# Differential Microstrip Antennas

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**Abstract:** The earliest antennas implemented by Hertz for the discovery of radio waves were dipole and loop. They are differential. It was Marconi who introduced the ground concept into antennas and realized single-ended monopole antennas for wireless transmission. Compared with differential antennas, single-ended antennas have smaller size and therefore single-ended antennas have dominated in antenna designs. Compared with single-ended circuits, differential circuits permit higher linearity and lower offset and make them immune to power supply variations, temperature changes, and substrate noise. As a result, differential circuits have dominated in integrated circuit designs. Differential circuits call for differential antennas. This is particularly essential in highly-integrated system-on-chip and system-in-package solutions where the system ground plane may be much smaller than one free-space wavelength. Differential antennas perfectly marry (match) with differential circuits. No lossy balanced/unbalanced conversion circuit is needed. As a result, the receiver noise performance and transmitter power efficiency are improved.

In this lecture, I present differential microstrip antennas with an emphasis on the comparison of them with single-ended counterparts. First, I extend the well-known cavity model for the single-ended microstrip antennas to analyze the input impedance and radiation characteristics of differential microstrip antennas. Then I examine the design formulas to determine the patch dimensions and the location of the feed point for single-ended microstrip antennas to design differential microstrip antennas. It is shown that the patch length can still be designed using the formulas for the required resonant frequency but the patch width calculated by the formula usually needs to be widen to ensure the excitation of the fundamental mode using the probe feeds. The condition that links the patch width, the locations of the probe feeds, and the excitation of the fundamental mode is the electrical separation, which is a new and unique concept specifically conceived for the design of differential microstrip antennas. Next, I turn to the miniaturization of differential microstrip antennas and discuss some latest achievements. Finally, I summarize the lecture and provide recommendations.

**Biography:** ZHANG Yueping is a full Professor with the School of Electrical and Electronic Engineering at Nanyang Technological University, Singapore, a Distinguished Lecturer of the IEEE Antennas and Propagation Society (IEEE AP-S), a Member of the IEEE AP-S Paper Award Committee, and a Fellow of IEEE.

Prof. ZHANG was a Member of the IEEE AP-S Field Award Committee (2015-2017), an Associate Editor of the IEEE Transactions on Antennas and Propagation (2010-2016), and the Chair of the IEEE Singapore MTT/AP joint Chapter (2012). Prof. ZHANG was selected by the Recruitment Program of Global Experts of China as a Qianren Scholar at Shanghai Jiao Tong

University (2012). He was awarded a William Mong Visiting Fellowship (2005) and appointed as a Visiting Professor (2014) by the University of Hong Kong.

Prof. ZHANG has published and accepted numerous papers, including two invited and one regular papers in the *Proceedings of the IEEE* and one invited paper in *the IEEE Transactions on Antennas and Propagation*. He is probably the first and only Chinese radio scientist who has managed to publish a historical article in an English learned journal such as *IEEE Antennas and Propagation Magazine*. He holds 7 US patents. He received the Best Paper Award from the 2nd IEEE/IET International Symposium on Communication Systems, Networks and Digital Signal Processing, July 18–20, 2000, Bournemouth, U.K., the Best Paper Prize from the 3rd IEEE International Workshop on Antenna Technology, March 21–23, 2007, Cambridge, U.K., and the Best Paper Award from the 10th IEEE Global Symposium on Millimetre-Waves, May 24–26, 2017, Hong Kong, China. He received the prestigious IEEE AP-S Sergei A. Schelkunoff Prize Paper Award in 2012.

Prof. ZHANG has made pioneering and significant contributions to the development of the antenna-in-package (AiP) technology that has been widely adopted by chipmakers for millimetre-wave applications. His current research interests include the development of antenna-on-chip (AoC) technology and characterization of chip-scale propagation channels at terahertz for wireless chip area network (WCAN).