# Gain and Bandwidth Enhancement of Micro-Radio-Repeaters for Ad-hoc Wireless Communication

Young Jun Song* and Kamal Sarabandi
Radiation Laboratory
Department of Electrical Engineering and Computer Science
University of Michigan, Ann Arbor, MI, 48109-2122
E-mail:{yjsong,saraband}@eecs.umich.edu

Sub-wavelength micro-radio repeaters have recently been developed to enhance the signal coverage of low-power radios in complex communication environment. Although numerous approaches have been studied to miniaturized the dimensions and complexity of the radio repeater system, up until recently, the near-field mutual coupling between the transmit (Tx) and receive (Rx) antennas has been the main cause that had limited their physical dimensions and performance. The new concept of radio repeater design makes use of a near-field cancellation technique and also suppression of the surface waves (Y.J. Song and K. Sarabandi, IEEE Trans. Antenna and Propag., 3913-3920, 2012). This sub-wavelength radio repeater is shown to have the ability of amplifying the received RF signal by 50 dB without going to oscillation. The overall repeater gain is characterized using the repeater in backscatter direction and measuring its Radar Cross Section (RCS). Compared with the standard metallic sphere, the repeater showed an RCS value of 21.3 dBsm while having a very small form factor.

In this presentation, the system gain and RCS of the radio repeater are analyzed and discussed. Due to the intrinsic mutual coupling between the Tx and Rx antennas, the micro-radio-repeater forms a closed-loop system. As a result, its overall closed-loop transfer function should be considered rather than a sum of the RF amplifier gain and the antenna gains. This closed-loop transfer function determines the stability of the system and the overall system gain, which can be verified through its RCS measurement.

In addition, the proposed closed-loop transfer function is illustrated through two other repeater designs. First of all, the Tx and Rx antennas are redesigned to increase the repeater system bandwidth. By utilizing parasitic elements through magnetic and electric coupling, the redesigned antennas show vertical polarization and improved radiation efficiency and bandwidth. Secondly, a pair of single quarter wavelength isolator is adopted in order to decrease the mutual coupling between the Tx and Rx and increase the overall system gain. In both cases the closed-loop system transfer functions are investigated and analyzed. The overall system transfer function and its validation through the RCS measurement will be presented at the symposium.