EverSet® Antenna Considerations

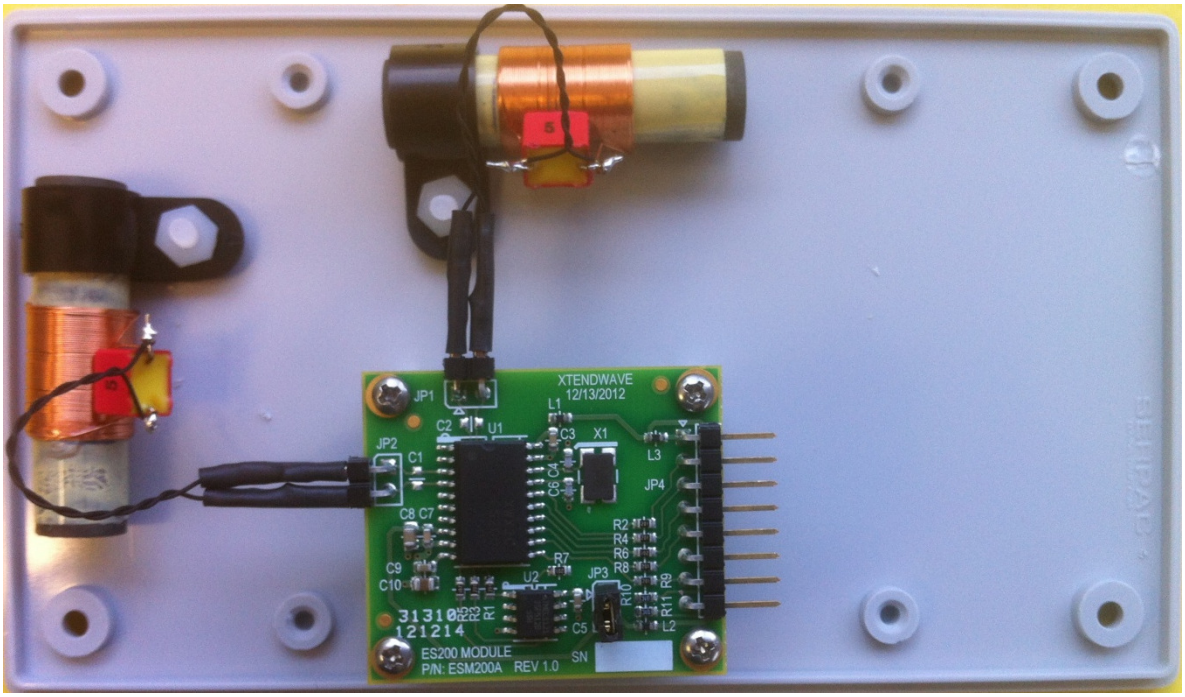
SCOPE

This application note provides information on the advantage of using two antennas in a WWVB receiver design. It will be shown that using two antennas greatly increases the possibility of a successful date and time acquisition.

BACKGROUND

The Everset® product line was designed to receive and decode the enhanced WWVB signal that is broadcast from Fort Collins, Colorado. The broadcast format, detailing the assignment of each bit in the one-minute frame, is described in the document "Enhanced WWVB Broadcast Format", which is available at the NIST Radio Station WWVB website.

Everset® products support two antennas mounted perpendicular to each other, and parallel to the floor, so that regardless of the clock's orientation, at least one antenna will be positioned to receive the signal with minimal loss. Being perpendicular, if one antenna is positioned in a "null", the other will be positioned for optimal signal reception. It is likely that in most orientations, both antennas will receive the signal, thus providing the receiver with a degree of freedom that may be helpful in avoiding interference.



SINGLE ANTENNA LIMITATIONS

Most, if not all, Radio Controlled Clocks (RCC) that are designed to receive the legacy WWVB amplitude modulated signal use only one antenna. This contributes to unreliable indoor reception, which results in a high number of tech support calls and a high rate of clock returns from consumers. This section describes the limitations of using just one antenna.

Figure 1 shows a map of the United States with the circles representing the WWVB signal radiating away from the transmitter in Fort Collins, Colorado. On the right of the circles is a bar that represents a ferrite rod antenna that is oriented broad-side toward Fort Collins. (To simplify the explanation, it is assumed that this ferrite rod antenna is due east of Fort Collins.) This is the optimal orientation for reception; the flux lines of the signal can enter the ferrite at the ends. This typically occurs when the clock face is oriented directly towards Fort Collins or directly away from Fort Collins (i.e. assuming the clock is due east of Fort Collins, it would be mounted on a west-facing or east-facing wall).

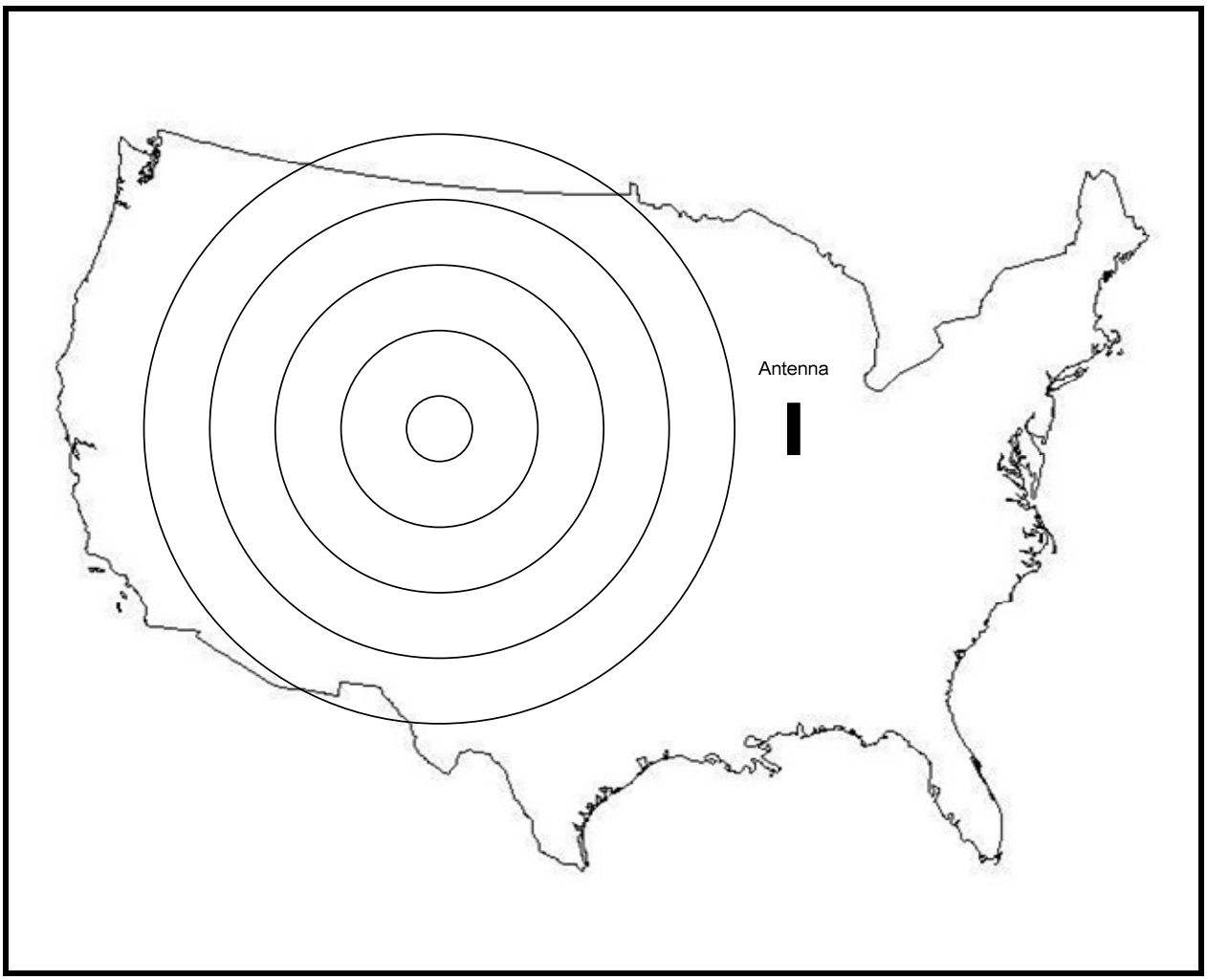


Figure 1 - Single Antenna Oriented Broadside Toward Ft. Collins

Figure 2 shows the single antenna rotated 45° clockwise from the broad-side orientation. In this case, the relative antenna gain is reduced by 3dB (20 log (cos (45°)) = -3dB). This would occur with the clock mounted on a northwest-facing or southeast-facing wall.

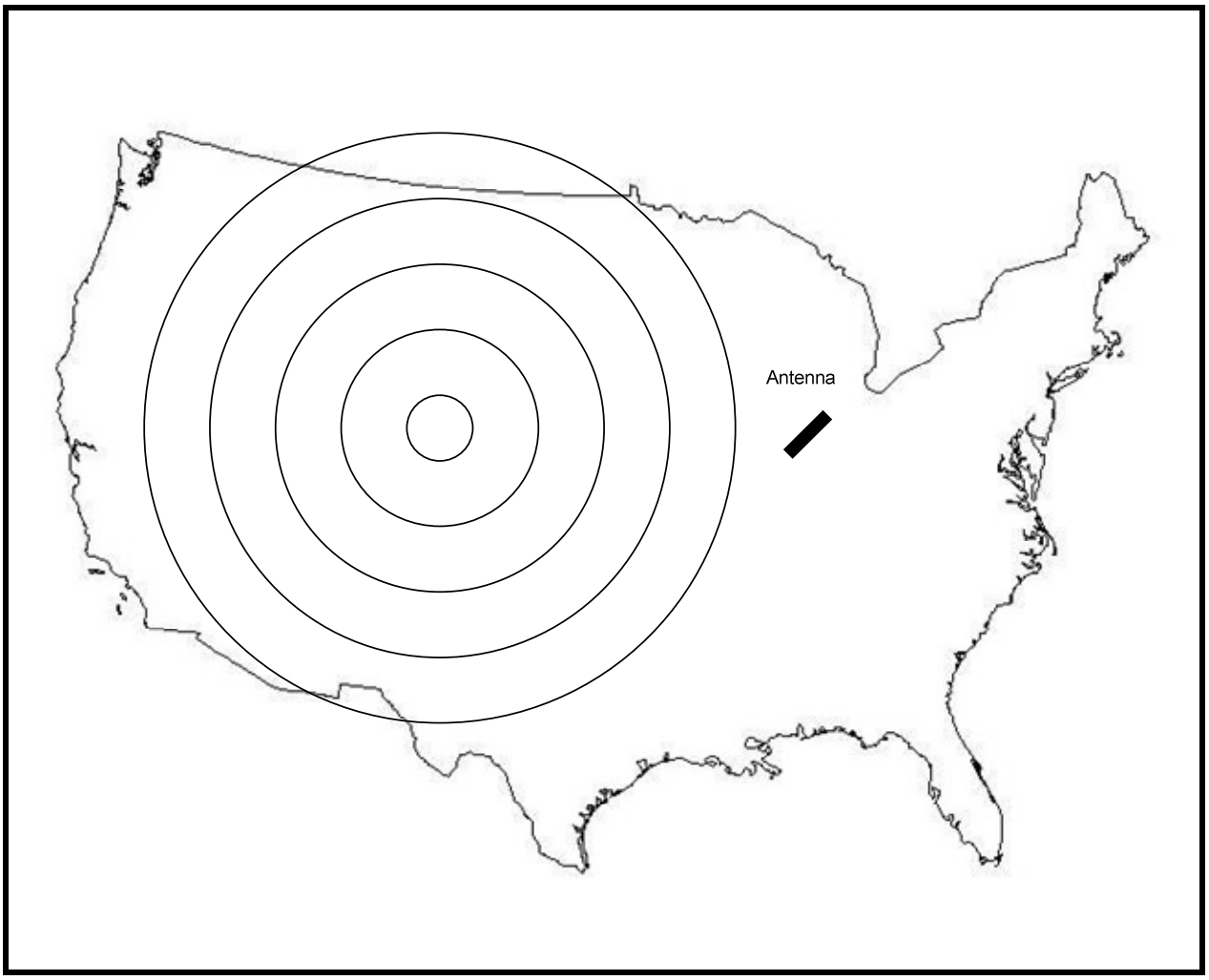


Figure 2 - Single Antenna Rotated 45° Clockwise

Figure 3 shows the single antenna rotated 67.5° clockwise from the broad-side orientation. In this case, the relative antenna gain is reduced by 8dB (20 log (cos (67.5°)) = -8dB). This orientation is likely to be problematic, especially as the distance from the transmitter in Fort Collins increases.

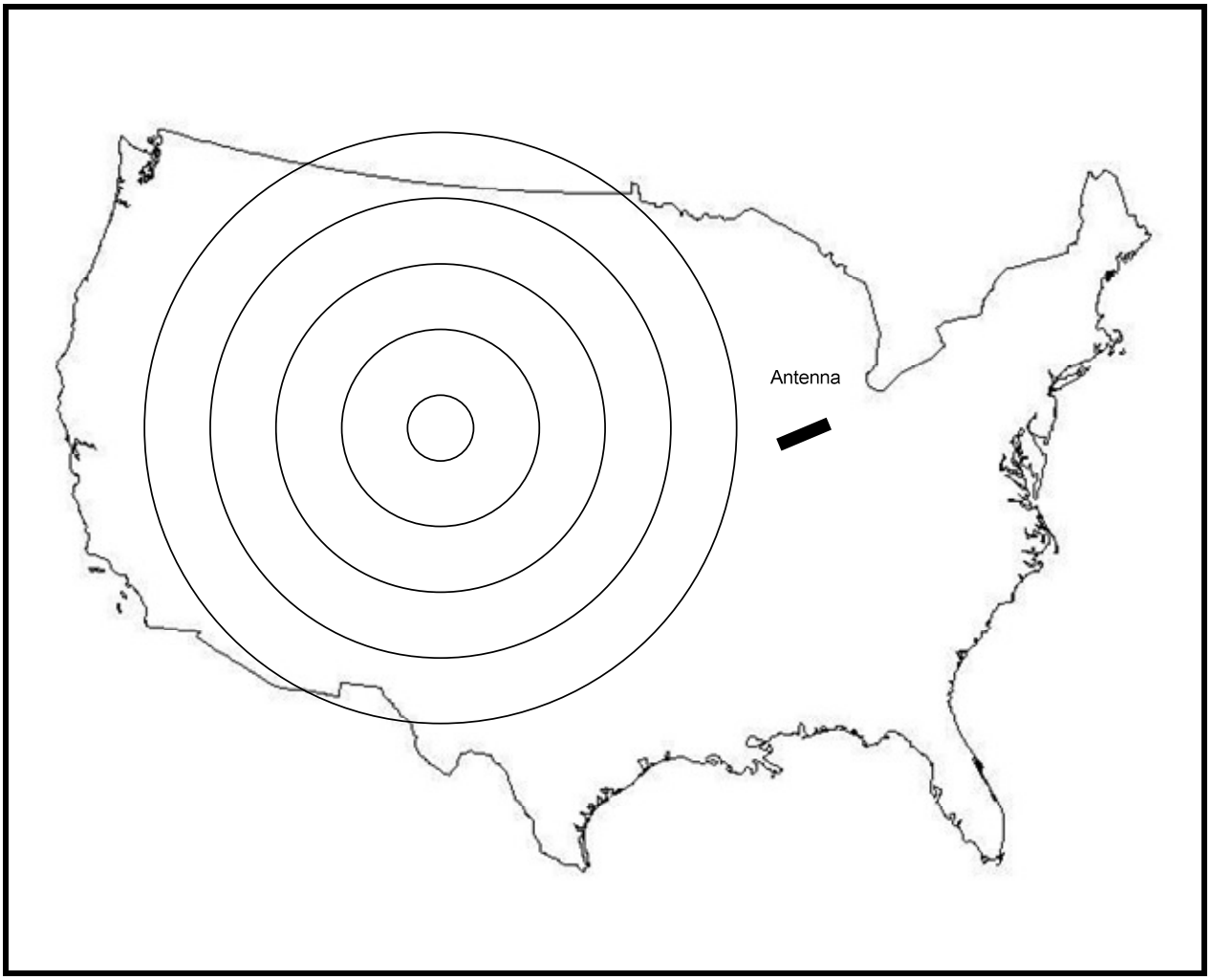


Figure 3 - Single Antenna Rotated 67.5° Clockwise

Figure 4 shows the single antenna rotated 90° clockwise from the broad-side orientation. This typically occurs when the clock face is oriented so that the antenna is parallel to an imaginary straight line to Fort Collins (i.e. assuming the clock is due east of Fort Collins, it would be mounted on a north-facing or south-facing wall). In this case, the relative antenna gain is at its minimum and reception will be nearly impossible, even at night. This is why some legacy RCC instructions suggest moving the clock to another location, etc. Most consumers would prefer to place their clock in the location of their choosing, and have it receive the signal at that location.

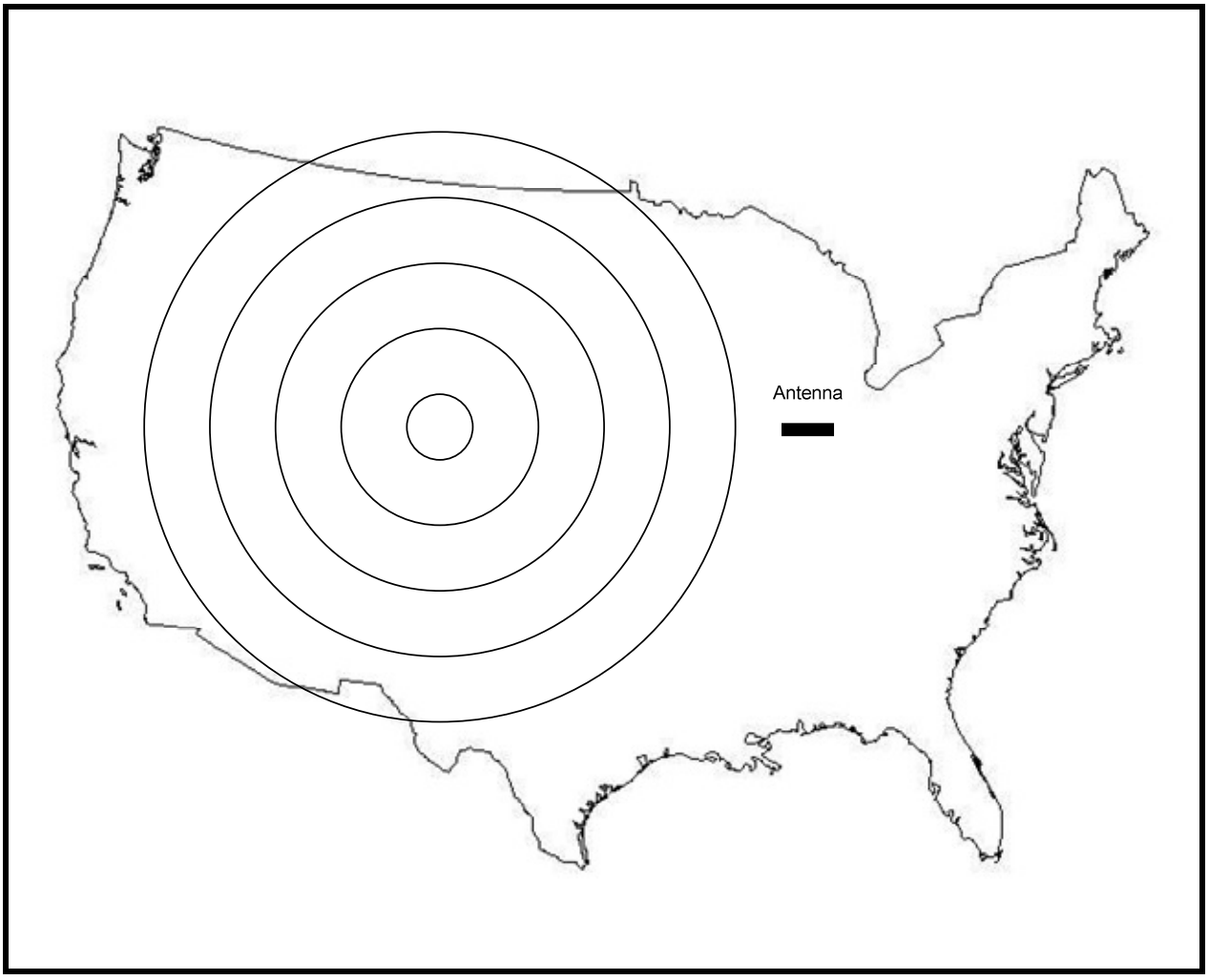


Figure 4 - Single Antenna Rotated 90° Clockwise

DUAL ANTENNA ADVANTAGE

This section explains the advantage of using two antennas to receive the WWVB signal.

Figure 5 shows two ferrite rod antennas, with antenna 1 broadside toward Fort Collins and antenna 2 at 90° relative to antenna 1. In this orientation, antenna 1 gain will be at its maximum and antenna 2 gain will be at its minimum. Reception will be excellent on antenna 1.

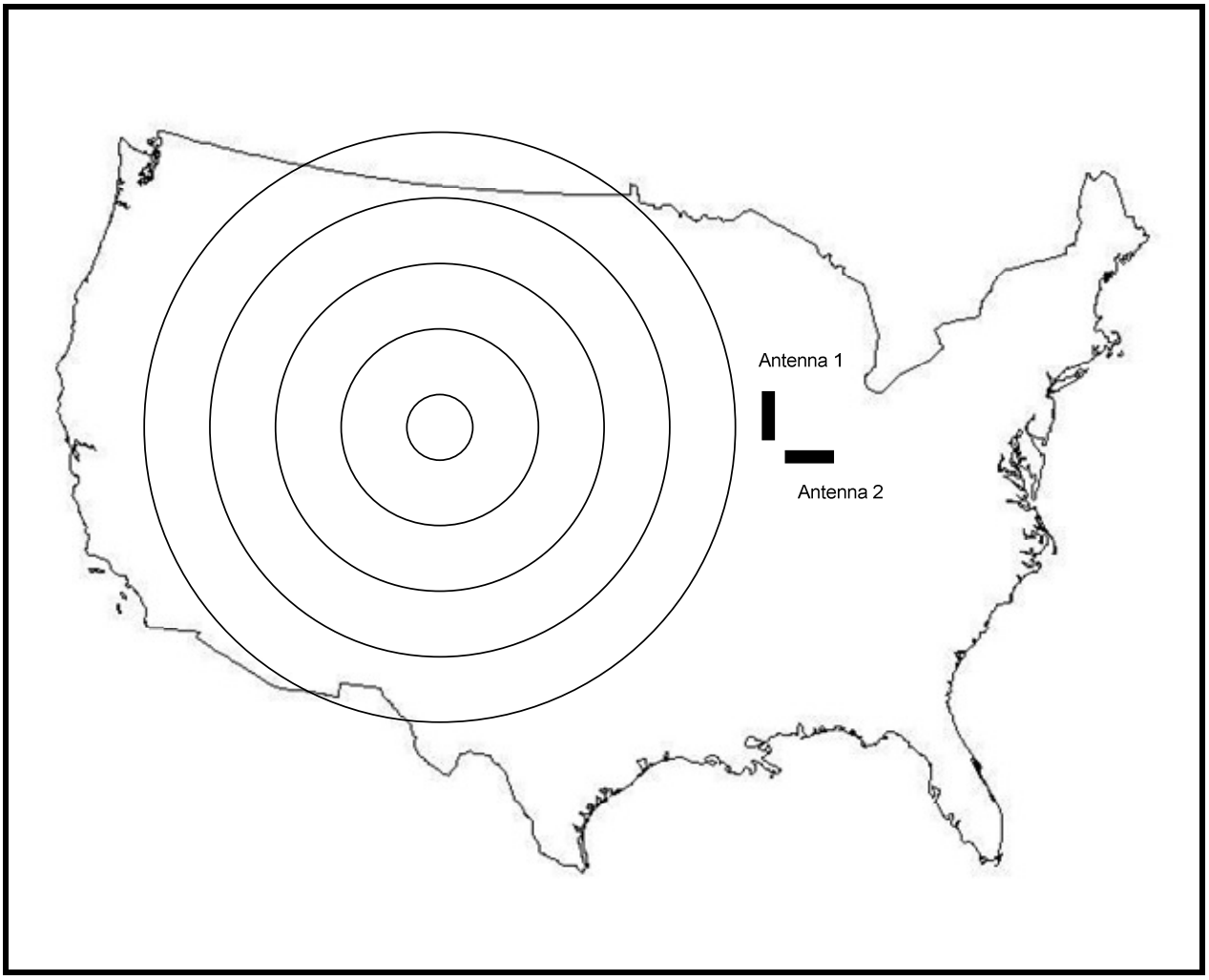


Figure 5 - Dual Antenna With Antenna 1 Oriented Broadside Toward Ft. Collins

As the antenna pair is rotated to 45°, relative to the previous figure, the signal loss on antenna 1 will increase and the signal loss on antenna 2 will decrease. Figure 6 shows both antennas at 45° relative to Fort Collins which results in both antenna gains at 3dB below their maximums. In this orientation, both antennas will be capable of very good reception.

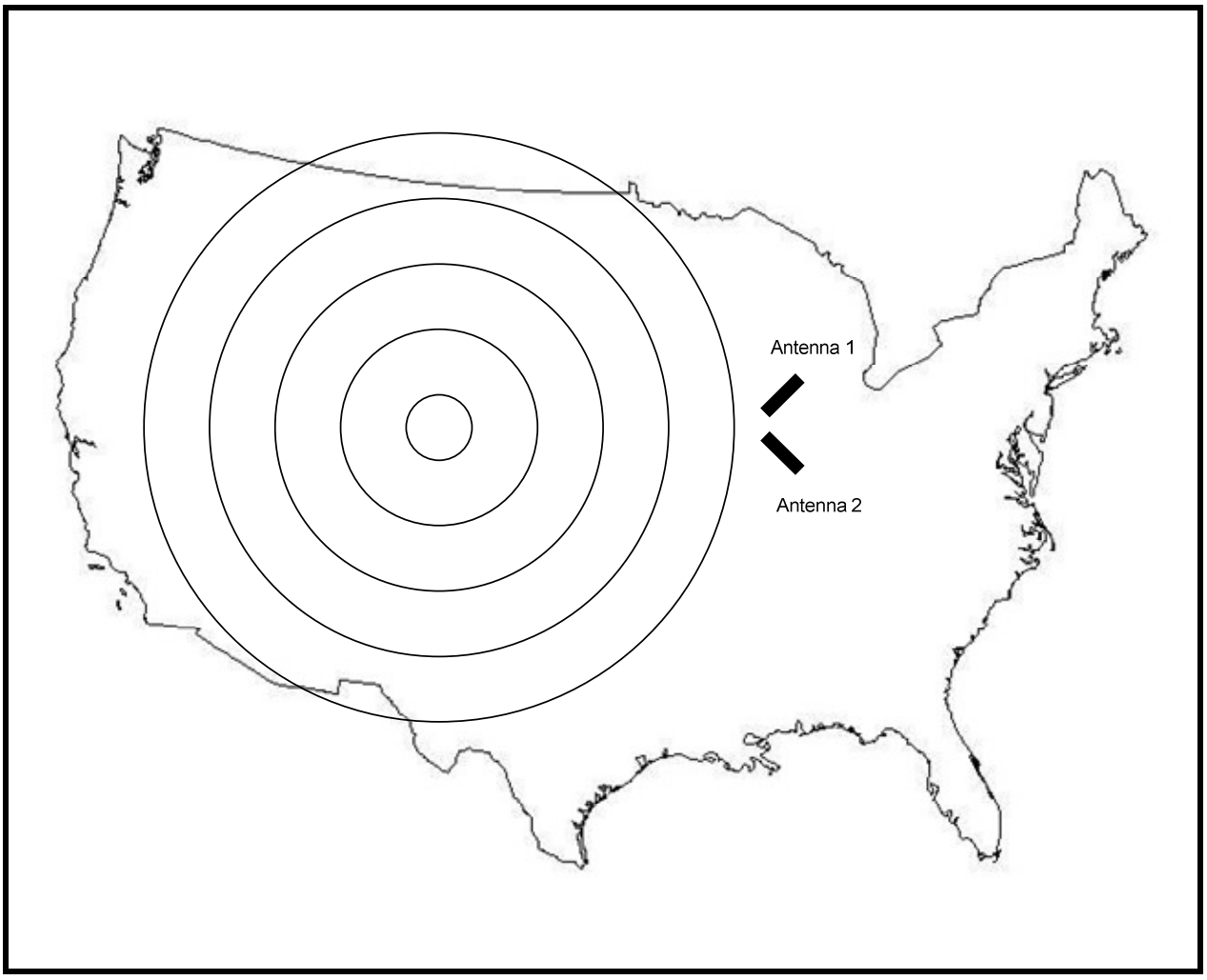


Figure 6 - Dual Antenna Rotated 45° Clockwise

Figure 7 shows the antenna pair rotated 67.5° clockwise from the original orientation. In this case, the relative loss of antenna 1 is increased to 8dB, but the relative loss on antenna 2 decreases to ~1dB. In this orientation, the reception capability on antenna 2 will be excellent.

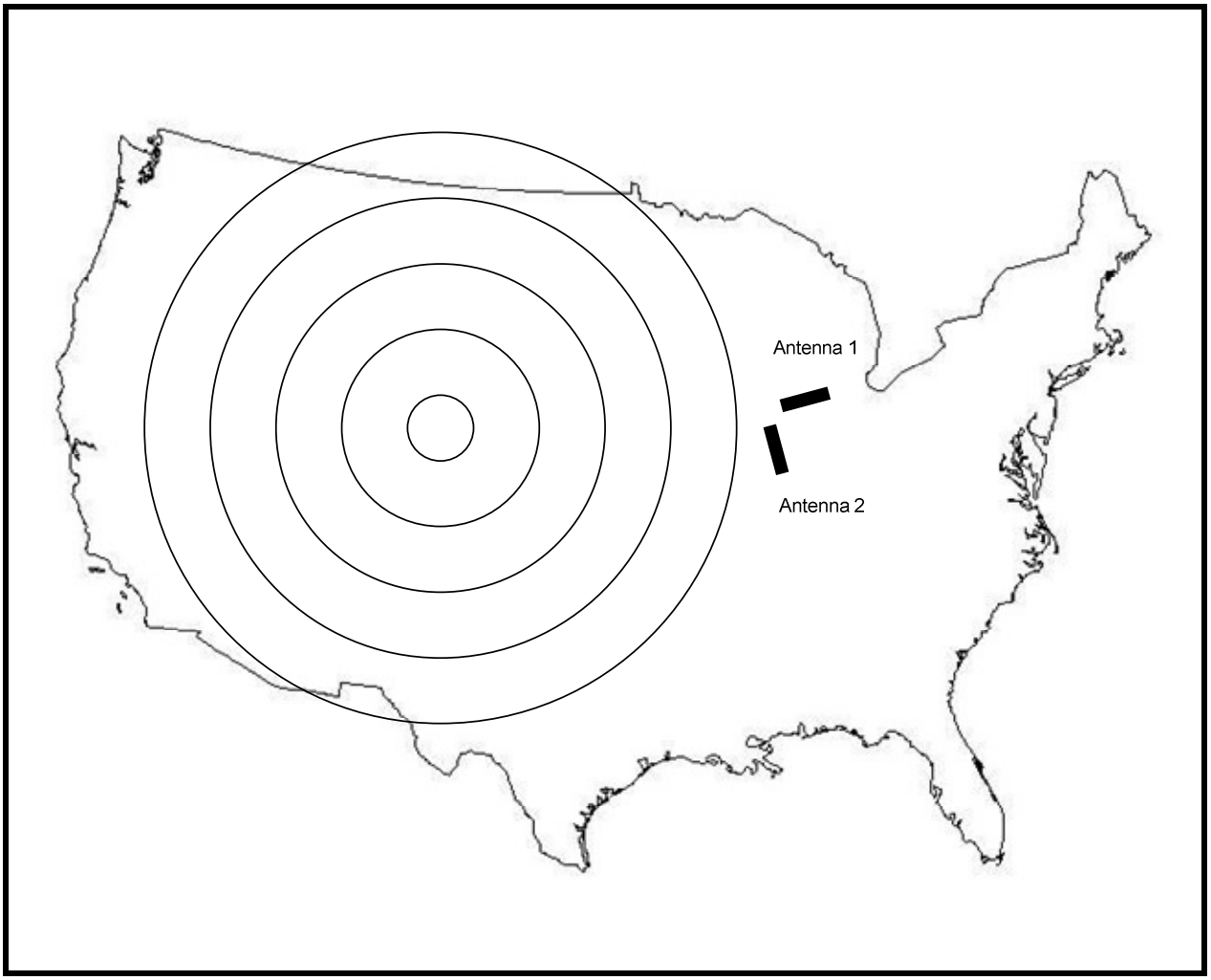


Figure 7 - Dual Antenna Rotated 67.5° Clockwise

Figure 8 shows the antenna pair rotated 90° clockwise from the original orientation. In this case, the relative gain of antenna 1 is reduced to the minimum, but the relative gain of antenna 2 is at its maximum due to its broadside orientation toward Fort Collins. Reception will be excellent on antenna 2.

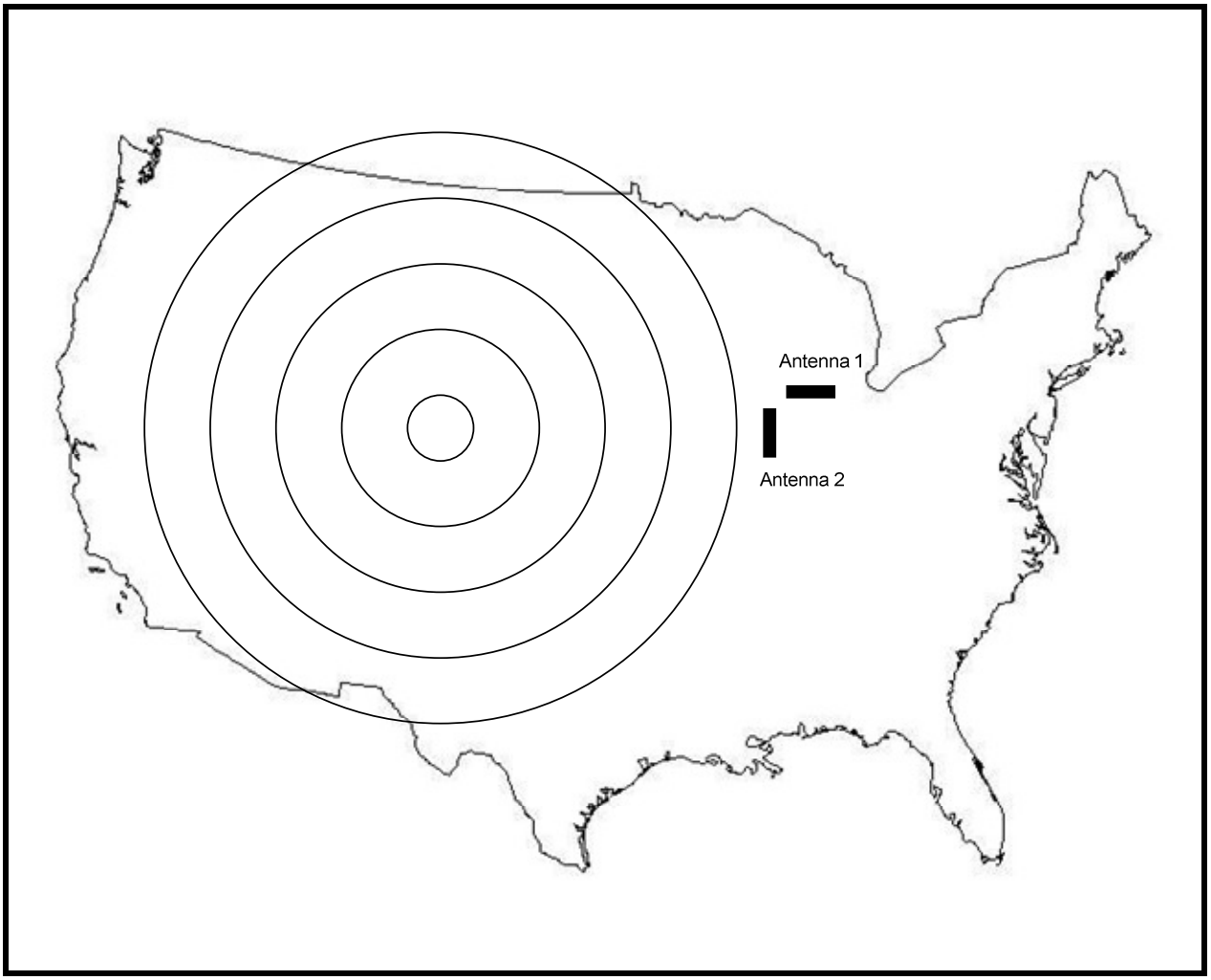


Figure 8 - Dual Antenna Rotated 90° Clockwise

CONCLUSION

For a single antenna, the normalized gain curve for 90° of rotation is shown in Figure 9. With two antennas, mounted orthogonally and parallel to the ground, at least one of the two antennas will always be oriented so that its relative gain is in the 0dB to -3dB range. The normalized gain curve for a dual antenna system is shown in Figure 10. With the Everset® products support for two antenna inputs, along with the inherent improvement in sensitivity due to the new WWVB phase modulated signal, the receiver's ability to acquire and decode the WWVB signal will be greatly improved over legacy single-antenna AM receivers. The end result for the clock manufacturer will be fewer technical support calls and fewer product returns.

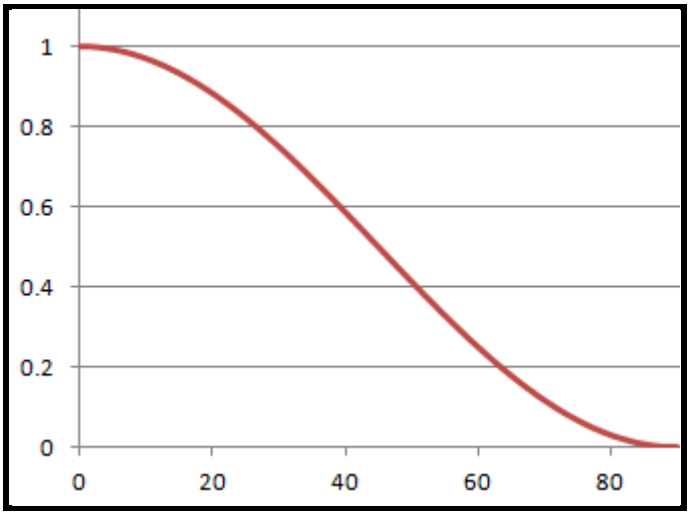


Figure 9 Single Antenna Gain Curve

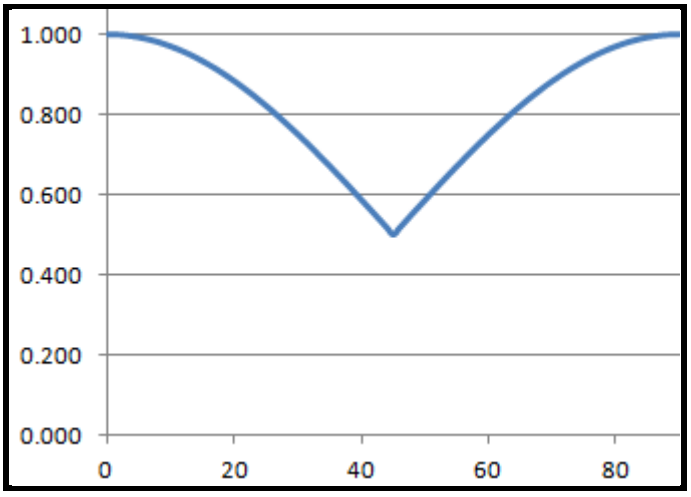


Figure 10 Dual Antenna Gain Curve