Directional Loop-Type Antenna Technologies Applied to Satellite and Terrestrial Integrated Mobile Phone Applications

Wei-Yu Li[1*], Wei Chung[1], and Amane Miura[2]
[1]Information and Communications Research Laboratories, ITRI, Taiwan
[2]National Institute of Information and Technology (NICT), Japan
[*]email: liwy@itri.org.tw

***Abstract* – In this article, a brief overview and discussion on some loop-type antenna technologies applied satellite and terrestrial integrated mobile phone applications is presented. By properly applying distinct characteristics of different resonant modes of various loop-type antenna designs as array elements, different application requirements of beamforming array antennas for satellite mobile phones including multi-band operations, dual-polarization or wide beam-scanning coverage could be achieved.**

***Keywords* — loop-type antennas, satellite mobile phones, array element, beam-forming array antennas.**

I. INTRODUCTION

In recent years, many attractive applications scenarios have been developing in satellite communication fields by the emerging new system technologies such as satellite integration into 5G network [1], the High Throughput Satellite (HTS) [2], or mega-constellation satellite system by using LEO satellites. Therefore, many new requirements and challenges for satellite antennas, prediction and attenuation mitigation of wideband propagation channels, hybrid/integrated user terminal antenna designs for Ka or higher mmWave bands and the integrated networks have been discussed [1-2].

For implementing the satellite communication functions of Ka or higher mmWave bands in user terminals, the applications of directional beamforming array antenna architectures are necessary [3]. However, the developing various satellite system links may require beamforming array antennas to achieve different functions such as wide beam-scanning coverage, multi-band operations or dual-polarization communications.

From the basic theories of beamforming array antennas [4], it demonstrates that total array antenna patterns are the superposition of element antenna pattern and array factor. An array factor is mainly affected by the number of array elements, the element spacing, and the amplitude and phase of input signals [4]. Besides, directivities and radiation beamwidths of total array antenna patterns are mainly affected by the array factor. However, polarizations, beam-scanning coverages, operating bandwidth and frequencies are mainly affected by the element antenna designs [4]. Therefore, some critical solutions for requirements of satellite user terminals are on the proper designs of element antenna patterns.

In this article, a brief overview and discussion on some loop-type antenna technologies [5-6, 8] jointly studied by ITRI in Taiwan and NICT in Japan is presented. It shows that by properly choosing and applying distinct characteristics of different resonant modes of these developed loop-type antennas [5-6, 8], they may be good candidates as array elements for various satellite link requirements of mobile user terminal.

II. ARRAY ELEMENT ANTENNA DESIGN

Fig. 1 shows the simulated current distribution and the measured radiation pattern for a properly folded loop antenna to be designed operating at 1.5λ loop resonant mode [5-6]. For the 1.5λ loop mode, the loop current resonant path will exist three current-null spots. And it shows that four marked resonant currents 1, 2, 3, 4 can be formed in parallel to each other as an equivalent 4-current

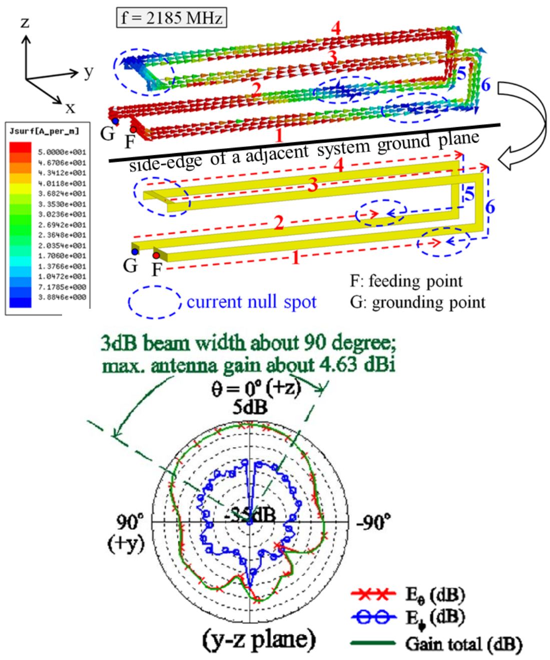

Fig. 1. Simulated current distribution and the measured radiation pattern for a properly folded loop antenna to be designed operating at 1.5λ loop mode.

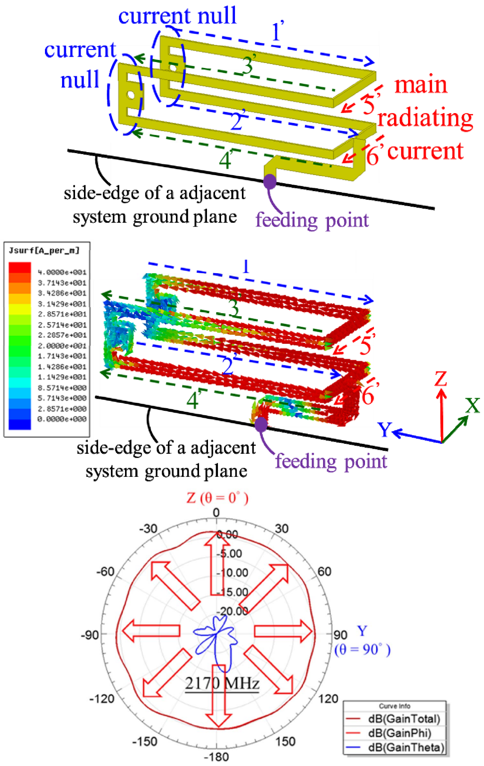

Fig. 2 Simulated current distribution and the radiation pattern for a properly folded loop antenna to be designed operating at 1.0λ loop mode.

array, and the adjacent side-edge of handset ground could perform as an effective reflector structure [5-6]. The characteristic of the properly folded 1.5λ loop antenna architecture has been demonstrated to be a critical part as applying an array element for implementing highly-integrated mmWave 28 GHz and 39 GHz two beamforming array antennas by adjacently compatible with the other parallel-connected dual open-slots antenna [7]. It shows that by properly designing the 0.25λ slot mode to cover 28 GHz band and the 1.5λ loop mode to cover the 39 GHz band, the two 28 GHz and 39 GHz array antennas with independent and separated feeding ports can be compatible and coexisted within a limited side space of a mobile phone with keeping independent beamforming and beam scanning operations for avoiding grating lobe issues, reducing complexity and overall loss of RF front-ends and achieving a higher space utilization rate [7].

Fig. 2 shows simulated current distribution and the radiation pattern for a properly folded loop antenna to be designed operating at 1.0λ loop resonant mode [8-9]. It shows that there are two current-null spots on the designed loop path, and making that the marked resonant currents 5' and 6' orthogonal to the system ground plane would dominate the far-filed radiation because the marked currents 1' and 3' would cancel out the currents 2' and 4'. Therefore, it can radiate and generate a quasi-omnidirectional pattern successfully in the y-z plane surrounding the handset ground plane to achieve wide-coverage element pattern due to the small blockage and reflection by the system ground plane [8-9]. The characteristic of 1.0λ loop antenna applying as an array antenna element will be useful for achieving wide beam-scanning coverage [4]. Besides, it could also be expected as a critical part of a hybrid array element for implementing dual-polarization beamforming array antenna designs by compatible and integrating with another linear polarized antenna parallel with the side-edge of the system ground plane [9]. More details and analysis results will be discussed and presented in the conference.

III. CONCLUSION

In this article, a brief overview and discussion on some developed loop-type antenna technologies expected applying to satellite and terrestrial integrated mobile phone applications is presented. It shows that by properly choosing and applying distinct characteristics of different resonant modes of these developed loop-type antennas, they could be good and attractive candidates as array elements for achieving various satellite link requirements of mobile user terminal including multi-band, wide beam-scanning coverage or dual-polarization operations.

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