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The Wireless World Above 30 MHz Challenges and Opportunities

This overview should be of interest to our younger readers—those who were not around during all the time periods covered in the discussion. Old-timers, on the other hand, might nod, smile and feel a bit nostalgic.—mfe

Prior to World War II, the frequency spectrum generally used for wireless communications had an upper limit of about 30 MHz. However, the wireless spectrum actually extends to approximately 300,000 MHz. Over the years, many applications have been developed to take advantage of the opportunities associated with using these higher frequencies. One of the attractions is the vast amount of spectrum available. In contrast, the spectrum used for short-wave communications extends only from about 3 MHz to 30 MHz.

For ease of discussion, the world above 30 MHz can be divided into four regions. Each of those regions has its own unique characteristics, advantages, and challenges.

- Very High Frequencies (VHF), 30 MHz to 300 MHz, or 10 meters to 1 meter
- Ultra High Frequencies (UHF), 300 MHz to 3,000 MHz, or 1 meter to 0.1 meter
- Super High Frequencies (SHF), 3,000 MHz to 30,000 MHz, or 10 to 1 centimeters
- Extra High Frequencies (EHF), 30,000 MHz to 300,000 MHz, or 1 to 0.1 centimeters

Usually, but not always, radio signals at these frequencies are not reflected off the ionosphere and are limited to a local area near a transmitter. However, there are exceptions. Sometimes, radio signals at VHF frequencies do interact with the ionosphere and travel for great distances.

Early Development

During the 1930s, the spectrum above 30 MHz was starting to be employed for use in emerging communications applications. In the VHF region, civilian engineers were developing experimental television transmitters, military personnel were working on two-way radio communications, and amateur radio operators were doing experimental work. They all quickly learned that it is a real challenge to transmit and receive radio and television signals at these high frequencies, and the higher you go the tougher the challenges.

The technical challenges relate to the fact that the wavelengths are very small. For example, at 30 MHz the wavelength is 10 meters, but at 300 MHz the wavelength is only one meter. So as the frequency increases, the length of wires in vacuum tubes, the spacing between tube elements, and the transit time for electrons become very important. Dimensionally, most 1930s vacuum tubes were far from ideal for efficient handling of signals above 30 MHz.

Adding to the difficulties were the stability problems inherent in operations at these high frequencies. Also, simply connecting transmitters and receivers to their antennas required special low-loss transmission lines.

Because the decade of the 1930s was a time of great economic depression, funds for research and development at these very high frequencies were limited. The spectrum above 30 MHz was a vast wasteland, mostly unused. However, that all changed during World War II, when both radar and military communications began to occupy the very high frequencies.

Because of wartime needs, new vacuum tubes, equipment, and transmission lines were developed for use at the very high frequencies. By the end of the war, engineers were available who were experienced in this work. Also, there were military personnel returning to civilian life with experience in operating equipment at above 30 MHz.

In addition, manufacturing companies now had the expertise to build equipment that worked at these frequencies. And people had money for new products like television sets and FM radio receivers that made use of them.

Advent of Television and FM

One of first post war applications was

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This collection of antennas for various services illustrates just how extensive the use of frequencies above 30 MHz has become. Clockwise from top: AT&T microwave antennas; satellite antenna used for data communications; cell phone antenna tower; satellite antennas used for television reception (two pictures).

commercial television. The wide bandwidth of a television signal requires that operations take place in the VHF and UHF regions.

Both VHF and UHF TV were broadcast in the VHF region as specified in the table at the beginning of this article. Digital TV operates in the UHF region and also uses a part of the VHF region. Because VHF and UHF signals are essentially local in coverage, a television channel that serves one city or metropolitan region can also be used at other locations across the U.S.

VHF and UHF television transmitters have to generate a large amount of power to create a signal that can effectively cover a city or metropolitan area. Also, the broadband nature of a television signal requires the use of sophisticated transmitters. Television transmitter design engineers are faced with numerous technical challenges, including dealing effectively with frequency drift. Of course the development of UHF transmitters presents even more problems than that of VHF transmitters.

There is a relatively small market for television transmitters. Even allowing for three or four in each of several hundred U.S. cities, the transmitter market numbers only a few thousand. Thus the costs for design and engineering work has to be charged against a relatively small number of units.

Over the years, the real money has been made in designing and selling television receivers by the millions. However, like the transmitters, those receivers have to be very sophisticated. They are both subject to frequency drift and required to extract a lot of information from the television signal. A weak signal can create a rolling picture that cannot be stabilized. Thus television receivers tend to be complicated and expensive.

Another post WWII application was commercial FM radio broadcasting in the VHF region. FM transmitter design engineers also had to deal with the challenges of generating significant amounts of power and minimizing frequency drift. Again, the relatively small number of radio transmitters was a means to ultimately sell millions of FM radio receivers that were easier to design than television receivers. Unfortunately, FM radio took much longer than television to become

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popular with the general public.

Other Applications

There were also less publicly visible uses of the spectrum above 30 MHz. In the 1950s, radio repeater equipment operating at these frequencies was installed across the U.S. This equipment made it possible for television programs to be distributed nationwide and was also used for long distance telephone calls. Eventually, satellite communications, using the SHF spectrum, made worldwide television broadcasting a reality.

Two-way VHF radio communications systems for police cars, fire trucks, taxi cabs, and other types of mobile operations became common after World War II. In addition, there was some limited availability of mobile telephone service for the general public. These bulky mobile transmitters and receivers had to be located in car trunks—not the most favorable of environments.

With access to improved vacuum tubes and other components, hams took a renewed interested in the VHF spectrum. In larger cities, with many hams, local VHF communications could take place using simple low powered transmitters and receivers. In smaller cities, with few hams, high-powered VHF transmitters were required to communicate with hams who were outside of the local area.

Ham activity on the VHF bands really took off with the introduction of repeaters in the 1960s. The availability of transistorized ham equipment in the 1970s further increased the popularity of the VHF ham bands.

Arguably, the ultimate use of the spectrum above 30 MHz came with the introduction of cell phones in the 1970s. UHF was ideal for this service. The use of microelectronics ultimately made cell phones small, convenient, inexpensive, and ubiquitous.

Over the years, the demand for frequencies above 30 MHz has continued to increase for new applications like wireless communications for local area computer networks. The demand for these frequencies is a far cry from what existed in the 1930s, when the world above 30 MHz was a vast wasteland.

Today's extensive use of this spectrum is a testament to human ingenuity and resourcefulness. Technical and economic challenges have been successfully overcome, and the possible future applications can only be imagined.