Mobile TV Receiving Antenna System of Direct Broadcasting Satellite for Train Application

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INTRODUCTION

The direct broadcasting satellite (DBS) is now experimentally operated by NHK in Japan. And a lot of TV receiving terminals have been developed for domestic use. In this paper, as the mobile TV receiving terminal of the DBS, newly developed mechanically steered planar antenna system is presented. This system is developed for train application and the trial product is installed in SHINKANSEN (the bullet train). Now its running data is collected.

DESIGN & CONSTRUCTION

The block diagram is shown in Fig. 5. This system consists of planar array antenna, TV receiver, antenna driver and controller (desktop computer). It applies the combination of the open-loop and closed-loop control for satellite tracking. As the open-loop control, the program tracking is used. The satellite direction is calculated based on the data of train position and cant of the rail, known by the distance from the start point. The above data is written in RAM of the antenna driver. On the other hand, as the closed-loop tracking, a kind of lobing method is used. In this mode, the beam is dithered in four directions (two in azimuth plane and two in elevation plane) in high frequency. By dithering the beam, when the antenna axis is offset from the satellite direction, the receiving level is modulated. Demodulating this modulated signal, the tracking error signal to drive the antenna to direct the satellite is got. To make the construction simple, the AGC signal is monitored as the modulated receiving level.

The antenna consists of four planar antennas, and mounted on 880*880 (mm) aluminum honeycomb plate, and its surface accuracy is maintained within 0.45 mm rms. The planar antenna is a crank array antenna printed on a glassfiber reinforced PTFE and its beam is tilted by 30 degrees in elevation plane in order to make the antenna hight lower. Each antenna has LNA to reduce the C/N degradation because of the feeder loss. The phase shifters connected behind LNAs are switched by phase shifter driver in 100-400 Hz to steer the antenna beam sequentially in four directions which are 0.2 degrees offset from antenna axis. The above LNAs and phase shifters are mounted on a PTFE board and attached at the rear side of the planar antenna.

MECHANICAL CONSIDERATION

The vibration and the pressure are important design factors for mobile antenna system. This system is designed to satisfy JIS-E-4031 (Japanese Industrial Standard on the vibration test method for the parts of railway rolling stock). Furthermore, as the bullet train SHINKANSEN runs at the speed of 220Km/h, then the highest pressure to be born is 800 kg/m^2 in the tunnel. To satisfy the condition, the radome is constructed with three layers (two FRP layers and one poly-urethan layer), maintainig its transmission loss within 0.5 dB.

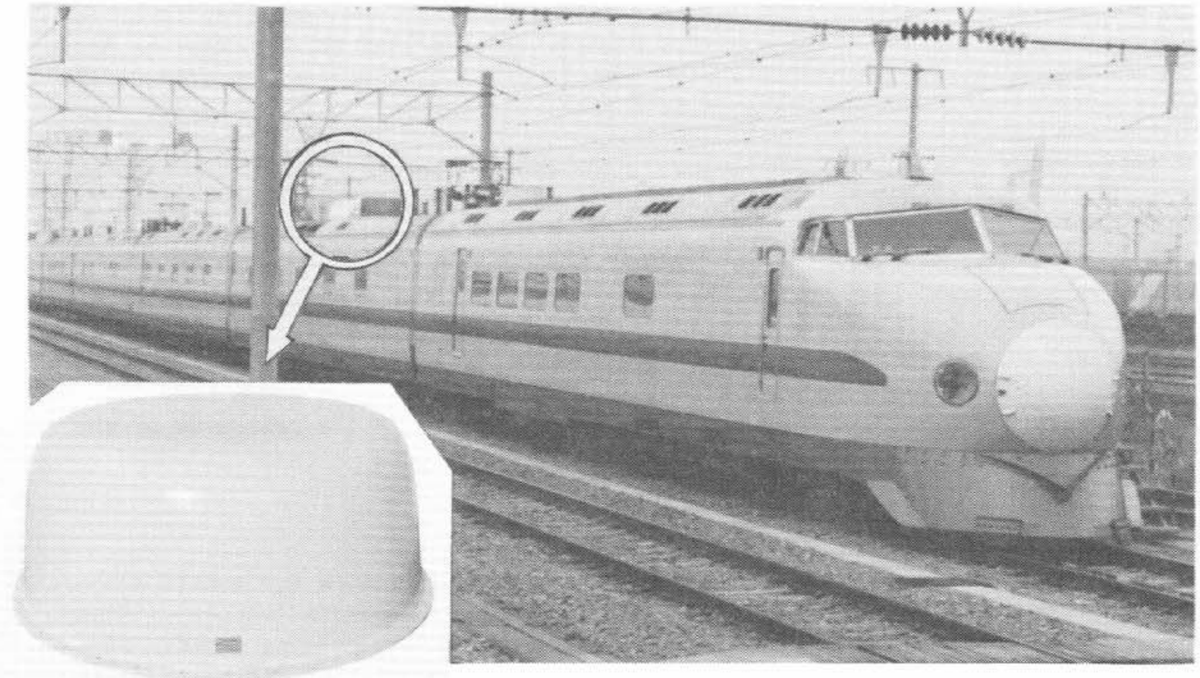
PERFORMANCE

The antenna performance is summarised below.

Gain	35 dB/11.95 GHz
Polarization	RHCP
Beam Tilt	30°
Dimension	Φ1430 * 630 (mm)
Operation Range	25 - 58° (EL) ± 120 ° (AZ)

TABLE- 1

Fig.6~Fig.9 show the closed-loop tracking performance. Fig. 6 shows the beam switching position in diamond shape, and its offset angle is maintained about 0.2 degrees. Fig. 7 shows the main beam pattern switched in El plane, and Fig. 8 shows the tracking error signal got by demodulating the receiving level modulated by beam switching. Its demodulation sensitivity is about 7.5 V/deg . Fig. 9 shows the tracking error at the rolling test, and it results in about ±0.17 degrees error at the speed of 3 deg/s in azimuth plane and about ±0.2 degrees error at the speed of 2 deg/s in elevation plane respectively.



(Antenna Radome)
Fig. 1 Antenna mounted on SHINKANSEN

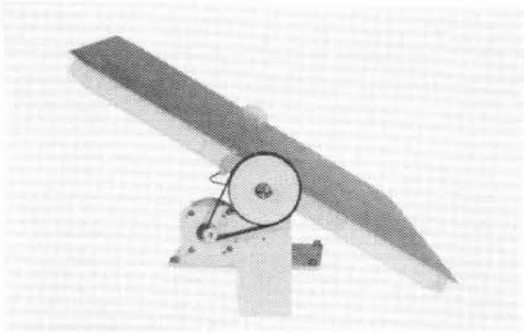


Fig.2 Planar Antenna

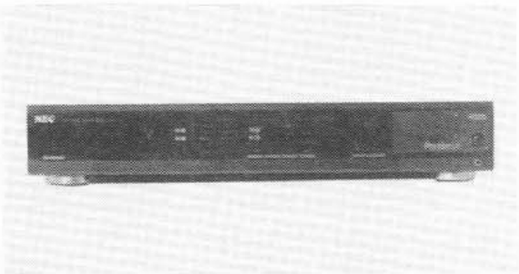


Fig. 3 TV Receiver

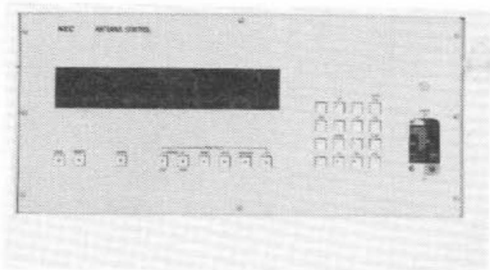


Fig. 4 Antenna Driver

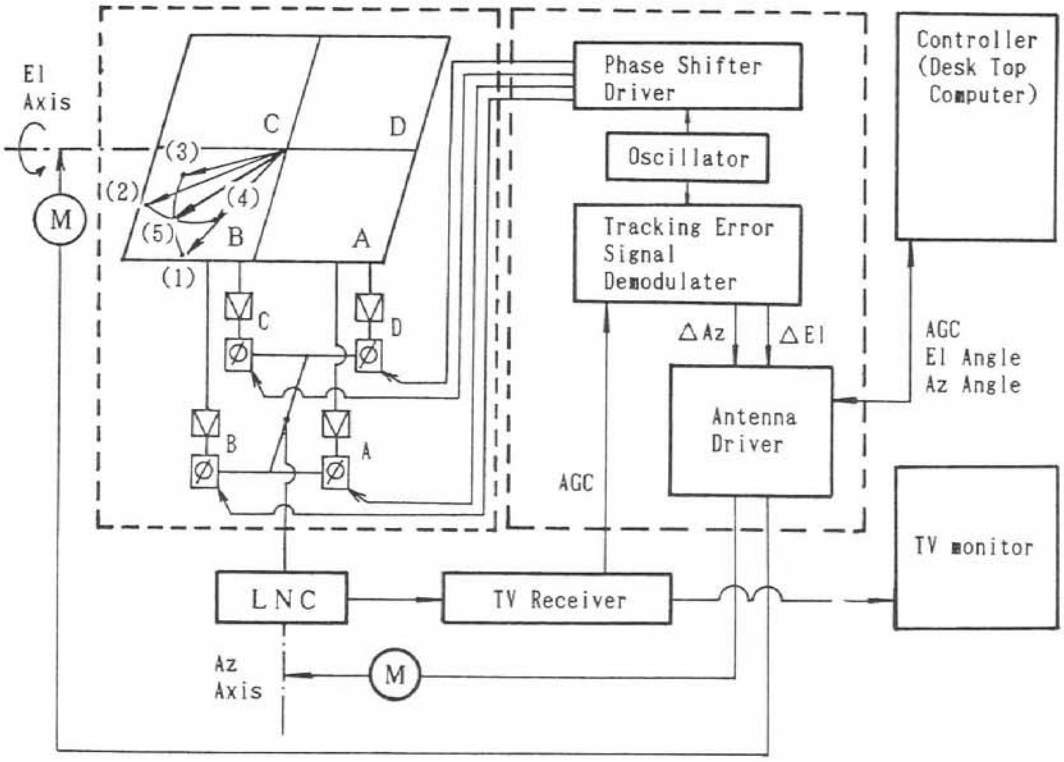


Fig. 5 Block Diagram of the Antenna System

CONCLUSION

Mobile TV receiving antenna system for train application is developed. And its antenna and tracking performance is confirmed to be suitable for train. Now it is installed in SHINKANSEN and the running test is being performed.

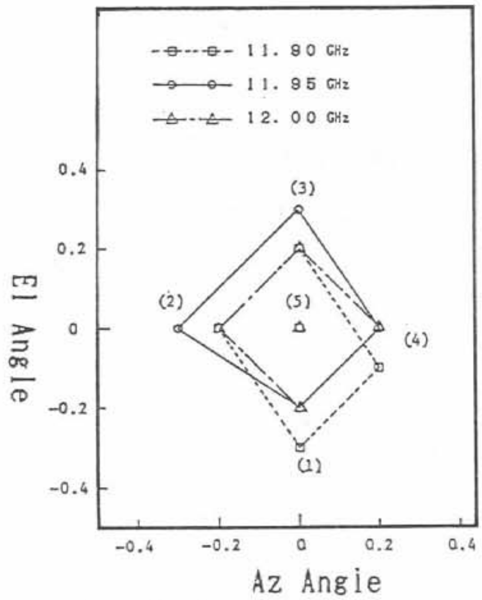


Fig. 6 Beam Steering Characteristics in Diamond Shape

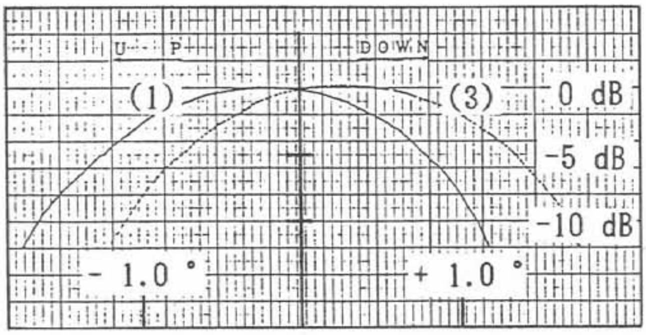


Fig. 7 Steered Pattern in El.

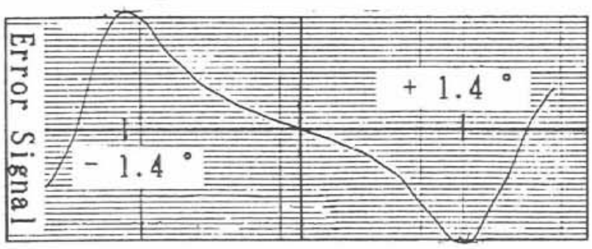


Fig. 8 Tracking Error Signal by demodulating the modulated AGC signal.

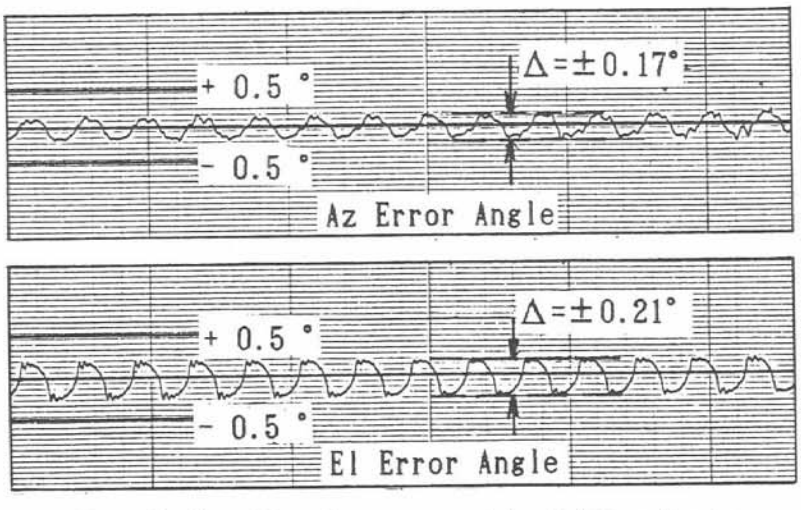


Fig. 9 Tracking Error caused by Rolling Test