Abstract

Smart antenna technology in applications such as the next-G wireless communication networks may improve the quality of service (QoS). One category of smart antennas is the switched beam smart antenna (SBSA). These antennas can be grouped into plug and play antennas and adaptive internal antennas. Four types of switched beam smart antennas were investigated including a six monopole array on circular ground plane with conducting sleeve, five monopoles on a circular ground plane without a conducting sleeve, a reconfigurable monopole on a cylindrical hollow ground structure, and a reconfigurable adaptive internal antenna.

The first two antennas were constructed with a switched parasitic array of elements combined with an RF circuit with microcontroller. Two of the four antenna prototypes were capable for steering the beam pattern automatically based on signal strength (RSSI) or bit error rate (BER) scanning. The two remaining antennas were designed for electronic beamforming and electronic frequency tuning. Both numerical and empirical investigations were undertaken to measure performance and investigate manufacture difficulties. The numerical investigations were undertaken using both the method of moment (MoM)-NEC and the finite element method (FEM)-HFSS modeling. The fabrication and testing in an anechoic chamber were used to explore the actual performance of the designed antennas. The fabrication of the last two types of antennas was not implemented. Further work is required to find the optimal design for all antennas investigated. This study suggests significant promise for these antennas in wireless networks.

The six monopoles on a circular ground plane with conductive sleeve was designed with a centre frequency of 1.5 GHz. The circuit was built from various electronics components such as LNA MAX2611, RF detector AD8314 (later re-assembled using MAX2015), DC amplifier, PIC16F62X controller device, microwave diodes, passive electronics components, and DC power supply regulator. The numerical and experimental studies validated an impedance bandwidth based on S11 of greater than 200 MHz (13%). The time required to update the beam pattern automatically under RF signal fading conditions was estimated to be 64.5 μs. This is sufficient to overcome typical fade durations of approximately 5 ms. The fabricated antenna was
confirmed to have the gain of approximately 7.1 dBi. The co-polar cross-polar ratio of the main beam was 15dB.

The plug and play SBSA of five monopoles on circular ground plane without conducting sleeve, was initially constructed to operate on two different frequencies of ISM bands simultaneously, i.e. 433 and 915 MHz. The physical structure of the antenna was supported by an RF microcontroller CC1010 that has both digital and RF processing. The designed antenna is suitable for short range communication applications such as sensor networks, Bluetooth, and RFID systems. Investigations demonstrated bandwidth variations from 35 MHz to greater than 100 MHz can be achieved on the frequency of operation. The gain at 900 MHz was measured to be approximately 6 dBi. The co-polar cross-polar ratio in the main beam was 15 dB.

Another plug and play antenna studied was developed to electronically reconfigure a single monopole on a circular cylindrical hollow ground structure. The feasibility study confirmed that the operation frequency was between 1.3 and 1.9 GHz depending on the number of monopole slices activated and pattern direction of the antenna could be electronically steered to maintain the maximum RF power at the selected frequency. The total bandwidth exceeded 750 MHz.

A new model for a planar adaptive internal antenna suitable for the next G-WiMAX network was numerically studied by exploiting the reconfigurable structure of single active rectangular patch with two parasitic stripline folded dipoles in close proximity. The design was initially constructed to work at 5 GHz, however the frequency operation at both 10 and 15 GHz was confirmed through the numerical investigation. This antenna has the potential to produce the large bandwidth required for a WiMAX system i.e. from 100 to 250 MHz.

Control circuit implementation and antenna tolerances proved difficult in this work due to the variability of pin diode impedance, and the requirement to switch the parasitic elements between two states – open circuit and short circuit to ground. While these fabrication difficulties remain unresolved, antenna switching was achieved and 360 degree performance maintained with a signal variation of less than 3 dB. Possible solutions include the use of MEMs RF switches and careful RF circuit layout.