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A NOVEL PHASE - FREQUENCY SCANNED PLANAR PHASED ARRAY ANTENNA

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This paper describes a novel phase-frequency scanned planar array antenna which has been developed and manufactured in Japan as the first operational phased array antenna.

Configuration

The antenna is shown in Fig.-1, and the configuration of RF circuitry is shown in Fig.-2, schematically.

Operated in S-Band, the aperture of the antenna consists of 64 identical waveguide linear arrays each of which contains 76 inclined radiating slots. The feed system consists of the sinuous delay line with crossguide directional couplers in broadwall of the guide for frequency scanning, and of the 4-bit digital, non-reciprocal ferrite phase shifters each of which is assigned to each linear array row for phase scanning.

While the elevation scan is performed by the combined phase-frequency scan, the azimuthal scan is performed by the mechanical rotation.

Phase-Frequency Scanning

The frequency scanning is performed by means of the transmission of a series of sequential sub-pulses conveyed along the sinuous line which results a series of sequential beams in elevation separated approximately 1 degree with each other.

Furthermore, these sequential beams are subjected to phase scan in group to acquire the steering up to 24 degrees or more in elevation by means of the programmed control of the digital phase shifters which have been developed specifically for this project.[1]

It is worthy of special notice that the methodology described above enables us to make the beneficial use of the features of the frequency scanning technique and that of the phase scanning, minimizing required frequency bandwidth and scanning time.

The use of a computer has been found prerequisite to obtain the final design parameters, particularly, for the reduction of sidelobe levels due to the quantized phase errors of the digital phase shifters by the method offered recently by the authers.[2]

Performance Achieved

Colossal amounts of radiating patterns have been recorded. Fig.-3 and -4 show typical radiating patterns in azimuthal and elevation planes, respectively.

Fig.-5 shows an example of successive patterns of the combined phase-frequency scan in elevation plane. The phase scanning patterns under the actual scanning conditions were also recorded which verify the proper operation of the scanning control circuits as well. The following table summarizes typical measured data on this antenna.

Scanning Angle		24 degs. or more
Beam Steering Accuracy		Better than 0.04 degs.
Beamwidth	AZ.	1.25 degrees
	EL.	1.52 degrees
Gain		More than 39 dB
Sidelobe Level	AZ.	Less than 28 dB
	EL.	Less than 24 dB
Circular Polarization		ICR More than 25 dB

References

1. N.Ogasawara, M.Sugie, and J.Aiba, " High power Latching Phase Shifters for S,C-Band " International Conference on Ferrites, 884.3 (July, 1970)
2. N.Goto, M.Sugie, and K.Fukumoto, " Radiation Patterns of a Scanning Antenna Using Digital Phase Shifters " NEC Research & Development, No.16 pp.73-80 (January, 1970)

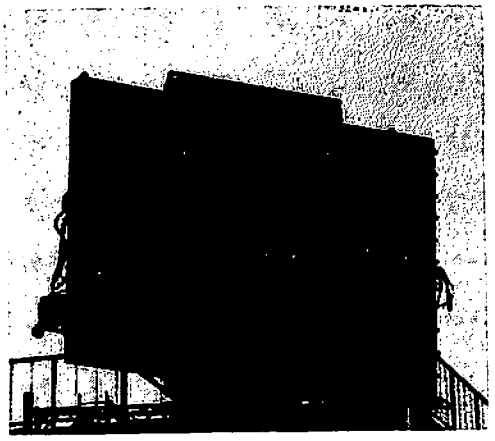

Fig.1 The Phase-Frequency Scanned Planar Array.

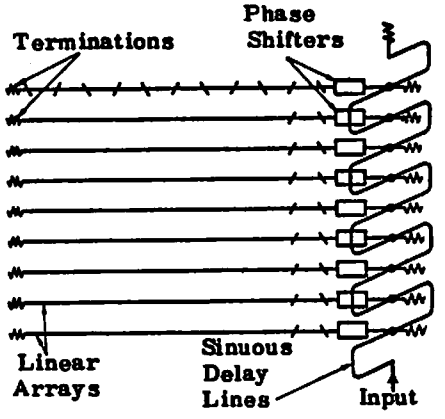

Fig.2 The RF Circuitry.

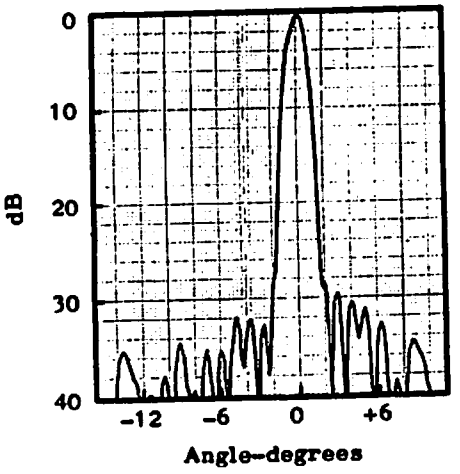

Fig.3 Azimuth Pattern.

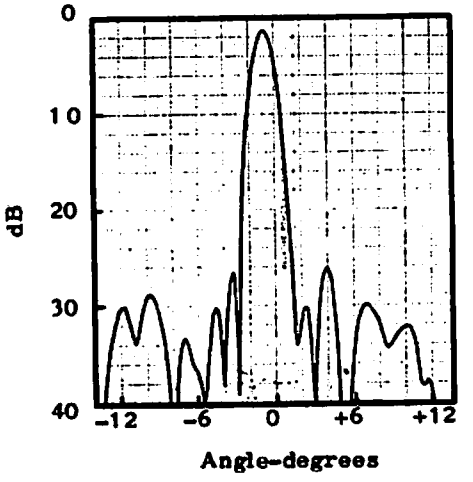

Fig.4 Elevation Pattern.

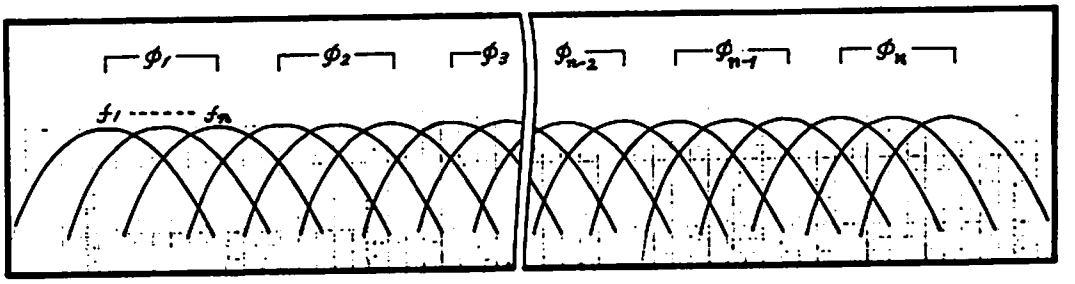

Fig.5 Patterns of The Combined Phase-Frequency Scan in Elevation Plane.