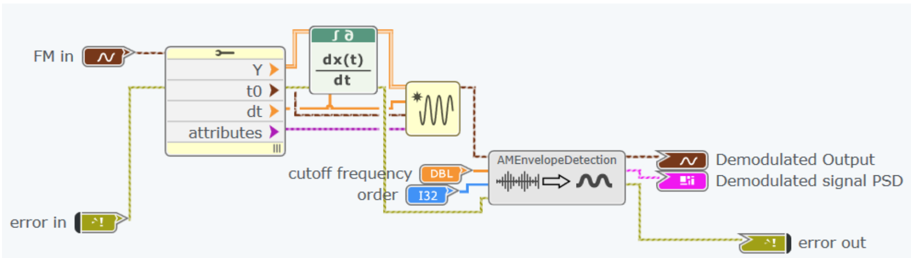
- As delta f increases, you can more easily see the variations in frequency of the FM signal.
- In the frequency domain, you can see the message signal spread across a larger bandwidth.

Exercise 2: FM Demodulator

- Theory is that the derivative provides a sinusoidal signal which has amplitude proportional to the message signal.
- This is just like AM modulation, so the envelope detection method works to retrieve the signal from the differentiated signal.
- Coherent detection would not work because we do not know the phase of the resultant signal

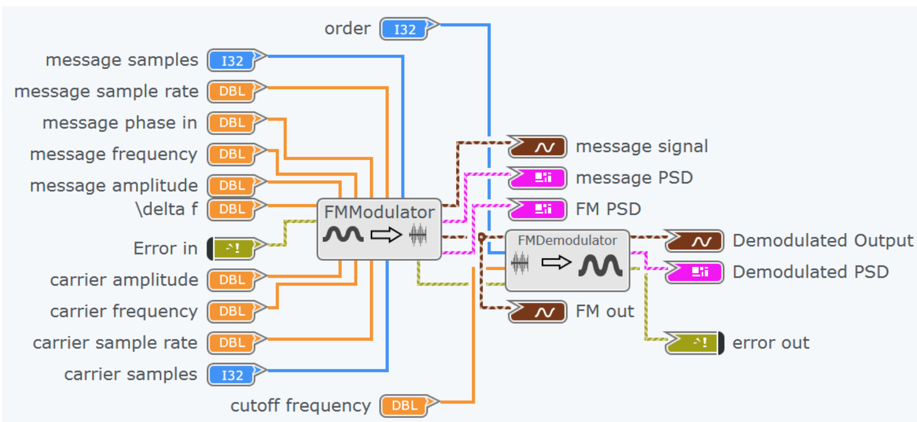


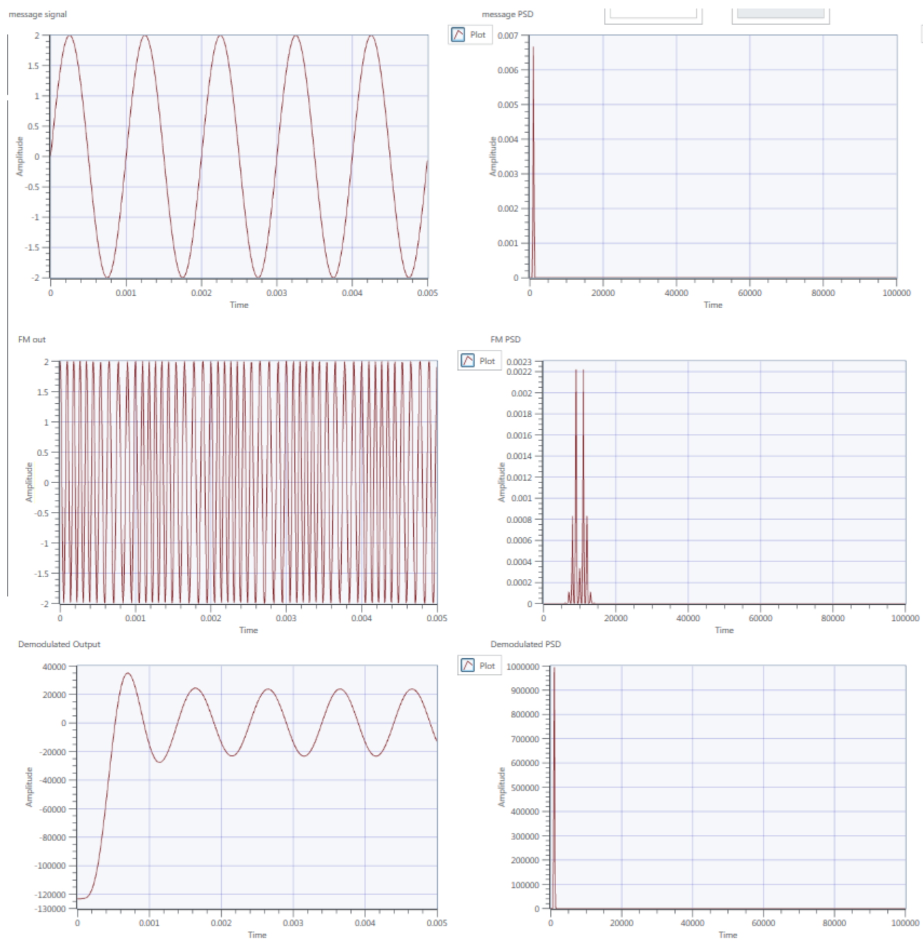
Envelope Detection



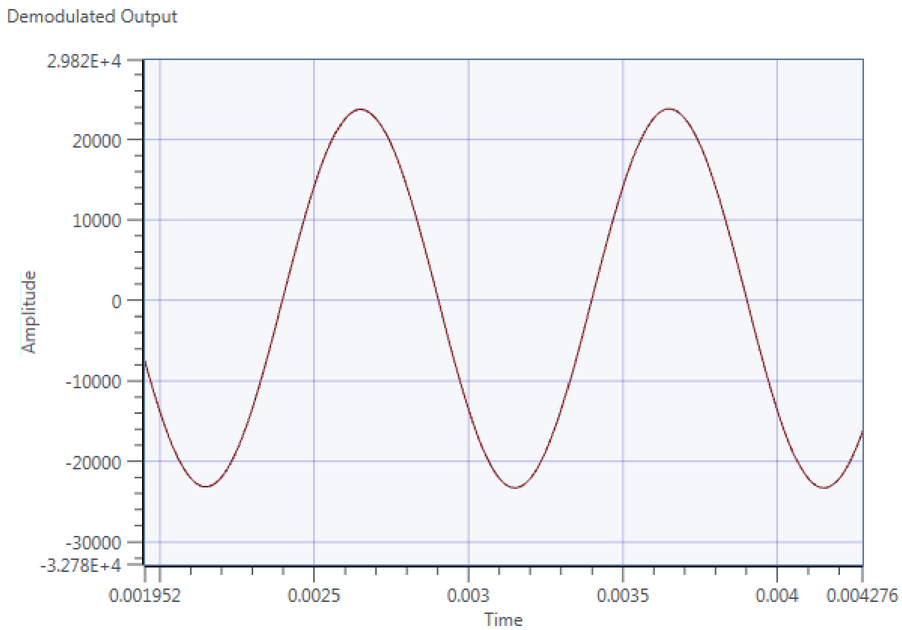
Exercise 3: FM Simulation

Top level Diagram



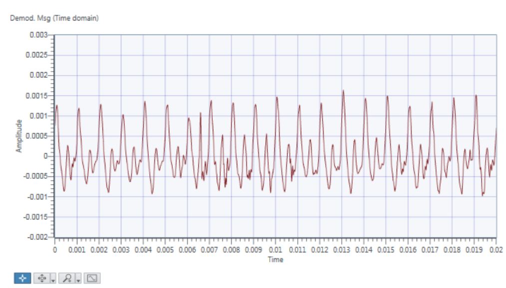


message signal
message PSD
FM out
FM PSD
Demodulated Output
Demodulated PSD

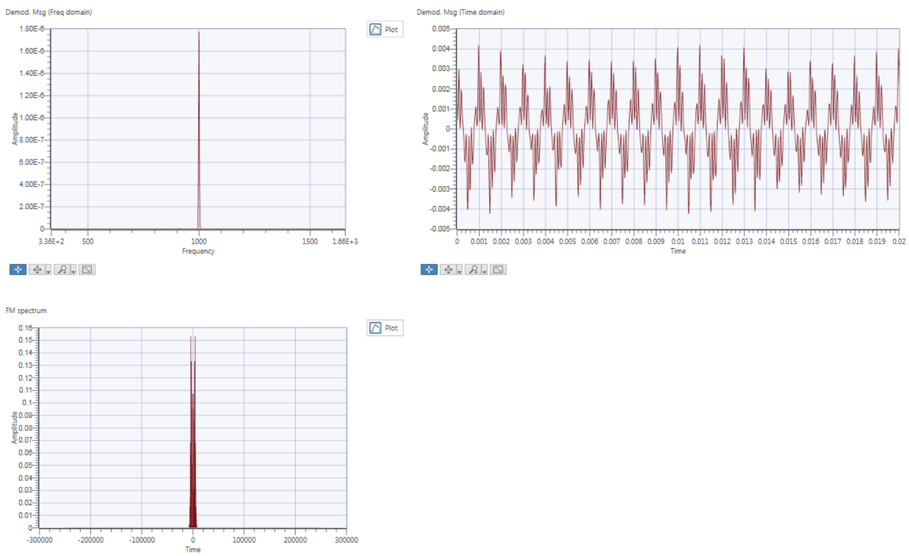


Exercise 4: FM USRP

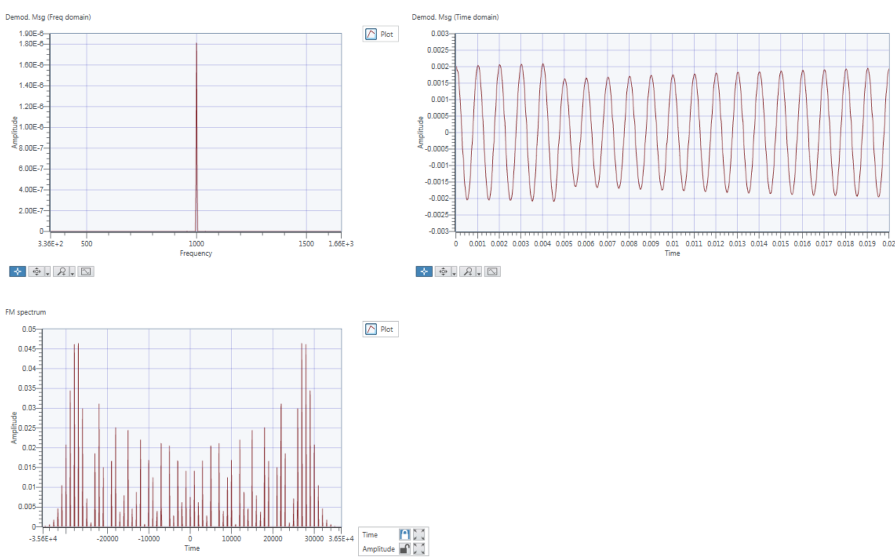
Delta f = 1kHz



Delta f = 5kHz



Delta f = 30kHz



- Note that the bandwidth of this signal is 62kHz, which agrees with Carsons rule for delta f = 30kHz and B = 1kHz:

$$B_{FM} \cong 2(\Delta f + B) = 62\text{kHz}.$$