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Radio Propagation: Estimating AM and FM Signal Range Using C3

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Abstract :

The main motive of this paper is to use C programming language for the calculations of distances of AM and FM waves based on their frequencies and powers. Previous papers have predominantly addressed different methods and formulas for finding the distance, yet an easy way to know it remains underexplored. The process behind the transmission is, the AM or FM waves are transmitted using different modulation techniques through transmission towers in the form of carrier waves and received through receiving antenna by demodulation. The findings hold the practical significance for diverse communication situations by finding the travelling range of AM and FM waves. This paper contributes to the people, whose works are based on signal transmissions, by easily knowing the travelling range of AM and FM waves of various frequencies and powers they can easily plan, where to construct new towers for transmission and can know the range of already constructed towers, facilitating applications in fields such as communication, engineering and signal transmission.

Keywords : Amplitude Modulation(AM), Frequency Modulation(FM), Modulation, Demodulation, Applications, Radio communication, Signal transmission.

I. INTRODUCTION

Amplitude modulation (AM) is a modulation technique used in electronic communication, most commonly for transmitting messages with a radio wave. In amplitude modulation, the amplitude (signal strength) of the wave is varied in proportion to that of the message signal, such as an audio signal. This technique contrasts with angle modulation, in which either the frequency of the carrier wave is varied, as in frequency modulation, or its phase, as in phase modulation. On other hand, Frequency modulation (FM) is the encoding of information in a carrier wave by varying the instantaneous frequency of the wave. This technology is used in telecommunications, radio broadcasting, signal processing, and computing. In analog frequency modulation, such as radio broadcasting, of an audio signal representing voice or music, the instantaneous frequency deviation, i.e. the difference between the frequency of the carrier and its center frequency, has a functional relation to the modulating signal amplitude. Basically in electronics, telecommunications and mechanics, modulation means varying some aspect of a continuous wave carrier signal with an information bearing modulation waveform, such as an audio signal which represents sound, or a video signal which represents images. In this sense, the carrier wave, which has a much higher frequency than the message signal, carries the information. At the receiving station, the message signal is extracted from the modulated carrier by demodulation.

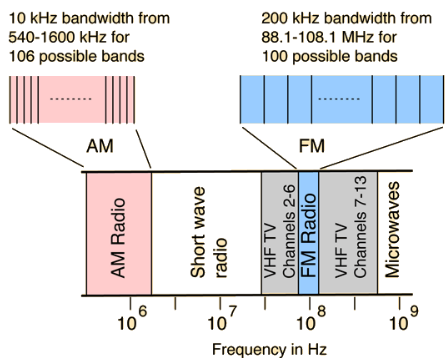

Fig. 1 : Frequency range of AM and FM waves

As shown in fig. 1, AM waves travel with the frequency ranging between 540 to 1600 kilohertz(this range may vary based on antennas and more different aspects) and FM waves travel with the frequency ranging between 88.1 to 108.1 megahertz(similar to AM waves, FM waves frequency range also varied based on antennas, but mostly they travel in these ranges).

II. METHODOLOGY

Generally, the methodology of Amplitude Modulation and Frequency Modulation is based on two processes i.e., Modulation and Demodulation(excluding applications and challenges).

A. AMPLITUDE MODULATION(AM)

Modulation circuit designs may be classified as low- or high-level (depending on whether they modulate in a low-power domain—followed by amplification for transmission—or in the high-power domain of the transmitted signal).[1]

Firstly, low-level generation In modern radio systems, modulated signals are generated via digital signal processing (DSP). With DSP many types of AM are possible with software control (including DSB with carrier, SSB suppressed-carrier and independent sideband, or ISB). Calculated digital samples are converted to voltages with a digital-to-analog converter, typically at a frequency less than the desired RF-output frequency. The analog signal must then be shifted in frequency and linearly amplified to the desired frequency and power level (linear amplification must be used to prevent modulation distortion). This low-level method for AM is used in many Amateur Radio transceivers. AM may also be generated at a high level, using analog methods.[1][2]

Coming to high-level generation, High-power AM transmitters (such as those used for AM broadcasting) are based on high efficiency class-D and class-E power amplifier stages, modulated by varying the supply voltage. Older designs (for broadcast and amateur radio) also generate AM by controlling the gain of the transmitter's final amplifier (generally class-C, for efficiency).

Demodulation techniques for Amplitude Modulation (AM) involve extracting the original message signal from the modulated carrier wave. Common methods include:

First one in this list is Envelope detection. A straightforward technique that rectifies the AM signal to obtain its envelope, followed by smoothing. Simple but can introduce distortion, especially at high modulation indices.[2] Second one is synchronous detection or Coherent detection. It Involves using a coherent local oscillator synchronized with the carrier signal. This method provides better demodulation quality compared to envelope detection but requires precise synchronization. And the third one is Product detector. Similar to synchronous detection but simpler. It employs a mixer to generate the product of the received signal and a local oscillator. Effective for both AM and SingleSideband (SSB) demodulation.[1][2]

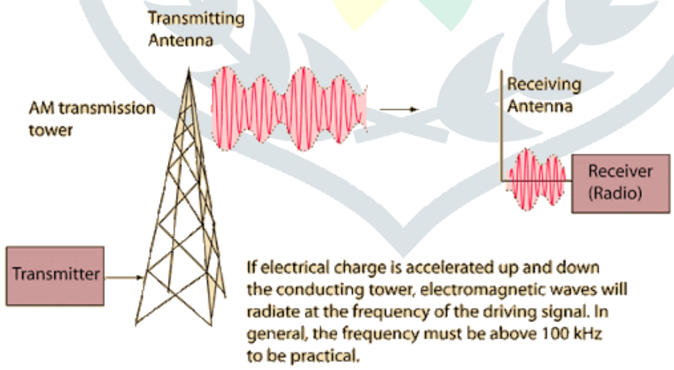

Fig. 2 : Transmitting of AM wave using transmitter and receiver

As shown in above fig. 2 and as mentioned in above paragraphs, to transmit an AM wave modulation techniques are used to modulate it, then it is sent to transmitting antenna and it is transmitted to the receiver, then the wave gets demodulated using demodulation techniques. Hence, final signal will be received.[3]

B. FREQUENCY MODULATION(FM)

FM signals can be generated using either direct or indirect frequency modulation. Direct FM modulation can be achieved by directly feeding the message into the input of a voltage-controlled oscillator. For indirect FM modulation, the message signal is integrated to generate a phase modulated signal. This is used to modulate a crystal-controlled oscillator, and the result is passed through a frequency multiplier to produce an FM signal. In this modulation, narrowband FM is generated leading to wideband FM later and hence the modulation is known as indirect FM modulation.[4]

Coming to demodulation, many FM detector circuits exist. A common method for recovering the information signal is through a Foster–Seeley discriminator or ratio detector. A phase-locked loop can be used as an FM demodulator. Slope detection demodulates an FM signal by using a tuned circuit which has its resonant frequency slightly offset from the carrier. As the frequency rises and falls the tuned circuit provides a changing amplitude of response, converting FM to AM. AM receivers may detect some FM transmissions by this means, although it does not provide an efficient means of detection for FM broadcasts. In Software-Defined Radio implementations the demodulation may be carried out by using the Hilbert transform (implemented as a filter) to recover the instantaneous phase, and thereafter differentiating this phase (using another filter) to recover the instantaneous frequency. Alternatively, a complex mixer followed by a bandpass filter may be used to translate the signal to baseband, and then proceeding as before.[5] This whole process of Modulation and Demodulation of AM and FM waves happens in the same time based on respective frequency range(as mentioned in fig. 1), so that we send and receive signals or information as shown in fig. 3 and fig. 2.

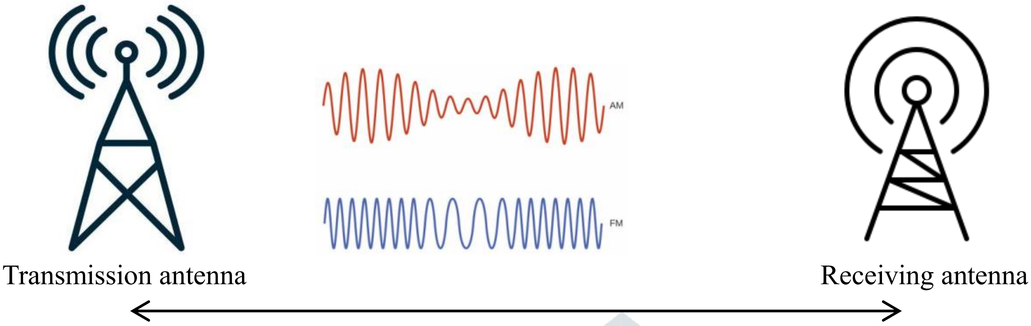

Fig. 3 : Block diagram of AM and FM transmission

RELATION BETWEEN DISTANCE, POWER AND FREQUENCY :

$$d = \sqrt{\frac{\lambda}{4\pi}}\left(\frac{Pt}{Pr}\right)^2$$

Where, λ = speed of light / frequency

The above equation which gives relation between distance, power(Transmitting power(Pt) and Receiving power(Pr)) and wavelength(λ) is derived from Friss transmission formula, which was proposed by Harald T. Friss. This derived equation is known as Free Space Path Loss(FSPL) formula, In this formula, we even have directivity of antennas, but as we are considering the antennas are isotropic. Hence the directivity becomes 1. Using this formula, the distance travelled by AM and FM waves can be calculated in the free space. Basically, this formula is used to calculate the distance travelled by AM and FM waves in free space i.e. in air and in different layers of atmosphere(mostly Ionosphere) as shown in fig.4. [6]

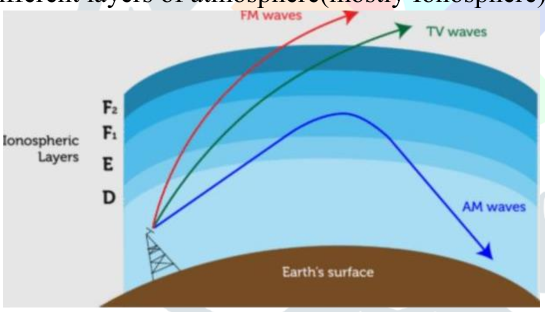

Fig. 4 : Transmission of waves through Ionospheric layers

Based on flowchart shown below, a C program is designed to calculate the distance, To compile the program, navigate to the directory containing the source code file using a terminal or command prompt. Use the GCC command with your chosen C compiler to compile the source code file and generate an executable named amfm. In the terminal or command prompt, enter the command to execute the amfm executable, compiling the program to find the distances based on given inputs will be done. Compiling the program involves following its instructions. Follow any provided instructions for inputting data or selecting options. The program should handle the required calculations based on user input and display the results accordingly. After completing the desired tasks, exit the program as instructed. Pay attention to any error messages displayed during compilation or execution for troubleshooting.

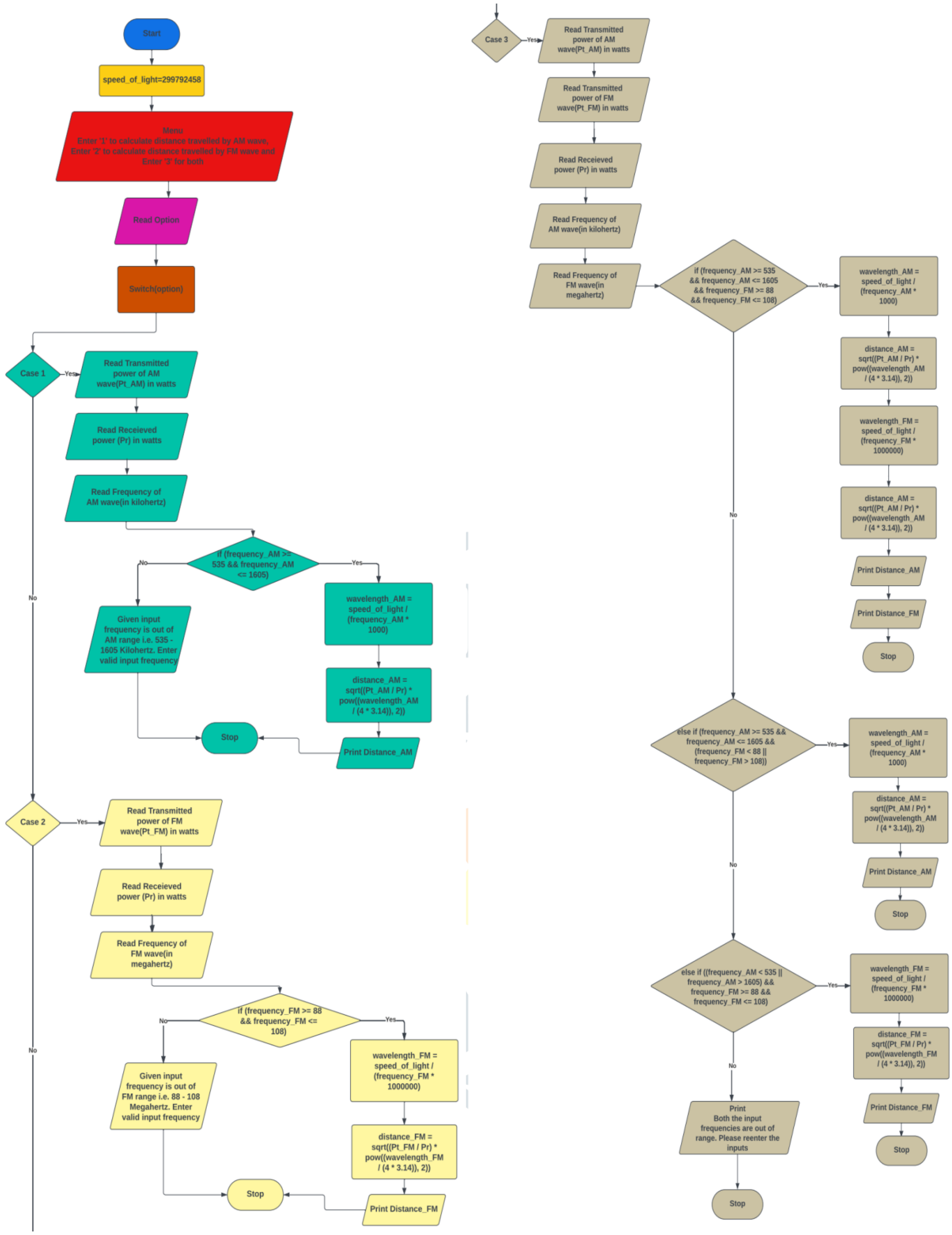

Fig. 5 : Flowchart to calculate distance travelled by a FM wave and an AM wave

III. RESULTS

From figure 5, based on that flowchart we can calculate distance travelled by an AM wave or an FM wave or even both at a time, by taking power(transmitting power and receiving power) and frequency. Here, the inputs(powers and frequency) are taken in a specified units. Following table shows, few sample results

Table - 1 : Calculation of distances of AM and FM waves of different frequencies of distances travelled by AM and FM waves, which are calculated with the help of C program.

Serial No.	*Type of Modulation*	*Transmitting power (watts)*	*Receiving Power (watts)*	*Frequency*	*Distance (Kms)*
01.	AM	1000	15	700 KHz	278.41
02.	AM	1000	16	800 KHz	235.8
03.	AM	1000	17	900 KHz	203.4
04.	AM	1500	19	1000 KHz	212.08
05.	AM	1500	21	1100 KHz	183.3
06.	AM	1500	25	1200 KHz	154.07
07.	FM	2700	20	91.1 MHz	3044.2
08.	FM	2700	10	91.9 MHz	4267.7
09.	FM	2700	18	92.7 MHz	3153.5
10.	FM	3300	12	93.5 MHz	4233.3
11.	FM	3300	14	98.3 MHz	3727.9
12.	FM	3300	13	104 MHz	3656.6

The below figures i.e. fig. 6,7 and 8 are few examples of the compilation of the C program to know the distances.

```
Enter '1' to calculate distance travelled by AM wave
Enter '2' to calculate distance travelled by FM wave
Enter '3' for both
Enter the option: 1
Enter Transmitting power of AM wave (in watts): 1000
Enter Receiver power (in watts): 15
Enter Frequency of AM wave (in kilohertz): 700
Distance travelled by AM wave is 278411.643477 meters or 278.411643 kilometers
```

Fig. 6 : Calculation of distances travelled by AM wave

Taking option '1' as input, distance travelled by an AM wave based on power and Frequency is measured(while giving input frequency, the measurement should be in kilohertz for AM waves and it should range from 540 to 1600 kilohertz). Here, the output of the AM wave is calculated in 0.2 seconds based on given inputs, as output is distance, so it is displayed in meters and kilometers.

```
Enter '1' to calculate distance travelled by AM wave
Enter '2' to calculate distance travelled by FM wave
Enter '3' for both
Enter the option: 2
Enter Transmitting power of FM wave (in watts): 2700
Enter Receiver power (in watts): 20
Enter Frequency of FM wave (in megahertz): 91.1
Distance travelled by FM wave is 3044244.785476 meters or 3044.244785 kilometers
```

Fig. 7 : Calculation of distances travelled by FM wave

Taking option '2' as input, distance travelled by an FM wave based on power and Frequency is measured(while giving input frequency, the measurement should be in megahertz for FM waves and it should range from 88 to 108 megahertz). Here, the output of the FM wave is calculated in 0.223 seconds based on given inputs, as output is distance, so it is displayed in meters and kilometers.

```
Enter '1' to calculate distance travelled by AM wave
Enter '2' to calculate distance travelled by FM wave
Enter '3' for both
Enter the option: 3
Enter Transmitting power of AM wave (in watts): 1000
Enter Transmitting power of FM wave (in watts): 2600
Enter Receiver power (in watts): 17
Enter Frequency of AM wave (in kilohertz): 800
Enter Frequency of FM wave (in megahertz): 92.7
Distance travelled by AM wave is 228831.925962 meters or 228.831926 kilometers
Distance travelled by FM wave is 3184296.816646 meters or 3184.296817 kilometers
```

Fig. 8 : Calculation of distances travelled by both AM and FM waves

Taking option '3' as input, distances travelled by both AM and FM waves are calculated, as we are choosing to calculate to both the distance, Hence two different sets of inputs are given, they should match with the requirements, then the outputs of AM and FM waves are displayed along with time taken . Here, the time taken to calculate the distances of both AM and FM waves is 0.22 seconds. (The whole Calculations may differ, when we take real life situations, as we have obstacles and many more
parameters to calculate)

IV. CONCLUCSION

This study of Amplitude Modulation (AM) and Frequency Modulation (FM) underscores their enduring significance in telecommunications. Coexistence of AM and FM reflects the subtle needs of modern communication systems. While AM persists in certain applications due to its simplicity and familiarity, FM's superior performance in terms of sound quality and noise resistance makes it the preferred choice for many high-fidelity audio and broadcasting applications. Moreover, advancements in digital signal processing and modulation techniques continue to enhance the capabilities of both AM and FM systems, leading to hybrid modulation schemes and innovative approaches aimed at further signal transmission reliability. Looking ahead, the evolution of telecommunications technology will likely see continued innovation in modulation and demodulation techniques, with a focus on improving efficiency, reliability, and adaptability to evolving communication needs by employing many programming languages. Through this endeavor, this paper contributes to the accessibility and practicality of AM and FM waves travelling range computation, thereby enhancing understanding and utilization within relevant disciplines.

V. REFERENCES

1. Roder, Hans. "Amplitude, phase, and frequency modulation." Proceedings of the Institute of Radio Engineers 19.12 (1931): 2145-2176.
2. Henquin, Jean-Claude. "Regulation of insulin secretion: a matter of phase control and amplitude modulation." Diabetologia 52.5 (2009): 739-751.
3. Moore, Brian CJ, and Aleksander Sek. "Effects of carrier frequency, modulation rate, and modulation waveform on the detection of modulation and the discrimination of modulation type (amplitude modulation versus frequency modulation)." The Journal of the Acoustical Society of America 97.4 (1995): 2468-2478.
4. Tse, K. K., et al. "A comparative study of carrier-frequency modulation techniques for conducted EMI suppression in PWM converters." IEEE transactions on industrial electronics 49.3 (2002): 618-627.
5. Gasquet, H., and A. J. Wootton. "Variable-frequency complex demodulation technique for extracting amplitude and phase information." Review of scientific instruments 68.1 (1997): 1111-1114.
6. Obot, I. B., and Ikenna B. Onyeachu. "Electrochemical frequency modulation (EFM) technique: Theory and recent practical applications in corrosion research." Journal of Molecular Liquids 249 (2018): 83-96.