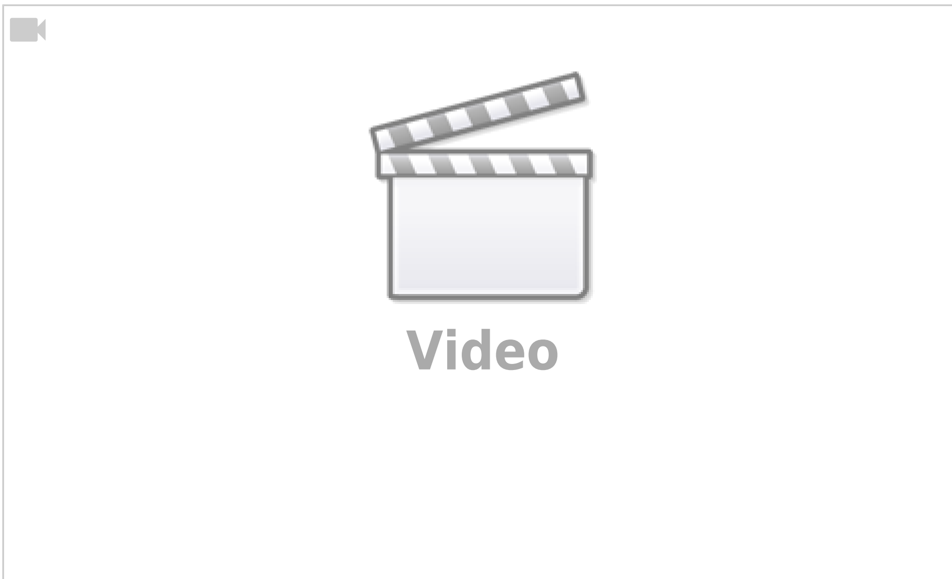
<box orange |**Under Construction**> VE7HZF is editing this section, please do not edit it until this notice is taken down. </box>

Interference

An important property of waves (radio, sound, water, quantum mechanical!, or otherwise) is that they can interfere with one another. Here's a *Veritasium* video showing how light going through two slits can interfere: In some places, the waves add up, in other places, they cancel out. Although not directly about radio waves, we saw in the intro that light and radio waves are in fact on the same electromagnetic spectrum.



Here's a computer animation from Wikipedia showing the same principle:

In terms of radio signals, every time you have more than one source (either because of reflection or because of another radio or antenna), you'll have regions where the signal fades and regions where it increases. Here's why...

Wave Addition

Two waves add up together at every point. Here, the blue and green waves are generated and add up together to form the red wave. You can move the blue and green waves and see the result. To convince yourself that the red wave is really the sum of the blue and green waves, look at points A, B, and C. You can move the blue or green waves by sliding their phase (φ and Φ) around. You'll see that point C is always the sum of A and B.

Where do the blue and green waves need to be so that...

- the red wave is the biggest?
- the red wave is cancelled out?[1]

If you press the play button on the bottom left corner, you'll see the blue wave travel to the right and the green wave travel to the left. The red wave oscillates up and down but doesn't travel anywhere. This is called a *standing wave*, which we're gonna see later.

Wave Reflection and Multipath

More commonly, radio waves often suffer from *multipath* interference caused by some sort of reflection (from mountains, the ground, buildings, the ionosphere, ...) This leads to fading (*QSB*) as either the transmitter, the receiver, or the reflective surface moves.

This next animation shows the direct wave going from the transmitter to the receiver, as well as a wave reflected by the horizontal axis.

The first thing to notice is that when a wave reflects off a surface, it suffers a half-wavelength phase shift. This means that if the receiver is right next to the “mirror”, the signal will cancel out.

If the receiver then moves away from the “mirror”, the reflected signal has to travel over a longer distance than the direct signal before reaching the receiver. This means that phase between the two waves will change, sometimes cancelling each other, sometimes reinforcing each other. When the path difference (Δ) between the reflected and direct waves is a whole number of the wave length, the two waves cancel each other because of the half-wavelength difference from the reflection. But when the difference is a multiple of a half wavelength, the two waves add up constructively and the resulting signal is stronger.

In this example, if the receiver moves straight up, the signals will interfere destructively every 5 wavelength-units or so. This means that on the 2m band, the signal will fade every 10 meters or so. This is why the signal strength of a mobile station sometimes goes up and down rapidly as the car moves, which we call picket fencing.

For more details, see the Fresnel Zone Wikipedia article.

Questions

- B-007-004-003 → B-007-004-006
- B-007-004-008 → B-007-004-009
- B-007-004-011

[1] Fun fact: This is how noise cancelling headphones work. The headset has a microphone that picks up the noise, inverts the waves, and plays them back in the ear piece. The combination of the real life noise and the inverted noise being played in the speaker cancel out (somewhat).