National Aeronautics and Space Administration

Dual Band Circularly Polarized UHF Antenna Concept Development

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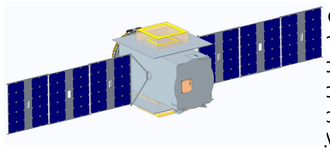
Program: FY21 R&TD Innovative Spontaneous Concepts

Objectives

The proposed work will mature the antenna RF design concept to reduce the technical, schedule, and cost risks associated with implementing this type of antenna for a flight project. The current state of the art is a single loop antenna. Although preliminary studies indicate that the dual loop antenna is feasible, many design details have not been investigated, such as how the antenna will be fed, what type of balun will be used, and how the matching network will be implemented.



Background

JPL is preparing a proposal for a mission called SnowOp in response to the NASA EVM-3 AO call. The SnowOp instrument requires a SmallSat-compatible circularly-polarized UHF low gain antenna over the frequency bands 240-270 MHz and 360-380 MHz. The proposed antenna concept consists of two circularly polarized nested loops, similar to the MarCO loop antenna design, but with some key differences that significantly increase the complexity of the design. The MarCO antenna was a single loop design with a narrow bandwidth requirement. For the proposed dual frequency antenna, the two nested loops will interact with each other, which makes the design more difficult since the loop parameters are not independent of each other. The wider SnowOp bandwidths make the design more challenging, particularly in regards to the feeding and matching network. The Dual loop designs have potential for applications other than the SnowOp project, such as being employed on the Mars proximity link, using telecom antennas finely tuned to the UHF transmit and receive bands, as seen in the figure below

Significance/Benefits to JPL and NASA

The significance or benefit of the study is that it achieved its goal, which was to mature the Dual UHF Loop antenna RF design concept. This study will reduce the technical challenges, the schedule, and cost risks associated with implementing this type of antenna for a flight project, such as the SnowOp project.

Acknowledgements: The authors would like to thank Emmanuel Decrossas (337), the Engineer who developed of the MarCO antenna, for providing me with the initial HFSS model, of the single loop.

References

[1] Emmanuel Decrossas, Nacer Chahat, Phillip E. Walkemeyer,B. Savannah Velasco, “Deployable Circularly Polarized UHF Printed Loop Antenna for Mars Cube One (MarCO) CubeSat”, IEEE *, International Symposium on Antennas and Propagation, USNC-URSI Radio Science Meeting* (July 2019), pp. 1719-1720.

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Approach and Results

The approach was to use a basic HFSS electromagnetic model of the radiating loops that was previously created to show feasibility of the concept. The initial model does not include many design details and has not been optimized. The design is based on the MarCO UHF Loop antenna, then investigate the compatibility between two such UHF loops that can provide circularly polarized pattern with ~3dBic of gain, with one operating over the frequency band 240-270 MHz and a second loop operating over 360-380 MHz. The goal of the study is to obtain an input reflection coefficient of ≤ -10dB for both antennas, and although there is no cross-polarization requirement, a self-imposed goal of cross-polarization to co-polarization difference of >6dB. The proposed work focused on the following: maturing a dual loop antenna design by electromagnetic modeling, addressing whether an internal or external balun should be used, along with the kind feed lines to used (e.g., twisted pair or coax lines), determining the loop spacing both between them and the spacecraft while meeting the stated RF performance. Also determine if a matching circuit scheme will need to be used, whether internal or external to the loop. The MarCO antenna required a deployable design due to available CubeSat accommodation. Although the SnowOp program plans to use non-deployable loops, the configuration should be kept flexible in preparation for small-sat missions that may have accommodation issues as well

The study was successful, yielding very encouraging RF performance. The objectives were successfully achieved. This can be seen in the pattern plots of Gain > 3dB in the figures below; the input reflection coefficient ≤-10dB also shown below, over their individual frequency bands (see above). Also, the design uses a single feed transmission line with a built in balun, minimizing the need of additional tuning circuits. The only observed limitation is the self-imposed goal of cross-polarization to co-polarization difference of ≤ 6dB over the bandwidth. This appears due to the loops and feed lines phasing being somewhat out of phase quadrature, thus giving values as low as 4dB difference, rather than the desired 6dB. However, although desirable it is not a requirement for the first potential application, currently the SnowOP project, since this problem it’s believed it can be dealt with in post processing, bringing this study to a successful completion.

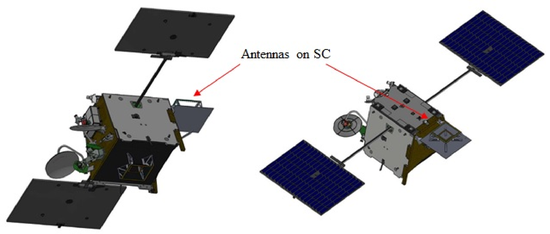


Figure 1. UHF Dual Loop Antennas for a SnowOP radar type application

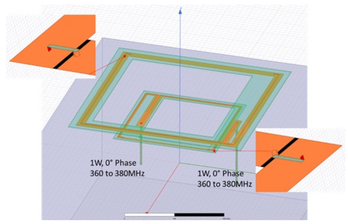
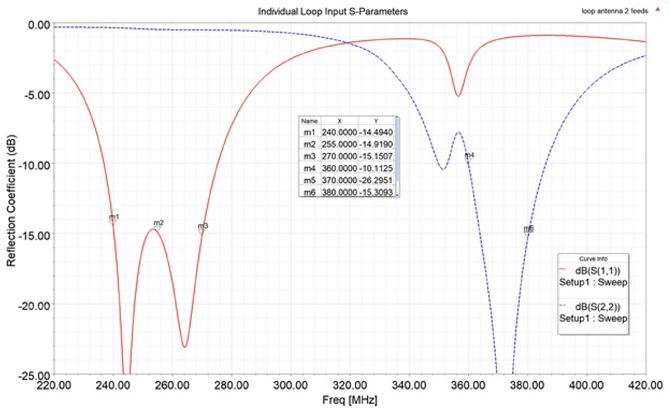


Figure 2. Dual UHF Antennas configuration



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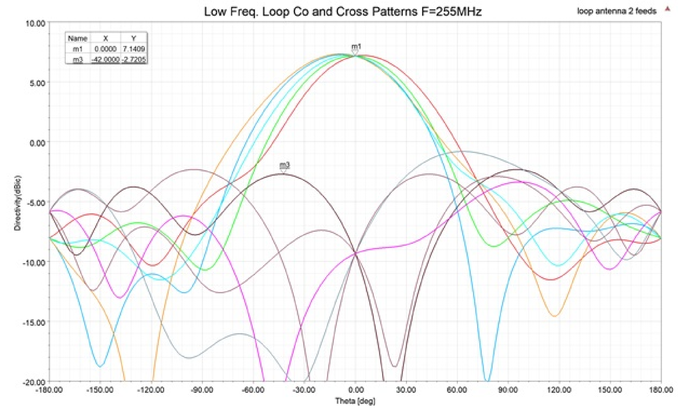

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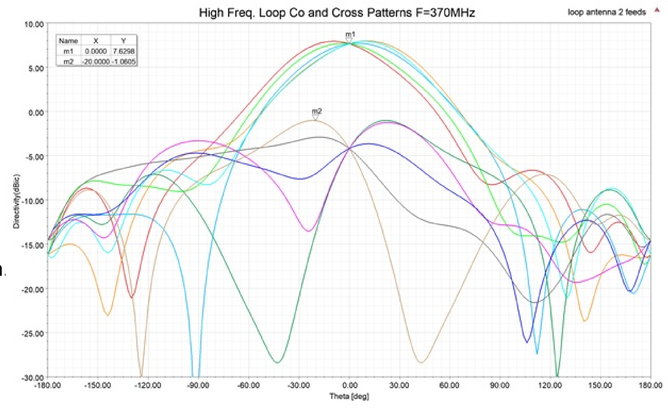

Figure 1. UHF Dual Loop Antennas for a SnowOP radar type application

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