PHILLIP SMITH - A BRIEF BIOGRAPHY

Theodore S. Saad

Sage Laboratories, Inc.
Natick, Massachusetts

In 1975, the Microwave Society of the IEEE presented to Phillip H. Smith a Special Microwave Application Award for his invention and application of the Smith Chart. The Smith Chart is perhaps the most widely used design tool in the microwave field. Although the Smith Chart has been called by a number of different names, such as Reflection Chart, Circle Diagram, Additance Chart, etc., Phil Smith, a very modest man, reluctantly chose the name Smith Chart, because "none of the other names were in themselves sufficiently definitive to be used unambiguously when compared with similar charts."

The idea for the chart had its first beginnings in 1931, when Phil developed a rectangular chart which was used to assist in the solution of transmission line problems. The rectangular plot was a graphical plot of a modified form of J.A. Fleming's 1911 telephone equation, which expressed the impedance characteristics of high frequency transmission lines in terms of measureable effects of electro-magnetic waves propagating thereon. For example, the standing wave amplitude and the wave position. However, because the rectangular chart had certain limitations, specifically the limited range of normalized impedance values and standing wave amplitude ratios, Smith was stimulated to transform the curves into a more useful arrangement, which ultimately resulted, in 1936, in the first circular Smith chart, in which reflection coefficient sets the diameter of the circle along which impedance admittance is transformed by line length translated into degrees of arc.

In January 1939, there appeared in Electronics the famous article that described the Smith Chart, much as we know it today. A second article, which was published in 1944, incorporated further inprovements, including the fact that it could be used both as an impedance chart and as an admittance chart.

From the beginning of World War II until the time of the introduction of the microprocessor and digital techniques, the Smith Chart was the dominant tool for microwave engineers. When Phil Smith retired from Bell Labs in 1970, he organized a small company - Analog Instruments Company of New Providence, NJ, which initially merchandised simple navigational instruments for light aircraft, but later began supplying his charts and a dozen or more chart-related items. At this time, he has shipped his charts to nearly every civilized country on earth. He had sold through 1975 about 9 million copies, and as he pointed out, microwave engineers all over the world, despite the almost universal access to digital test equipment were ordering the chart in large quantities and were using it on a day-to-day basis to provide a direct graphical insight into the frequency-impedance behavior.

But, while one is aware of the Smith Chart, they may not be aware of Phillip H. Smith, the engineer who designed it. He received his BSEE from Tufts College in 1928 and upon graduation he joined the Technical Staff of Bell Telephone Laboratories (now A T & T Bell Laboratories), where he remained until he retired. He was involved in the early development of transmission lines and directional antennas for the Bell Systems Shortwave Overseas Radio Telephone Circuits, and it was during that period that he developed the early forms of the chart. During the war, his experience was utilized in the design and development of radar antennas, where his numerous contributions placed him on the Reserved List of War Manpower Commission's Committee of Scientific and Research Personnel. Following the war, he turned his attention to commercial FM radio broadcasting antenna design and supervised groups responsible for the electrical design of the DEW Line, Nike Zeus and the ABM System, which became SAFEGUARD.

One of the programs that Phil Smith worked on that can help to illustrate his creativity in antenna design was an acquisition radar system on the Island of Kwajalein. This was an experimental system in the early days of the Safeguard program. The design of the antenna involved using a Luneburg lens technique. The classical Luneburg lens is a spherical lens of varying dielectric constant which has the

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property that when the lens intercepts a plane wave, it will always be focused at a point perpendicular to the wave itself on a line through the center of the sphere at a point on the opposite surface of the sphere, regardless of the direction from which the plane wave approaches the lens.

The technique that was used at Kwajalein was to build one half of the sphere - that is a hemispherical Luneburg lens - with a ground plane significantly larger than the diameter of the sphere itself. The lens was made up of a series of polyfoam cubes about 2'x2'x2' loaded with aluminum slivers, so that the polyfoam block had a uniform dielectric constant throughout. By varying the amount of aluminum slivers one could vary the dielectric constant of the block. The required values of dielectric constant were thus quantized to achieve the Luneburg lens performance. It turned out for this system that about 10 to 12 different discreet values of dielectric constant were required. There was a separate transmitter located nearby which illuminated the target with beams narrow in azimuth and broad in elevation. When a signal was received, by virtue of the location of the receivers and the action of the Luneburg lens, one could determine the azimuth and elevation of the target.

The system worked as predicted by theory; its action was essentially equivalent to the complete spherical lens, except, of course, for the limits in coverage of low-elevation angles as imposed by the finite ground plane.

The operation of the antenna relied on the ability to build the homogeneous aluminum-loaded polyfoam blocks of varying dielectric properties. The idea for the blocks came from Phil Smith - also the inventor of the Smith Chart.

Mr. Smith has 20 U.S. patents in the field, including basic patents on the optimum ratio coaxial transmission line and the transmission line matching stubs. He published over 35 technical papers on antennas and transmission lines and he was responsible for a book entitled "Electronic Applications of the Smith Chart", which describes the many applications of the Smith Chart.