

RF Assignment

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Radio Frequency Systems

Investigating the Effect of Noise in DSB-SC and FM Systems

Embedded Electronic Systems

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Introduction

In this report I will model two types of analog modulation to research the effects of noise when applied to a transmitted signal. I will produce two models on Simulink to represent a Double Sideband – Suppressed Carrier modulator and demodulator and for a Frequency Modulation modulator and demodulator. Using these models, I will transmit a modulated and receive a demodulated multimedia file to establish what effect the additive noise has on the input wave.

Background research

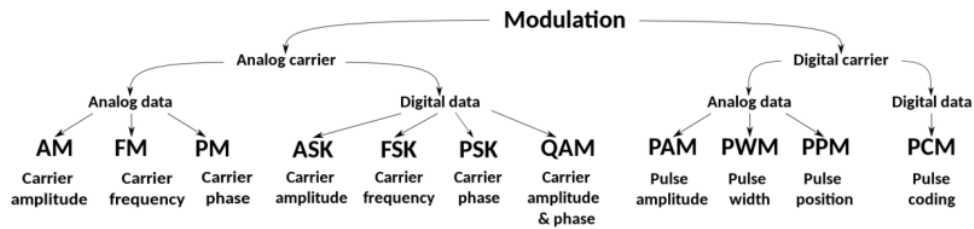


Figure 1 – Modulation Techniques^[1]

Both Amplitude and Frequency Modulation are analog data-carrier modulation techniques meaning both the modulating and carrier waves are analog in nature. This means that the two waves are superposed when frequency mixing occurs in both up and down conversion.

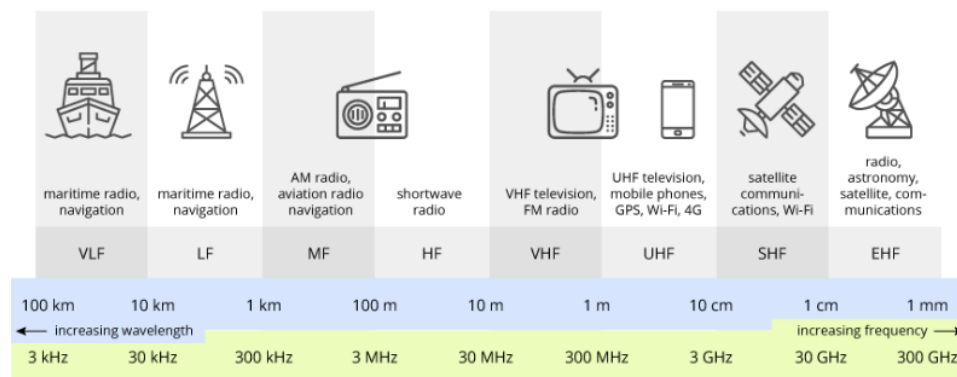


Figure 2 – Radio Frequency Bands^[2]

Amplitude Modulation

Amplitude modulation refers to the continuous variation of instantaneous amplitude of a carrier wave in accordance with a modulating signal. This produces a high frequency transmission with a varying amplitude determined by the message signal being transmitted; which is generally used in radio and telecommunication broadcasts.^[3]

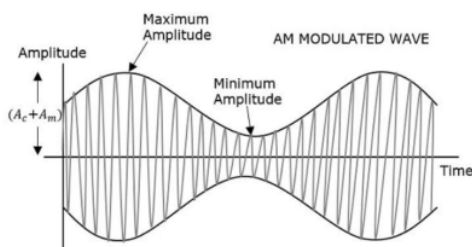


Figure 3 – Amplitude Modulated Signal

Amplitude modulation operates in the Medium Frequency band at 300-3,000kHz – specifically between 535-1605kHz. AM is capable of a 10kHz bandwidth allowing for 106 possible bands.^[4] most notably early radio broadcasts were transmitted as AM waves because it was cheaper to transmit and could be transmitted over long distances but is more susceptible to noise interference due to

the information being stored as an amplitude. AM also has lower bandwidth allowing for more stations in the given frequency range and the bandwidth of a message is twice the highest modulating frequency.^[5]

Double Sideband – Suppressed Carrier

In amplitude modulation a message signal is split over two sidebands at a fixed distance from a carrier wave; this is known as Double Sideband Full Carrier. DSBFC is considered inefficient as two-thirds of the total power is dedicated to the carrier wave, therefore typically AM is transmitted in a suppressed carrier format such as Double Sideband – Suppressed Carrier.

DSB-SC is a type of amplitude modulation which suppresses the carrier wave by using the power of the carrier to provide more power to the two sidebands which are situated either side of the carrier. This is more efficient as each message signal has more power so is less affected by noise and very little power is used in the transmission of a carrier wave containing no information.^[6]

Frequency Modulation

Frequency modulation varies the frequency of the carrier against the amplitude of the modulating signal. The frequency of the signal is a linear function of the modulating signal, this makes it possible to see variations in amplitude. FM is also widely used in radio and telecommunication broadcasting.^[7]

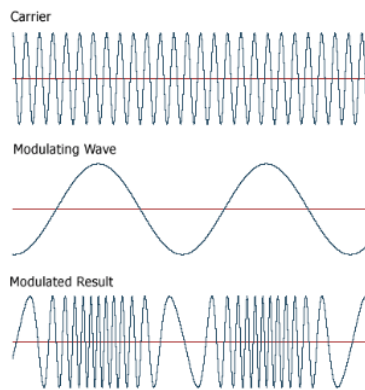


Figure 4 – Frequency Modulated Signal

Frequency modulation operates in the Very High Frequency band at 30-300 MHz – specifically between 88.1-108.1MHz. FM is capable of a 200kHz bandwidth allowing for 100 possible bands.^[4]

FM has mostly replaced AM in broadcasting as it is less susceptible to noise as the message information is stored as a varying frequency not as an amplitude. FM broadcasts also have a higher bandwidth (allowing for better sound quality) equalling twice the sum of the modulating frequency and frequency deviation. However, FM transmissions are affected by physical barriers due and cannot transmit over long distances.^[5]

Amplitude Modulation

Block Diagram

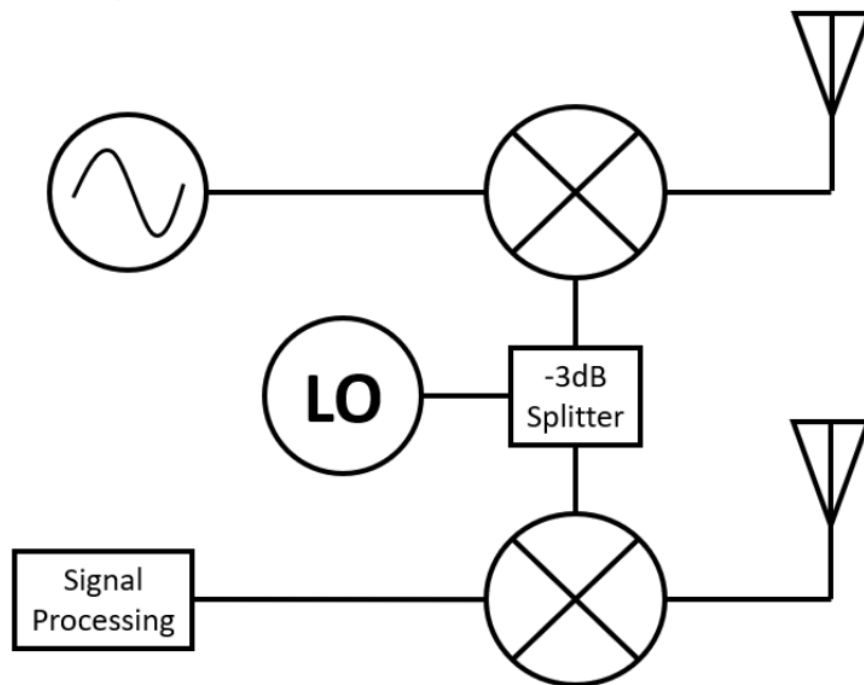


Figure 5 – Block Diagram of Transmitter and Receiver

Circuit design

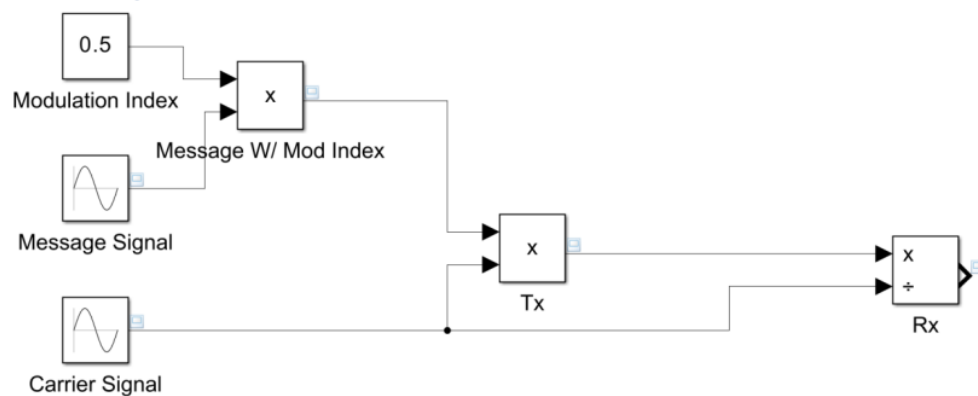


Figure 6 – Amplitude Modulation Model

Transmitter and Receiver Architectures

In this model the message and carrier signals are represented by the sine wave function blocks. A modulation index is provided by multiplication of the message sine wave by a constant – 0.5 in this instance. The modulation then occurs when the modulating signal from the initial product block is

then multiplied with the carrier wave at the second product block. I have used the same wave signal for the carrier function to ensure they are the same.

The connection between the product and division block represents the transmission of the waveform either through a coaxial cable or free space. The demodulation occurs at the division block when the modulated signal is divided by the carrier waveform, from this block a representation of the original message is output.

Simulated Outputs and Results

Sine Wave

Output a sine wave:

$$O(t) = \text{Amp} * \sin(\text{Freq} * t + \text{Phase}) + \text{Bias}$$

Sine type determines the computational technique used. The parameters in the two types are related through:

$$\text{Samples per period} = 2 * \pi / (\text{Frequency} * \text{Sample time})$$

$$\text{Number of offset samples} = \text{Phase} * \text{Samples per period} / (2 * \pi)$$

Use the sample-based sine type if numerical problems due to running for large times (e.g. overflow in absolute time) occur.

Parameters

Sine type:

Time (t):

Amplitude:

Bias:

Frequency (rad/sec): 6283.2

Phase (rad):

Figure 7 – Message Signal Parameters

Using the sine wave function blocks a message and carrier wave were produced and set at 1kHz and 10kHz respectively. This is done by inputting the equation $2\pi \times f$ to convert from rads^{-1} to Hz.

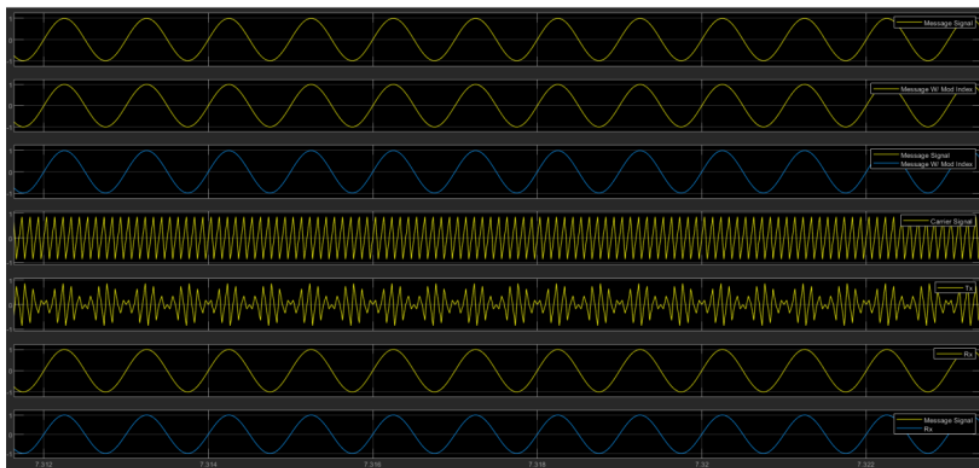


Figure 8 - Amplitude Modulation

Figure 9 shows critical modulation with a modulation index of 1, this produces a modulating wave that is at the same amplitude as the original message source and leads to a correctly modulated wave when combined with the carrier wave.

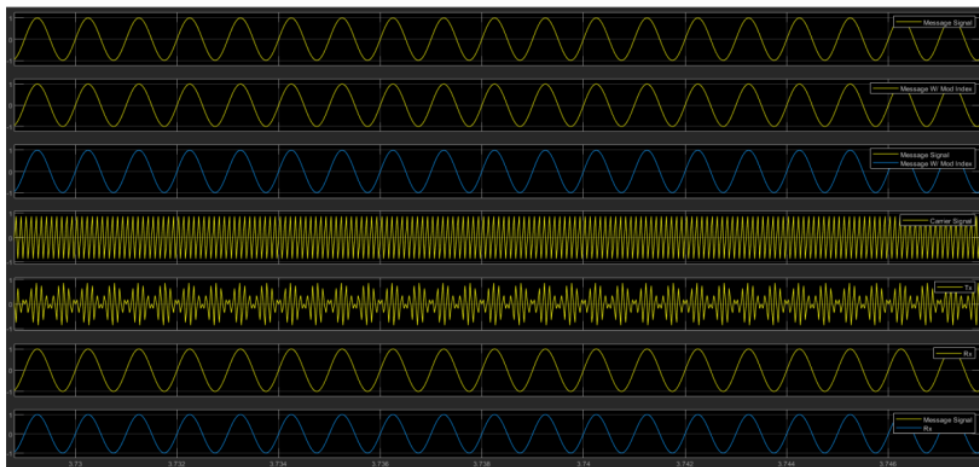


Figure 9 – Amplitude Modulation Index of 1

Figure 10 shows the effects of under modulation on a wave with a modulation index of 0.8, the effect of under modulation is shown in figure 10 but is not as noticeable as the example in figure 11.

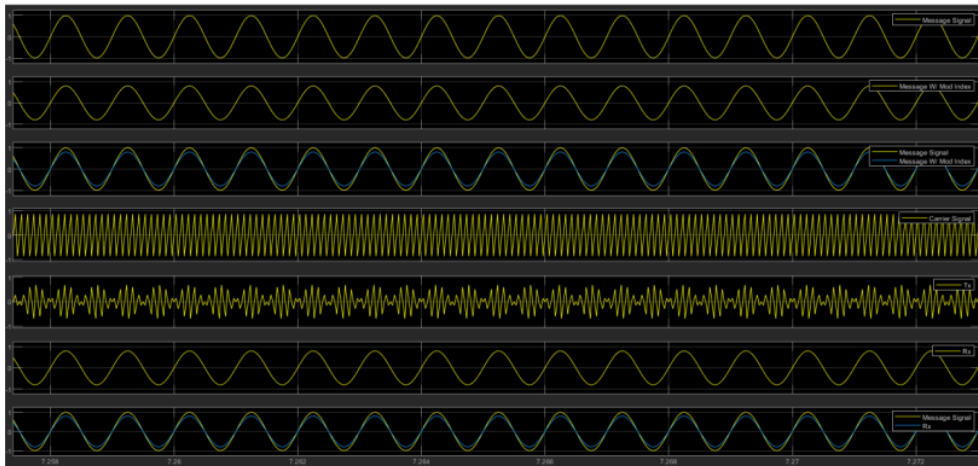


Figure 10 – Amplitude Modulation Index of 0.8

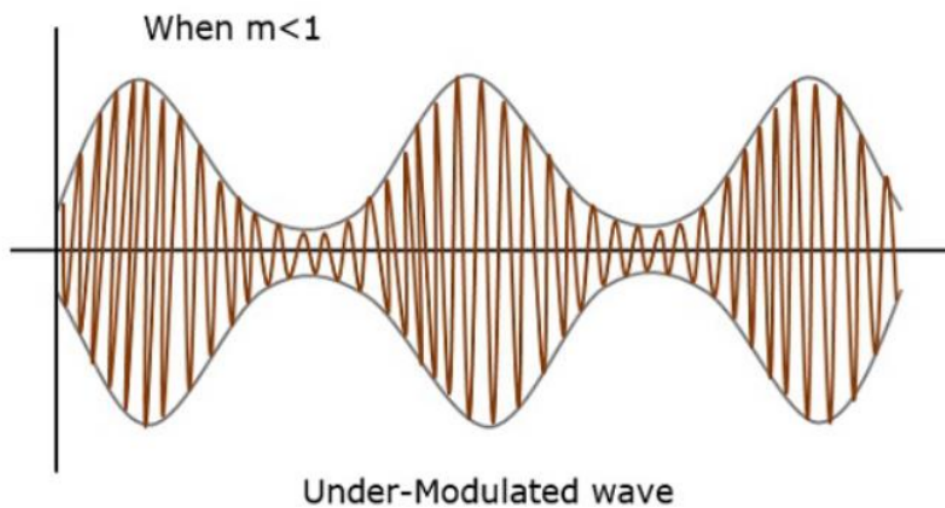


Figure 11 – Under Modulated AM Wave ^[3]

Figure 12 shows the effects of over modulation on a wave with a modulation index of 2, the effect of the over modulation is not as apparent in the model as with examples as displayed by figure 13.

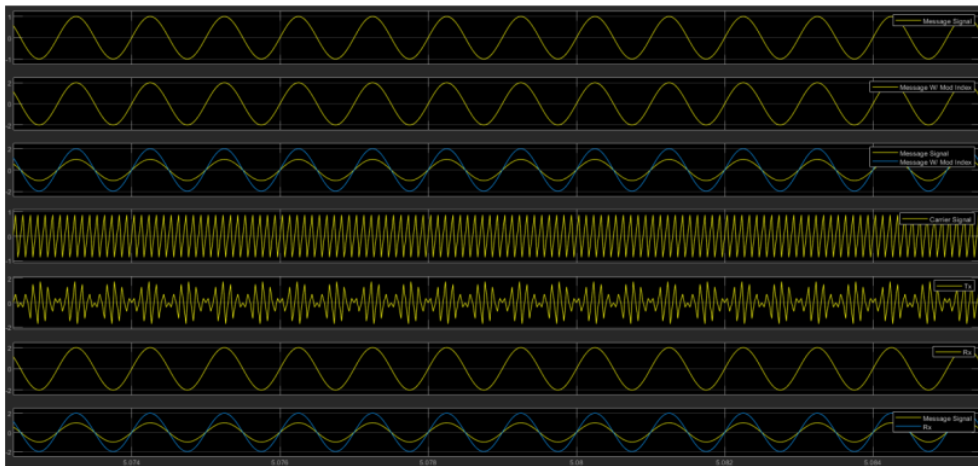


Figure 12 – Amplitude Modulation Index 2

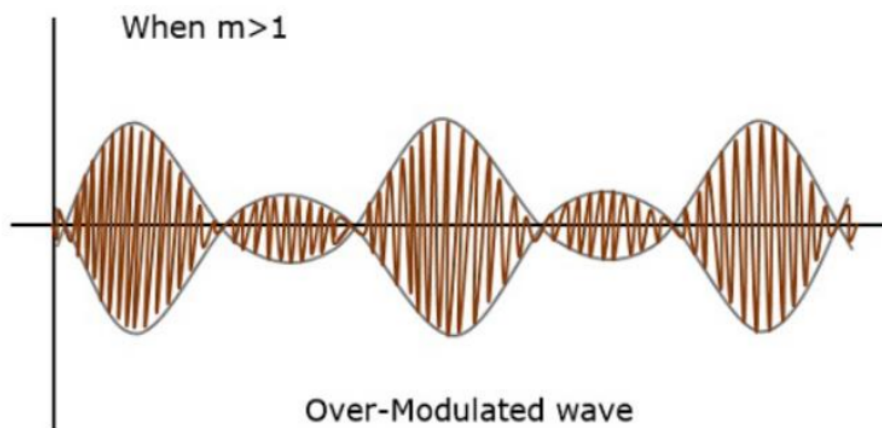


Figure 13 – Over Modulated AM Wave ^[3]



Double Sideband - Suppressed Carrier Amplitude Modulation

Block Diagram

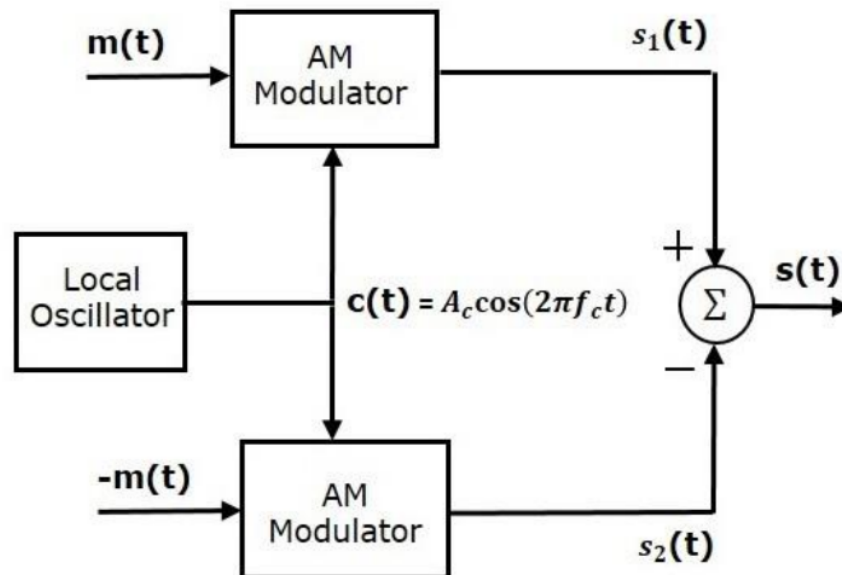


Figure 14 – Block Diagram of DSB-SC Modulator

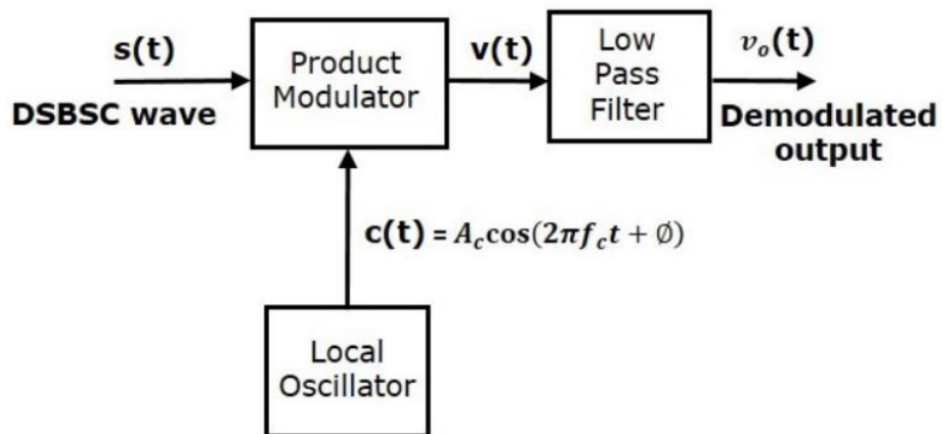


Figure 15 – Block Diagram of DSB-SC Demodulator

Circuit design

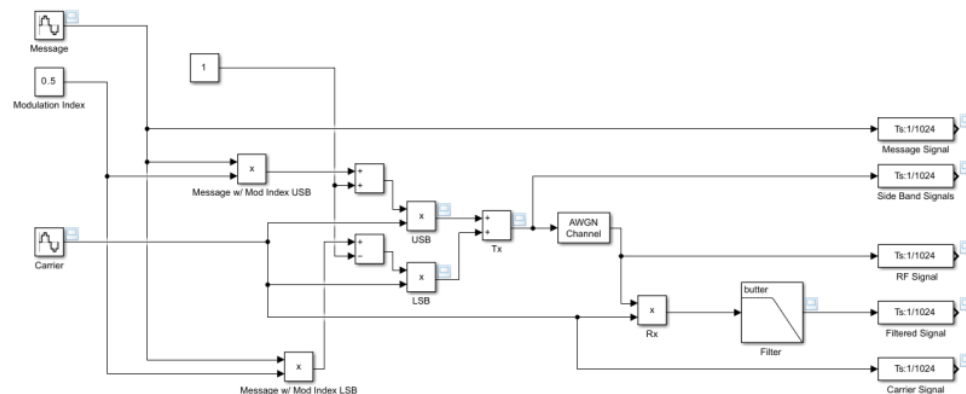


Figure 16 – DSB-SC Amplitude Modulation Model

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Transmitter and Receiver Architectures

In this model the message and carrier signals are represented by the sine wave function blocks. A modulation index is provided by multiplication of the message sine wave by a constant. I have then separated the upper and lower side bands into two individual equation functions, there are two message signals to which I have added and subtracted one respectively to produce the upper and lower side bands these have then tied to the carrier by multiplying each by the carrier wave and then the two signals have been added in the addition block to represent a Double Sideband-Suppressed Carrier transmission.

An Additive White Gaussian Noise block has been added to provide a real-world noise approximation, to ensure that the received message is representative of what would be received for demodulation. The received signal is then demodulated as the carrier is then mixed out of the incoming transmission at the multiplication function, the received message is then filtered to remove excess noise using a Butterworth lowpass filter.

The signal specification blocks on the right-hand side of the model act to ensure the signals are at the correct sample rate for the spectrum analyser.

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Simulated Outputs and Results

Carrier – 11Hz, 5V

Message – 2Hz, 1V

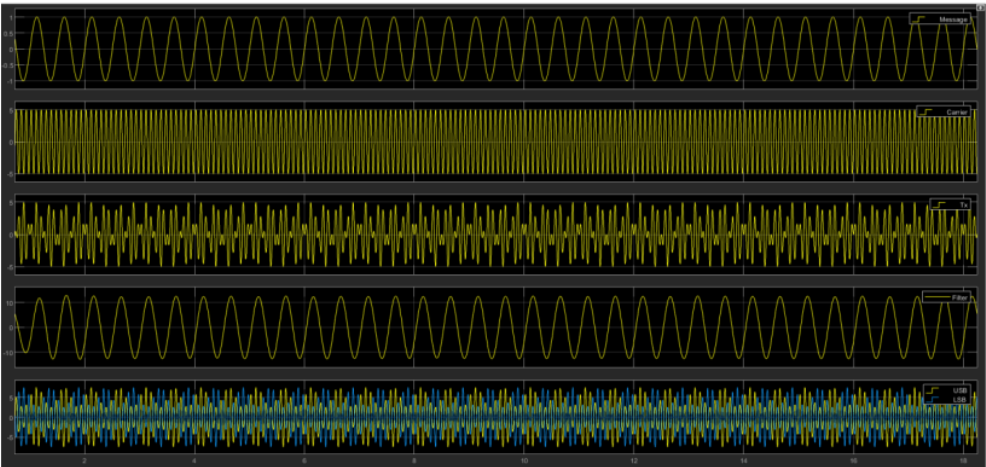


Figure 17 – 6 Amplitude Modulation Time Domian

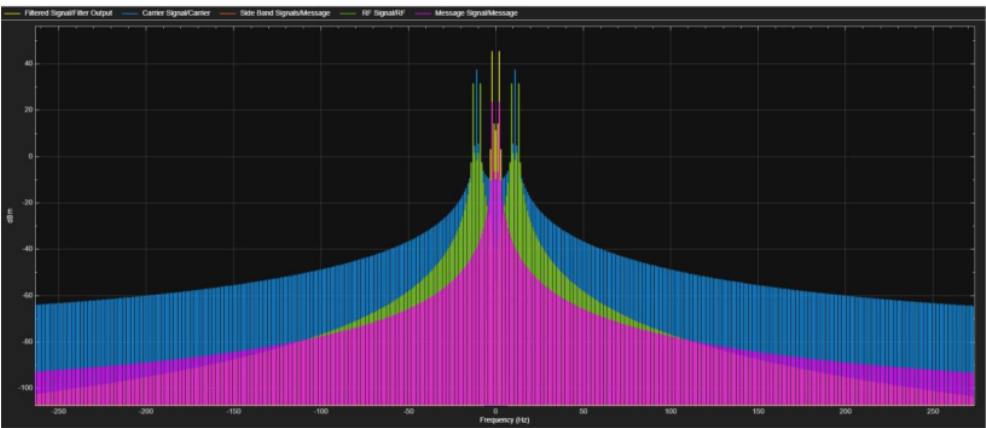


Figure 18 – DSB-SC Amplitude Modulation Frequency Domain

8 7

Multimedia Circuit design

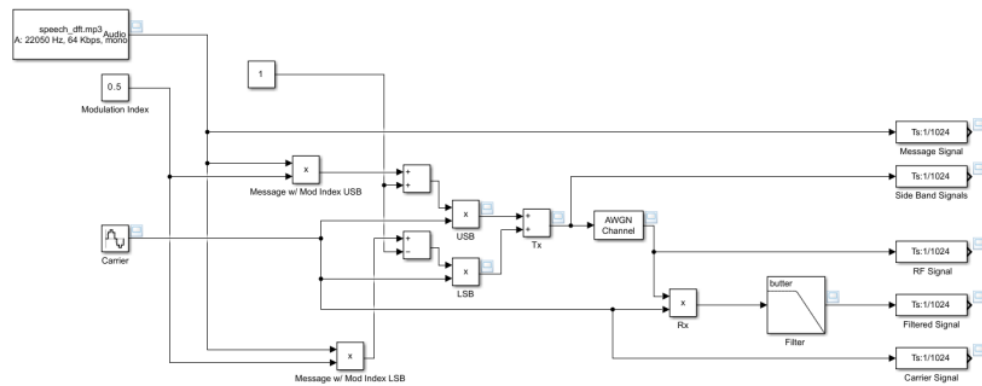


Figure 19 – DSB-SC Amplitude Modulation Multimedia Message Model

Multimedia Simulated Outputs and Results

Carrier – 112kHz, 7V

Message – 22.05kHz, 1V

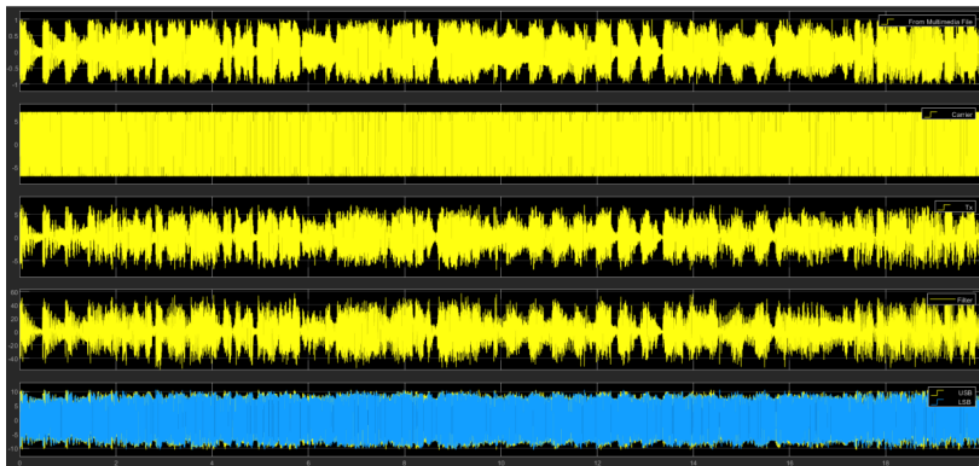


Figure 20 – DSB-SC Amplitude Modulation Multimedia Message Time Domain



Figure 21 – DSB-SC Amplitude Modulation Multimedia Message Frequency Domain

Two signals were then modelled with an Additive White Gaussian Noise function block, the SNR was set to 60dB and 10dB respectively for each instance.

$$P_m = \frac{A_m^2}{2} = \frac{1^2}{2} = 0.5W$$

$$P_c = \frac{A_c^2}{2} = \frac{7^2}{2} = 24.5W$$

$$P_{DSB-SC} = 2P_{SB} = 2 \times (2.824229597 \times 10^{-3}) = 5.65 \times 10^{-3}W$$

Equation 1 - Power in DSBSC AM Transmissions [8]

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Table 1 - Power Calculations for Multimedia Amplitude Modulation

Power Measurement	Watts (W)	Decibels (dBm)
P _m	0.5W	-3.01dBm
P _c	24.5W	13.89dBm
P _{DSB-SC}	5.65x10 ⁻³ W	-22.48dBm

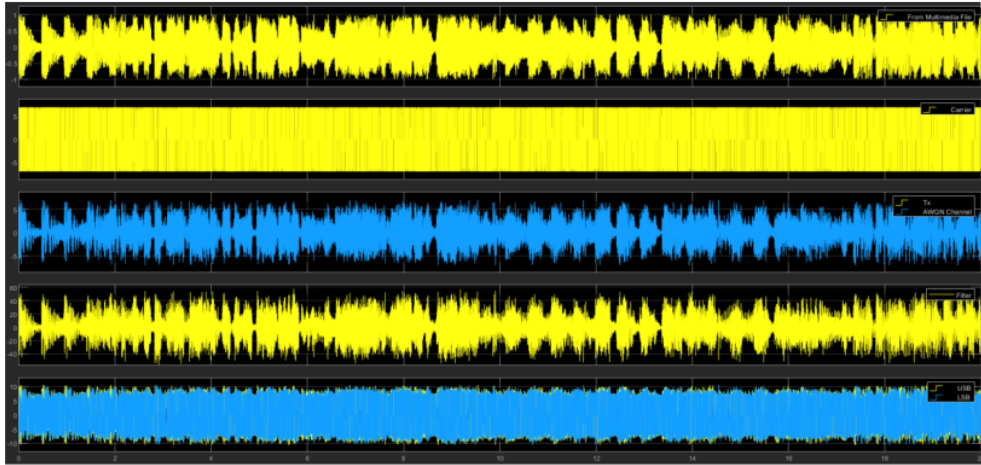


Figure 22 - DSB-SC Amplitude Modulation Multimedia Message Time Domain in the presence of 60dB SNR



Figure 23 - DSB-SC Amplitude Modulation Multimedia Message Frequency Domain in the presence of 60dB SNR

AWGN Channel SNR Value: 60dB

Equation 2 - Output and Channel SNR equations [8]

$$SNR_0 = \frac{\text{Signal Power}}{\text{Noise Power}} = 10 \log_{10} \left(\frac{7.116394248}{0.0000233572} \right) = 61.87269311 \text{ dB}$$

$$SNR_c = \frac{\text{Signal Power}}{\text{Noise Power}} = 10 \log_{10} \left(\frac{35.94926372}{0.0000233572} \right) = 46.37779311 \text{ dB}$$

Equation 3 - Watts to Decibel Watts equations [9]

$$\text{Watts} - \text{dBm} \rightarrow P_W = 10^{\left(\frac{P_{dBm} - 30}{10}\right)}$$

$$\text{Decibels} - \text{Watts} \rightarrow P_{dBm} = 10 \log_{10} \left(\frac{P_S}{P_N} \right)$$

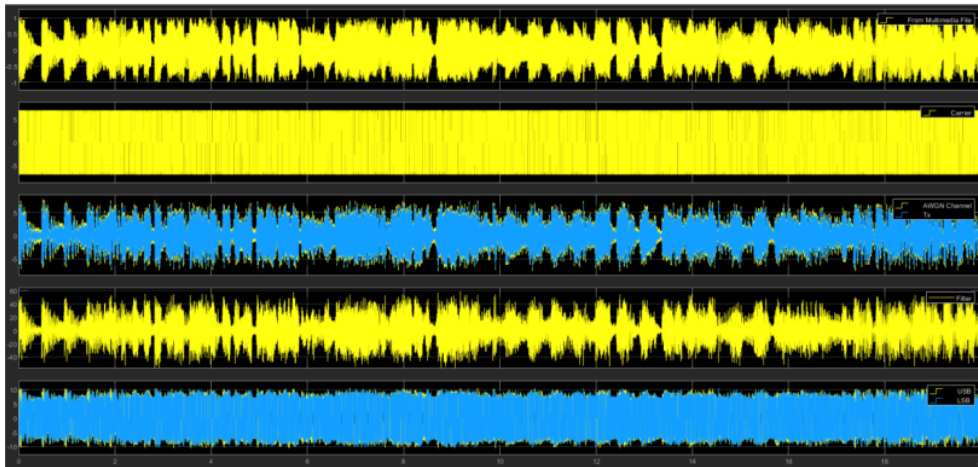


Figure 24 – DSB-SC Amplitude Modulation Multimedia Message Time Domain in the presence of 10dB SNR



Figure 25 – DSB-SC Amplitude Modulation Multimedia Message Frequency Domain in the presence of 10dB SNR

AWGN Channel SNR Value: 10dB

$$SNR_o = \frac{\text{Signal Power}}{\text{Noise Power}} = 10 \log_{10} \left(\frac{36.23764783}{0.039765726} \right) = 29.59651083 \text{ dBW}$$

$$SNR_c = \frac{\text{Signal Power}}{\text{Noise Power}} = 10 \log_{10} \left(\frac{1.014378417}{0.039765726} \right) = 14.06691083 \text{ dBW}$$

$$\text{Watts} - \text{dBm} \rightarrow P_W = 10^{\left(\frac{P_{dBm} - 30}{10}\right)}$$

$$\text{Decibels} - \text{Watts} \rightarrow P_{dBm} = 10 \log_{10} \left(\frac{P_S}{P_N} \right)$$

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Frequency Modulation

Block Diagram

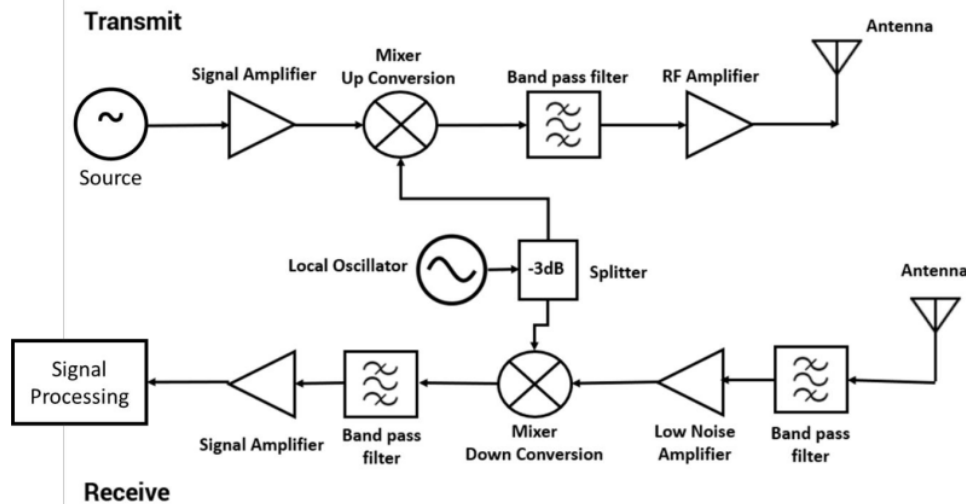


Figure 26 – Block Diagram of Transmitter and Receiver

Circuit Design

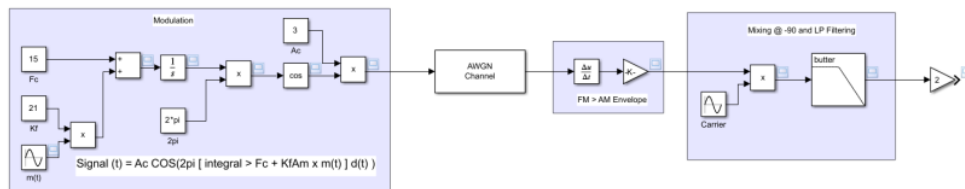


Figure 27 – Frequency Modulation Model

Transmitter and Receiver Architectures

In this model the message and carrier signals are represented by the sine wave function blocks. A modulation index is provided by multiplication of the message sine wave by a constant k_f and then the addition of the carrier wave frequency which is represented by the constant f_c – this represents the equation: $\beta = \frac{A_m k_f}{f_m} = \frac{\Delta f}{f_m}$

The rest of the modulation of the message signal is performed by the integrator and the multiplication of that output by 2π , that result is the input to a cosine trigonometric function, which is then multiplied by the Carrier Wave amplitude constant (A_c).

The AWGN channel provides the noise approximation in an effort to distort the transmitted signal. The received signal is then demodulated in two stages, firstly the differentiation function forms the amplitude modulation envelope – the gain reduces the signal else it would be too large based on the maths operations being performed – the carrier wave is then mixed out at -90° to the incoming wave, the resulting wave is then passed through a Butterworth lowpass filter to extract the initial message signal.

Simulated Outputs and Results

Carrier – 15Hz, 5V

Message – 2Hz, 1V

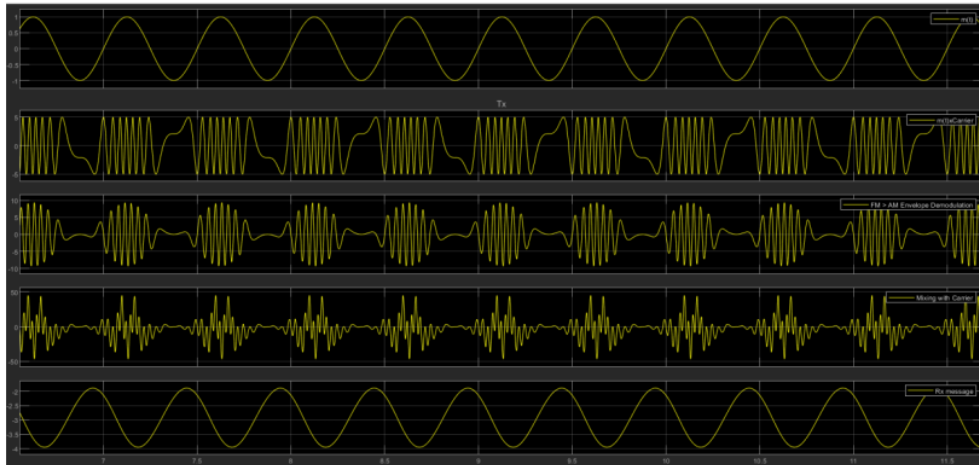


Figure 28 – Frequency Modulation and Demodulation in the Time Domain

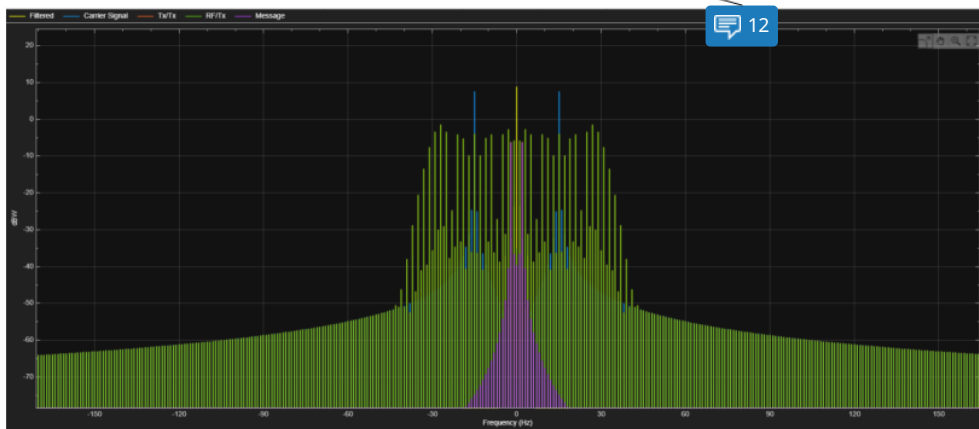
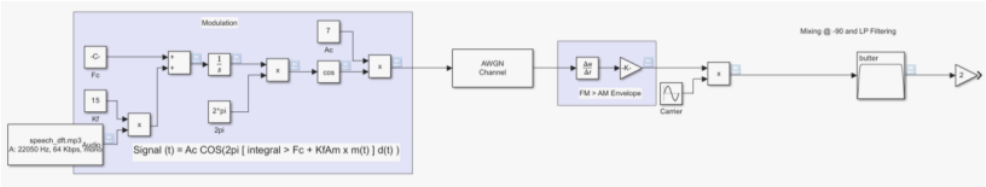


Figure 29 – Frequency Modulation in the Frequency Domain

Multimedia Circuit design



Multimedia Simulated Outputs and Results

Carrier – 40kHz, 7V

Message – 8kHz, 1V

$$P_m = \frac{A_m^2}{2} = \frac{1^2}{2} = 0.5W$$

$$P_c = \frac{A_c^2}{2} = \frac{7^2}{2} = 24.5W$$

Equation 4 – Power in FM transmission equation [10]

$$P_{FM} = P_c$$

Table 2 - Power Calculations for Multimedia Frequency Modulation

Power Measurement	Watts (W)	Decibels (dBm)
P _m	0.5W	-3.01dBm
P _c	24.5W	13.89dBm
P _{FM}	24.5W	13.89dBm

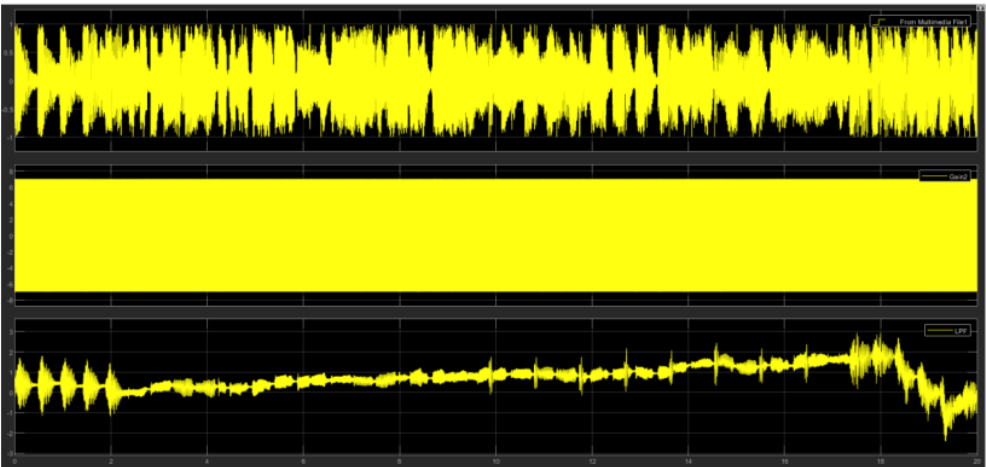


Figure 31 – Frequency Modulation Multimedia Message Time Domain in the presence of 60dB SNR

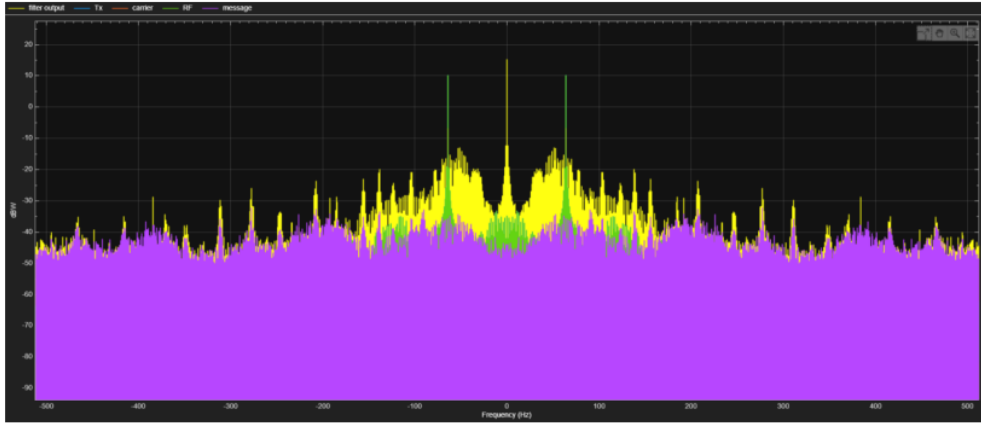


Figure 32 – Frequency Modulation Multimedia Message Frequency Domain in the presence of 60dB SNR

AWGN Channel SNR Value: 60dB

$$SNR_0 = \frac{\text{Signal Power}}{\text{Noise Power}} = 10 \log_{10} \left(\frac{18.13635466}{0.000243445} \right) = 48.72149311 \text{ dB}$$

$$SNR_c = \frac{\text{Signal Power}}{\text{Noise Power}} = 10 \log_{10} \left(\frac{10.57279959}{0.000243445} \right) = 46.37779311 \text{ dB}$$

$$\text{Watts} - \text{dBm} \rightarrow P_W = 10^{\left(\frac{P_{dBm} - 30}{10}\right)}$$

$$\text{Decibels} - \text{Watts} \rightarrow P_{dBm} = 10 \log_{10} \left(\frac{P_S}{P_N} \right)$$

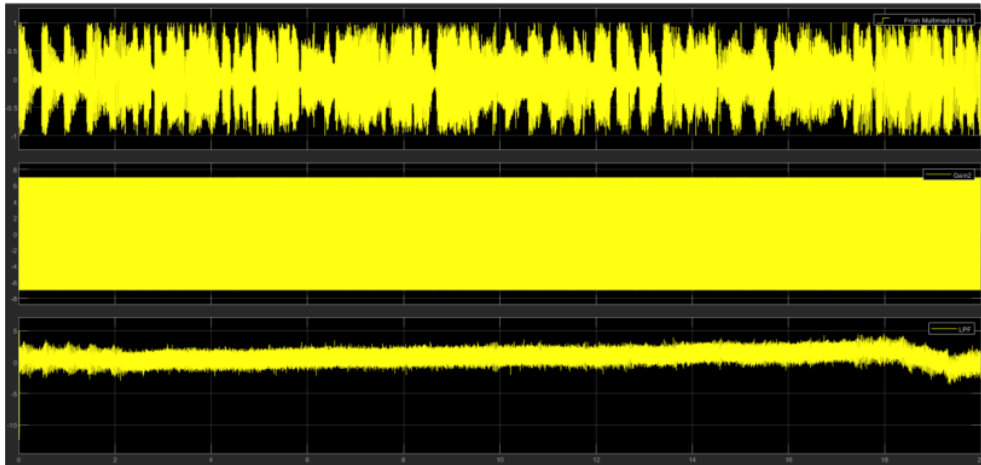


Figure 33 – Frequency Modulation Multimedia Message Time Domain in the presence of 10dB SNR

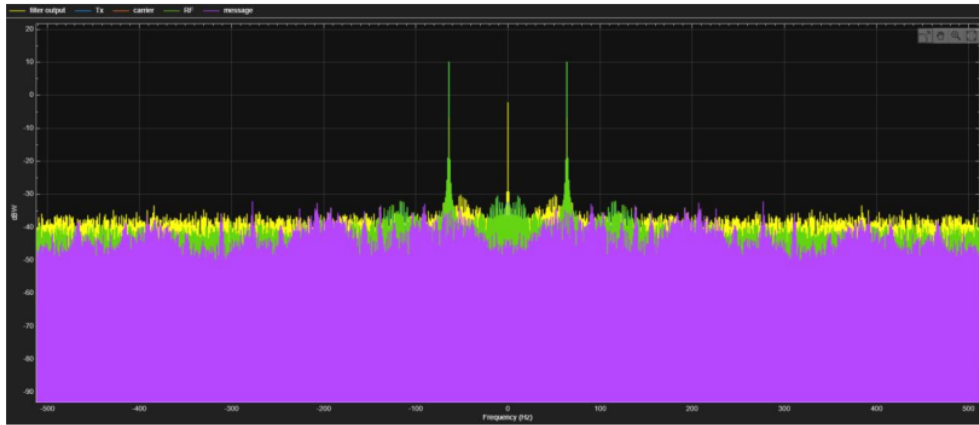


Figure 34 – Frequency Modulation Multimedia Message Frequency Domain in the presence of 10dB SNR

AWGN Channel SNR Value: 10dB

$$SNR_0 = \frac{\text{Signal Power}}{\text{Noise Power}} = 10 \log_{10} \left(\frac{0.479457371}{0.025592935} \right) = 12.72629906 \text{ dB}$$

$$SNR_c = \frac{\text{Signal Power}}{\text{Noise Power}} = 10 \log_{10} \left(\frac{10.57279959}{0.025592935} \right) = 26.16069906 \text{ dB}$$

$$\text{Watts} - \text{dBm} \rightarrow P_W = 10^{\left(\frac{P_{dBm} - 30}{10}\right)}$$

$$\text{Decibels} - \text{Watts} \rightarrow P_{dBm} = 10 \log_{10} \left(\frac{P_S}{P_N} \right)$$

Conclusion

Analysing the Results

Figure of Merit

Equation 5 - Figure of Merit equation [5]

$$\begin{aligned} \text{Input SNR} \quad SNR_I &= \frac{\text{Average Power of Modulating Signal}}{\text{Average power of Noise at Input}} \\ \text{Output SNR} \quad SNR_O &= \frac{\text{Average Power of Demodulated Signal}}{\text{Average power of Noise at Output}} \\ \text{Channel SNR} \quad SNR_C &= \frac{\text{Average Power of Modulated Signal}}{\text{Average power of Noise in Message Bandwidth}} \end{aligned}$$

The figure of merit for a device is given by $\frac{SNR_O}{SNR_I}$ and for a receiver is $\frac{SNR_O}{SNR_C}$ because the channel is considered as the input to the receiver.

Double Sideband – Suppressed Carrier

$$\begin{aligned} SNR_{I,DSBSC} &= \frac{\text{Average Power of DSBSC Modulating Signal}}{\text{Average power of Noise at Input}} \\ SNR_{O,DSBSC} &= \frac{\text{Average Power of DSBSC Demodulated Signal}}{\text{Average power of Noise at Output}} \\ SNR_{C,DSBSC} &= \frac{\text{Average Power of DSBSC Modulated Signal}}{\text{Average power of Noise in Message Bandwidth}} \\ \text{Figure of Merit} &= \frac{SNR_{O,DSBSC}}{SNR_{C,DSBSC}} \end{aligned}$$

Equation 6 – AM SNR output and channel equations [8]

$$\begin{aligned} SNR_{O(\text{Theoretical})} &= \frac{A_c^2 k_a^2 P}{2N_0 BW} = \frac{7^2 \times 0.5^2 \times 0.5}{2 \times (1W) \times (2 \times 22050 \text{ Hz})} = 6.944444444 \times 10^{-5} W \approx -41.58 \text{ dBW} \\ SNR_{C(\text{Theoretical})} &= \frac{A_c^2 (1+k_a^2) P}{2N_0 BW} = \frac{7^2 (1+0.5^2) 0.5}{2 \times (1W) \times (2 \times 22050 \text{ Hz})} = 6.25 \times 10^{-4} W \approx -32.04 \text{ dBW} \end{aligned}$$

Equation 7 - DSBSC AM Bandwidth equation [6]

$$BW = f_c + f_m - (f_c - f_m) = 2f_m$$

(N_0 refers to the input signal power the equation is as follows: $N_0 = kT_e = 1$ in the model produced the value of N_0 is taken as 1W.)

$$\text{Figure of Merit}_{\text{Theoretical}} = \frac{-41.58}{-32.04} = 1.30$$

AWGN SNR Value 10dB:

$$\begin{aligned} SNR_O &= 29.60 \text{ dB} & SNR_C &= 14.07 \text{ dB} \\ \text{Figure of Merit}_{\text{Simulation}} &= \frac{29.59651083}{14.06691083} = 2.10 \end{aligned}$$

This value is higher than the expected 1.3 provided by the theoretical figure of merit, this is due to the calculation of the output SNR being incorrect. As shown the SNR_O is given as 22.57dB when the AWGN channel is set to 10dB, as such the signal power is more than it should be – due to a simulation error – as such the figure of merit value for this simulation scenario is larger than it should be. Had the SNR_O sat around ~11dB this figure of merit value would be ~1.7, which falls more in line with the expected 1.3 of the theoretical.

AWGN SNR Value 60dB:

$$SNR_O = 61.87\text{dB}$$

$$SNR_C = 46.38\text{dB}$$

$$Figure\ of\ Merit_{Simulation} = \frac{61.87269311}{46.37779311} = 1.33$$

This figure of merit is slightly larger than the theoretical value but is far closer than the value from the 10dB SNR simulation. This is likely due to the larger signal power of 61.99dB, the simulation seemed to run as expected and provide a realistic SNR_O value unlike the previous simulation. This ensured that the figure of merit produced was much closer at 1.43 for this simulation.

Frequency Modulation

$$SNR_{I,FM} = \frac{\text{Average Power of FM Modulating Signal}}{\text{Average power of Noise at Input}}$$

$$SNR_{O,FM} = \frac{\text{Average Power of FM Demodulated Signal}}{\text{Average power of Noise at Output}}$$

$$SNR_{C,FM} = \frac{\text{Average Power of FM Modulated Signal}}{\text{Average power of Noise in Message Bandwidth}}$$

$$Figure\ of\ Merit = \frac{SNR_{O,FM}}{SNR_{C,FM}}$$

Equation 8 – FM SNR output and channel equations ^[11]

$$SNR_{O(Theoretical)} = \frac{A_c^2}{2N_0BW} = \frac{7^2}{2 \times (1W) \times (2(15Hz + 2Hz))} = 0.001528384W \approx -28.16dBW$$

$$SNR_{C(Theoretical)} = \frac{A_c^2 k_f^2 P}{2N_0BW^3} = \frac{7^2 \times 15^2 \times 0.5}{2 \times (1W) \times (2(15Hz + 2Hz))^3} = 6.69142 \times 10^{-10}W \approx -91.74dBW$$

Equation 9 - FM Bandwidth equation ^[12]

$$BW = 2(\Delta f_c + f_m)$$

$$Figure\ of\ Merit_{Theoretical} = \frac{-28.16}{-91.74} = 0.31$$

AWGN SNR Value 10dB:

$$SNR_O = 12.73\text{dB}$$

$$SNR_C = 26.16\text{dB}$$

$$Figure\ of\ Merit_{Simulation} = \frac{12.72629906}{26.16069906} = 0.49$$

Having simulated the multimedia message at 10dB in the frequency modulation models an output SNR of 12.73dB and a channel SNR of 26.16dB were calculated, giving a figure of merit of 0.49. This is quite close to the theoretical figure of merit calculated for the system, which means the simulation was close to the intended value and therefore was simulating correctly.

AWGN SNR Value 60dB:

$$SNR_0 = 48.72dB \quad SNR_c = 46.38dB$$

$$Figure\ of\ Merit_{Simulation} = \frac{48.72149311}{46.37779311} = 1.05$$

The simulation of FM at 60dB SNR seemed to produce a lower output SNR than expected, meaning the simulation did not run efficiently and the process of adding noise reduced the fidelity and therefore the calculated SNR. This in turn impacts the figure of merit associated with this simulation producing an FoM or 1.05 which is much greater than the 0.31 value of the theoretical calculation.

Recommendations on future work

In future work the models need to become more robust and able to handle noise value and multimedia files because as can be heard in the multimedia files the model struggles to sample the input wave at the correct rate.

References

- [1] 'Amplitude-shift keying', *Wikipedia*. Jun. 23, 2023. Accessed: Oct. 13, 2023. [Online]. Available: https://en.wikipedia.org/w/index.php?title=Amplitude-shift_keying&oldid=1161574964
- [2] 'Radio Frequency Bands | TeraSense'. Accessed: Nov. 13, 2023. [Online]. Available: <https://terasense.com/terahertz-technology/radio-frequency-bands/>
- [3] 'Amplitude Modulation'. Accessed: Nov. 13, 2023. [Online]. Available: https://www.tutorialspoint.com/analog_communication/analog_communication_amplitude_modulation.htm
- [4] 'Radio Broadcast Signals'. Accessed: Nov. 13, 2023. [Online]. Available: <http://hyperphysics.phy-astr.gsu.edu/hbase/Audio/radio.html>
- [5] 'AM vs FM - Difference and Comparison | Diffen'. Accessed: Nov. 14, 2023. [Online]. Available: https://www.diffen.com/difference/AM_vs_FM
- [6] 'Analog Communication - DSBSC Modulators'. Accessed: Nov. 14, 2023. [Online]. Available: https://www.tutorialspoint.com/analog_communication/analog_communication_dsb_sc_modulators.htm
- [7] 'What is FM, Frequency Modulation » Electronics Notes'. Accessed: Nov. 13, 2023. [Online]. Available: <https://www.electronics-notes.com/articles/radio/modulation/frequency-modulation-fm.php>
- [8] 'Analog Communication - SNR Calculations'. Accessed: Nov. 30, 2023. [Online]. Available: https://www.tutorialspoint.com/analog_communication/analog_communication_snr_calculations.htm
- [9] 'dBW (Decibel-Watt)'. Accessed: Nov. 30, 2023. [Online]. Available: <https://www.rapidtables.com/electric/dBW.html>
- [10] 'Numerical Problems 2'. Accessed: Nov. 30, 2023. [Online]. Available: https://www.tutorialspoint.com/analog_communication/analog_communication_numerical_problems_2.htm
- [11] 'Signal-to-noise ratio', *Wikipedia*. Nov. 10, 2023. Accessed: Nov. 28, 2023. [Online]. Available: https://en.wikipedia.org/w/index.php?title=Signal-to-noise_ratio&oldid=1184390748
- [12] 'Frequency modulation'. Accessed: Nov. 30, 2023. [Online]. Available: https://www.slideshare.net/Akanksha_Seth/frequency-modulation-12759213

RF Assignment

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

86/100

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Comment 1 | Engagement with literature(10)

The literature review adequately covers the topic of AM and FM concepts

PAGE 6

PAGE 7

PAGE 8



Comment 2 | Practical Skills (30)

The outputs of AM is well captured.

PAGE 9

PAGE 10



Comment 3 | Knowledge & Understanding(20)

A good comparison is made on the different variations of modulation index.

**Comment 4** | **Cognitive & Intellectual (20)**

Well Done! The designing the Mod- Demod models are well pan and extraordinarily presented.

**Comment 5** | **Knowledge & Understanding(20)**

Good

**Comment 6** | **Practical Skills (30)**

The graphs are up to the required expectations of the tasks. This indeed proves that you have obtained good practical skills from this module.

**Comment 7** | **Cognitive & Intellectual (20)**

Good Job!

**Comment 8** | **Knowledge & Understanding(20)**

It could be more enhanced if some writings were added to this

**Comment 9** | **Transferable Skills (20)**

An outstanding approach of designing and presenting the blocks in DSBSC Modem is seen which is appreciable.

**Comment 10** | **Knowledge & Understanding(20)**

Great job! This truly demonstrates your proficiency in calculating power and skill in comparing the expected and obtained calculations.

**Comment 11** | **Cognitive & Intellectual (20)**

Good Analysis is made by giving different values of DBs and calculating the values of SNR.



Comment 12 |  **Practical Skills (30)**

Good Observations



Comment 13

Well Done



Comment 14 |  **Cognitive & Intellectual (20)**

Your investigations covers more depth which is appreciable.

GRADING FORM: RF

JACK HEEKS

86

ENGAGEMENT WITH LITERATURE(10)

Effectively engage with RF literature by conducting thorough reviews using databases like critically analyzing sources, and ensuring proper

citation. Stay updated on RF technology, collaborate with peers, and consider ethical aspects for comprehensive literature engagement. Adapt to evolving technology and integrate information to enhance understanding.



Good engagement with literature. Solid review of AM literature with sound critical analysis.

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KNOWLEDGE & UNDERSTANDING(20)

Develop expertise in RF communications by mastering core theories, electromagnetic waves, antennas, and modulation techniques. Acquire a comprehensive understanding of RF propagation, collaborating with peers, engaging in research, and seeking mentorship for knowledge enhancement.



Task 1: (a) (i) Exceptional understanding. Clear grasp of AM principles, accurate definitions of signals, and recognition of modulation indices.
Task 1 (a) (ii): Clearly explains critical, over, and under modulation. Demonstrates a deep comprehension of how modulation indices impact the modulated carrier.
Task 1 : (b) Clearly explains the process of demodulating the AM signal and provides a comprehensive comparison with the modulating signal.
Task 2 : (a) Clearly explains the principles of DSB SC modulation and demodulation, highlighting the role and significance of the modulation index.
Task 2 : (b) Clearly explains the process of generating a modulated signal using a real message signal. Demonstrates an in-depth understanding of the principles involved.

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Task 2 : (c) Exceptional application of analysis. The process of adding random noise, demonstrates distortion, and provides various observations on the impact on the original signal.

Task 3 a,b,c : Exceptional application of analyses

COGNITIVE & INTELLECTUAL (20)

Refine cognitive and problem-solving skills in RF communications, emphasizing creativity . Acquire practical proficiency in utilizing simulation tools to optimize the design of RF systems. Foster collaborative abilities to excel in interdisciplinary RF projects.



Task 1 (a) : Exceptional application of analysis, clear presentation and identification of key components.

Task 1 : (b) Exceptional application of analysis. Clearly presents the demodulation process and provides insightful observations in the comparison, indicating a good understanding.

Task 2 : (a) & (b) Strong application of analysis. Articulates the processes with minor areas for improvement. Demonstrates a good understanding of the DSB SC modulation, demodulation, and the modulation index's impact.

Task 2 : (c) Exceptional application of analysis. The process of adding random noise, demonstrates distortion, and provides various observations on the impact on the original signal. Applies critical thinking to draw connections between theory and practical results.

Task 3 (a) & (b) Exceptional application of analysis. Neatly presenting the process of implementing an FM modulator, demodulating, and provides

insightful observations on the frequency and time domain analysis, indeed shows

PRACTICAL SKILLS (30)

Gain hands-on experience in noise modelling and analysis to effectively address noise-related challenges. Utilize software tools to simulate real-world scenarios, ensuring optimal RF system performance while adeptly managing noise issues.

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Task 1 (a) (i) : Exceptional use of tools, clear demonstration of signals, and understanding of their behaviour.

Task 1 (a) (ii): Successfully varies modulation indices, demonstrating a clear understanding of their impact on the modulated carrier. Provides insightful observations.

Task 1 : (b) Successfully observes and demonstrates the demodulated AM signal, providing clear comparisons with the modulating signal.

Task 2 &3 : (a) Successfully implements the DSB SC modulation using a Balanced Modulator, demodulates it,. Provides insightful observations.

Task 2&3 : (b) Successfully generates a modulated signal using a real message signal, demonstrates frequency domain consistency between DSBSC modulator and demodulator.

Task 2&3: (c) Successfully adds random noise, demonstrates distortion, and effectively explains the impact on the original signal in both time and frequency domains.

TRANSFERABLE SKILLS (20)

Demonstrating proficiency in organization and time management is crucial for efficient project planning. Uphold ethical principles, showcasing responsible research conduct and adherence to industry standards.



Strong transferable skills are evident with effective communication, good organization, and evident time management. The report is well-structured but may benefit from minor improvements in clarity.

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