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Experiment 4: Frequency Modulation

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1 Objectives

To realize frequency modulation using XR-2206. Observe both time domain and frequency domain plots on DSOs for various scenarios.

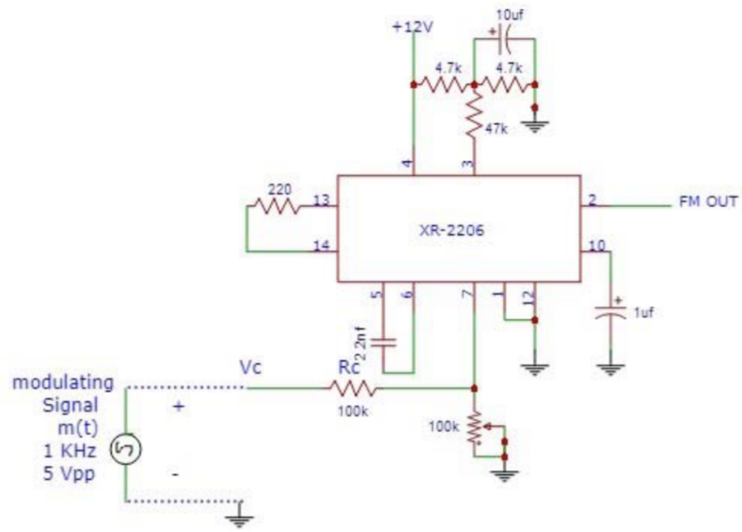

Figure 1: Frequency modulation using XR-2206

2 Instruments and Materials Used

1. RIGOL Signal Generator
2. ScientiFIC SMO10C Digital Signal Oscilloscope
3. +12V, -12V DC source and ground
4. MC 1496 integrated circuit
5. Resistors
6. Capacitors
7. Diodes
8. Breadboard
9. Connecting wires

3 Brief Theory and Procedure

In frequency modulation, the final signal is of the form:

$$V(t) = A\cos(2\pi f_i(t)t) \tag{1}$$

where $f_i = f_c + k_f m(t)$

We define frequency deviation as: $\Delta f = f_{i,max} - f_c$

And the modulation index as:

$$m = \frac{\Delta f}{f_m} \tag{2}$$

where f_m is the highest frequency of the messaging signal.

We calculated the f_{max} of the signal using two methods:

1. By calculating the time difference between consecutive peaks in the densest region and then using: $f_{max} = \frac{1}{T_{min}}$
2. By looking at the FFT and noting down the right-most peak.

4 Observations and Results

4.1 Carrier Wave

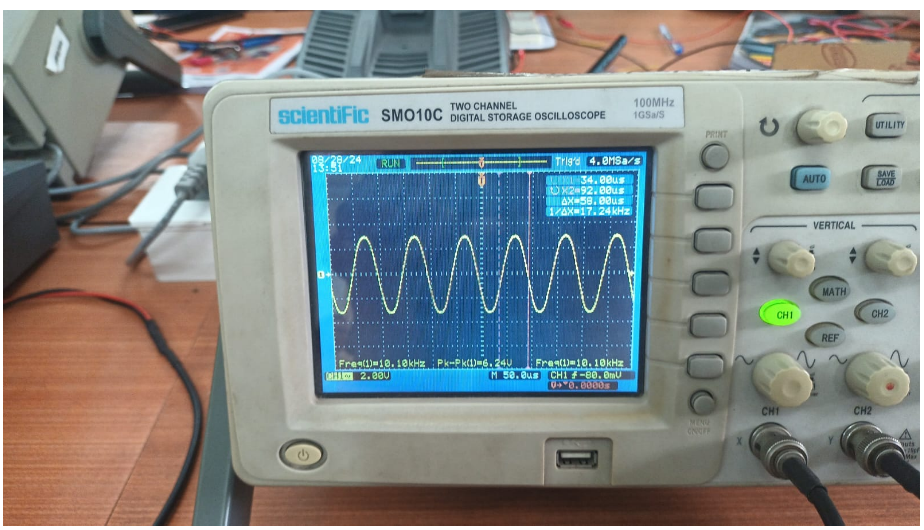

Figure 2: Carrier wave with frequency $f_c = 10.08$ kHz and $V_{pp} = 6.24V$

4.2 Modulated Signal

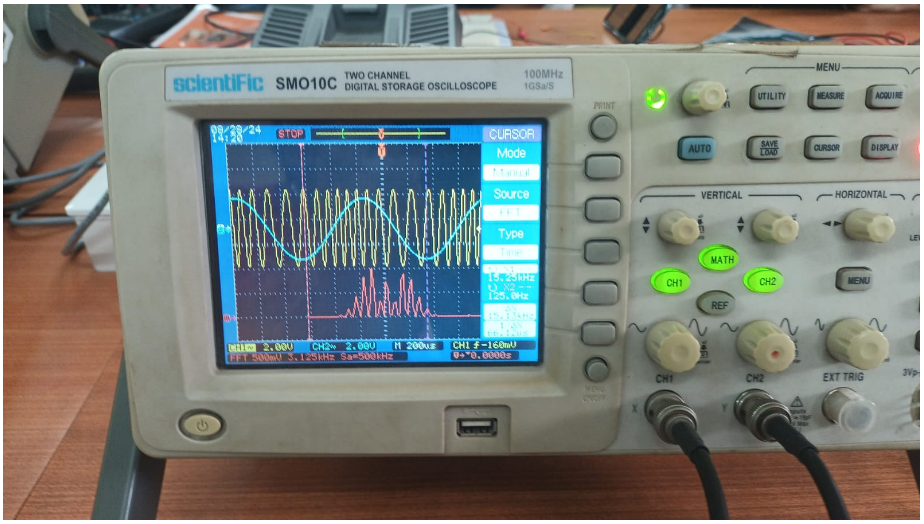

Figure 3: Frequency modulated output with $V_{pp} = 5V, f_m = 1kHz$, and corresponding FFT

From the measurements in time domain: $f_{max} = 13.89kHz, f_{min} = 8.621kHz$

From measurements in the frequency domain i.e. using the FFT: $f_{max} = 15.25kHz, f_{min} = 5.25kHz$

Since the measurements from the FFT aregoing to be more accurate, we will use that to calculate the modulation index:

$$m = \frac{\Delta f}{f_m} = \frac{f_{max} - f_c}{f_m} = \frac{15.25 - 10.08}{1} = 5.17 \tag{3}$$

4.3 Varying the amplitude

Figure 4: Final output and FFT with $V_{pp} = 1V$ for the message

$$m = \frac{\Delta f}{f_m} = \frac{11.25 - 10.08}{1} = 1.17 \tag{4}$$

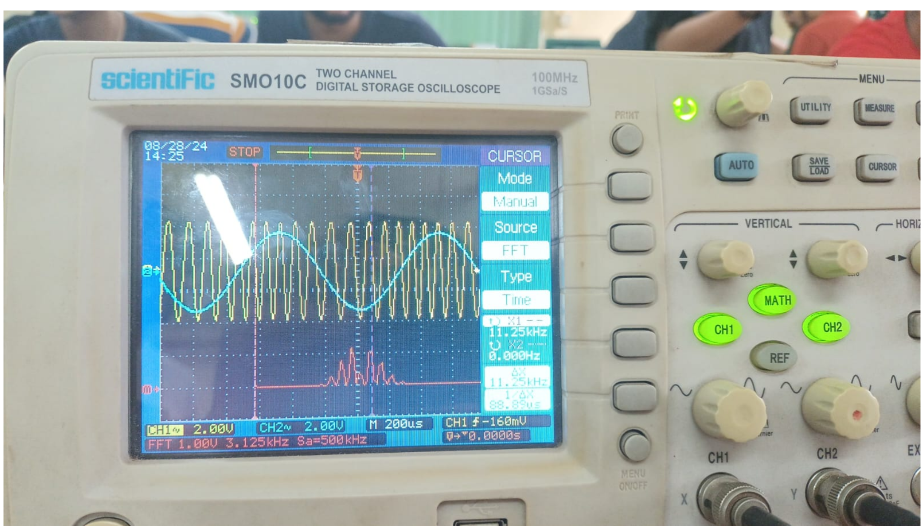

Figure 5: Final output and FFT with $V_{pp} = 3V$ for the message

$$m = \frac{\Delta f}{f_m} = \frac{13.25 - 10.08}{1} = 3.17 \tag{5}$$

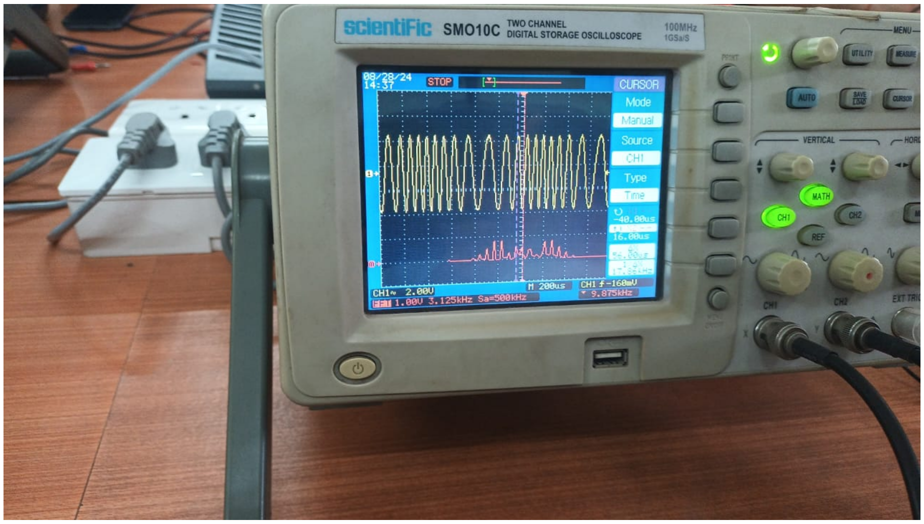

Figure 6: Final output and FFT with $V_{pp} = 7V$ for the message

$$m = \frac{\Delta f}{f_m} = \frac{17.25 - 10.08}{1} = 7.17 \tag{6}$$

Figure 7: Final output and FFT with $V_{pp} = 8V$ for the message

$$m = \frac{\Delta f}{f_m} = \frac{17.25 - 10.08}{1} = 7.17 \tag{7}$$

5 Discussion

5.1 Samyak Sheersh, 22EC30045

1. We saw that increasing the amplitude of the message gave a higher modulation index. This is because, as we can see from the expression for f_i, Δf is larger when the amplitude of the message signal is larger.

2. We also saw that at larger amplitudes of the message, more harmonics were coming in the FFT. In the ideal case, we'll see that the harmonics will be stretching on all the way to ∞

3. Due to overmodulation, the peak at 10kHz gets suppressed

4. Also, as we went above $10V_{pp}$, the signals were no longer sinusoidal and thus weren't properly modulated.

5. The XR 2206 is composed of 4 functional blocks: a voltage controlled oscillator, an analog multiplier and sine shaper, a unity gain buffer amplifier, and a set of current switches.

6. The VCO produces an output frequency proportional to an input current, which a resistor sets from the timing terminals to the ground. We tune the potentiometer to adjust the output frequency, it provides the desired control voltage to the VCO for generating that frequency.

7. By balancing the potentiometer, we generate the required carrier signal. It will set the appropriate control voltage to the VCO for generating that carrier frequency.

8. And just like in the AM case, as the bias level approaches the $\frac{V_{dd}}{2}$ level, the carrier flips and thus, the phase inversion that we see in the output.