The Mizusawa 10-m Antenna and Its VLBI Observation System

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Abstract. Mizusawa Astrogeodinamics Observatory, which is a branch of the National Astronomical observatory (NAO), has constructed a 10-m radio telescope for the VLBI measurement of the earth rotation and the VLBI observation of astronomical radio sources. In this paper, we will report the performance of the 10-m VLBI system and the results of preliminary VLBI experiments.

1. Present Status

The performances of the Mizusawa 10-m antenna are presented in Table 1. The telescope has a shaped Cassegrain reflector and an Alt.-Az. mount. Main reflector consists of 36 aluminium panels and has the surface accuracy of 0.34 mm rms which is measured with a theodolite. Hence, the telescope can observe up to 43 GHz or higher frequencies. This telescope has two feed systems for simultaneous observations with the 2 GHz and 8 GHz bands. One is ordinary type feed horn for frequencies higher than 2 GHz, and another feed for 2 GHz is divided into four parts and constructed around the higher frequency feed horn. Signals of 2 GHz corrected by each divided feeds are composed with a phase-composite device before amplification. Observing frequency higher than 2 GHz is selected by changing a wave guide which connects the horn and a receiver. The most notable characteristics of this antenna is a very high slew speed and a smooth motion which shows no overshoot beginning and ending the slew motion. These are resulted from a newly developed digital-servo control system.

The antenna is equipped with 2 (S-band), 8 (X-band), and 22 GHz receivers. The 2 and 8 GHz receivers are used for the geodynamical observations and the 22 GHz is for the geodynamical and the astrophysical observations. Measured characteristics of these receivers are shown in Table 2. The system temperatures of S-band and 22 GHz are relatively high. One of the reasons of the high value in S-band is because the telescope is designed to exhibit its ability in higher frequency region. In the case of 22 GHz, the high system temperature is partly due to a cooling temperature of HEMT amp which we could cool down to only about 100 K when the measurement was done (in usual, it should reach to 20 K or less in normal operation).

Table 1. Antenna design and performances.

DIAMETER	10 m
SURFACE ACCURACY	0.34 mm rms
OPERATING	S-band (2.2 GHz)
FREQUENCIES	X-band (8.8 GHz)
	22 GHz
	43 GHz (now planning)
ELEVATION RANGE	2.°4 to 91.°5
AZIMUTH RANGE	-91° to +451°
POINTING ACCURACY	0.'4 rms
SLEW SPEED	3.°0 sec^{-1}
SLEW ACCELARATION	3.°7 sec^{-2}
WIND RESTRICTION	30 m sec^{-1} (operation limit)
	60 m sec^{-1} (survivable limit)

Table 2. Receiver characteristics.

RECEIVERS	FREQUENCIES	GAIN	T_{RX}	T_{SYS}
S-band FET	2.15 - 2.35 GHz	40 dB	50 - 75 K	340 K
X-band cooled FET	8.18 - 8.60 GHz	39 dB	55 K	130 K
22 GHz cooled HEMT	19.5 - 25.0 GHz	49 dB	120 K	290 K

The receiver temperature (*Trx*) of 22 GHz was measured at the cooling temperature of 15 K. We have a plan to install a 43 GHz HEMT receiver within 1994.

Figure 1 shows a diagram of our VLBI observing system. The RF signals which are amplified in each receiver are converted to IF frequency in a down converter. Phase-stable optical fiber transmits the IF signals from the antenna to observing building which is 120 m away from the antenna. K-4 recording system is used as a backend and it can record digitized 16-channel data with 4 Mbps sampling rate. An H-maser frequency standard is used in our system. A reference signal made by H-maser is distributed to phase-locked local oscillators for the down convert of signal frequency and to a phase calibration unit. The recorded signals are correlated using a XF type correlator NAOCO, which is developed by NAO (SHIBATA *et al.*, 1994).

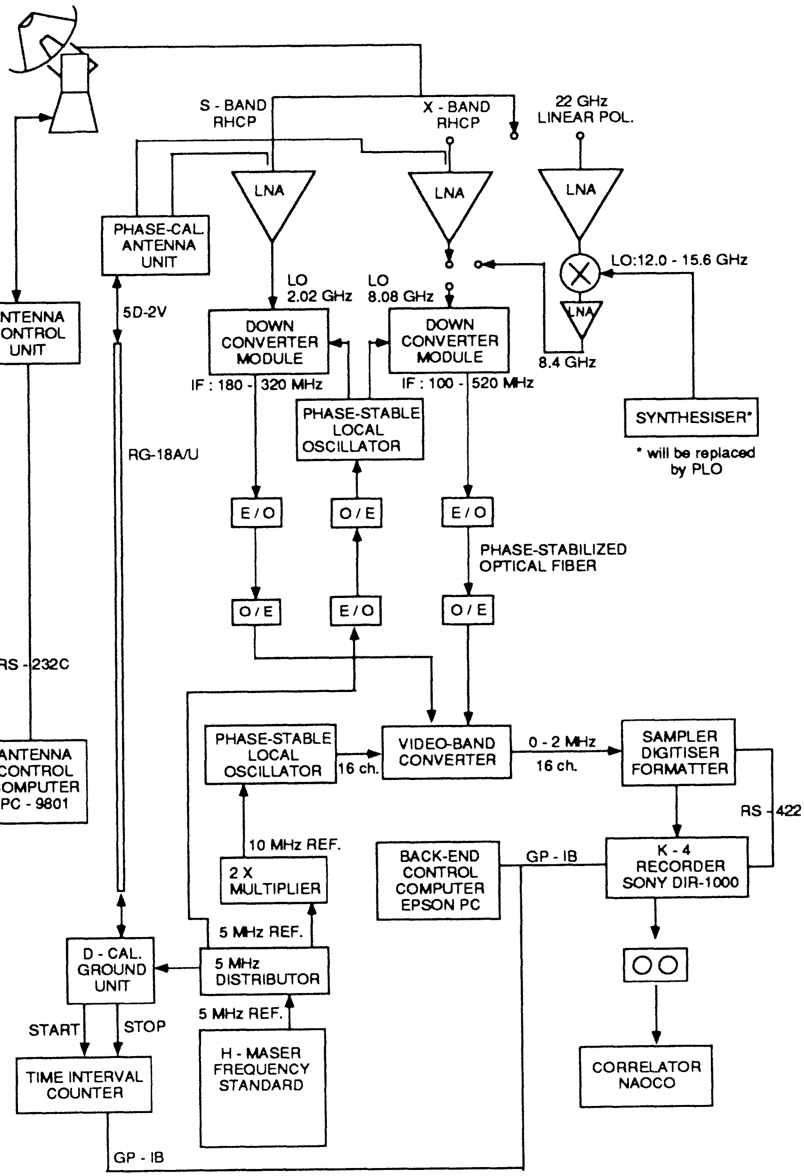

Fig. 1. System block diagram of 10-m antenna.

2. Performance Measurements and VLBI Experiments

We have measured the pointing errors of the 10-m antenna by observing astronomical radio sources, Cyg A, Cas A, 3C58, Tau A, Ori A, 3C273, and Vir A with 8 GHz continuum. Pointing correction function is derived from the least square fitting to the measured data. The correction function takes account of the tilt of azimuth axis, the difference from perpendicularity between azimuth and elevation axes, the difference between mechanical and optical axes, the encoder offsets, and the gravitational change of beam axis. An estimated pointing accuracy after the correction is about 0.4 arcmin. Although this accuracy is sufficient to the observation at the 22 GHz band, more accurate measurements of pointing error using 22 GHz maser sources are necessary for the 43 GHz observation.

Table 3 presents the results of antenna efficiency observations. We note that the

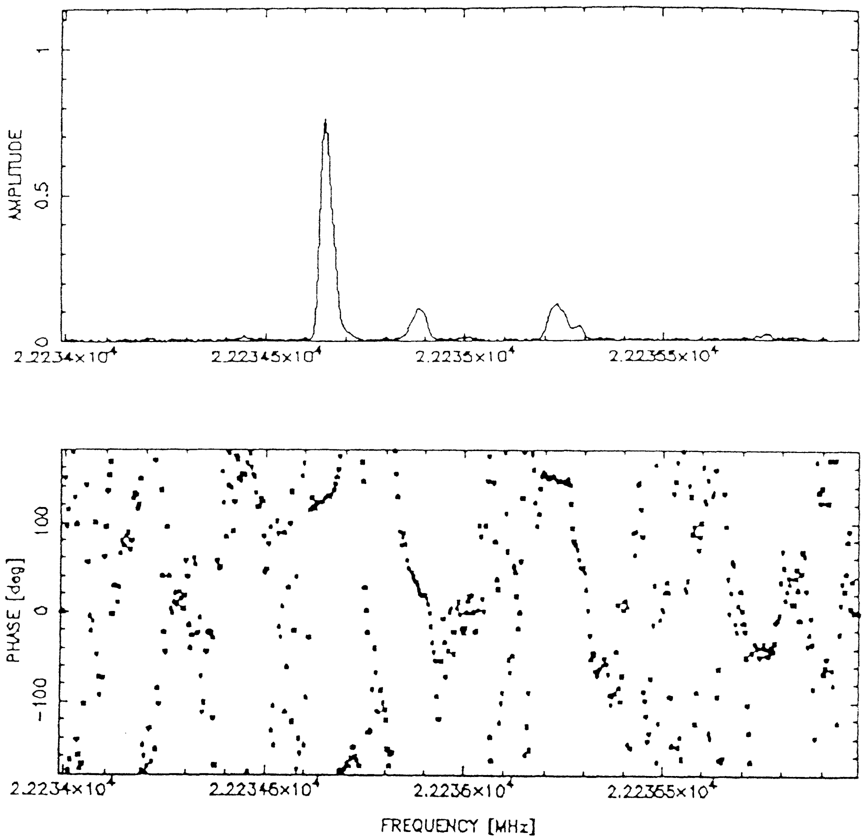

Fig. 2. Cross power spectrum of the 22 GHz H_2O maser of Orion-KL. Mizusawa-Nobeyama baseline.

Table 3. Antenna efficiencies.

	S-band	X-band	22 GHz
APERTURE EFFICIENCY	0.38	0.63	0.36
MAIN BEAM EFFICIENCY	0.55	0.73	0.47
HPBW (arcmin)	54	13	5.2

S-band is suffered by many interferences from ground sources. Hence, efficiencies and beam size of the 2 GHz have large uncertainty.

The first VLBI experiment was made with Kashima 34-m station in S/X-band at June 22, 1993 and the 22 GHz experiment with Nobeyama 45-m was made 6 days later. We could find fringe peak very easily in both experiments except that we had small trouble to use the software. Figure 2 shows the cross power spectrum of H_2O maser emission from Orion KL obtained from the 22 GHz experiment at June 28.

We had tentatively joined to the International Radio Interferometric Surveying-Pacific (IRIS-P) observation in July, 1993. In this observation, Mizusawa 10 m could perform its role successfully. The coordinates of the 10-m antenna position are derived as follows from this observation.

$X = -3857236.0270 \pm 0.0110$ m,
$Y = 3108803.2741 \pm 0.0026$ m,
$Z = 4003883.1041 \pm 0.0025$ m.

3. Conclusion

From the results of above experiments, we could confirm that Mizusawa 10-m VLBI system is well performed and that we are now able to organize and execute the VLBI observations with confidence. On the other hand, we think that it is necessary to continue the improvement and the development of the VLBI system for higher reliability and higher accuracy.

We are now planning following subjects.

(1) Carry out the IRIS-P observation regularly for the measurement of earth rotation.

(2) Execute the 22 GHz VLBI observations for astrophysics with Nobeyama 45 m, Kashima 34 m, Kagoshima 6 m, and foreign stations. Astronomical targets are H_2O maser emission from evolved stars, galactic HII regions, and Galaxies and continuum emission from QSOs, etc.

(3) Install 43 GHz receiver to 10-m antenna and execute the 43 GHz VLBI observations.

(4) Construct an Acousto-Optical Spectrometer (AOS) and use the 10-m antenna as a single dish telescope.

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