P5-053

Pioneer Force

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TOKYO DENKI UNIVERSITY

科学衛星搭載 X/Ka 帯共用 1 次放射器の試作結果

Prototype of an X/Ka Dual-Band Primary Radiator for Satellite-Borne Cassegrain Antennas

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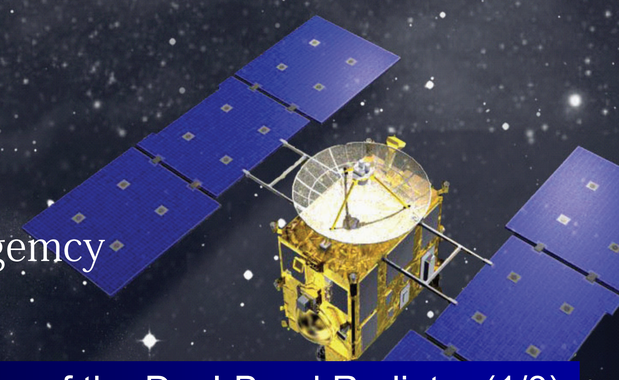

1. Research background

- Traditionally, satellite communication space exploration using deep X-band
- The role of X-band＝All communications necessary for survival craft
  - –（Observation data transmission，Command transmission，Housekeeping data acquisition）
- A small number of channels available X-band（10 MHz bandwidth）
- The role of the Ka-band
  - ➢ Increase in the number of available channels
  - –　（500 MHz @ 32.05 GHz）
  - ➢ Performance to complement the missing band X
- （High-speed transmission，High precision positioning）
- An X/Ka Dual-Band Primary Radiator for Satellite-Borne Cassegrain Antennas

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2. Purpose of research

- Primary radiator of Cassegrain antenna aboard spacecraft
- Examples of primary radiator X/Ka-band sharing
- X-band: Corrugated horn antenna, Ka-band：Disk-on-rod antenna
  - ➢ The problem is the weight and length in the axial direction
- Alternative: Sequential Array Using the square MSA (X-band)
  ＋4-elements helical array antenna (Ka-band)
  - ➢ VSWR is high because of the bond between the elements
  - ➢ ± large reverse-handed wave component in the cross-section of 45 °
- MSA rectangle that single-point feeding from an oblique direction (simulation)
  - ➢ Suppression of Mutual Coupling
  - ➢ Reverse-handed suppression of wave components
  - ➢ Wider bandwidth
- Prototyping and evaluation of (4-elements sequential array) primary radiator to be shared frequency Ka-band

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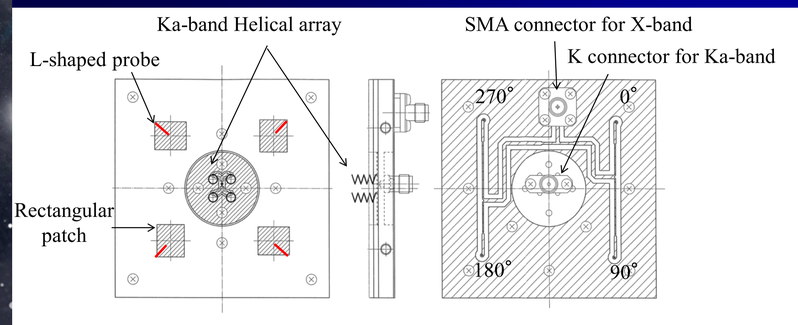
3. Construction of the Dual-Band Radiator (1/3)



- Place a sequential array-band X-band helical Ka, around its center
- Electrical coupling is small
- Are phase shifted by 90 ° by adjusting the length of the line
- L-shaped probe feed from an oblique angle of 45 °

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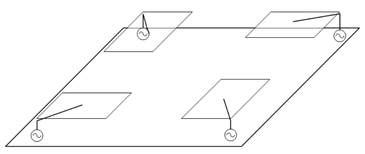
3. Construction of the Dual-Band Radiator (2/3)

- X-band antenna.



Type	Four-element sequential array of rectangular patch antennas
Size of patches	0.24 λ × 0.277 λ (10.1×11.6 mm)
Length of L-shaped probe	0.161 λ (6.76 mm)
Substrate	NPCH220A Relative permittivity = 1.27 tan δ = 0.005
Thickness of substrate	0.0415 λ (1.742 mm)
Element spacing	0.9 λ (37.79 mm)

•K. Ikeda et al., "A cross polarization suppressed sequential array with L-probe fed rectangular microstrip antennas," *IEICE Trans. Commun.*, vol. E94-B, pp.2653-2655, Sept., 2011

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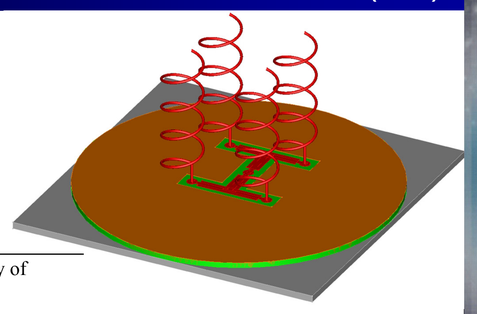
3. Construction of the Dual-Band Radiator (3/3)

- Ka-band antenna.



Type	Four-element array of helical antenna
Circumference of helices	λ (9.4339 mm)
Angle of inclination of helices	14°
Turns of helices	4
Diameter of conductor	0.24 mm ϕ
Element spacing	1.6 λ (5.9 mm)
Height of feeding points	-1.5 mm relative to the X-band patches

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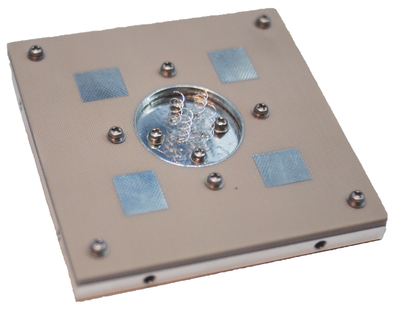
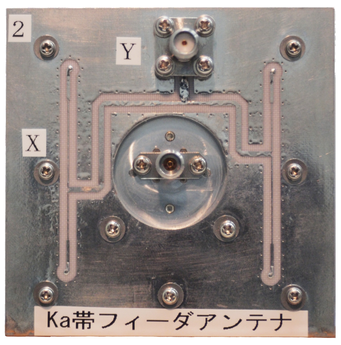
4. Primary Radiator

- Photo of the X/Ka Dual-Band Primary Radiator for Satellite-Borne Cassegrain Antennas.





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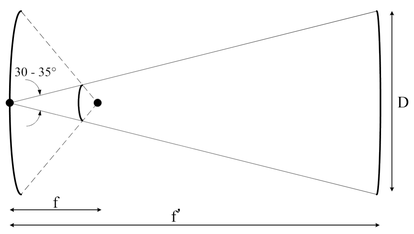
5. Reflector

- Specifications of satellite-borne high-gain antenna.



Diameter of the main reflector	1.5 m ϕ
Type	Axially-symmetic Cassegrain
Frequency reflector	X-band: 7.145 - 7.19 GHz 8.4-8.45 GHz Ka-band: 31.8 - 32.3 GHz
Polarization	Right-hand circular
FD ratio* of the main	0.33
Equivalent FD ratio*	1.45

*Focal length to diameter ratio

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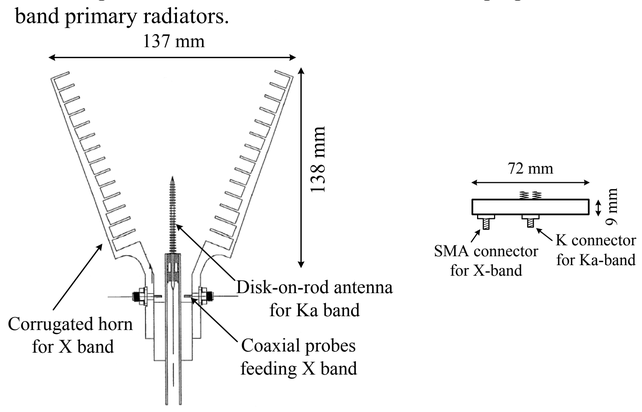
6. Proposed radiator

- Size comparison between the conventional and the proposed dual-band primary radiators.



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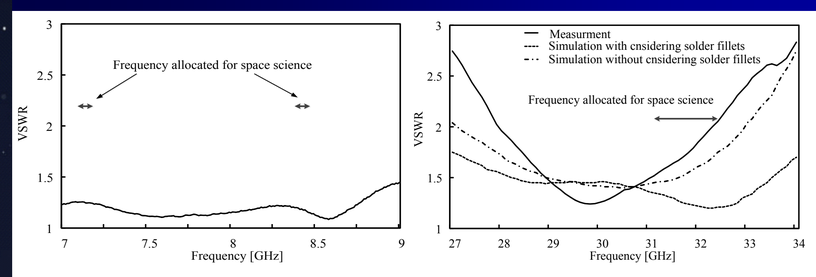
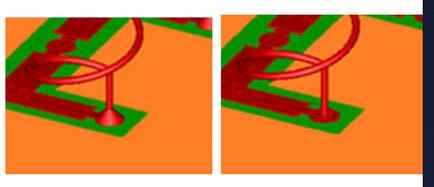
7. VSWR



- Measured results of VSWR in X and Ka bands.
- Simulation models of the bottoms of helices (a) with (b) without solder fillets.



(a)　(b)

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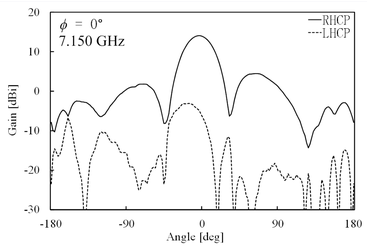
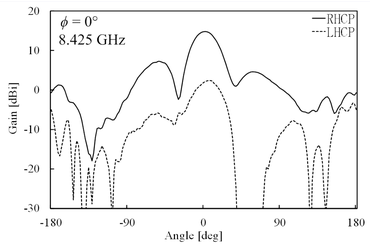
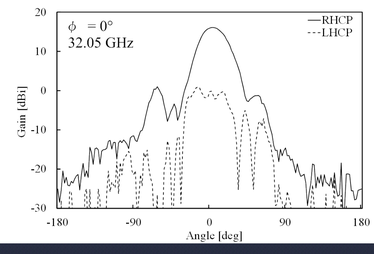
8. Radiation pattern







- Rdiation patterns of right- and left-handed circular polarizations in the $\phi = 0°$ and the 45° planes were measured with use made of horizontally- and vertically-polarized horn antennas.
- Measurement results are presented in Figures.

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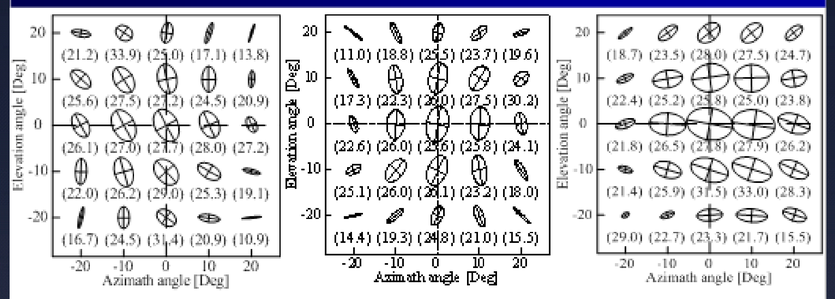
9. XPD



- The XPDs in X and Ka band were measured by employing a polarization pattern method with use of axially-rotatable linearly-polarized horn antennas.
- The frequency characteristics of XPDs in the boresight direction are presented.

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10. Conclusion

- A novel X/Ka dual-band primary radiator for a satellite-bone high-gain Cassegrain antenna has been proposed, prototype, and measured.
- A four-element sequential array fed with L-shaped probe and a four-element array of helical antennas were successfully collocated on the same plane. Satisfactory radiation characteristics—VSWR, radiation patterns, and XPD—were validated with use of a prototype.
- A discrepancy between the design and the realized center frequencies was observed, which was attributable to the effects of solder fillets at the bottoms of the helices.
- Significant reduction of size and weight was achieved in comparison with a conventional radiator comprising a corrugated horn for X band and a coaxially-arranged disk-on-od antenna for Ka band.

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