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Design and fabrication of X-band LP antenna for wideband synthetic aperture radar

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ABSTRACT

The synthetic aperture radar (SAR) is a kind of an active sensors. To acquire the images of target in remote area, the SAR uses microwave for its own signal. Among the wide range of microwave, X-band (8-10 GHz) is widely used for the high-resolution target imaging.
Josaphat microwave remote sensing laboratory (JMRSL) is planning to develop the X-band airborne SAR system using Boeing 737-200 as a platform. But the antenna mounting space is limited. In addition, to offer the high-resolution images, the proposed X-band antenna has the characteristics of wide bandwidth. This paper proposes the small sized wideband X-band antenna design and simulation result obtained by using CST MW STUDIO which has wide bandwidth and small size.

INTRODUCTION

❖ **Motivation**

- Synthetic aperture radar (SAR) is used for various kinds of the Earth observation
  -> High-resolution performance is required
  - To realize high resolution, the wide bandwidth antenna is required.
    - Relationship between the resolution and the chirp signal bandwidth
      - $r = c\tau/2 = c/2B$
      - Higher the chirp signal bandwidth, better the resolution
    - To use wide chirp signal bandwidth, the antenna bandwidth is also needed to be wide.
- The antenna mounting space of Boeing 737-200 is limited.
  - Smaller the size, better for space.

❖ **Requirement of this experiment**

BOEING 737-200 On-board SAR Mission

Categories	Specification	Rationale
Platform specification		
Platform	Boeing 737-200	
Cruising speed	Max. 0.74 mach / 906.53 km/h	
Ground speed	420-460 kts / 777.84-851.92 km/h	
Altitude	Max. 35,000 feet / 10,668 m	
Radome dimension		Max. size
Width	508.66 cm	
Height	38.10 cm	
Depth	50.80 cm	
Antenna constraints		Planar antenna
Antenna dimension	0.3 m x 0.6 m	Width x Length
Beam width (q_{el}, q_{az})	5.36° and 2.68°	
Min. antenna size	0.09 m^2	
Antenna efficiency	0.7	
Signal properties		
Center frequency	9.4 GHz	X-band
Chirp bandwidth	800 MHz	DDFS
Pulse width	15 ms	
Maximum duty cycle	10 %	RF constraint
Geometry parameters		
Off nadir angle	50°	Tilt angle = 40°
Incidence angle	50.11°	
SNR parameters		
Peak power	50 W	
NESZ	-17 dB	Land monitoring
SNR	27 dB	

SMALL SIZED WIDEBAND ANTENNA

❖ **Each layer precise model**

- The proposed antenna consists of 3-layer. The actual size and shape are shown below.

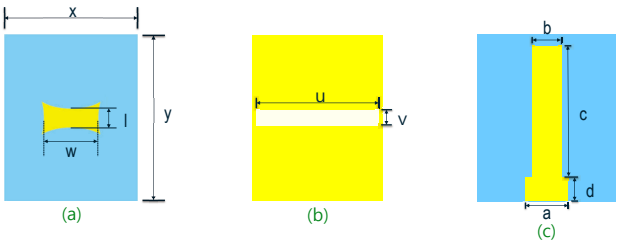

Figure 1. Antenna layer design
(a) patch layer (b) slot layer (c) feed layer

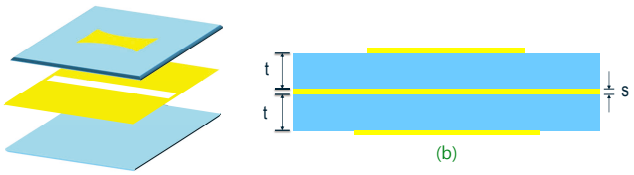

Figure 2. Antenna geometry
(a)structure view (b) side view

Figure 3. fabricated antenna
(a) patch layer (b) slot layer (c) feed layer

Table 1. each part size of this antenna

parameter	x	y	l	w	u	v	a	b	c	d	t	s
Value(mm)	16	21	2.3	6.5	15	2	4.94	3.4	16.5	3	1.6	0.035

❖ **Antenna structure**

- Rectangular patch
  - Truncated with ellipse on edge.
  - The radius of ellipse are 1mm and 2mm.
- Antenna specification
  - Substrate : NPC-H220A (NIPPON PILLAR PACKING Co.,Ltd)
  - Dielectric constant : 2.17
  - Loss tangent : 0.0005
- Antenna structure
  - 3-layer : Top (patch), middle (slot), bottom (feed).
- Feeding method
  - In this design, aperture-coupled feed is used.
  - The reason is flexibility of feeding size.

SIMULATION RESULT

❖ **Antenna performance using CST**

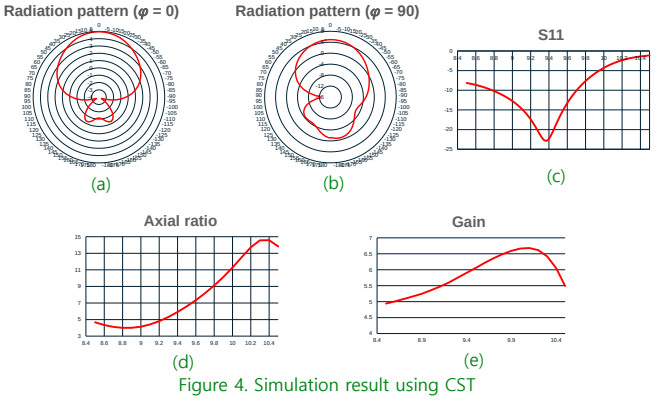

Figure 4. Simulation result using CST
(a) Radiation pattern (φ = 0) (b) radiation pattern (φ = 90)
(c) S11 value (d) Axial ratio (e) gain

- The measured values of S11, gain and radiation pattern (φ=0) are in good agreement. However, minimum value of axial ratio is around 4dB from the simulation result. It means the polarization of this antenna is elliptical polarization. This disagreement with my aim is considered happened by the shape of the patch.
  The other disagreement is radiation pattern (φ=90). As you can see from figure 4 (b), the radiated wave is not symmetry and curve to y direction. The result can be consider which is caused by width difference of feed. In this situation, the area which has 4.94 of width affect to patch and bend the wave.

CONCLUSION

- This research presents the design and simulation result of X-band SAR antenna. Simulation results almost satisfy the requirement, however, calibration is required. To realize linear polarization and wide band, this research will continue.

REFERENCE

[1] Josaphat Tetuko Sri Sumantyo, Progress On Development Of Synthetic Aperture Radar Onboard Uav And Microsatellite, *IGARSS*, pp.1081-1084, 2014.
[2] C.A.Balanis, *Antenna Theory Analysis and Design*, John Willey & Sons, Inc, 2005.