Introduction

Radio direction finding (DF), the science of determining the location of radio transmission sources, has a wide range of personal, commercial, and governmental applications. Over the past century, the methods used in DF have grown from simply turning an antenna by hand into using multiple antenna-arrays and complex computer algorithms to resolve the direction of arrival of incoming radio waves. This paper outlines some of the recent applications of direction finding and explains the technology behind those applications along with the building blocks that make up a DF system.

Commercial DF Applications

Current applications employing direction finding technology are numerous and diverse. One such use in the commercial arena is handheld avalanche beacons. Traditionally, ski patrol are equipped with direction finders to locate a trapped skier wearing a transmitting beacon. However, innovations in technology have allowed manufacturers to produce small handsets that can operate as a transmitter and a direction finding locator. This allows two or more skiers to each carry a beacon, so they can quickly locate an avalanche victim without having to wait for ski patrol [1]. Another innovative commercial DF device, designed by the DaimlerChrysler Corporation, employs a direction finder in a key fob that communicates with a car. The car owner can use the device to locate the car in a large parking lot [2].

Many departments of the government use direction finding devices. The National Interagency Fire Service, which is comprised of several government agencies, uses direction finding antennas to locate lightning strikes. They use the information to quickly locate and contain wildfires caused by lightning [3].

Radio direction finding is also a popular hobby for many amateur radio enthusiasts. Participants in this activity, sometimes called foxhunting or amateur radio direction finding (ARDF), combine direction finding techniques with orienteering skills to track and locate transmitters. The International Amateur Radio Union, among other organizations, holds ARDF contests every year across the United States [4].

DF Underlying Technology

Modern direction finding systems consist of an array of stationary antennas that can receive signals from any direction. The radio receiver uses the phase or amplitude of
the signal to determine the angle of arrival. Well-designed DF setups have a direction resolution of one to two degrees and a bandwidth that can span from kHz all the way to GHz. Among the current methods used for direction finding are pseudo-Doppler systems, Watson-Watt systems, and Wullenweber systems [5].

The Watson-Watt technique uses the difference in the amplitude of a wave at different locations to find its angle of arrival. Most Watson-Watt systems employ three or four Adcock antennas. All of the antennas are connected to a single receiver. A computer algorithm processes the amplitude information from each antenna to determine the signal's direction [6]. Another system that uses amplitude comparison DF is the Wullenweber. A Wullenweber is a very large array of many circularly disposed antennas. However, this type of system is mainly used by the government, since it is impractical and cost inefficient [7].

The pseudo-Doppler technique compares the difference between the phase of the signal as it is detected in separate antennas. Pseudo-Doppler systems usually consist of three to four antennas. A single receiver sequentially switches between each of the antennas, collecting data about the incident signal. Next, a computer algorithm processes the phase information from the receiver to determine the angle of arrival of the signal. The term "pseudo" distinguishes this DF method from a system that physically moves an antenna around a circle to achieve a true Doppler effect. Actual Doppler direction finders are no longer used [8].

**DF Building Blocks**

Any modern direction finding apparatus consists of four main building blocks. The first part is the antenna array. While most antennas are metal, some companies construct them from polymer composite materials [9]. Direction finder antenna styles include whip, dipole, and Adcock antennas [6]. The distance between antennas in a DF is known as the aperture. Wide aperture direction finders (WADF) spread over a distance greater than one wavelength of the received signal. Conversely, narrow aperture devices usually have a distance of one or two tenths of a wavelength between each antenna [10].

The second building block of a direction finder is the receiver. The receiver takes the signal information from the antenna and demodulates it. DF receivers are usually
specialized to meet the needs of a specific situation, but, in general, they are very similar to an ordinary radio receiver [6].

The third DF component is the processor, sometimes called the bearing processor. The processor performs the algorithm that determines the angle of arrival of a signal. These algorithms can be very simple or very complex, depending on the users needs. A processor can also perform statistical calculations such as averaging techniques to determine the relative importance of a signal [11].

Once the calculations are complete, the processor sends its data to a display, the fourth component of a direction finder. Displays can take on many different forms. Low-end direction finders use a simple magnetic pointer or an LED indicator to show the direction of an arriving signal. More advanced systems have a real-time display that can show signal strength and accurate angle readings [5].

References


