Student Notes

In this investigation, students will learn the relationships between radio (RF) transmitters and receivers in a technological system. Students will use the Vex Robotics System in a laboratory setting and conduct scientific inquiry-based experiments to determine the effect of transmitter antenna length and position on signal strength relative to the receiver. Students will construct a basic model of a working system that includes a radio transmitter, receiver, controller and motor driven output. Students will gain an understanding of math and science concepts related to frequency and the time period of a sinusoidal signal (sine wave).

The underlying scientific factor that allows the precise transmission frequency of the transmitter lies within the crystal chosen by the VEX engineers. The exact same crystal then must be used for the receiver. The existing phenomenon that allows the precise frequency generation is call resonance. An explanation of resonance and its application to crystals will be provided.

Students will apply engineering notation to determine frequency and time period calculation and demonstrate the ability to use a calculator programmed for engineering notation to easily determine the appropriate unit.

This investigation consists of 5 activities: four of which are lab based. These activities support robotics instruction and participation in competitive events.

Introduction to resonance

The fundamental concept to be considered in this presentation is resonance. The definition of resonance is the induction on a physical object of vibrations by a vibrating force having the same frequency. When dealing with resonance, strange behavior of physical objects may be observed. A drastic demonstration can be seen in the video of the bridge constructed over the Puget Sound in the state of Washington. Every bridge is constructed to vibrate at some natural, or resonant frequency. However, the civil engineers who designed this bridge erred when they did not check to determine the value of the bridge's resonant frequency. It turned out that the bridge's natural frequency was equal to the frequency of the wind that flows from the Puget Sound and across the bridge. During resonant conditions, energy from the wind is transferred to the bridge and the amplitude of the bridge vibration became larger and larger until the maximum bridge forces were exceeded and the bridge was destroyed.

For another example of resonance consider a trumpet and a kettledrum, tuned to the note of "E", placed in the same room. If the trumpet were to play the "E" note, the sound wave would leave the trumpet, and travel through the air. The air molecules would then vibrate against the surface of the drum and, because the drum is tuned to the same frequency, the drum will vibrate with an audible sound.

Resonance in electronic circuits

The relationship between resonance and crystals is critical for this exercise. The crystal placed in the transmitter is contained in a circuit called an oscillator. The oscillator circuit then uses a concept called feedback to send electrons to vibrate the crystal in the same manner that the air molecules vibrated the kettledrum. This will cause the crystal to vibrate at its resonance frequency and the oscillator circuit will send a sinusoidal signal to an amplifier. The amplified signal will then travel to an antenna where the electrical signal is changed to an electromagnetic wave that will travel through the air.

The VEX receiver circuit uses an antenna to receive all electromagnetic waves in its vicinity changing these waves to an electrical signal. An amplifier then amplifies the

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Figure 1

Figure 2

electric signal and is sent to a circuit containing a crystal. If the amplified signal is at the same frequency of the crystal, then the crystal circuit generates a large sinusoidal signal. Upon the generation of this sinusoidal signal another circuit will be initiated causing the motor to be activated.

Antenna transmission

There are two basic ways the electromagnetic wave leaves the transmitting antenna. The first is the axial method of transmission. Here the energy of the electromagnetic wave leaves the antenna in a manner that light leaves a flashlight as illustrated in figure 1.

The second method of antennal transmission is the radial method. Here the energy of the electromagnetic wave radiates in a radial direction as shown in figure 2.