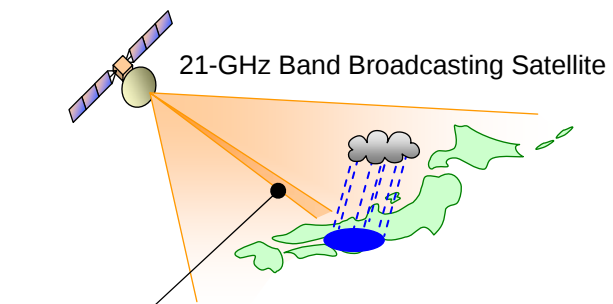


## Onboard Traveling Wave Tube for 21-GHz Band Broadcasting Satellite

NHK Science and Technical Research Laboratories

At NHK Science and Technical Research Laboratories, we are doing research on the satellite broadcasting system in the 21-GHz band to provide a next generation service such as Super Hi-Vision which has high definition imaging with a resolution of over 4000 scan lines. To compensate for rain attenuation in the 21-GHz band, we are developing a system with a phased-array antenna that increases the radiation power only in heavy rainfall areas.

Each array element consists of a traveling wave tube (TWT) amplifier, a filter and a horn antenna. In order to arrange densely TWTs in an array formation, we made a

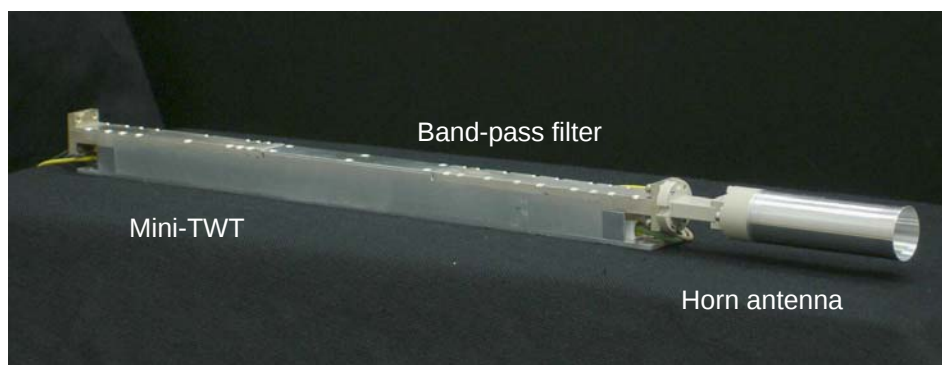


Boosted beam to compensate for rain attenuation

Concept of the compensation technique for rain attenuation

Performance of the mini-TWT

|                    |                        |
|--------------------|------------------------|
| Frequency          | 21.7 GHz               |
| Input power        | 4.2 dBm                |
| Output power       | 40.3 dBm (10.5 W)      |
| Gain               | 36.0 dB                |
| Overall efficiency | 44%                    |
| Helix voltage      | 4.65 kV                |
| Dimensions         | 15.3 X 20.0 X 300.0 mm |
| Weight             | 270 g                  |

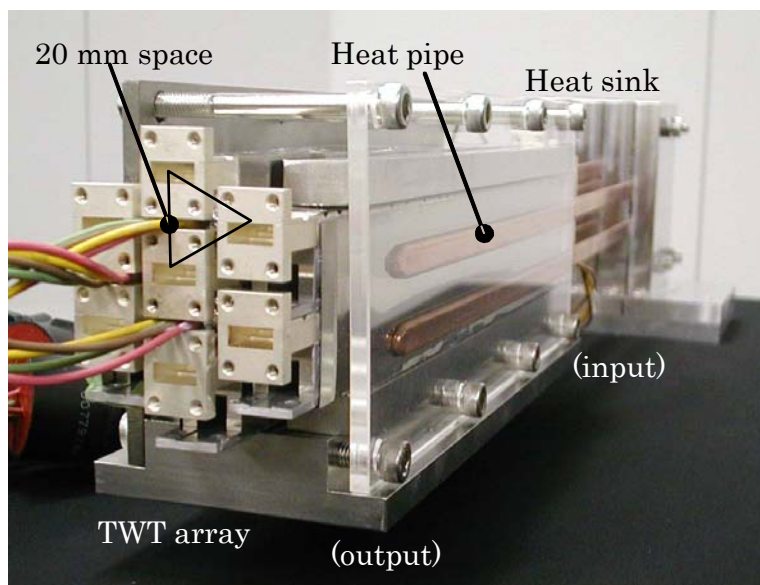


Trial Miniature TWT

prototype miniature TWT with small cross-sectioned area. The cross section dimensions were 15.3 X 20.0 mm, the weight was 270 g and the output power was 10.5 W with total efficiency of 44%.

To protect radio astronomy service which uses the frequency band adjacent to 21-GHz band for satellite broadcasting, we made a five-stage Chebyshev band-pass filter with large attenuation outside a broadcasting band. This prototype filter fitted with a miniature TWT.

In the array structure, neighboring TWTs create mutual magnetic interference. So a thin magnetic shield was inserted to reduce interference. Heat pipes were used to eliminate the heat generated by TWTs. The prototype TWT array was given a triangular arrangement with 20 mm spacing (corresponding to 1.5 wavelengths at 21.7 GHz) between TWT elements. The TWTs arranged in the array performed almost the same as a single operation.



Miniature TWT Array Model

In the future, we plan to develop a beam forming network (BFN) and a nonlinear compensator which have the nearly the same cross-sectional area as a miniature TWT.

NEC Microwave Tube Ltd. is cooperating in our efforts to develop miniature TWT prototypes.