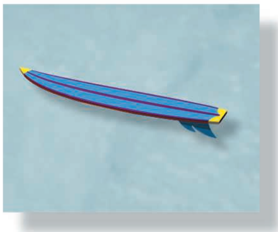

Microwave Surfing

A Moonshot?

■ Rajeev Bansal

Quiz: Take a look at the image in Figure 1 and guess what it represents.

a) a Venn diagram representing political polarization in a neighborhood
b) hexagonal close packing in a germanium crystal
c) a cellular radio concept
d) none of the above.

If you guessed c), you can give yourself a pat on the back. Figure 1 appeared in a 1947 Bell Labs internal technical memorandum [1] by D.H. Ring. While 1947 is now remembered as the year when the transistor was invented (also at Bell Labs), the eight-page document filed by Ring laid the foundation for what has become the dominant communication technology in the 21st century. In the context of car phones, Ring made the following modest proposal [1]:

> In this memorandum it is postulated that an adequate mobile radio system should provide service to any equipped vehicle at any point in the whole country. Some of the features resulting from this conception of the problem are discussed along with reference to a rather obvious plan for providing such service. The plan which is outlined briefly is not proposed as the best solution resulting from exhaustive study, but rather is presented as a point of departure for discussion and comparison of alternative suggestions which may be made.

Editor's Note: An earlier version of this column originally appeared in the February 2021 issue of *IEEE Antennas and Propagation Magazine*.

While Ring was the first person to document the concept of cellular mobile communication, he acknowledged that the idea originated with another Bell Labs scientist, W.R. Young, who had "pointed out . . . the best general arrangement for the minimum interference and with a minimum number of frequencies is a hexagonal layout in which each

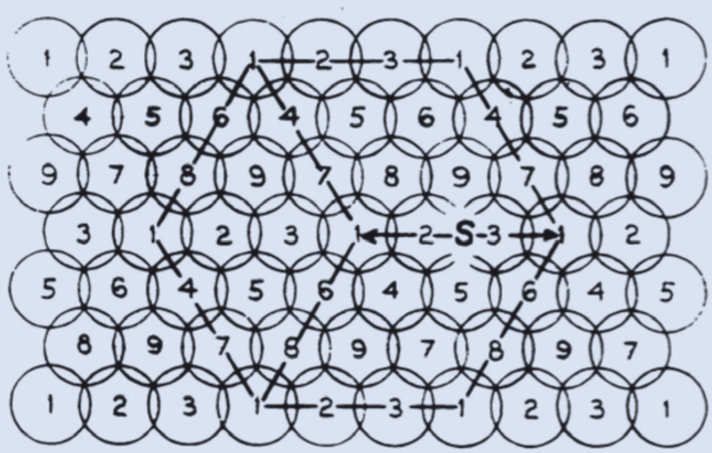

Figure 1. *What does this represent?*

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station is surrounded by six equidistant stations [1]."

So what is Bell Labs up to now? Owned currently by the Finnish company Nokia, it recently received a US$14.1 million contract from NASA to design and develop a 4G network on the moon [2]. According to Bell Labs, "Astronauts will use its wireless network for data transmission, controlling of lunar rovers, real-time navigation over lunar geography (think Google Maps for the moon), and streaming of high-definition video" [2]. It is all a part of the long-term NASA plan [3], "which entails 37 launches of private and NASA rockets, as well as a mix of robotic and human landers . . . with a 'Lunar Surface Asset Deployment' in 2028, likely the beginning of a surface outpost for long-duration crew stays."

At least in principle, the proposed 4G network should "work better on the moon than it does here—it won't have any trees, buildings or TV signals to interfere with the 4G signal" [2]. On the other hand, it will have to be "specially designed to withstand the particularities of the lunar surface: extreme temperature, radiation and space's vacuum. It will also stay functional during lunar landings and launches, even though rockets significantly vibrate the moon's surface" [2]. Like the 5G networks being developed currently on Earth, the lunar mobile network will make use of the so-called small cells [2], [4]. I can't wait to see images of an astronaut traipsing around on the moon asking, "Can you hear me now?"

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From the Editor's Desk *(continued from page 6)*

for these nonidealities, negative group delay circuits are often employed. This article covers a number of circuit topologies for group delay compensation, along with numerous references, allowing you to delve deeper into the operation of these circuits.

In the second article, "Waveguide Components Based on Multiple-Mode Resonators," Wong et al. look at the use of multimode resonators in waveguides as a method to improve the frequency selectivity of the resonator while reducing the overall footprint. The article provides a tutorial on multimode waveguide resonators and shows numerous examples of these structures in applications such as diplexers, filters, and baluns.

The third feature, "Tunable Balanced Power Dividers" by Lin et al., provides an overview of balanced power dividers. Balanced power dividers (and their combining counterparts) are particularly useful because the balanced nature of their circuit operation provides some immunity to common mode issues as well as noise. A number of circuits are shown with explanations of their operation; an extensive reference list is also provided for those wishing to learn more.

We also have an "Application Notes" column in this issue by Zubair Ahmed, "Revisiting the Binomial Multisection Transformer." This impedance matching structure is commonly studied in various microwave engineering textbooks, but the author takes a different approach in explaining its operation. If any of your students have difficulty understanding common textbook approaches, this alternative explanation may be useful.

Also in this issue is the MTT-S president's column, where Dr. Gregory Lyons introduces you to the new MTT-S president-elect for 2021 as well as returning Administrative Committee (AdCom) members for new three-year terms. As you have read about in the previous Society news "Spotlight" columns on the various AdCom committees, the MTT-S AdCom is a group of volunteers engaged in promoting the direction and growth of the Society.

One area that the AdCom is involved with is the organization, promotion, and presentation of our MTT-S webinar series, and this month we have a short column on the planned webinars through the middle of the year. We also have a review of the recently published book *Millimeter-Wave Circuits for 5G and Radar* that you may wish to read or add to your library. Our "MicroBusiness" column speaks to all members about the pandemic restrictions on travel and how they affect the way we work as well as our lives. In addition, we have a "Microwave Surfing" column focusing on the origins of the concept of cellular mobile communication. Finally, Dr. Takashi Ohira continues his "Enigmas, etc." series with another waveform engineering problem for you to solve. The solution to last month's enigma is also included. I hope you enjoy the issue.