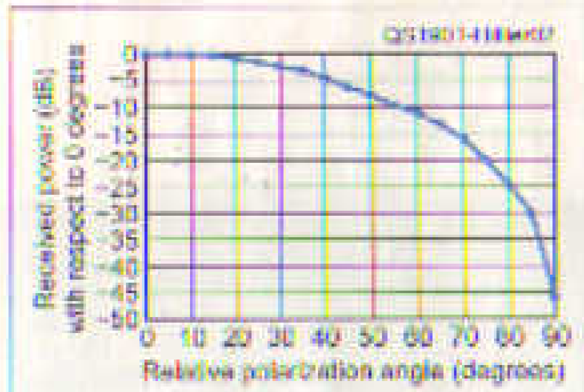

Figure 2 — Results of the polarization test shows the sign drop off as the polarization angles are misaligned.

and reflections substantially reduce the received power. Beyond a certain distance — referred to as the "critical distance" — the power received becomes related to the inverse of the fourth power of the distance when there is just a single ground reflection and the antenna heights are low. This is due to the reflected ray subtracting from the direct ray. In a worst-case scenario under the same conditions and with handheld radios at standing height in simplex communication, the two-ray path model allows a radio range of only 24 kilometers in the 2-meter band, rather than 16,000 kilometers. In this case, with no extra noise, the range with a 20 dB loss would be 7.5 kilometers, and with a 46 dB loss, would be 1.7 kilometers. Of course, this gets worse in the presence of noise. [Propagation losses in various scenarios are described in "Radio Wave Propagation: How Waves Attenuate with Distance," *QST*, Feb. 2016, pp. 37 – 40. — *Ed.*]

So, remarkably, the radio range is still usable, even while purposely trying to maximize cross-polarization loss. This helps explain how people who hold their radios any which way can still communicate. For small differences in antenna orientation angle, there is only minimal signal loss.

Even with 30° cross-polarization, received power is still at 75% — a loss of only 1.25 dB. However, loss can be severe when the angle approaches 90°. While trying to maximize cross-polarization loss, I was able to reduce the signal by 46 dB, or by a factor of 40,000 in power loss. Due to the magic of electronics, even a badly cross-polarized signal can often be received if there is not too much noise. However, for best reception, keep handheld radios oriented vertically.

Circular Polarization

A right-hand circularly polarized radio wave will be cross-polarized with a left-hand circularly polarized antenna, and there can easily be more than 20 dB loss. Signal strength is reduced by 3 dB when a linearly polarized antenna is used to receive a circularly polarized wave, and vice versa. When the orientation between antennas varies (such as with satellite communication between ground and low-Earth orbit [LEO] satellites), circularly polarized antennas can be used to receive linearly polarized satellite radio waves (or vice versa), thereby avoiding polarization fading effects. The penalty is a fixed 3 dB loss, but there will not be a varying signal due to shifting cross-polarization — at least not in the plane defined by the vertical and horizontal polarization orientations. However, remember that there are three dimensions. If the axis of the transmitting antenna is pointed straight at the receiving antenna, the receiving antenna is in the direction of a field null, and no receiving antenna polarization can remedy that.

Interestingly, ground reflections can alter circularly polarized radio waves. At the Brewster angle, the vertical component of a circularly polarized wave drops out and the reflection becomes linearly polarized in the horizontal direction. For normal medium-dry soil, this would correspond to an angle of about 15°. At a grazing angle smaller than the Brewster angle, a reflected right-hand circularly polarized wave will remain right-hand circularly polarized because both the vertical and horizontal components are reflected in the same manner, with a negative reflection. At a grazing angle above the Brewster angle, the reflection will become left-hand polarized (this can be useful to reject reflected signals at large grazing angles). In most cases, the circular polarization will become elliptical because the reflection coefficient for vertical and horizontal polarizations are not generally equal.

Polarized sunglasses also make use of the Brewster angle. The light from the sun is not polarized and so half of the light arriving directly from the sun will be blocked by polarized sunglasses. However, light reflecting off a flat surface at the Brewster angle will only be horizontally polarized. Vertically polarized sunglasses will block these horizontally reflected polarized waves. For angles near the Brewster angle, the vertically polarized waves will still be weak, and the sunglasses will block most of the reflected waves.

Adeline F. Hillier, AA7HH, a Life Member of ARRL and of the American Junior Academy of Science, earned her Technician license in 2013 while in seventh grade, and her Amateur Extra-class license in 2016. She's an active member of the West Seattle Amateur Radio Club, serving at radio outreach events, training Boy Scouts, monitoring local parades, and teaching the electricity, components, and circuits portion of the club's ham radio classes. As a participant in the Washington State Science and Engineering Fair since second grade, she has done several projects related to Amateur Radio — this article is based on one of them. She is currently studying electrical engineering at the Massachusetts Institute of Technology. You can reach Adeline via email at aa7hh2000@gmail.com.

For updates to this article, see the *QST* Feedback page at www.arrl.org/feedback.

> "Remarkably, the radio range is still usable, even while purposely trying to maximize cross-polarization loss."

The Cell Patch

Updating the old phone patch concept to work with cell phones.

Gene Hinkle, K5PA, and Jim Millner, WB2REM

In October 2017, a few weeks after Hurricane Irma devastated Puerto Rico and other Caribbean islands, I heard a faint signal on the 7.163 MHz DX net. The station, originating from the city of Ponce in Puerto Rico, was weak but readable. The radio operator was requesting assistance in contacting his daughter in New Jersey. He needed to be evacuated from the island and had no other means of reaching her.

When the station asked for someone on the frequency to contact his daughter, my first thought was to use a phone patch. Unfortunately, I had gotten rid of mine and now that I no longer had a landline, it wouldn't have worked anyway. In the end, messages were passed and transportation was arranged, but without some sort of phone patch connection, we could not afford the parties the comfort of hearing each other's voices.

In order to be better prepared for the next emergency situation, we developed an easy-to-build cellular phone patch that takes advantage of modern cell phone technology and can be used from both fixed and remote locations.

Cell Patch in the Modern Era

The cell patch is the modern-day version of the original phone patch. A phone patch enables a person on a phone line to talk over a radio under the control of a licensed radio amateur. Last century, these patches were routinely used by people wanting to stay in touch with family members overseas in areas that were not readily accessible by telephone.

The realization that today's cell phones can connect three or more parties in a conference call led to the cell patch concept. Figure 1 shows how the system works. At a local Amateur Radio station, a cell phone connects to the station's transceiver via audio cables from its headphone and microphone jacks. A second cell phone is used to make a call to a third party who will be talking over the radio channel. The local transceiver

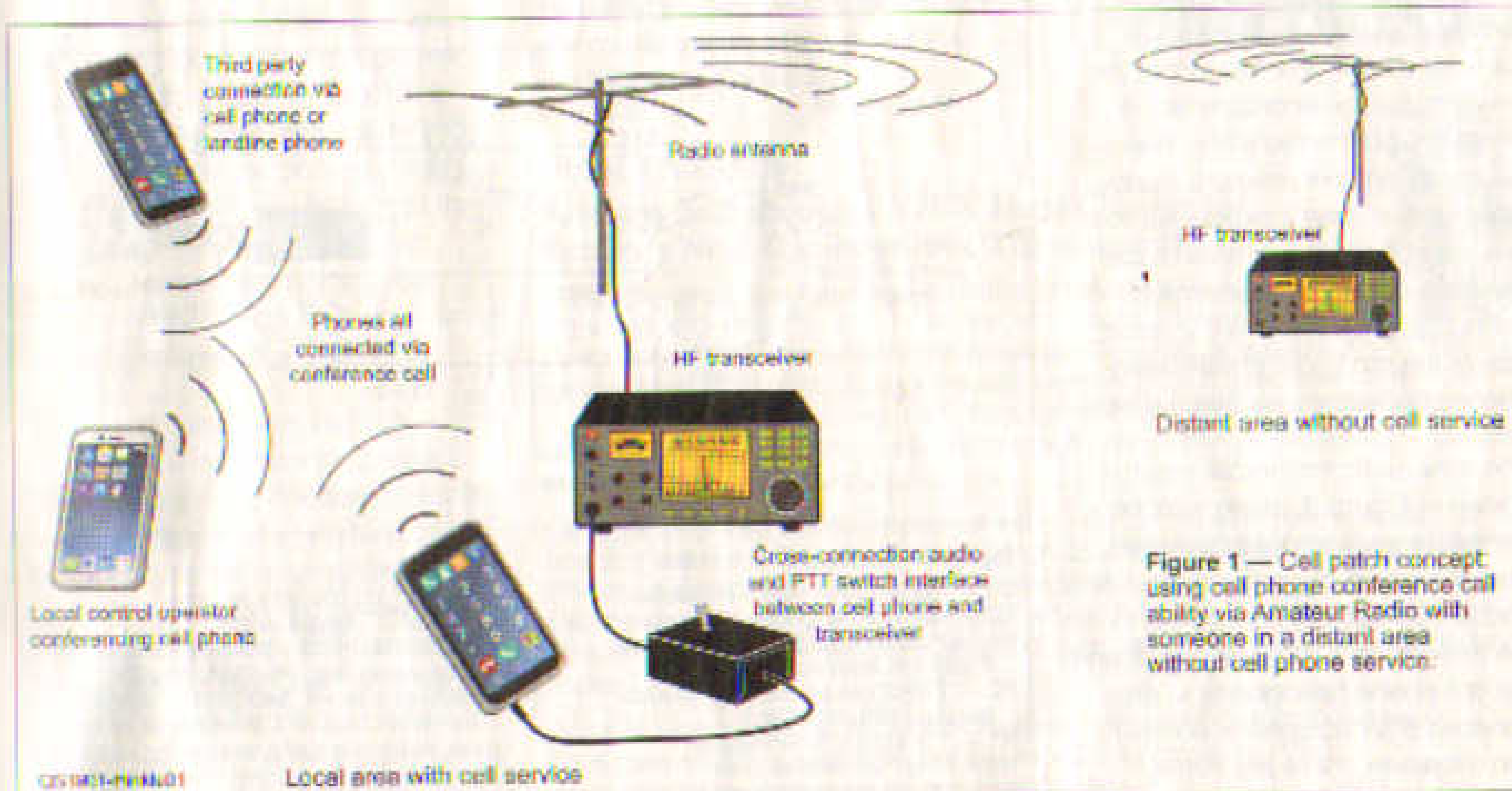

Figure 1 — Cell patch concept using cell phone conference call ability via Amateur Radio with someone in a distant area without cell phone service.