

RF Circuits, Antennas, and Integration for Broadband Applications

Organizer: Ruey-Beei Wu, National Taiwan University

Time: 1:30-5:15pm, Jan. 7, 2003

Agenda (tentative):

1:30-1:45 Ruey-Beei Wu, Introductory Remarks

1:45-3:00 Chin-Kuang Tzuang, An Advanced Coplanar Strip System for
Integration Design

3:15-4:15 Ruey-Beei Wu, Flip-Chip and CPW Transitions Design

4:15-5:15 Shyh-Jong Chung, Novel Millimeter-Wave Antennas Design

Background:

The emergence of broadband wireless applications has brought new demands for low-cost, miniaturized, high-volume circuits and modules in the millimeter-wave frequency range. Following its successful strategy in shaping the infrastructure for the electronics industry, Taiwan has selected the RF key components and systems as one of the few highly supported areas for academic excellence and next-generation technology thrusts. This has triggered intensive and comprehensive researches at both National Taiwan and Chiao-Tung Universities in the design of RF circuits, antennas, and system integration at 30GHz and beyond.

Overview:

The workshop will review the design of key components in millimeter-wave transceivers and the development in the system integration technologies developed under this national excellence project. Typical subjects includes an advanced coplanar strip system technology for the component building blocks in various microwave communication system, a novel flip-chip technology capable of dc up to 60GHz interconnection, various wide band transitions between CPW and other transmission structures, and three novel antenna arrays with various features of wide-band, high-gain, low-side-lobe, and/or high beam steerability required by the advanced wireless communication systems.

Titles, Speakers, and Abstracts

I. An Advanced Coplanar Strip System for Integration Design

Prof. Chin-Kuang Tzuang, Department of Communication Engineering, National Chiao Tung University, Hsinchu, Taiwan, ROC

Abstract – This seminar presents a completely planar solution to the integration of millimeter-wave RF front-end components. Two feasibility studies are investigated. First is the 30GHz FSK transceiver module, the second is the 30GHz self-hetrodyne broadcast transceiver module. Both employ the ACSS (advanced coplanar strips system) guiding structure concept. As will be discussed in the seminar the ACSS guiding technology is fundamentally a multi-layered guiding structure that incorporates microstrips, coplanar waveguides, coplanar strips and rectangular waveguides. All of the RF front-end functional blocks, including low-profile antenna, high-power local oscillator with waveguide cavity resonator, frequency doubler, rectangular waveguide filter, and sub-harmonic quadrature mixer, are implemented simultaneously in a planar form by the conventional photolithographic techniques. Notice that, the state-of-art planar integrated circuits using microstrip and coplanar waveguide may confront with a critical restriction of large transmission losses at millimeter-wave frequencies. Therefore novel H-plane mode converters are proposed in the ACSS guiding technology to incorporate low-loss rectangular waveguide in the PCB-based circuits simultaneously; thereby the RF module performance can be greatly enhanced. Owing to its planar nature, the ACSS module is compatible with CPW probe testing, rendering fast evaluation cycle.

II. Flip-Chip and CPW Transitions Design

Prof. Ruey-Beei Wu, Department of Electrical Engineering, National Taiwan University, Taipei, Taiwan, ROC

Abstract – CPW shows great potential over microstrip lines at millimeter-wave spectrum and beyond. This talk is focused on the wide-band miniaturized design for the flip-chip transition and the transitions between CPW and various other transmission structures, e.g., microstrip line, coplanar strips, and slotlines on the board and the metallic waveguides. For the flip-chip transition, a local matching technique has been proposed to render a wideband performance better than the previous approaches. Systematic procedure for the optimum design is established and the experimental realization demonstrated less than -25dB return loss from DC to Ka band. For CPW transition to slotline and coplanar strips, several novel miniaturized designs are accomplished by the lumped-element realization of conventional

Marchand balun. They are compact, wideband, planar, and suitable for MMIC applications. For the CPW transition to metallic waveguide, a new structure of a tapered coplanar strip E-plane probe and a CPS to CPW matching section is developed, demonstrating the advantages of broad bandwidth, compact size, low fabrication cost, and high reliability. The CPS and CPW transitions have also been extended side by side to yield wideband CPW to microstrip and microstrip to waveguide transitions. The back-to-back measurements are performed and validate the design approach successfully.

III. Novel Millimeter-Wave Antennas Design

Prof. Shyh-Jong Chung, Department of Communication Engineering, National Chiao Tung University, Hsinchu, Taiwan, ROC

Abstract - Three novel millimeter-wave antennas are to be introduced, that is, a printed Yagi antenna, a waveguide-fed microstrip antenna array, and a folded reflectarray. The first antenna is with fixed beam, and the others are beam steerable. All the antennas are designed and tested near 38 GHz. The printed Yagi antenna is composed of a printed dipole, several printed directors, and a reflector that is performed by the truncated ground plane of the feeding microstrip line. The effects of the structure parameters, such as the dielectric constant and thickness of the substrate, the spacing between directors and dipole, and the number of directors, are studied. Wide-band, high-gain, and low-side-lobes printed Yagi antenna and array are demonstrated. The waveguide-fed microstrip antenna array is composed of 15 sub-arrays fed by a rectangular waveguide through apertures on the waveguide's top wall. Each sub-array contains two parallel series-fed microstrip antenna arrays. There are totally 270 microstrip antenna elements used. The array has a fixed beam in the E-plane and a variable beam in the H-plane. The phase difference between adjacent sub-arrays is controlled by changing the waveguide width so as to steering the array beam. Experiment shows good agreement with the theory. The folded reflectarray antenna contains a planar main reflector, a sub-reflector, and a feeding microstrip antenna on the main reflector. The main reflector is composed of hundreds of microstrip antennas used to produce twisted re-radiation fields and provide phase compensation for focusing. The sub-reflector parallel with the main-reflector is made of a substrate printed with high-density metal grid, which is transparent to one polarization but would reflect the other polarization. The position of the feed antenna is proposed to be movable so as to steer the radiation beam of the antenna. Design and measurement results of these antennas will be shown.

Biography of Speakers

Ruey-Beei Wu was born in Tainan, Taiwan, Republic of China in 1957. He received the B.S.E.E. and Ph.D. degrees from National Taiwan University, Taipei, Taiwan, in 1979 and 1985, respectively.

In 1982, he joined the faculty of the Department of Electrical Engineering, National Taiwan University, where he is currently a Professor. He is also with the Graduate Institute of Communications Engineering established in 1997. From March 1986 to February 1987, he was a Visiting Scholar at the IBM East Fishkill Facility, NY. From August 1994 to July 1995, he was with the Electrical Engineering Department, University of California at Los Angeles. From May 1998 to April 2000, he was appointed Director of the National Center for High-performance Computing. Since November 2002, he has also served as Director of Planning and Evaluation Division, National Science Council, and is involved in the planning, coordination, budget allocation, and evaluation for national policy on science and technology.

His areas of interest include computational electromagnetics, transmission line and waveguide discontinuities, microwave and millimeter wave planar circuits, and interconnection modeling for computer packaging. He has published more than 50 journal papers in prestigious IEEE transactions and more than 60 conference papers.

Shyh-Jong Chung was born in Taipei, Taiwan, R.O.C. He received the B.S.E.E. and Ph.D. degrees from the National Taiwan University, Taipei, Taiwan, R.O.C., in 1984 and 1988, respectively.

Since 1988, he has been with the Department of Communication Engineering, National Chiao Tung University, Hsinchu, Taiwan, R.O.C., where he was promoted to a Professor in 1995. From 1997 to 1999, he served as the vice Department Chairman. From September 1995 to August 1996, he was a Visiting Scholar in the Department of Electrical Engineering, Texas, A&M University, College Station, TX. His areas of interest include the designs and applications of active or passive planar antennas, communications in Intelligent Transportation Systems, propagation and scattering of transmission lines, packaging effects of microwave circuits, and numerical techniques in electromagnetics. In these areas, he has published over 60 technical papers in international journals or conferences, including several invited papers and speeches. Dr. Chung is the leader of a sub-program in the four-year national research program “Advanced Technologies for Telecommunications”, which is sponsored by the Ministry of Education, Taiwan. He also served as the treasure of IEEE Taipei Section.