If The Frequency Of A FM Wave Is 8. 85 107 Hertz, What Is The Period Of The FM Wave? A. 2. 58 108 Seconds

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Understanding the fundamental properties of electromagnetic waves, such as frequency and period, is crucial in physics and engineering. In particular, frequency modulation (FM) waves play a vital role in telecommunications, broadcasting, and wireless technology. When given a specific frequency, calculating the period of the wave becomes an essential step in analyzing wave behavior. This article delves into the concepts behind frequency and period, provides a detailed calculation of the period for an FM wave with a given frequency, and explores related topics to enhance your comprehension.

What Is Frequency and Period in Electromagnetic Waves?

Definition of Frequency

Frequency refers to the number of oscillations or cycles an electromagnetic wave completes in one second. It is measured in hertz (Hz), where 1 Hz equals one cycle per second. For example, if a wave oscillates 8,851,070 times in one second, its frequency is 8,851,070 Hz.

Definition of Period

The period of a wave is the time taken to complete one full cycle. It is the reciprocal of the frequency, meaning that as the frequency increases, the period decreases, and vice versa. The period is measured in seconds (s).

Mathematically, the relationship between period (T) and frequency (f) is expressed as:
\[T = \frac{1}{f} \]

Understanding the Given Frequency: 8.85 x 10^7 Hz

The provided frequency is 8.85 x 10^7 Hz, which is scientific notation for 88,500,000 Hz. This value indicates a very high-frequency wave, typical of radio frequency (RF) signals used in FM broadcasting and other wireless communications.

Context of Such Frequencies in FM Waves

FM radio signals generally operate within the frequency range of approximately 88 MHz to 108 MHz (megahertz). The given frequency falls within this range, suggesting this could be representative of a typical FM broadcast wave.

Calculating the Period of the FM Wave

Given the frequency, calculating the period involves applying the inverse relationship. Let's proceed step-by-step.

Step 1: Write Down the Formula

$$
T = \frac{1}{f}
$$

Step 2: Substitute the Given Frequency

$$
T = \frac{1}{8.85 \times 10^7 \text{ Hz}}
$$

Step 3: Calculate the Reciprocal

Using a calculator:

$$
T \approx \frac{1}{8.85 \times 10^7} \approx 1.129 \times 10^{-8} \text{ seconds}
$$

This is approximately 11.29 nanoseconds (ns).

Step 4: Express the Result in the Given Options

The options are generally presented in scientific notation as well. The question states "A. 2.58 x 10^8 seconds," but based on our calculations, the period is roughly 1.13 x 10^-8 seconds, which suggests a potential typo or misinterpretation in the options.

Note: The value "2.58 x 10^8 seconds" is vastly larger than the actual period for this frequency, indicating that the correct period is closer to 10^-8 seconds, not 10^8 seconds.

Understanding the Discrepancy in the Options

The options provided may contain a typographical error or may refer to a different aspect of the wave. For accurate calculation, the key takeaway is:

- The period T of an FM wave with frequency \(8.85 \times 10^7\) Hz is approximately 1.13 x 10^-8 seconds.

If the options are precise, none match this value exactly, but the closest understanding is that the period is on the order of nanoseconds.

Practical Significance of the Wave's Period

Knowing the period of an FM wave helps in various practical applications:

- **Signal Timing:** Designing receivers and transmitters that can accurately process signals within specific time frames.
- **Bandwidth Calculations:** Understanding how fast the wave oscillates aids in allocating appropriate bandwidths.
- **Wave Propagation Analysis:** Shorter periods (higher frequencies) generally mean more rapid oscillations, influencing how signals propagate and attenuate.

Related Concepts in Wave Physics

1. Wavelength and Its Relationship to Frequency and Speed

The wavelength (λ) of an electromagnetic wave is related to its speed (c) and frequency (f) as:

$$
\lambda = \frac{c}{f}
$$

where c is approximately 3×10^8 meters per second in a vacuum.

For our frequency:

$$
\lambda = \frac{3 \times 10^8}{8.85 \times 10^7} \approx 3.39 \text{ meters}
$$

2. Speed of Electromagnetic Waves

Electromagnetic waves travel at the speed of light in a vacuum, which is approximately 3×10^8 m/s. This constant allows us to relate frequency, wavelength, and speed seamlessly.

3. Modulation Techniques in FM

Frequency modulation involves varying the frequency of the carrier wave in accordance with the information signal. The high frequency and short period are critical for transmitting audio signals with high fidelity.

Conclusion

Understanding the period of an electromagnetic wave given its frequency is fundamental in physics and engineering. For an FM wave with a frequency of 8.85×10^7 Hz, the period is approximately 1.13×10^{-8} seconds, or about 11.3 nanoseconds. This rapid oscillation underscores the high-frequency nature of FM radio signals, enabling high-quality audio transmission over long distances. Mastery of these concepts not only aids in theoretical understanding but also plays a crucial role in designing and optimizing communication systems.

In summary:

- Frequency and period are inversely related.
- High-frequency waves have very short periods.
- Precise calculations are essential for designing effective communication systems.
- The given options may contain typographical errors; the calculated period is approximately \(1.13 \times 10^{-8}\) seconds.

By grasping these principles, students and professionals alike can better understand the behavior of electromagnetic waves and their applications in modern technology.

Frequently Asked Questions

What is the formula to calculate the period of a wave given its frequency?

The period (T) of a wave is the reciprocal of its frequency (f), given by $T = 1/f$.

What is the frequency range of FM waves in the given problem?

The frequency range provided is from 8.85 Hz to 107 Hz.

How do you calculate the period of an FM wave with a frequency of 8.85 Hz?

Using $T = 1/f$, so $T = 1/8.85 \approx 0.113$ seconds.

What is the significance of the period in wave analysis?

The period indicates the time taken for one complete cycle of the wave, important for understanding wave behavior.

Is the given answer of 2.58 x 10^8 seconds accurate for the wave with frequency 8.85 Hz?

No, the accurate period is approximately 0.113 seconds; 2.58 x 10^8 seconds is not correct for 8.85 Hz.

How does the frequency of an FM wave affect its period?

Higher frequency results in a shorter period, while lower frequency results in a longer period.

What is the importance of understanding wave period in communication systems?

The wave period affects signal timing, synchronization, and bandwidth management in communication systems.

Why might there be confusion about the period of an FM wave in this problem?

Because the given answer (2.58 x 10^8 seconds) does not align with the reciprocal of the provided frequency, indicating a possible error or misinterpretation.

Additional Resources

Frequency and Period in FM Waves: A Comprehensive Analysis

Understanding the fundamental properties of electromagnetic waves, especially in the context of Frequency Modulation (FM), is crucial for both academic pursuits and practical applications such as broadcasting, telecommunications, and signal processing. One key parameter that often arises in this domain is the relationship between the frequency of a wave and its period. This article delves into the specific case where the FM wave's frequency is given as 8.85 × 10^7 Hertz (Hz), and we are tasked with determining its period—highlighting the scientific principles, mathematical relationships, and real-world implications involved.

The Basics of Frequency and Period in Electromagnetic Waves

Understanding the core concepts of frequency and period is foundational for grasping the behavior of FM waves. These two parameters are intrinsically linked, representing different aspects of the wave's oscillatory nature.

What Is Frequency?

Frequency (denoted as \(f\)) refers to how many complete oscillations or cycles a wave completes in one second. It is measured in Hertz (Hz), where:

- 1 Hz = 1 cycle per second

In the context of radio waves, including FM signals, the frequency determines the wave's position within the electromagnetic spectrum. For example, FM radio broadcasts typically operate within the range of about 88 MHz to 108 MHz, where 1 MHz equals 1 million Hz.

In our case, the given frequency is:

$$
f = 8.85 \times 10^7\, \text{Hz}
$$

which is equivalent to 88.5 MHz, comfortably within the FM broadcasting band.

What Is Period?

Period (denoted as T) is the duration of time it takes for one complete cycle of the wave to occur. Essentially, it measures how long a single oscillation lasts, and it is measured in seconds.

Mathematically, period is the reciprocal of frequency:

$$
T = \frac{1}{f}
$$

This inverse relationship means that as frequency increases, the period decreases, and vice versa.

Calculating the Period of the FM Wave

Given the wave's frequency, calculating the period is straightforward using the fundamental formula:

$$
T = \frac{1}{f}
$$

Step-by-Step Calculation

Given:

$$
f = 8.85 \times 10^7\, \text{Hz}
$$

then:

$$
T = \frac{1}{8.85 \times 10^7}
$$

Calculating this:

$$
T \approx \frac{1}{88,500,000}
$$

which yields:

$$
T \approx 1.129 \times 10^{-8}\, \text{seconds}
$$

Expressed more clearly:

$$
T \approx 11.29\, \text{nanoseconds}
$$

since 1 nanosecond = 10^{-9} seconds.

Final Result and Comparison

The calculated period:

$$
\boxed{
T \approx 11.29 \text{ nanoseconds}
}
$$

This indicates that each cycle of the FM wave lasts approximately 11.29 billionths of a second, a remarkably brief interval characteristic of high-frequency radio signals.

Understanding the Significance of the Result

The period of approximately 11.29 nanoseconds holds several implications, both theoretically and practically, especially within the context of FM broadcasting.

Implications for Signal Processing and Transmission

- High Frequency, Short Period: The extremely short period signifies that the wave oscillates very rapidly. Such rapid oscillations enable the transmission of large amounts of information over the wave, which is essential for high-quality audio broadcasting.

- Bandwidth Considerations: FM signals at this frequency (around 88.5 MHz) are within the standard FM broadcast band. The short period correlates with high bandwidth requirements, influencing receiver design, antenna specifications, and modulation techniques.

- Timing Precision: In digital signal processing, understanding the period helps in timing synchronization, filter design, and error correction strategies to ensure the fidelity of transmitted audio.

Relevance to Real-World Applications

- Broadcasting: FM radio stations operate within this high-frequency range, and knowing the period assists engineers in designing transmitters and receivers that can efficiently handle these rapid oscillations.

- Wireless Communications: Similar principles apply in cellular networks, Wi-Fi, and other wireless technologies, where wave periods affect data rates and transmission quality.

- Scientific Research: Precise knowledge of wave periods enables scientists to develop better models for electromagnetic wave propagation, interference, and signal attenuation.

Theoretical Context and Broader Perspectives

While our focus is on a specific FM wave frequency, understanding the broader context enriches our appreciation of electromagnetic wave behavior.

Relationship to Wavelength

The wavelength (λ) of a wave is related to its frequency and the speed of propagation:

$$
\lambda = \frac{v}{f}
$$

where:

- v is the speed of light in vacuum ($\approx 3 \times 10^8\, \text{m/s}$)
- f is the frequency

Applying this:

$$
\lambda = \frac{3 \times 10^8}{8.85 \times 10^7} \approx 3.39\, \text{meters}
$$

This confirms that the wave's wavelength is approximately 3.39 meters, a practical size for antenna design and placement.

Significance of the Frequency-Period Relationship

Understanding the inverse relationship is fundamental in physics and engineering:

- Designing antennas: Antennas are often a fraction or multiple of the wavelength.
- Filtering and tuning: Electronic components are tuned based on the wave's period and frequency.
- Signal integrity: Knowledge of timing and oscillation helps in minimizing noise and distortion.

Conclusion: The Value of Precise Calculation and Its Implications

In conclusion, for an FM wave operating at a frequency of 8.85×10^7 Hz, the period is approximately 11.29 nanoseconds. This brief duration underscores the rapid oscillatory nature of high-frequency radio signals, with broad implications across communication technology, signal processing, and scientific research.

Key Takeaways:

- The inverse relationship between frequency and period allows straightforward calculation.
- The period's brevity is characteristic of radio frequencies used in FM broadcasting.
- This understanding informs the design of transmission systems, antennas, and receivers.
- The wave's wavelength (~3.39 meters) aligns with practical antenna dimensions.

By understanding these fundamental properties, engineers and scientists can continue to innovate and optimize the transmission and reception of electromagnetic signals, ensuring efficient communication in our increasingly connected world.

Note: The provided answer aligns with the multiple-choice option of "2.58 × 10^8 seconds" as the period. However, based on standard physics calculations, the actual period for 8.85 × 10^7 Hz is approximately 11.29 nanoseconds, which is a much smaller value. The initial multiple-choice appears to be a typographical or formatting error, but the precise scientific calculation remains as shown.

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