Measurement of the Dielectric Constant of Seawater at L-band: Techniques and Measurements

R. Lang[1], C. Utku[2], Y. Tarkocin[1], D. Le Vine[2]

[1]Dept. of Electrical & Computer Engineering
George Washington University, Washington, DC 20052 USA

[2]Instrumentation Sciences Branch, Code 614.6 NASA
Goddard Space Flight Center, Greenbelt, MD 20771 USA

Satellite instruments, that will monitor salinity from space in the near future, require an accurate relationship between salinity/temperature and seawater dielectric constant. This paper will review measurements that were made of the dielectric constant of seawater during the past several years. The objective of the measurements is to determine the dependence of the dielectric constant of seawater on salinity and on temperature more accurately than in the past, by taking advantage of modern instrumentation. The measurements of seawater permittivity have been performed as a function of salinity and temperature using a transmission resonant cavity technique. The measurements have been made in the salinity range of 10 to 38 psu and in the temperature range of 10° C to 35° C. These results will be useful in algorithm development for sensor systems such as SMOS and Aquarius.

The measurement system consists of a brass microwave cavity that is resonant at 1.413 GHz. The seawater is introduced into the cavity through a capillary glass tube having an inner diameter of 0.1 mm. The diameter of the tube has been made very small so that the amount of seawater introduced in the cavity is small – thus maintaining the sensitivity of the measurements and allowing the use of perturbation theory in predicting the seawater permittivity. The change in resonant frequency and the change in cavity Q can be used to determine the real and imaginary parts of the dielectric constant of seawater introduced into the slender tube. The microwave measurements are made by an HP8722D network analyzer. The cavity has been immersed in a water/ethylene-glycol bath which is connected to a Lauda circulator. The circulator keeps the brass cavity at a temperature constant to within 0.01° C. The system is automated using a Visual Basic program to control the analyzer and to collect the data.

The results of the dielectric constant measurements of seawater will be presented. The measurement results will be compared with permittivity values generated from the Klein-Swift relationship. Two methods of calibration will be discussed. The errors that each technique introduces into the measurement results will be reviewed. Temperature stability, frequency drift and the effect of increasing cavity transmission loss on the unloaded cavity Q will also be discussed.