PLTW Engineering

10-12/Signal to Noise Ratio

April 29, 2020

10-12/DE

Lesson: **4/29/2020**

Students will be able to determine the strength of radio signals in relation the noise that tends to obscure it.

What is a radio signal?

Radio waves, like light waves, are part of the electromagnetic spectrum.

Radio waves have long wavelengths, low frequencies, and important for our ground based communications, they penetrate Earth's atmosphere.

What is a radio signal?

Unlike x-rays and shorter wavelengths, you don't have to protect yourself from them because they are harmless to humans.

All of these characteristics make radio waves an ideal choice for carrying signals for our radios and cell phones as well as for carrying signals to and from spacecraft.

How radio waves travel

Like all waves of the electromagnetic spectrum, radio waves travel at the speed of light.

The speed of light in a vacuum is 299 792 458 meters per second, often approximated simply as 3 x 108 m/s.

Radio waves used in space travel

Not only do spacecraft transmit valuable data, but also spacecraft "health" information is returned to Earth through these communication systems.

It is important to know that the spacecraft's power systems, heating and cooling systems, and instruments are all operating as expected.

Radio waves used in space travel

When you turn on the light switch the light seems to reach your eyes instantaneously.

However, if you happen to be a mission operations flight controller sending an important command to a spacecraft, a signal that must travel many billions of kilometers, even the speed of light can seem slow.

What is meant by signal “noise”

The signal from the spacecraft is not only extremely faint, it is mixed with “noise.” This noise comes from all objects in the universe and is always present in space.

As the spacecraft gets farther away, the background noise remains at a somewhat constant level. So as the signal becomes fainter it becomes more difficult to distinguish it from the noise.

Signal to Noise Ratio (SNR)

The signal-to-noise ratio (SNR) compares how much of the desired signal we receive with the noise we receive.

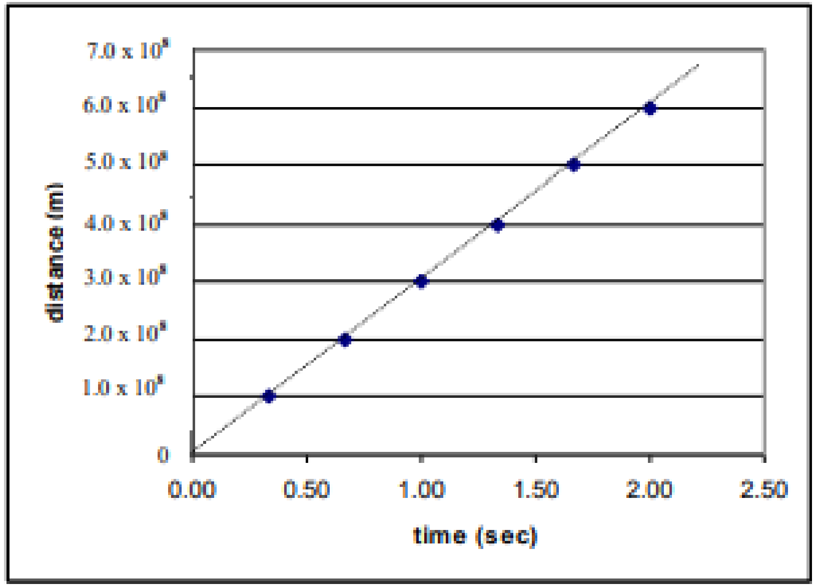
A larger SNR indicates a stronger signal, or one that is easier to distinguish from the background.

So as the spacecraft travels farther away, the SNR gets smaller.

Signal to Noise Ratio Graphs

The data below indicates the longer a signal has to travel, the longer it will take to arrive at its destination.

time (sec)	distance (m)
0.33	1.0×10^8
0.67	2.0×10^8
1.00	3.0×10^8
1.33	4.0×10^8
1.67	5.0×10^8
2.00	6.0×10^8



Signal to Noise Ratio Graph Questions

Use the information from the data and graphs below to answer the questions on the following slides.

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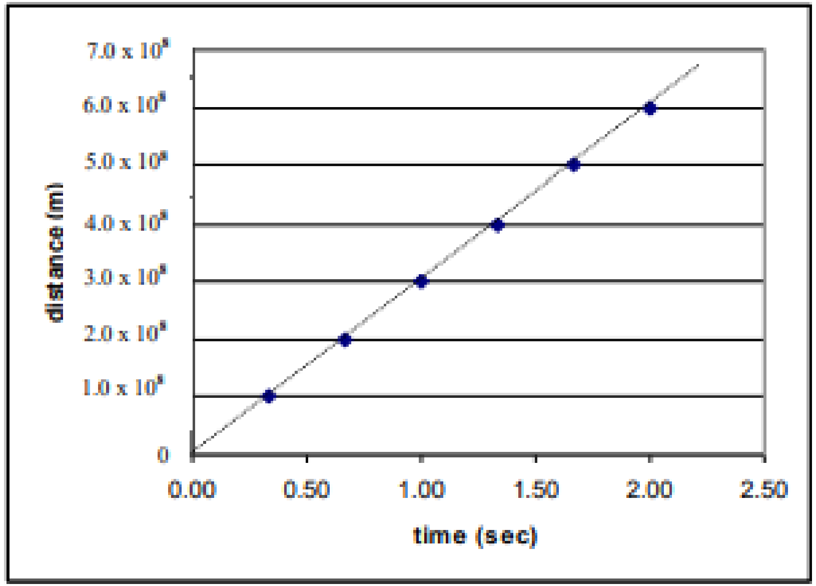

Signal to Noise Ratio Graph Questions

Use the information from the data and graphs below to answer the questions on the following slides.

1. If the signal traveled to the Moon (about 4.0 x 108 meters) in 1.33 seconds, how long would it take to travel 8.0 x 108 meters?

2. Would a signal traveling from Earth to the Moon and back arrive at Earth a) before b) after or c) at the same time as the signal that traveled 8.0 x 108 meters?

Helpful links

A computer science based view of signal to noise ratio

Video on mathematical relationships and signal to noise ratio